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Innovation, Time, and Territory: Space and the Business Organization of Dell Computer

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Abstract: Businesses reshape the territorial configuration of economic activity by creating new forms of organization as part of the innovation process. Focusing on the case of Dell Computer, this article builds an argument about the geographic development of economies that is structured around four elements: (1) the firm, (2) the innovation process occurring within the firm, (3) the business organization of the firm, and (4) the territory in which the firm operates and extracts profit. In tracing this route from the enterprise to territory, this article draws upon the notion of "communications revolutions" as a catalyst for the innovative impulse of firms. In adapting to communications revolutions, firms, such as Dell, emerge as innovators by learning to recalibrate the time increments that are expended during the steps of making and marketing products, thereby shifting competition from the product to the processes of capitalist circulation. This recalibration of time results in the creation of process-driven routines for making profit and a transformation in the organizational arrangements through which firms implement such routines. As firms reinvent forms of organization to implement these time-based innovative routines, they alter the linkages between adjacent steps in their profit-making activity. By reorganizing these linkages and changing the nature of business organization, innovative firms reconfigure the territory in which they operate and accumulate. This reconfiguration of territory, however, is not the mechanical result of efficiency criteria. Firms use power over other firms to redeploy the location of activity in their production networks in an effort to achieve time economies and innovative efficiencies.

Key words: innovation, territory, business organization, communications, Dell Computer.

Business firms and the forms of organization that they assume in pursuit of profit are inherently territorial (Walker 1988). Companies assume territorial attributes in the ways in which they organize the different activities that go into creating and selling products and the way they allocate these activities within their own enterprises and among other firms with which they interact. Such managerial allocation of the various steps that are involved in the production and sale of goods creates linkages of economic activity within and across firms. From these intrafirm and interfirm linkages emerge forms of business organization that are marked by boundaries within and between enterprises that reflect an organizational distribution of economic activity. This organizational distribution of economic activity, built from the boundaries within and between firms, spreads economic activity territorially across space. In this way, business organization has territorial outcomes. This article reveals how business firms reshape the territorial configuration of economies in creating new forms of organization as part of the innovation process.

Innovation and technological change play decisive roles in the geographic transformation of economic activity (Storper and Walker 1989; Angel 1994; Castells 1996).

Nevertheless, while the relationship between innovation and the spatial reorganization of economies is well established in the geographic literature, what is less clearly specified are the mechanisms by which innovation transforms the geography of economies. Part of the problem involves the choice of what is to be studied as a unit of analysis from the myriad approaches to the puzzle of innovation and spatial change. Some researchers have insisted on establishing the connection between innovation and territory through the study of specific *places* and the cultures of interactive learning that flourish in such places (Saxenian 1994). Others with a similar perspective have shifted the emphasis from specific places to more generalized territorial units, most notably the region or the nation, in accounting for the emergence of regional or national *systems of innovation* (Asheim and Gertler 2005; Nelson 1993). A different approach connects innovation to the spatial transformation of economies through the study of specific *industries* and the shifting locational patterns of industries as they develop new products and processes and seek territorial outlets for producing and selling in new ways (Angel and Engstrom 1995). Still another approach focuses on the process of *capital accumulation* in which territorial change results from the creatively destructive and innovative tendencies of industries as they seek new spaces for investment, resources, markets, and growth (Storper and Walker 1989). A final group of researchers have uncovered the nexus between innovation and territorial change in forms of *business organization*—commodity chains and interfirm networks—that emerge in response to new technologies and new relationships among lead producer firms, suppliers, and buyers (Gereffi and Korzeniwicz 1994; Castells 1996).

This article draws from each of these literatures, but uses an "actor-centered" approach to the issue of business organization in uncovering the sources of spatial change in economies (Markusen 1994, 2003).[1] It focuses on the competitive experience of the business *firm,* reconfiguring territory as an agent making strategic decisions about accumulation and innovation and acting on such choices. Its aim is to contribute to a surprisingly limited theoretical and empirical literature in economic geography on the nexus between the firm and territory (see especially Maskell 2001; Dicken and Malmberg 2001; Taylor and Asheim 2001). Thus, this article situates the firm at the center of changes in economic geography, while examining the specific mechanisms that link the business enterprise as an agent to innovation and territorial transformation.

In developing this connection between business enterprise and territory, this study builds an argument that is structured around four elements: (1) the firm, (2) the innovation process occurring within the firm, (3) the business organization of the firm, and (4) the territory in which the firm operates and accumulates profit. It connects the firm to territorial development by focusing on the *organizational* attributes of innovation and the *spatial* attributes of business organization. To establish this connection among the firm, innovation, business organization, and territory, this study elevates as its central protagonist one of the most pioneering enterprises of the current period, Dell Computer Corporation.[2]

[1] Markusen (2003) argued forcefully how in much of the economic geography literature, "abstract processes are the principal actors" and how our understanding of spatial change has been compromised by a move away from real actors that are involved in transforming economies, primarily firms and workers.

[2] Following Schoenberger (1991), the study used interviews with procurement and logistics managers at Dell, some of whom allowed me to use their names, and interviews with logistics managers at three of Dell's key suppliers, none of whom allowed me to use their names or company. Dell is extremely guarded about its business practices and, as a rule, does not partici-

By focusing on Dell to trace this route from the enterprise to territory, this study draws upon the catalytic role of "communications revolutions"—new communications technologies and their systems of use—as a starting point for the innovative impulse of firms (John 1994; Albion 1932). It links this phenomenon to territorial outcomes by examining how new communications technology enables firms to exploit economies of time and speed as a source of innovation. It shows how such time-driven process innovations compel the innovative firm to reorder the sequencing and allocation of the discrete steps that constitute this innovative activity, both inside the enterprise and across other firms in the production network of the innovator. What this article reveals is how the innovative enterprise restructures the organizational linkages within and between firms to accommodate time- and speed-driven routines and how in building such new forms of organization, the innovative firm reshapes territorial patterns of economic activity. In this way, it gives geographic meaning to what is commonly referred to as "the nature of the firm," the problem that was derived originally from Coase's (1937) article on how firms choose forms of business organization, while imbuing this problem with a spatial dimension.

Dell is a compelling case in the way it adapted to the communications revolution of the Internet and learned to accumulate profit differently. As Dell incorporated the Internet into its business routines, it ascended from a decent-sized, but by no means dominant, firm in 1994 to the top rank of the personal computer (PC) industry by 2001. In the process, it helped shape a new geography of global profit making, influencing a range of other firms, both within the PC industry and outside it.

pate in academic studies in which it will not materially benefit. Consequently, these interviews were secured through unofficial channels, as were the interviews with suppliers.

Three questions frame the story of Dell and the route from the firm to territory in this study: (1) How does technological change in communications systems enable business users of these systems to transform their strategies and operational routines for producing and selling? (2) How do the changes in strategies and operational routines of firms stemming from new communications systems result in the transformation of business organizations through which firms compete and seek profit? and (3) How do innovations in business organization reshape the geography of economic activity? With its focus on Dell to address these questions, this article uncovers how business users of communications systems reorient their operational routines and organizational structure as the technology of these systems changes and how the spatial patterning of economic activity gets reshaped as firms deploy new communications technology to compete and accumulate profit differently.[3]

Time, organization, and territory became integrally linked in Dell's innovative advance to dominance in the industry. Owing to its dependence on process innovation, Dell became a firm that was obsessed with compressing time between the various steps of making and selling PCs as the most critical element in its business model. The time-driven business system that Dell developed from Internet technology as part of this ascent is what compelled the PC maker to reconfigure the territorial arrangements between its key operations to make the high-speed logistics of its business model viable.

At the same time, it was the organizational power that Dell exerted over firms in its production network that enabled it to force these other companies to organize their

[3] Methodologically, this article is an *intensive* case study. It reveals how a specific causal process—in this case the route from communications to territory—is observable in the case itself and how, in reflecting this process, the case is representative of a broader, more generalized, trend (see especially Sayer 1992, 242–43).

activities in certain spatial patterns, so that Dell could profit from the innovative time economies it had developed from the Internet. In implementing its time-driven routines, Dell, in effect, confronted a challenge that firms have faced throughout periods of capitalist development. Dell was compelled to reshape the landscape to access the benefits of a shift in the temporal dimensions of producing and selling, a tendency that is often referred to as "spatial fix" (Harvey 1982; Schoenberger 2004). In what is a sharp rebuke to the idea of Internet technology simply collapsing time and space, the case of Dell reveals how the Internet, far from providing the PC maker with the capabilities to escape the frictions of geography, made it more dependent than ever on *proximity* between key nodes in its network.

The focus of this article on operations and organization as the basis of economic territory has important implications for the study of industrial geography. With Dell as a reference point, the article expands on notions of industrial geography that are derived from an emphasis on the locations of facilities alone. While not discounting the role of facilities in the spatial patterning of economic activity, this study broadens ideas about the construction of economic territory by focusing on the operations of the firm and the organizational connections between them.

This article is organized in four sections. The first section presents a theoretical framework for the argument that links the firm to innovation, organizational change, and territorial transformation. The second section describes the PC industry prior to Dell and how the competitive structure of this industry provided Dell with an opportunity for process, as opposed to product, innovation. The third section examines how Dell used the Internet to transform its process-oriented business routines and organization. The fourth section analyses the territorial consequences of Dell's innovative advance. Through an intensive case study, this article engages in a theoretical conversation about the territorial dimensions of the innovation process and the geography of profit seeking and power that are at the foundation of contemporary capitalist development.

Theoretical Frame

Business firms are actors that shape the spatial development of economies. As a consequence, "studying firms" in their role as agents that make decisions about profit making is a logical imperative for understanding how economies develop spatially (Markusen 1994, 2003). Numerous approaches to the issue of the firm and its role in spatial outcomes characterize the geographic literature.

Theorists, influenced by the insights of Alfred Marshall (1890) on external economies and industrial districts, have argued that the firm is a place-based entity. According to this view, the innovative behavior and competitive differentiation of firms and their role in driving territorial development are derived from the unique history, culture, and institutions of the locations in which the firms are embedded (Brusco 1982; Saxenian 1994; Herrigel 1996; Storper 1997; Scott 1998; Gertler 1995; Asheim and Gertler 2005). Others have studied the firm and its impact on the geography of economic activity within the context of broader organizational forms, such as the *production network* or *commodity chain* (Porter 1985; Gereffi and Korzeniwicz 1994; Castells 1996; Sturgeon 2002; Gereffi, Humphrey, and Sturgeon 2005). Perhaps most common is the approach that positions firms within *industries* (Schoenberger 1986; Angel 1994; Angel and Engstrom 1995; Harvey 1975, 1982; Storper and Walker 1989; Scott 2005). In these representations, what is decisive in driving the process of spatial formation and differentiation are historical, cultural, economic, and organizational forces that act upon and operate *outside* the business enterprise.

A different orientation to studying firms as drivers of territorial development focuses on what occurs *inside* the enterprise. This

approach takes as its starting point the process of organizational decision making and the contingent activities that occur within the so-called black box of the firm (Rosenberg 1982, 1994; Nelson and Winter 1982; Dosi 1988). Yet, this framework that focuses on the firm as an *actor* remains uncommon in economic geography owing to the absence of microlevel theory on the "firm-territory nexus" (Markusen 2003; Maskell 2001; Dicken and Malmberg 2001; Taylor and Asheim 2001).

Two critical insights emerge from the emphasis on the activities and choices internal to the enterprise that provide the analytical bridges between the firm and the territorial development of economies. The first focuses on the innovative nature of the firm. The second focuses on the organizational nature of the innovation process.

Although innovation occupies a position of centrality in the literature on the spatial development of economies, the role of the innovative firm in such outcomes is explored far less systematically. Schumpeter (1939, 1942) was arguably the first theorist to elevate the firm as the central actor and protagonist of economic development. Yet, even he conceded that the activities occurring inside the firm that enable it to assume the role of innovator remained unspecified in his work (Schumpeter 1947). Theorists who have been influenced by Schumpeter have argued that innovation is a process of *learning* in which firms assume mastery over new sets of organizational *capabilities* (Nelson and Winter 1982; Rosenberg 1982; Dosi 1988, 1997; Lazonick and Mass 1995; O'Sullivan 2000). Such an augmentation of capabilities, in turn, becomes embedded within the enterprise as changes in organizational structure (Chandler 1962, 1977). In this way, innovation is a process with organizational consequences.

Yet, to understand innovation as a change in the organizational structure of the firm, it is necessary to probe the fundamental nature of business organization. For Coase (1937), business organization is the result of decisions by firms on how to manage and coordinate the linkages among the different steps in producing and selling a product or service. Such decisions establish organizational *boundaries* within and between firms. These boundaries become fixed, depending on the extent to which firms absorb different steps internally and become *integrated* and the extent to which firms leave different activities to contracting relationships with other companies, resulting in disintegrated market links between companies. For Coase, choices about whether to absorb sequential steps of economic activity internally or contract with other companies depend upon a single variable—the *transaction costs* of undertaking such activities internally or externally. This model yields two basic typologies for business organization, one that is integrated and hierarchical and the other that consists of highly specialized disintegrated firms contracting through market links (Coase 1937; Williamson 1975).

Critics have assailed the model inspired by Coase for neglecting organizational forms "neither market nor hierarchy." These critics argue that *networks of firms* constitute a unique form of business organization existing outside the continuum represented by vertically integrated firms and firms contracting through markets (Powell 1990; Castells 1996; Amin and Hausner 1997). Such intermediate organizational forms reflect a more complex division of labor between firms (Gereffi and Korzenwicz 1994; Sturgeon 2002; Gereffi, Humphrey, and Sturgeon 2005). Other critics have insisted that transaction costs as a singular explanation for business organization is fundamentally misguided. For these critics, business organization results from efforts to augment *capabilities*, not to economize on costs (Chandler 1977; Lazonick 1991, 2003; Langlois 2003).[4] As firms assume mastery of new capabilities and remake their organizations, they reassess the allocation and coordination of the different steps in

[4] In commenting on the work of Williamson (1975), Chandler (1988) conceded that changes in business organization *may* result in reductions in transaction costs for the firm, but he argued that such reductions were by-products, not catalysts, of organizational change.

producing and selling products (Chandler 1988). From these reallocations of economic activity and transformations in capabilities emerge new operational routines for producing and selling products, and new forms of organization to implement them (Chandler 1977).

Although Chandler's theory of business organization contains a highly determined relationship among strategy, capabilities, and structure (McCraw 1988, 17), his empirical data revealed the route to organizational change to be the result of contingent decisions exercised by actors within the firm. The innovative organization is one that acts strategically by using its own administrative *power* to control the allocation and sequencing of economic activity, a process of replacing market links in the economy with the managerialism of "the visible hand" (Chandler 1977). Such nonmarket forms of power and control constitute "the social foundations of the innovative enterprise" (Lazonick 1991, 2003). In this way, innovation and organizational change are social processes. It is this social character of innovation and organizational change, emphasizing the power of the firm to control, that elevates firms as actors and conditions the trajectory of an innovative advance.

Toward a Geography of the Innovative Organization

By positioning the firm within this framework of innovation and organization, it is possible to outline how enterprises such as Dell transform their capabilities and organizational structure and, in the process, reshape the territory of profit making. As a territorial entity, the firm possesses two basic attributes. First, the firm as an embodiment of territory emerges from the stocks of facilities where it locates and manages work. Second, the firm as a territorial entity emerges from the flows of material and information between its own stocks of assets and those of other firms with which it interacts. The economic activity that is derived from the linkages between stocks and flows and the organizational connections that are developed to coordinate and manage these activities create patterns in space and give the firm its territorial attributes.

The organizational arrangements that are used to coordinate the activity linking facilities and flows reflect choices made by firms on the extent to which they internalize operations and contract with other companies in producing and selling. These decisions define the organizational boundaries and structure of the firm. In demarcating boundaries between its own capabilities and those of other companies, the firm allocates economic activity organizationally and, through such allocation, distributes economic activity spatially. In this way, firms are territorial in the way they strategically choose to organize the sequencing and fulfillment of their profit-seeking activities.

Among historical factors that affect the environment of strategic choice for profit making, one of the most decisive is the technology in systems of communication and the build-out of such systems (Lee and Whitley 2002, 235). When the technology for these systems changes and the infrastructure that is based on such new technology is built out, society experiences the beginning of communications revolutions (John 1994). The Internet represents a historically specific instance of this phenomenon. Nevertheless, communications revolutions, such as the Internet, do not result from new infrastructure alone (Abbate 1999; Fischer 1992). Users of the new infrastructure, especially business users deploying the new systems in their business models, are what enable communications revolutions to spread and become generalized throughout the economy.

When put into use, new communications technologies reshape the systems of access and circulation by which users of these systems secure the resources—material, informational, and human—and the outlets to customers that are necessary for producing and selling. What these firms exploit from communications revolutions are changes in systems of access and circulation for economic activity that is structured around relationships of *time* and *space.* In

the profit-driven economy, control over the time and space relationships in the systems of economic access and circulation is a centrally important strategic, operational, and organizational problem for the firm (Schoenberger 1997, 12). Systems of access and circulation are what provide firms with routes to the inputs and sales outlets that are necessary for producing and selling goods and services. By enabling firms to recalibrate the time and space relationships in systems of access and circulation, a new communications infrastructure creates opportunities for firms to reorganize how they procure materials, combine materials to produce goods and services, obtain customers, and market what they produce to customers.

Communications revolutions, in effect, are *control* revolutions (Beniger 1986; Chandler 1977).[5] They change the environment of profit making by providing firms with possibilities to control the time and space relationships in economic activity in new ways. Such control alters how firms reach customers, process orders, procure resources, and produce goods and services. These changes in systems of access, in turn, enable firms to recalibrate the pacing of economic activity and rearrange these activities spatially to process output by means of the newly discovered economies of time and speed.

Although bound together, time and space play different roles in the reorganization of business activity. It is actually *time* that constitutes the basis of value and profit in capitalist production (Harvey 1996, 241). For this reason, the recalibration of time—altering the pacing of business processes and driving down the increments of labor time embedded in units of output—is the primary strategic route that firms take to achieve greater levels of efficiency in business activity. Despite this primacy of time in the economic life of capitalist production, however, reconfigurations of space are inseparable from, and a logical outcome of, temporal changes in business activity (Harvey 1996, 240; Sahay 1997). Firms fix space as they recalibrate the pacing of economic activity and reassess shifts in the organization of profit making (Harvey 1982; Schoenberger 2004). Consequently, in the innovation process, time leads and space follows, but the two are linked through the strategic choices made by the firm.

In this process of spatial fix, firms do not mechanically graft innovative routines and business organization onto pliable geographic landscapes. Firms reshape territory as part of a *social* process. To develop the organizational capabilities that drive the reconfiguration of territory, the innovative firm cooperates with and confronts resistance from actors inside the enterprise and from firms in its network that play roles in the deployment of an innovative advance. These relationships inside the innovative firm and with external actors shape how capabilities get created and deployed, how organizations get restructured, and how territory ultimately gets reconfigured. Territorial transformation is therefore the result of the search by firms for efficient routines, mediated by social processes of cooperation and coercion. In this way, landscapes, as sites for innovation, are socially constructed terrain.

Inside the firm, the pathway to recasting routines leads through relationships of consent and coercion between management and the workforce (Marglin 1974). The extent to which employees, both managerial and nonmanagerial, embrace or resist a company's efforts to create new sets of organizational capabilities within the enterprise influences the trajectory and outcomes of an innovative advance.

At the same time, the innovative enterprise resorts to relationships of cooperation and force with other firms not only to gain access to external capabilities, but also to spread capabilities to these other companies in order to implement an innovative advance. Such external relationships, built around mobilizing and extending organizational capabilities, are integral to the innovation process because the firm undertaking

[5] For a different view of communications revolutions as control revolutions, see Yates (1989).

the innovation, no matter how self-reliant or integrated, is embedded in interfirm networks. These interfirm *value chains* or *commodity chains* (Porter 1985; Gereffi and Korzeniewicz 1994) reveal patterns of cooperation, as well as conflict, as lead firms and suppliers compete to control the deployment path of innovation to secure more of the rents that are generated by an innovative advance. Such relationships affect innovative outcomes, including the timing and pacing of new routines; how new routines are allocated organizationally; and the territorial patterns where routines are performed and raw materials, along with semifinished and final products, circulate. In this way, socially constructed interactions among firms mediate the changes in time and space at the core of innovation.

To exploit innovative time economies and reconfigure space to accommodate these economies of speed, the innovative firm uses combinations of cooperation and force with its network partners in pursuit of two broad aims: to enforce locational choices on firms with whom it interacts in its network and to impose sets of operational imperatives on these other companies in places where they have "chosen" to establish facilities. This interplay of cooperation and domination enables the innovator to restructure the operations in the network, reallocate the operations organizationally, and reconfigure the pattern of facilities and flows in the network to align the timing, sequencing, and territorial spacing of operations. Such uses of organizational power complement the capacity of the innovative firm to deploy efficiency criteria alone in realigning time and space in economic activity and in developing innovative business practices. Consequently, the transformation of time in business routines and the fixing of space to accommodate these temporal shifts is a story about efficiency *and* power.

Territory for economic activity is thus the outcome of objective and subjective considerations. Firms reconfigure territory on the basis of efficiency criteria. Territory is also reshaped by relations of consent and conflict between innovators and actors, both internal and external to the innovative enterprise. Although this article links firms to territory by focusing on the spatial attributes of business organization, it seeks a role for firms as agents of power in shaping business organization through open-ended negotiation with other firms on the impacts of innovation. Some firms achieve decisive levels of control in this process of negotiating the impacts of innovation. Dell Computer is one such enterprise.

Dell and the PC Industry

Dell Computer entered the PC industry in 1984 essentially as a logistics firm (Fields 2004). It created a business model from the process of building and selling its products, exploiting the sphere of capitalist circulation as a source of accumulation, and extracting profit from the *gains of trade*. Such gains refer to increments of new value that accrue to raw and semifinished materials as they change location and assume different attributes in circulating from procurement to production to final sale.[6]

Dell uncovered how to extract profit from gains of trade in two principal ways: (1) by eliminating *intermediaries* in the route from producer to consumer and capturing that portion of the gains from trade normally accruing to these actors and (2) by compressing *time* between the various adjacent steps in producing and selling PCs, primarily between the final production of the PC and final sale to the consumer, thereby cutting costs that are associated with the time expended in essentially warehousing the product in inventory as preparation for final sale. That Dell was able to craft such a logistics-oriented business system focusing on circulation, rather than production, as a source of profit stems

[6] This concept differs from the idea in classical trade theory derived from Ricardo in which the parties to an exchange secure benefits—in theory—by producing according to the principle of *comparative advantage*.

from the historically conditioned attributes of the PC industry and role played by IBM.

Open Standards, Logistics, and Dell's Innovative Advance

When IBM began producing personal computers in 1981, its decision to outsource components and to create an open product architecture had two decisive impacts on the PC industry that would affect Dell. First, open standards enabled an array of specialized suppliers to emerge and exploit opportunities for producing parts for the IBM PC. Second, this open architecture helped enable firms to *clone* the PC. As a result, the industry evolved along a path marked by the proliferation of disintegrated supplier firms subcontracting to PC makers, who, in turn, became dependent on the *external capabilities* of these suppliers and embedded in interfirm networks to build the product (Langlois 1992). By 1984, Dell was one of roughly 100 clone makers that was able to produce PCs by taking advantage of the external capabilities of others.

Although a standardized commodity, the PC was in a state of ongoing technological change, driven primarily by the continuous improvement in semiconductor and microprocessor technology. Such changes compelled PC makers to develop new products at ever-shorter intervals (Dedrick and Kraemer 1998, 73). At the same time, these advances enabled costs as a measure of performance to plummet, with the price for PCs typically declining by 20 percent to 41 percent per year (Curry and Kenney 1999, 12).

As a product in flux, the PC was susceptible to competitive pressures derived not only from technology, but from two other variables—*price* and its relationship to *time* (Curry and Kenney 1999). When a new product came to market, it was under constant price pressure, its value shrinking with time in anticipation of the next new processing technology and application software. The system of selling through intermediaries, the dominant form of distribution by 1984, only worsened this problem, with a period of 9 to12 months often separating the procurement of parts and the sale of the final product (Steffens 1994, 175).[7] Consequently, the indirect selling channel, by delaying the time to market, exacerbated a fundamental weakness with the PC—the downward pressure on prices stemming from ongoing technical improvements that imbued the PC with a perishable-like quality (Kraemer, Dedrick, and Yamashiro 1999, 3). This quality posed a challenge to PC makers: how to get the product to the customer faster. Concurrently, the idea of capturing that portion of the value taken by intermediaries presented an equally compelling opportunity for PC firms. In effect, solving the twin problems of perishability and entrenched power created a potential pathway of innovation that was oriented around logistics and distribution exploited by Dell.

Dell's strategy as a new entrant was to challenge the route of distribution and seek profit in a more *direct* relationship to the final customer. This strategy created an innovative advance that ended up disrupting the industry. By using new communication technologies, such as the fax, to establish a direct path to the end user, Dell was able to capture that portion of the value accruing to the PC and taken by intermediaries as the product circulated from assembly to final sale. This direct path also represented a strategy for offsetting the decline in product value that occurred over time. In bypassing intermediaries, Dell sold PCs at prices closer to the value of components before their inevitable price decline associated with time. What Dell accomplished with this business system was a reduction in the time that the product sat in the sales channel as *inventory*, thereby eliminating inventory-carrying costs and

[7] Even by 1987, with Dell and Gateway selling direct, computer dealers still accounted for 56 percent of the total shipments, while the various indirect channels together accounted for 80 percent to 90 percent of all PC sales (Steffens 1994, 260).

providing the firm with a competitive advantage over its competitors (Kapuscinski et al. 2004). It was a strategy for producing PCs—profiting not from production, but from the logistics of making and marketing the product.

As it forged this direct link to the customer, Dell conceived of another innovation that played a decisive role in its business system. By communicating directly with the end user, Dell sought to deliver a product touted as "customized." From a menu of fundamentally standardized modular parts, Dell assembled slightly differentiated systems and sold these systems to end users as custom products by communicating with them directly, bypassing the intermediaries that dominated the industry.

The Early Dell Geography

The geography of this custom direct business system derived most decisively from the decision by Dell to perform the assembly work itself in an Austin, Texas, location while contracting for components from suppliers, mostly from East Asia, located long distances from this assembly site. Operationally, this geography articulated a pattern of spatially extended linkages between two major places with flows of materials moving to and concentrating in one city-region where Dell configured these supplies into finished PCs. At the same time, however, Dell's business model of creating custom-built computers compelled the firm to establish a distinct set of proximity relationships in which it maintained numerous warehouses in the Austin area where it stored components to pull them into the assembly process as it received orders. Consequently, Dell's operations created a spatial pattern built upon two distinct types of connections, one consisting of long-distance linkages between East Asia and Austin that delivered components near the site of assembly, where they were staged in warehouses and readied for the assembly process, and the other consisting of linkages of proximity between the parts warehouses and Dell's Austin assembly complex (see Figure 1).[8]

Organizationally, the linkages between Dell and its network partners that moved component parts geographically from suppliers' factories to the Austin warehouses occurred through *markets*. Market links are what enabled Dell to secure components from suppliers, while market relations between suppliers and Dell provided the coordination mechanism for components to change location in moving geographically from suppliers' factories in East Asia to Dell's component warehouses. Michael Dell described this process of contracting and coordination as one built upon "traditional bid-buy relationships" (Dell and Fredman 1999, 180). Consequently, in the geography of Dell's business system, an interfirm network organization of separate companies interacting through markets moved supplies from one location to another, creating a spatial pattern of long-distance linkages connecting East Asia to Austin. In Austin, Dell assumed organizational responsibility for the relationship of proximity in moving parts from its warehouses into its own assembly complex.

Although the interfirm structure of this network has remained intact until the present, Dell was forced to recast the market-oriented relationships in this business organization when the time came to deploy the Internet in its business. As Dell used the Internet to uncover new pathways for controlling time in its business

[8] Unlike just-in-time practices in the auto industry, in which numerous—though not all—suppliers established facilities close to the locations of assembly, Dell's network reflected this spatially extended separation between the sources of supply and the location of assembly (Angel and Engstrom 1995). Until the early 1990s, Dell was successful in storing a relatively small inventory of components in these warehouses, compared to the levels of its competitors. As a result, Dell had an advantage over other firms not only because of its low inventory of finished products, but also because of the low inventory of components that it maintained.

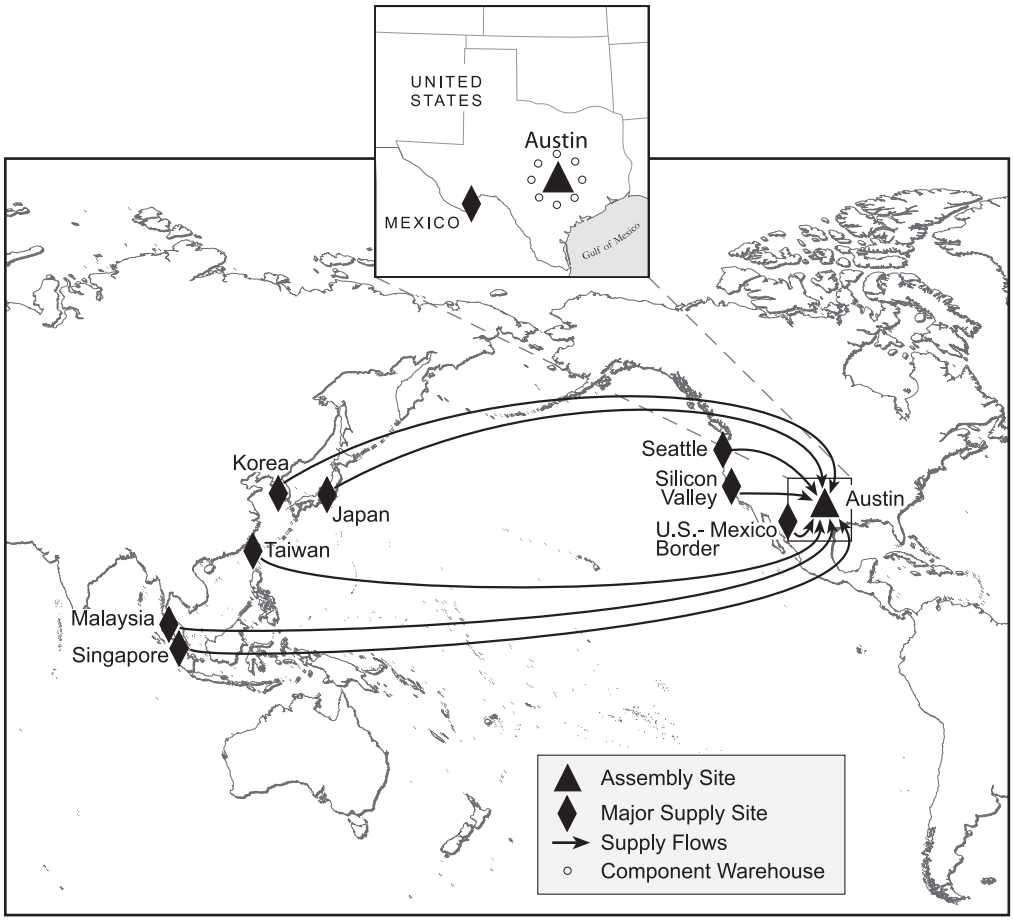

Figure 1. Dell production network, 1990.

system, it was exposed as never before to elevated levels of risk from the frictions of geography in trying to fulfill the imperatives of its just-in-time business model. Its response reflected an innovative approach to the challenges of risk and organization, time, and territory.

Dell and the Internet

When Internet communication emerged as a commercially viable sales channel in 1994–1996, Dell had an advantage over other PC firms in adapting to the new technology. Internet selling represented the same logic of disintermediation that was at the core of Dell's business model. As a result, Dell was the first PC firm to configure and sell its products over the Internet in 1996. Online selling, however, was only an initial set of innovative routines at Dell stemming from the deployment of the Internet in its business system.

A more profound set of changes resulted from Dell extending the Internet into procurement and assembly. By deploying the Internet in these processes, Dell aimed to reduce the time expended in procurement and assembly for information exchange, both internally and with suppliers. It accomplished this aim by creating a more tightly integrated, Internet-driven closed-loop form of organization linking order cycles to procurement and assembly cycles. In this

Table 1

Rank of PC Firms, 1994 and 2001 (by World Market Share)

1994 Rank	Firm	% Share	2001 Rank	Firm	% Share
1	Compaq	10.0	1	Dell	14.2
2	Apple	8.3	2	Compaq	11.1
3	IBM	8.2	3	IBM	7.2
4	Packard Bell	5.2	4	Hewlett Packard	6.9
5	NEC	4.1	5	NEC	5.0
6	Hewlett-Packard	4.0	6	Apple	4.8
7	Acer	3.0	7	Siemens	3.4
8	Toshiba	3.0	8	Gateway	2.8
9	Fujitsu	3.0	9	Toshiba	2.2
10	Dell	2.4	10	Fujitsu	2.0

Source: Fields 2004, 184, 214.

sense, organizational change, oriented around Internet communication, was integral to an acceleration in the pacing of economic activity. As a practical matter, this organizational and temporal shift was embodied in new routines that Dell developed for its system of *material balancing,* the way in which it allocates the flows of material and information over time throughout the different steps of the PC value chain. In transforming these routines, Dell aimed to shrink the increments of time both within and between the different operations. At the same time, this innovative advance led to the creation of a new form of organization. Thus, while the system of material balancing and the logistics of lowering inventory served as the focus of Dell's innovation, the PC maker was engaged in a broadly singular strategic objective. Dell committed itself to learning how to use the Internet for controlling the logistics of *time* in a fundamentally new and innovative way.[9]

Logistics and Time

When Dell entered the PC industry in 1984 by recalibrating what had emerged as a decisive competitive variable in the PC industry—the logistics of time—the company was both a pioneer and an inheritor of an already-established tradition in manufacturing. In creating a just-in-time production system with little inventory, Dell developed a novel approach in the PC industry, but its strategy echoed the effort developed decades earlier by Toyota in auto manufacturing.[10] The element of the Toyota

[9] What motivated Dell was a series of setbacks, following a period of extraordinary growth, that challenged its logistics-oriented business model. Despite predictions that its direct sales would not be competitive with the distribution networks of other PC makers, by 1990, Dell had become the twentieth largest PC firm, while four years later, it emerged in the top 10 (see Table 1). As Dell's expansion continued apace, it became more difficult for the firm to balance the two key elements of its business system—customized just-in-time production and little, if any component inventory—that it had successfully integrated in the early period. As a result, Dell lost $35.8 million on its sales of $3 billion in 1994, its first—and only—annual loss. Indeed, Dell conceded that its losses stemmed from excess procurement inventories. As Michael Dell admitted in his at-times revealing book, "we had quickly become known as the company with the inventory problem." He went on to concede how, by the early 1990s, Dell was "last place in inventory management" (Dell and Fredman 1999, 37).

[10] On just-in-time systems, see Linge (1991), Mair (1992), Kenny and Florida (1993), and Klier (2000). Where Dell departs from the just-in-time

system that Dell imitated most closely was continuous flow assembly without the buildup of inventory. For Toyota, continuous flow, absent inventory, compressed the time cycles between procurement and assembly, enabling the automaker to produce in high volumes and reduce the costs related to the buildup of time in each component.

While control over time is critical in virtually all types of economic activities, such control was critical in the PC industry and emerged as the fundamental impulse of innovation at Dell. In an environment in which the prices of components and the product itself were subject to constant devaluation with the passage of time in anticipation of the next round of technical innovation, terms of competition had shifted from the product to the production and distribution process. In these circumstances, the logistics of time compression between adjacent steps from PC production to final sale emerged as a potentially disruptive business model in the industry and a pathway of innovation that differentiated PC firms like Dell.

By forging a direct path to the customer, Dell was enormously successful in reducing the time that the product was held in inventory between the final assembly and the sale to the user. For most PC firms, this time lag in distributing the product, often measured in months, had a decisive impact on the companies' performance. Compaq, one of Dell's competitors during this period, typically had two months of final product in inventory. In contrast, Dell maintained a final product inventory that was measurable, at most, in days. This reduction in time from the assembly of the final product to final marketing was one of Dell's most critical competitive assets during these early years. Consequently, what Dell pioneered through direct selling was not only a different marketing model, but also a new standard in the industry for the relationship between time and profit.

When Dell experienced difficulties managing its growth by the early 1990s and began to resort to the buildup of an inventory of components, it was essentially recasting the relationship between time and the management of *risk* in its business system. Arguably, the greatest risk that Dell faces as a high-volume manufacturer is disruption in the supply of raw materials. In such firms, the inventory of raw materials is an offset against the risk of disruptions in supply. If supplies become unavailable, the inventory is able to even out such imbalances in supply and demand. This offset against risk, however, incurs costs. These costs, in turn, are related to time. The longer materials are held in inventory, the greater is the cost incurred as an offset to the risk of disruptions in supplies. By the early 1990s, as Dell succumbed to the pressure of having to hold more inventory as an offset to the risk of such disruptions, it sacrificed what was arguably its greatest competitive asset. The firm effectively lost its ability to minimize the buildup of time embedded in its system of balancing demand for finished PCs (orders) and supplies of components to build them (inventory). For Dell, risk management through the buildup of inventory had overwhelmed the advantages it had achieved over competitors by controlling time in its system of balancing supply and demand.

Broken down into its most basic element, supply-and-demand balancing involves two types of time management: *informational* and *logistical.* Informational time management for balancing the supply and demand of components consists of coordinating the myriad transactions at the core of the procurement process. Transacting, in turn, is fundamentally a process of information gathering to justify and initiate a purchase and sale and the exchange of information

practices in the auto industry is precisely on the issue of proximity to suppliers. Glasmeier and McClusky (1987) revealed that the auto industry was able to maintain the integrity of just-in-time supply systems even when suppliers were located eight hours' or two days' drive from assembly facilities. As I show later, Dell and its sources of supply operate in much closer proximity and on much tighter delivery schedules.

with the other party to consummate the terms of the transaction. As economic activities, information gathering and information exchange are processes that involve expenditures of time that incur costs based on the time that is expended.

Owing to the interfirm structure of the industry, procurement is a transaction-intensive set of activities between assemblers and suppliers in which time plays a critical role. In its role as assembler, Dell is positioned at the center of two sets of transactions underlying the procurement process: (1) the transactions from customers ordering PCs and (2) the transactions with suppliers to acquire the components for such orders. As a buyer of components from suppliers and the source for orders from customers, Dell oversees an information- and communication-intensive enterprise for coordinating the exchanges that are needed for the procurement of parts. In an effort to innovate this process and balance the demand for and supply of components in close to real time without holding components in inventory, the PC maker has sought to develop routines for compressing two time horizons. First, in deploying the Internet as the communication infrastructure for its interactions with customers and suppliers, Dell aimed to reduce the average time embedded in the transactions for order intake and procurement. Second, as the firm reduced the time increments embedded in its transactional processes with customers and suppliers, it sought ways to compress the time *lag* separating these two sets of transactional activities. In practical terms, balancing the supply and demand of materials without inventory in a high-volume environment compelled Dell to attack the increments of time that were expended in initiating and consummating the two sets of exchanges while aligning the two sets of transactions closer together in time. To accomplish this aim, Dell not only had to learn how to use the Internet to develop new transactional routines, but also had to build an organization with the capabilities of implementing these informational time economies.[11]

In contrast to the time expended in organizing information flows for transactions, *logistical* time management involves the recalibration of the time expended in executing the movement of materials from supplier factories to Dell's assembly sites. The objective is to reduce these time increments so that materials do not sit in any one place as inventory as they circulate between firms and locations. Although this task is also dependent on the gathering and exchange of information between sepa-

[11] Even Marx, despite his emphasis on profit deriving from labor expended in production, made trenchant observations on the role of time and transaction costs in profit making. In Volume 2 of *Capital*, Marx wrote how the circuit of capital, whereby money is turned into commodities and commodities into money, involves not only production, but also acts of purchase and sale in which the capitalist functions as both the buyer and the seller. The time during which these transactions take place and during which products move from one step to the next constitute what Marx acknowledged as "genuine costs of circulation" for the capitalist. "Just as the time of circulation of capital is a necessary segment of its reproduction time, so too is the time in which the capitalist buys and sells and scours the market also necessary in which he functions as a capitalist. . . . It is part of his business hours" (Marx 1974 [1885], 132). In this way, Marx regarded the circulation of commodities—their physical movement in changing location as they transition from raw materials to finished products—and the time expended in circulation as integral to the process of adding value. For Dell, compressions in the time increments embedded in the transactions that are central to the procurement process enable the firm to shorten the cycles whereby capital is turned into finished commodities and back into money with an increment of profit, thereby accelerating the number of circuits—turnovers—that the capital of the firm is able to make in a fixed period. Again, Marx was clear that turnover time is equal to production time plus time of circulation. With Dell, time and turnover are part of the same circulation-based business system.

rate firms, it is the process of moving materials from one step in the process to another and one location to another—and the time it takes to execute such movement—that differentiates it from the first type of time management.

Although informational and logistical time management differ, they share the same objective. Both seek to reduce costs by diminishing the time increments that are embedded in adjacent steps linking procurement to production and to the final sale. From an operational standpoint, the outcome from this recalibration of time is similar in both instances. Informational and logistical time management aim to increase the number of times that firms are able to turn inventory—turnover cycles—during a fixed period. From a financial standpoint, this recalibration of time enables money to be turned into commodities and back into money with an increment of profit—at a faster pace. Such acceleration in the turnover of capital and commodities is a basic objective of firms in seeking profit (Harvey 1996, 241).

In the Internet, Dell uncovered a path to two critical innovations for recalibrating time and rebalancing the supply and demand of materials in its demand-pull business system, which it refers to as *global supply planning* and *demand fulfillment*. Global supply planning involves the exchange of information among Dell, its customers, and its suppliers for the consummation of transactions in the procurement process. Demand fulfillment deals with the logistics of executing the movement of materials from procurement to assembly and to final marketing. These innovations represent the breakthroughs by Dell to control time in its system of material balancing by decreasing the average levels of inventory, measurable most visibly since 1994 when the firm conceded that its procurement practices were among the worst in the PC industry and committed itself to a program of change (see Table 2).

Innovation: Global Supply Planning

Global supply planning represents an effort by Dell to recalibrate the time horizons in one of its most time-driven activities, the process of procurement with its component suppliers. What Dell seeks from this innovation is a reduction in the time that is needed for communicating and exchanging information with suppliers as part of the transacting process to secure components and verify the terms of the exchange. Global supply planning uses both technology, in the form of the Internet, and organizational change, in the form of a different set of relationships between Dell and its supply-chain partners, to accomplish this aim. The rationale for global supply planning is derived from Dell's recognition that procurement is basically a transacting process that is driven fundamentally by expenditures of time in the collection of information and the exchange of communication.

At the core of global supply planning is a set of routines for modulating procurement flows by balancing four different time horizons in the procurement process: (1) 1-year periods for which Dell generates

Table 2

Days' Supply of Inventory at Dell

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Number of days' supply of inventory at Dell Computer	32	21	16	13	8	6	5	4	3

Sources: Dell Computer Corporation, 10-K reports (1996, 1999, 2000); Cihra (1998); Edwards and Park (2002); and an interview with Stephen Cook, Dell senior process engineering manager, 25 April 2002.

a Master Demand Plan for components based on historical data and information from its largest customers; (2) the 2- to 3-month lead times required by suppliers to secure their own supplies and fabricate components; (3) the 7- to 30-day period for transporting supplies to Dell's factories; and (4) the just-in-time requirements of Dell to postpone the delivery of components until orders are actually received, enabling the PC maker to "pull" components into its build cycle supposedly without inventory (Kapuscinski et al. 2004). The innovative character of the process is derived from the use of the Internet to automate and control the exchange of information between Dell and suppliers to accomplish Dell's aim of balancing the demand for and supply of components across and within these four time frames.

Operationally, suppliers commit to the material requirements of the one-year plan and coordinate their own two- to three-month production schedules, along with transport time, with the plan's general parameters. As orders are received and processed, however, Dell alerts parts vendors continuously through Internet-based communication of changes—*exceptions*—in these requirements for materials. When an exception exists and a change in the flow of materials is required, Dell triggers a requisition and automatically sends it through the web to the supplier. The supplier then commits to the order or, depending upon the circumstance, to a postponement in the flow of supplies. By late 2001, 90 percent of Dell's purchases of components were occurring through these Internet-based interactions with parts vendors, effectively recasting the informational routines in Dell's procurement process (interview with a vice president, 20 June 2001).

Yet, in remaking these routines, Dell confronted an organizational barrier that it had to overcome and transform. For global supply planning to function, suppliers had to operate on the same systems of information sharing and exchange as did Dell. This technical imperative forced Dell to shift the nature of its relationship to its suppliers—as well as the number of these suppliers—and restructure the form of business organization at the foundation of its procurement and production network. To supply Dell, parts vendors had to develop the same information-sharing capabilities and the same communications platform as Dell. This requirement compelled suppliers to make investments in their own information and communications systems that were compatible with Dell's system (developed jointly by Dell and the supply-chain software firm of i2) as a precondition to supplying Dell.[12]

While it is not uncommon for vendors to conform to often-onerous requirements that are imposed upon them by their customers, Dell's Internet-based procurement routines imposed a new type of organizational imperative on the supply base. Not only did parts vendors have to upgrade their information systems and accept the responsibilities for modulating the delivery of supplies in accordance with the material-balancing constraints of the global supply planning system, but in accepting these responsibilities, they had to become more organizationally integrated with the procurement planning routines that Dell was recasting. These routines, in turn, were operational only through a more integrated and controlled organizational relationship between Dell and the supply base. Dell, in effect, assumed the task of remaking its procurement routines by imposing a specific set of technical requirements on its suppliers and spreading a new set of capabilities among separate firms. In the process, it imposed a form of organization upon its supply base that resembled many of the attributes of integrated firms. Organizational

[12] In reference to these requirements on suppliers, CEO Michael Dell was unambiguous in describing the market power of his company and its effects. "Dell in the U.S. is 50 percent larger than its nearest competitor and growing four times as fast," he said. "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).

change was thus the route to technological innovation.

As it forced suppliers to become more functionally integrated with its global supply planning routines, Dell was compelled to reduce the *number* of its primary component vendors from more than 200 in 1994, to roughly 35 by 2002. The reason for this contraction stems from the fact that, in developing the capabilities to implement the routines of global supply planning and spreading these capabilities to other firms, Dell created an organizationally specific asset. This organizationally embedded asset, in turn, is not easily duplicated by switching to alternative suppliers through market mechanisms. Indeed, any such shift would force Dell to incur costs and bear risk. Consequently, far from using the Internet to expand the number of its suppliers in a market-oriented bid and auction system, Dell is using the Internet and its routines for global supply planning to establish an integrated and proprietary system of controlled interactions with suppliers. The PC maker refers to the form of organization created by this interplay of technical efficiency and organizational necessity as *virtual integration*.

Virtual integration combines the organizational structure of interfirm networks and authority relations that are typically ascribed to vertically integrated companies. Such organization takes advantage of capabilities lying outside the boundaries of Dell. At the same time, in assessing how this interfirm organization actually functions, it is critical to recognize Dell's capacity to exert control over the other actors in this network. Dell forces suppliers to conform to specific operational and organizational imperatives to implement routines that it has developed to become more competitive. In effect, virtual integration relies on administered relationships involving power and control, rather than on market relationships, to spread capabilities among the different firms in the network. This model of virtual integration, emerging from the control imperatives of global supply planning, is the organizational precondition for the second of the two Internet-driven innovations, demand fulfillment.

Innovation: Demand Fulfillment

Demand fulfillment, the second of the two Internet-driven innovations at Dell, consists of a process for transferring components from supplier factories into assembly sites for configuration to finished computer systems. Whereas global supply planning creates the informational routines for determining the requirements of components to be pulled into a system of just-in-time production and the transactional routines for consummating the exchanges with suppliers to secure access to these components, demand fulfillment creates the logistical routines for executing the movement of parts from one stage of the value chain to the next and from one location to another. Similar to global supply planning, demand fulfillment uses ongoing Internet-based communication between Dell and its suppliers but incorporates a crucial third actor in the process—third-party logistics providers (3PLs). These 3PLs function as intermediaries that are responsible for coordinating the transfer of parts from suppliers to Dell and for managing the storage and staging of these parts in supply logistics centers (SLCs) so that components can be pulled into Dell's assembly process on a just-in-time basis.

In contrast to the sales channel through which Dell bypassed intermediaries to reach the customer directly, Dell relies on the intermediary of the 3PL in the procurement channel to perform a critical step in moving parts from locations of supply to locations of assembly. These 3PLs and the SLCs in which they operate are part of a recent phenomenon in the organization and management of supply-chain systems known as vendor-managed inventory (VMI) in which Dell is a pioneer. The aim of VMI is to shift the costs and responsibilities for supplying components on a just-in-time basis to supply firms. The 3PLs have found a role in these VMI systems as managers of the SLCs, where parts are staged for transport

on the final leg of a trip to the factory floor for final assembly. It is suppliers that negotiate contracts for the operation and management of SLCs directly with 3PLs and pay what is called "pallet in/out charges" to 3PLs for storing the inventory of components (interview with Stephen Cook, senior process engineering manager, 12 June 2001). While Dell monitors the ability of 3PL-managed SLCs to provide the required parts-transfer services to Dell factories, the operation of SLCs is conducted independently of Dell (interview with Gregory Kelly, senior manager of materials and logistics, Dell Nashville, 4 May 2001). This organizational arrangement is a way for Dell to control aspects of the supply chain without assuming the formal ownership responsibilities or costs of these activities.[13]

While the largely planning-oriented routines of global supply planning and the logistical routines of demand fulfillment have different functions, both innovations share a fundamental objective—compressing time in the processes that go into producing and selling a product. As the logistical element in Dell's system of just-in-time production, demand fulfillment is actually a postponement system. Its aim is to delay the delivery of parts to Dell's factory sites until parts are ready to be used in the assembly process so as to preclude the buildup of an inventory of components. Operationally, demand fulfillment establishes routines whereby parts that are produced in the factories of suppliers are delivered to Dell's assembly sites at two-hour intervals and all "pulled" into assembly, where they are configured into finished products. Customers' orders that are cleared for assembly and processed in two-hour blocks are what provide the informational input that initiates these material pulls. Only components that are needed to fill orders for the two-hour cycle in question are delivered to Dell's receiving dock, where they are unloaded and allocated to various workstations where Dell assembly workers configure a finished computer from a kit of parts every two to three minutes. Dell considers demand fulfillment, with these two-hour material pulls triggered through ongoing Internet information exchange, to be the most innovative capability in its system of material balancing and just-in-time production (interview with Lance St. Clair, director of supply chain and materials management systems, Dell, 10 January 2002).

Although technology in the form of Internet communication provides a critical platform for enabling components to circulate from suppliers to Dell in two-hour intervals, the process of demand fulfillment relies on a necessary organizational component. Virtual integration among Dell, its component vendors, and 3PLs is the organizational precondition for the two-hour material pulls at the core of this innovation. For Dell, such time-driven levels of coordination are not possible through market relationships among firms. In this sense, demand fulfillment, much like global supply planning, is dependent on a fundamental change in business organization in which the boundaries between firms remain formally separated, but the functional relationship among these formally separate companies is one of integration.

What differentiates demand fulfillment as an innovation is the decisive role of "spatial fix" used by Dell for the two-hour material pulls. The PC maker needs this transformation in the territorial arrangement of economic activity to exploit its own innovative economies of time and speed. Dell, in effect, has been able to remake its time-driven system of balancing materials on the basis of a spatial strategy. The result is a geography of innovation—the creation of a new industrial space—fusing imperatives of time, organization, and territory. This geography is critical for understanding Dell as an innovative logistics firm, remaking territory and redefining the meaning of global production systems.

[13] Third-party logistics providers that manage SLCs that are involved in the delivery of parts to Dell include such firms as BAX, Menlo Logistics, Ryder, and Eagle Global Logistics.

Geographies of Innovation

Time and distance conspired to pose a formidable problem for Dell in its effort to implement the two-hour material pulls of demand fulfillment, especially in the aftermath of its expansion during the 1990s. In 1990, the logistics of assembling PCs for Dell, as a firm with one assembly location, consisted of controlling supply flows into Austin, where the PC maker staged and then pulled components into its factory. By the end of the decade, Dell was configuring products at six assembly sites on four continents.[14] In this expansionary configuration, the challenge for Dell as a just-in-time producer was how to overcome the geographic separation between locations of supply and locations of assembly while maintaining the continuous flow of two-hour material pulls at each assembly site without the buildup of an inventory of components. Operationally, what Dell confronted as a globally expanded firm was a set of logistical problems that were oriented fundamentally around issues of time and space.

To overcome this challenge, Dell developed two critical offsets for shrinking the geographic separation between locations of the fabrication of components and locations of final assembly. These two spatial fixes reveal the relationship of time to organization and territory. They also emphasize the importance of space in the PC maker's overall strategic vision of logistics as a business model.

On the one hand, Dell prevailed upon some of its suppliers to establish component factories in the locations where it assembles PCs. When Dell established its assembly facilities in Penang, in 1996, for example, it negotiated with and convinced two of its manufacturers of motherboards, Jabil Circuit and SCI, to locate factories there (interview with Simon Wong, general manager, Dell Asia Pacific, 2 October 2001). Although these two suppliers undoubtedly benefit from this arrangement, the importance of such proximity relationships is even more paramount for Dell in implementing its demand-fulfillment system of two-hour material pulls. Michael Dell was candid in acknowledging the importance of proximity to suppliers as a strategic aim for the PC maker (Dell and Fredman 1999, 178–79).[15] Such proximity relationships are not only recasting the linkages that form the basis of local economic geographies. In driving the locational decisions of other firms and crafting proximity relationships with these companies, Dell reveals itself as an agent in the creation of agglomeration economies, reinforcing existing place-based concentrations of high-technology activity where it has chosen to locate its own operations. In this reshaping of the economic landscape, Dell admits to a special role in exercising choices that contribute to a broader story of spatial development focusing on forces of cumulative causation and agglomeration (see Figure 2).

[14] Its objective in this expansion was to ease the capacity burden on the Austin facility as orders began to escalate after 1994 and on supply markets throughout the world from designated regional assembly sites located in each market zone. Instead of a centralized assembly system focused on Austin, by 2001, Dell had created a decentralized assembly system that was spread across the globe but concentrated in specific regional locales. Dell's locational preferences reveal a pattern. First, the locations Dell chose for expansion—Limerick (Ireland), Porto Alegre (Brazil), Xiamen (China), and Penang (Malaysia)—represent existing concentrations of high technology, although, with the exception of Penang, they may accurately be termed the world's "second-tier" high-technology cities (Markusen, Lee, and DiGiovanna 1999). Second, Dell revealed a preference for places that offer it direct incentives. Finally, Dell chose some of the same locations that are preferred by its most critical supplier of materials, Intel.

[15] "We came up with the phrase 'proximity pays' as a result of translating the ROIC [return on invested capital] metric down to each component and each supplier. . . . It was very clear that suppliers that located their factories close to ours helped us to deliver a higher ROIC than those who were farther away." Dell also acknowledged how its power of persuasion managed to prevail over these firms (Dell and Fredman 1999, 178).

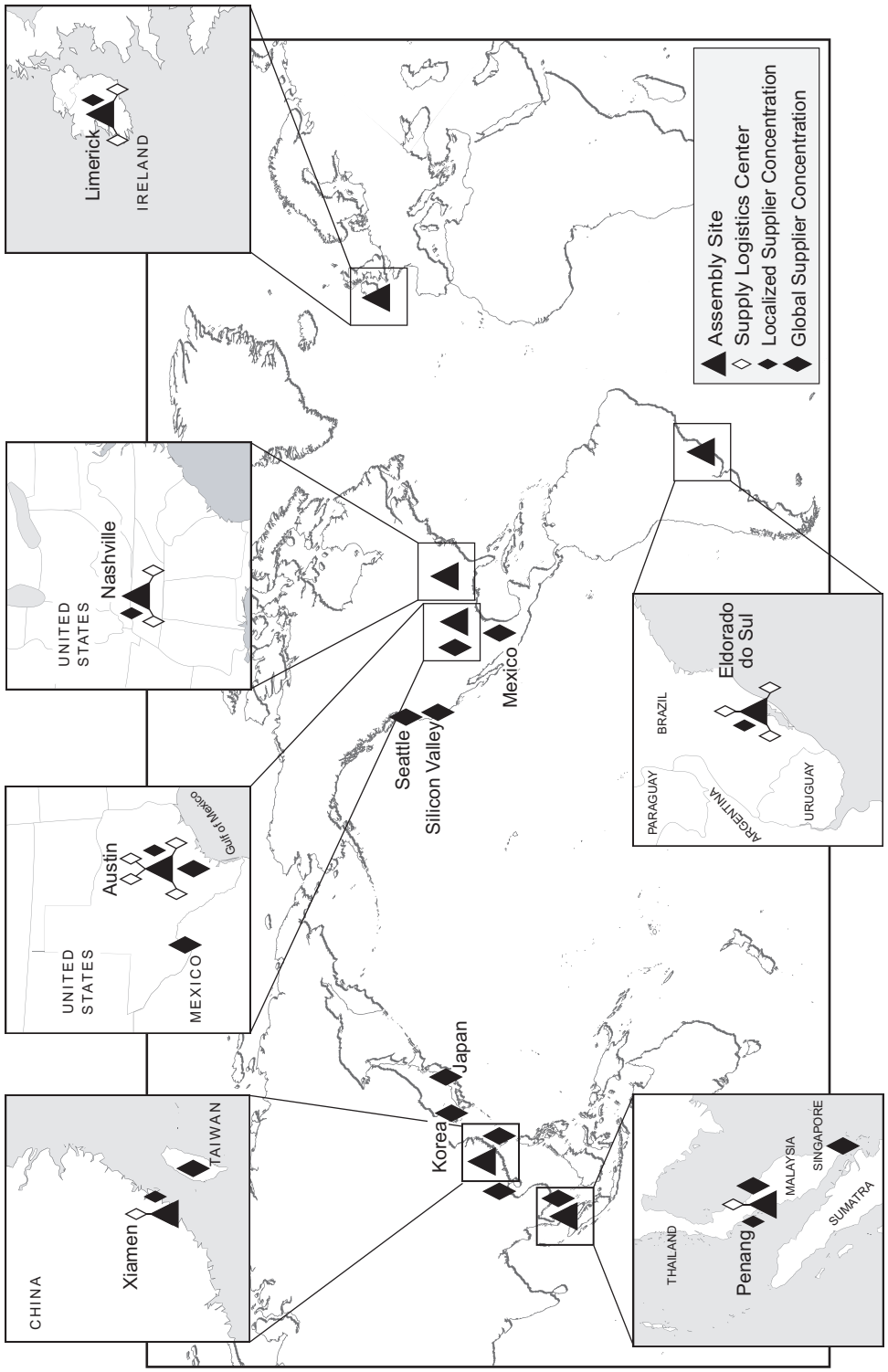

Figure 2. Dell production network, 2001.

While relocations of supplier factories are critical in Dell's geography of innovation, far more widespread as a business practice and spatial strategy is the intermediate step inserted by Dell between the fabrication of parts and the final assembly, crafted around the SLCs. Pioneered by Dell and increasingly imitated by its competitors, the SLCs reshape space by creating new relations of proximity between supply and assembly. SLCs are always located no more than a 20-minute drive from Dell's assembly sites. Dell requires parts vendors who do not have factories close to Dell's assembly sites to maintain at least two weeks' supply of inventory in these SLCs so that parts are always available to Dell to be pulled on an as-needed basis, regardless of short-term fluctuations in demand. Most significantly, in this arrangement, Dell forces suppliers to bear the carrying costs of this inventory.

In Dell's time-driven business model, the storage and staging of parts in SLCs is essentially a system for maintaining the rhythms of just-in-time business practices by collapsing the distance between the locations of supplies of components, and the locations of assembly. SLCs play the pivotal role in bridging this distance. These facilities, the costs of which are imposed on the supply base, create external economies for Dell from proximity relationships between key nodes in Dell's network. They are what enable Dell to manage the compressed time cycles for pulling material into production on a just-in-time basis. Perhaps more important, however, is that the staging and storage of supplies in these SLCs is a response to the greatest problem confronting Dell—the *risk* of securing access to supplies of components within specific parameters of *time* that are consistent with its high-speed, build-to-order pull system. What Dell seeks through the staging and storing process is *control* over the risks it encounters in securing supplies in a just-in-time, environment.

In seeking to remedy this risk of timely access to supplies of components, Dell reorganizes space as a substitute for inventory. It implements this territorial reorganization, however, organizationally, creating proximity between itself and its suppliers as a source of speed and certainty. It is through organization that Dell allocates the arrangement of activities in space and the linkages between these activities. It enforces these conditions of geography and proximity upon its suppliers owing to its power to control the behavior of these firms.

In effect, the economies of time compression that Dell pioneered in coordinating the two-hour material pulls into each of its assembly sites play the decisive role in influencing how the PC maker allocates and distributes the linkages in its network across and within geographic space. Nevertheless, Dell does not simply remake territory in some mechanical adaptation to the efficiency imperatives of time compression. Dell instead relies on the business enterprise that it created from the innovative process, specifically its power to influence and exert control over other firms, as the organizational precondition for this territorial reconfiguration.

Vendors of components are candid in the way this power relationship operates. "Dell has a significant amount of power with its suppliers based on the current and future business levels they offer," argued one of Dell's large parts producers. "They know it and they use it" (interview with Supplier 2, 2 July 2002). Another supplier insisted that the requirement by Dell to maintain at least two weeks' supply of inventory in SLCs has been and remains "the single biggest issue facing Dell's material suppliers." Dell's suppliers, this vendor explained, have been trying to negotiate with Dell to reduce this requirement to one week. "Dell has resisted for the past three years," this supplier explained, "because they do not want the risk" (interview with Supplier 1, 28 May 2004).[16] Suppliers that do not want to

[16] Dell, this supplier explained, has an explicit monthly grading system for assessing vendors' performance. If a supplier allows inventory in SLCs to fall below the required two weeks, it receives a warning from Dell. If the situation

conform to the inventory requirements of SLCs in the PC maker's demand fulfillment system will not supply Dell.

In this way, while there is much that is innovative about the logistics of demand fulfillment, Dell's claim that it has created an Internet-driven, just-in-time system of material balancing without procurement inventory is misleading. Indeed, despite the innovative advance of demand fulfillment, there *is* inventory in the just-in-time system of material balancing at Dell. This inventory, however, along with its costs, lies outside the formal boundaries of the PC maker. It is component vendors that Dell forces to bear these inventory costs as the price of inclusion in Dell's interfirm business organization. Similarly, it is the same supplier firms that are forced to reallocate their economic activities territorially in conforming to the requirements of Dell's own innovative routines.[17]

Dell's control over suppliers and use of force to influence the locational behavior of these firms in remaking territory reveals a critical organizational feature of the PC maker's interfirm network. Dell interacts with the suppliers in its network not through markets, but through highly controlled relationships. Similarly, the relationship between Dell and the entities managing the SLCs, although nominally between separate firms, is also far from what would qualify as a market transaction between independent agents. In Austin, for example, the SLC serving the Morton Topfer Manufacturing Center, where Dell assembles finished goods, is literally on the Dell property directly adjacent to the assembly activity. Moreover, this SLC facility was actually constructed by Dell and then leased to Eagle Global Logistics, a 3PL that is responsible for managing the inventory at this particular SLC. Formally, the relationships among Dell, Eagle, and the suppliers that maintain inventory in the facility are among separate firms. Functionally, 3PLs, such as Eagle, that manage the SLCs and the suppliers that position inventory in these warehouses are completely integrated into the Dell operation.

Both global supply planning and demand fulfillment, in effect, have compelled Dell to create a functionally integrated organization with the other firms in its network. At the same time, Dell is able to maintain clear organizational boundaries between itself and these other firms when such formal demarcations are advantageous for it, as, for example, in the postponement in the delivery of components until the very moment when Dell wants them. Such arrangements represent Dell's strategy for simultaneously taking advantage of external capabilities by passing certain obligations and costs on to other parties, while retaining necessary control over critical adjacent steps in the PC commodity chain. In assessing the time-sensitive nature of these linkages and their interfirm character, Dell has concluded that contracting with these other firms through markets to execute the necessary steps, from procurement through assembly, poses greater levels of risk than do relationships that are consummated through force.

In this sense, Dell's reliance on controlled relationships to link the adjacent operations in its network is strikingly 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 represented a response to the risk of managing complex procurement, production, and distribution

occurs more than twice, this vendor said, the offending supplier will probably be dismissed.

[17] Although there is inventory in the Dell model, the costs of which are born by suppliers, there are nevertheless aggregate efficiency gains in the system. In overseeing the supply chains of its suppliers, Dell forces the suppliers to become more proficient in managing their own inventory and supply chains (Kapuscinski et al. 2004). As another of Dell's suppliers conceded, "Dell dragged us over the coals to make certain that we knew about the risks in our own supply chain" (interview with Supplier 3, 24 July 2002). These suppliers, in conforming to the inventory requirements of Dell in the SLCs, have enormous incentives to cut their own expenses related to inventory.

systems without disruption, so, too, does Dell's virtually integrated enterprise confront similar types of risk by deploying similar control mechanisms. The difference is that whereas manufacturers in the early mass-production era tended to exert such control through mechanisms of administrative planning in concert with their 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 organization differ—vertically integrated firms own the assets in their network while Dell does not—the rejection of market-based interactions to accomplish operational objectives is fundamentally similar.

Thus, the idea that market linkages among nominally independent firms are emerging as the mechanism of governance in interfirm production networks is far removed from the experience of logistics-oriented production networks that are driven by the goal of time compression and dominated by firms like Dell. While the proliferation of the interfirm network as an organizational phenomenon is undeniable in the current period, the power relations of Dell's interfirm enterprise tell a far more revealing story about interfirm networking than does the focus on Dell's structural characteristics per se. In the high-risk, high-speed, time-driven business systems being pioneered by Dell, the story of interfirm cooperation is not based on markets. Instead, it is a story 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. Geographic proximity is one pivotal resource that Dell mobilizes through organizational power to accommodate a set of time-sensitive innovative routines.

What Dell has established in response to the problem of time and distance that is posed by the innovative routines of demand fulfillment is a decentralized system of supply-and-demand balancing for the allocation and transfer of parts at two-hour intervals into each different assembly site. At the same time, the company has standardized this system so that the routines it has created for the allocation and transfer of components are identical in each location. Commenting on this practice, Dell's vice president and general manager for Latin America explained: "We execute this same business model everywhere. It's like McDonald's" (interview with Daryl Robertson, 12 March 2002). Although there is undoubtedly some variation in the way this business model is implemented at the different Dell locations, the geographic impacts of this effort at standardization are profound. In creating a standardized set of innovative routines for the transfer of parts between sources of supply and assembly, the PC maker has contributed to homogenizing a set of territorial practices across space. Thus, by organizing relationships of proximity between sources of supply and assembly in its chosen regional locales, Dell has assumed the role of agent in crafting territorial features of the contemporary regional economic world.

Conclusion

What makes Dell a compelling and paradigmatic case is that it is part of a broader trend among firms to capitalize on new communications technology and use corporate power to rationalize supply-chain systems and forge innovative business models on the basis of distribution and the logistics of time compression. In this regard, Dell is a close counterpart to Wal-Mart, the one firm that is changing the economic environment worldwide most decisively. Like Dell, Wal-Mart is essentially a logistics firm that operates an enormously efficient supply-chain and inventory-management system through a combination of highly advanced communications and a system of throttling its supply base. As a dominant purchaser, Wal-Mart, like Dell, is able to impose technological imperatives on its suppliers—in 2004, it forced its 120 largest suppliers to adopt a new radio-frequency-identification technology system at their expense—while prevailing upon 450 of its

suppliers to open offices in its headquarters location in Bentonville, Arkansas. Operating a similar type of enterprise as Dell, Wal-Mart has had an immense impact in shaping the geography of its supply base. With business models closely aligned, Dell and Wal-Mart reveal similar stories about innovation that draw upon precedents for inventory management that were established earlier by Japanese automakers while focusing on logistics and communications, supply chains and power, business organization, and territory. More important, what is now broadly termed, "supply chain management," oriented toward controlling the costs of inventory, has become standard business practice as a result of the influence of Wal-Mart and Dell.

What also elevates Dell as paradigmatic is that specific aspects of its process-oriented and time-driven business model are diffusing among other firms within the PC industry. Such a development is consistent with Schumpeter's (1939) observation that innovations tend to spread and become generalized because other firms are compelled to imitate the routines of the successful innovator. According to one of Dell's main suppliers, the Internet-driven logistics-oriented routines pioneered by Dell are being duplicated by other PC makers. Since Dell's suppliers are providing components to other PC firms, it is not surprising that producers of components with experience in executing the logistical imperatives of the Dell system are the conduits for the diffusion of new knowledge to Dell's competitors. The entire industry, this supplier insisted, is now using SLCs as hubs for the allocation and transfer of parts into the assembly process, although this supplier conceded that Dell still executes the routines of this business system far better than its competitors (interview with Supplier 2, 28 May 2004).

Dell's impact across industries and the diffusion of innovation within the PC industry suggest that the Dell experience has characteristics from which it is possible to draw lessons. In broad outline, the thematic issue at the core of the Dell story focuses on the geography of innovation. Within this theme, the analytical puzzle that was explored in this study was how the territory for economic activity gets reconfigured by the innovative activity of the firm. In addressing this puzzle, this article has focused on innovation as a set of dynamic linkages that are involved in making and marketing products. These linkages, in turn, have operational, organizational, and ultimately territorial consequences. It is the recasting of these linkages that reveals the relationship among the process of innovation inside the firm, organizational change, and the territorial transformation of economies.

Communications revolutions are one of the most formidable historical forces that enable business firms to alter how they compete and accumulate profit. In responding to changes in communications technology, firms seek innovation as a pathway to competitive advantage. As firms learn to compete differently from the opportunities presented by communications revolutions and alter their routines for accumulating profit, they restructure the organizational arrangements through which they undertake their profit-seeking activity.

These changes in routines and organization have territorial consequences because economic activity and business enterprise are geographically embedded. Economic activity and business enterprise are essentially a series of linkages that connect routines that get coordinated within and between firms. When firms transform the routines by which they produce, buy, and sell and alter the organizational arrangements through which they coordinate these activities, they disrupt the nature of these linkages. Such disruptions, in turn, lead the innovative firm to reconfigure where it undertakes and distributes its profit-seeking activities and the pathways of connection between them.

Three specific findings emerge from the Dell case that reveal a broader story about innovation within the firm, organizational change, territorial transformation, and issues of power and control. First, in using the

Internet to create a highly innovative time-sensitive process for building and selling computer hardware, Dell has developed a set of routines that are critically dependent on relationships of territorial proximity between assembly facilities and sources of supply. Far from overcoming the frictions of space, Dell's Internet-driven business model and the business organization that Dell built to implement this system have elevated relationships of spatial proximity to a position of strategic primacy in the locations in which it undertakes its just-in-time assembly activities. In this respect, the firm has reconfigured space in the service of time.

Second, the experience of Dell reveals how the reconfiguration of territory through reorganization of the firm is not simply a function of efficiency imperatives. Territorial transformation is also the result of agency and the exercise of sometimes-contentious forms of power and control over other firms by the innovative enterprise to accomplish specific operational objectives. Such relations of power are actually the means by which logistics firms, such as Dell, are compelled to organize the relationships of proximity that are needed to mitigate the risks inherent in operating just-in-time business systems. In this way, the economies of time, pioneered by innovators like Dell, have had a decisive impact on how logistics-driven firms organize the relationships within their networks and how they distribute the nodes and linkages in these networks across and within territorial space.

Finally, although it is a highly disintegrated firm, dependent upon interfirm contracting for components and technologies, Dell interacts with other businesses not through markets, but through highly administered relationships. Such relationships, typically associated with vertical integration and described by Coase (1937) as "planning," by Williamson (1975) as "hierarchies," and by Chandler (1977) as "the visible hand," are essential to Dell in securing the collaboration from its interfirm partners that it needs to organize its extraordinarily innovative supply, production, and distribution chain. Consequently, while Dell's innovative enterprise and organizational disintegration appear to be part of the same phenomenon, the idea that interfirm networks are necessarily connected to a new ascendancy of market relations is misguided. Power and control, not prices and markets, are essential platforms for logistics- and time-driven innovative enterprises that are crafted in the image of the Dell model. These findings provide an image of how the organizational innovations of firms, such as Dell, with their interfirm structure and clearly defined centers of power, are recasting systems of procurement, production, and distribution in the spaces where they operate, while revealing the nature of the territorial transformations at the core of contemporary globalization.

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