OPEN INNOVATION IN SYSTEMIC INNOVATION CONTEXTS[i]

Chapter 12

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The competitive consequences of different types of innovation have been one of the central themes in research on technological innovation (e.g., Mansfield 1968; Abernathy and Utterback 1978; Henderson and Clark 1990; Tushman and Anderson 1986). Studies have repeatedly shown that incumbents ability to create and to adapt to non-incremental innovation differs starkly from their ability to deal with incremental innovation (Christensen and Bower 1996; Henderson and Clark 1990). Several types of innovations have been identified that create particular challenges for incumbents. Tushman and Anderson (1986) argue that *radical innovations* that change core technical concepts and their linkages create adaptive challenges for incumbents. Henderson and Clark (1990) extended this research by showing that innovations that change the linkages between core concepts, so called *architectural innovations*, create similar challenges for incumbents. More recently, Christensen and Bower (1996) yet extended this class of difficult to handle innovations by their concept of *disruptive innovations* that initially address new customer groups and focus on different performance characteristics. These three groups of innovations have in common that they require organizational arrangements for innovation that differ from processes and arrangements suitable to create or adapt to incremental innovations. The findings further suggest that firm behavior differs (and needs to differ) depending on the nature of innovation an incumbent is faced with in its operating environment.

While the above classifications of innovations and the different classes of non-incremental innovations have added to our understanding of the innovation process, they are yet incomplete. In this study we focus on *systemic innovation* (versus autonomous innovation), that is, innovations that require significant adjustments in other parts of the

business system they are embedded in (De Laat 1999; Teece 1996; Chesbrough and Teece 1996; Teece 1986). Due to the fact that systemic innovation processes frequently span beyond the boundaries of the firm they often entail the coordination of different parts of the value network and entail open innovation organization models of innovation activities (Chesbrough 2003b). In systemic innovation processes firms need to coordinate as well with producers of complementary products and in many cases even with direct competitors to ensure the viability of the innovation, rather than coordinating solely with suppliers and customers as is frequently the case in closed innovation models. While systemic innovation processes are widely practiced in industries such as telecommunications or information technology, the processes how incumbents and new entrants achieve this coordination and ultimately how they jointly create systemic innovation are ill-understood in academia.

Although some prior studies have examined innovations that could be characterized as systemic, these studies have not systematically analyzed the management of proactive creation of the entire commercialized system of innovations. The studies have frequently taken as given the long and evolutionary development process of the complementing innovations, such as the development of the petrochemical industry to provide fuel for the combustion engines of automobiles or the development of the production and distribution of electricity to enable electric light to displace gas lamps (Utterback 1994; Abernathy and Clark 1985; Hargadon and Douglas 2001). However, in many cases such complementing innovations are vital for the commercial success of the actual value creating innovation, and in current business environment companies rarely have the luxury of time to wait for the emergence of such essential complementary

resources for decades. The question is how can companies lead the development of systemic innovations proactively?

In this chapter we make several contributions to the innovation literature. First we contribute to a better understanding of open innovation by showing how systemic character of innovation acts as an underlying driver for open innovation processes. Second, our chapter shifts the focus of attention from the firm level to the value network level. In particular when faced with systemic innovation, resource allocation processes have to stretch beyond the boundaries of the firm and need to take complementary innovators into consideration. Proactive creation of systemic innovations requires a dynamic interplay between complementary innovators including incumbents, startups and research institutions through various collaboration mechanisms including external corporate venturing modes, research programs and industry consortia, a variety of mechanisms and innovation processes common in open innovation. Third, we develop a dynamic framework of resource allocation mechanisms. By analyzing multiple time horizons we are able to show how different boundary spanning mechanisms enable the firm to dynamically manage resource allocation. Finally, we show how in systemic innovations, industry leaders frequently play architect roles (Chesbrough 2003b) in steering other participants in the value network. To play this architect role, industry leaders add industry shaping activities to the strategic foresight processes that often drive resource allocation decisions in autonomous innovation. Ensuring the commitment of complementary innovators through signaling own commitment (e.g. Spence 1973) is an important part of resource allocation process in systemic innovation contexts.

The rest of the chapter is structured as follows. The following two sections briefly summarize prior literature on systemic innovation and make the case that traditional resource allocation approaches are insufficient for systemic innovations. The following section develops our framework for the management systemic innovation processes and necessary resource allocation processes. The final section discusses conclusions.

SYSTEMIC INNOVATION

We want to start our introduction to systemic innovation with an example. For third generation mobile telephone systems to be successfully commercialized, at the minimum, 3G network infrastructure needs to be developed by mobile network equipment providers and deployed by mobile operators, mobile phones need to be developed by mobile terminal producers (only some of which are the same companies that produce infrastructure) that are capable to interact with this new infrastructure and make use of the functionalities that it provides. Finally, applications and services need to be developed by mobile operators and third parties that make use of the new functionalities of both handsets and infrastructure so that mobile operators end-users have an incentive to purchase the handsets and use the infrastructure creating a business case for mobile operators to invest in deploying the infrastructure and distributing the handsets. If either of these building blocks (as was the case in 3G deployment in Europe) is delayed or functions below expectation, frequently the producers of other parts of the system cannot move forward with introducing their part of the system facing significant economic consequences.

Conceptually such systemic innovations were introduced to the literature of innovation management as a category of innovations requiring specialized complementary assets for successful commercialization of the innovation in question (Teece 1986). Extending this initial limited conceptualization, systemic innovation has been defined as an innovation whose "benefits can be realized only in conjunction with related, complementary innovations" (Chesbrough and Teece 1996). During the past decades and years we have seen that such innovations have become increasingly common including the Internet, the 3G mobile telephony, Linux, Java, Symbian, and many others. Systemic innovations thus have to be distinguished from autonomous innovations that "can be pursued independently from other innovations" (Chesbrough and Teece 1996). In the following we will assume that both of these refer to the requirements that can be observed at least in retrospect for full scale commercialization of the innovation, defining an innovation as an invention that has been fully diffused to the marketplace (Garcia and Calantone 2002).

Systemic properties of innovations have been subject to very limited discussion in the literature. The systemic characteristics of innovations have been identified to impact selected business dimensions of innovative activity, and examples of such discussion include the literature on platform leadership (Gawer and Cusumano 2002), Complex Product Systems (CoPS) (Hobday 1998; Miller *et al.* 1995), industry standardization questions (Kano 2000; Keil 2002b), and open innovation (Chesbrough 2003b). However, the existing research does not clearly identify the distinction between individual autonomous or systemic innovation and the broader system. The characterizations tend to classify innovations as linked to either one firm or one product or technology category,

forcing the analysis to extend to a more complex environment in terms of organization and dynamics of innovations. Literature that has directly focused on systemic innovations has largely focused on whether systemic innovation should be managed within a single firm by vertically and horizontally integrating complementary innovations or whether these innovations are better created through markets. Teece (1986) as well as Chesbrough and Teece (1996) have argued that systemic innovations should be typically managed in an integrated fashion to avoid the substantial difficulties in coordinating the innovation activities of multiple players in the market place. However, this view has been seriously challenged in some contexts (e.g., De Laat 1999) with the argument that many contemporary systemic innovations are just too big and complex even for the largest integrated companies to manage alone. While integrating systemic innovation economizes on the cost of coordination and provides control benefits, it is frequently infeasible since even the largest firms lack the financial resources let alone technological and market capabilities to create the simultaneous complementary innovations necessary for successful systemic innovation. Empirical evidence supporting the integration argument is rather inconclusive, limited (Teece 1996) and at least partly contradicting. Observations concerning for example the telecommunications and Internet technology industries since mid-1990s present several examples of highly systemic technologies pursued through various types of collaborative efforts by a number of firms (Kano 2000; Keil 2002b).

The systemic nature of innovation makes companies increasingly dependent on others. Because in complex systemic innovations, vertical integration is rarely an option, the innovation processes become increasingly collaborative processes. Innovating

companies are dependent on complementary innovators. The move from internal innovation processes to collaborative open processes forces companies to take a wider perspective to resource allocation processes and to adopt new governance modes to carry out activities related to the creation of systemic innovations. In systemic innovation, companies need new tools for foresight and shaping to manage the business environment of the corporation over different time horizons. This increases the role of tools such as external venturing, research collaboration, and industry consortia.

STRATEGIC RESOURCE ALLOCATION PROCESSES

Resource allocation processes in innovation processes have received continued attention in the strategy and technology and innovation literature. Starting from the general resource allocation model developed by Bower (1970), this literature has evolved through a cumulative body of research over a 30 year period (e.g., Bower 1970; Burgelman 1983a, b; Gilbert 2002a, b; Christensen and Bower 1996; Noda and Bower 1996). The Bower-Burgelman process model, named after the seminal contributions of Bower (1970) and Burgelman (1983a), views resource allocation as part of a larger strategic management process conceptualized to consist of multiple, simultaneous, interlocking, and sequential activities that take place on the front-line, middle and top management level of the organization. Through bottom up processes of defining technological and market forces and championing strategic initiatives in a socio-political impetus process and top down processes of structural and strategic context determination the organization arrives at strategic decisions and in particular at resource allocation decisions. The central feature of the Bower-Burgelman model is that strategic initiatives emerge predominantly from the activities of front-line managers and then compete for

resources and top management attention. In later work, Burgelman (1994) shows how the process of the emergence and selection of initiatives can be understood in an intraorganizational ecology perspective as a variation, selection and retention framework. Noda and Bower (1996) further extended the model by showing how iterative processes of resource allocation lead to escalation and de-escalation of strategic commitments. More recently scholars have identified limitations of the Bower-Burgelman model for some innovation types and have developed additional perspectives to explain how corporations can address resource allocation for different types of innovations. For instance Christensen et al. (1996) argue that resource allocation along the lines of the Bower-Burgelman model fails for disruptive innovations. Disruptive innovations differ from incremental innovation in that they lower product performance along traditional metrics, but find an untapped need with a new set of applications, find a broader set of new and initially different customers, who value these attributes and applications, and creates a significant change in the underlying business model of the firm, often lowering gross margins or changing the basic drivers of firm profitability (Christensen 1997; Christensen and Bower 1996; Gilbert 2002a, b). Resource allocation in line with the Bower-Burgelman model frequently fails to support such innovations since they do not fit the financial and operating criteria required to sustain the core business. The problem for incumbent firms is that when disruptive proposals are considered, analysis based on established performance criteria reveals the new opportunity as inferior when compared with other potential opportunities that sustain the existing business. Gilbert (2002a, b) complements this perspective by arguing that organizations frequently need to employ different and changing cognitive frames for disruptive innovations. Yet others have

suggested separating the development of disruptive innovations in new venture divisions with separate resource allocation processes to enable them to survive in organizations (Tushman and O'Reilly III. 1997).

The research on disruptive innovation suggests that different innovation types might require differing resource allocation logics. For corporations to be able to develop radical or disruptive innovations, the prescription has been to establish separate new venture divisions to insulate the immature disruptive ventures from the pressures of the core businesses and to thereby create space for the long term development of more explorative ventures that are critical for the long term competitiveness of the firm. However, we argue here that these prior resource allocation models optimized for allocating the internal resources of the corporation are insufficient for systemic innovation. For corporations to be able to create systemic innovations, yet further development is needed in the resource allocation processes. In prior research into the resource allocation processes, the resource allocation deals with allocation of internal resources i.e. employees, machinery, financial resources of the focal company. However, for innovation processes that require multiple simultaneous innovations in independent companies, such a perspective is too narrow. In systemic innovations, partners and external developer communities make up a significant resource pool working on developing different components of the systemic innovation (West 2003; Franke and von Hippel 2003; Hertel, Niedner, and Herrmann 2003; von Hippel and von Krogh 2003). These developer communities and external partners are critical for the success of the innovation in question but are not under direct control of the focal corporation. Attracting and retaining the commitment of these external resources is the key to proactively

building systemic innovations. The difference between resource allocation processes in autonomous innovations versus systemic innovations is highlighted in Figure 12.1. For creating disruptive innovations, the recommendations from prior literature have included the advice to establish separate new venture divisions. However, optimizing the allocation of internal resources in a corporation may lead to suboptimization when viewed from the perspective of creation of systemic innovations. In systemic innovation, resource allocation is not only about own resources. For successful proactive management of systemic innovations, resource allocation processes have to take the external resources into account. The allocation of internal resources, and credible commitments to do so in the future, influence the allocation of external resources that form a major part of the total pool of resources that are needed to create systemic innovations.

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Resource allocation processes that do not consider these external resources and provide mechanisms to steer the resource allocation in these partner companies and communities outside the boundaries of the focal firm run the risk to lead misallocation of resources and to the ultimate failure of the systemic innovation. In the following section we will develop some arguments how boundary spanning mechanisms can support internal resource allocation mechanisms and processes in systemic innovation.

A FRAMEWORK FOR PROACTIVELY MANAGING SYSTEMIC INNOVATIONS IN INDUSTRY LEADING COMPANIES

In systemic innovation, innovating companies are dependent on other complementary innovators and need to learn to proactively lead the development of systemic innovations. Systemic nature of innovations will increase the need and alter the means of corporations to manage their dependencies of their environment by creating foresight and shaping the development of their industries over different time horizons. This calls for open innovation processes and dynamic resource allocation processes that consider both internal and external resources available to further the systemic innovation in question. In these processes, in particular, the linkages between different activities need to be understood to capture the dynamics of systemic innovation. Our framework, as depicted in Figure 12.2, highlights these aspects that are needed for proactive creation of systemic innovations in large corporations.

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The framework consists of three building blocks. First, similar to the top down and bottom up processes of the Bower-Burgelman model we identify two main processes: Foresight and Industry Shaping. Foresight and industry shaping are fundamental goals relating to resource allocation that firms aim to accomplish when interacting with firms in their environment. Our second building block is the time dimension. By focusing on three

time dimensions we develop a dynamic resource allocation model that spans beyond technology creation. In systemic industries, a focus on the technology creation process alone falls short of understanding systemic innovation processes, since the drivers of resource allocation shift as a firm moves from early technology development to full technology commercialization. We argue that the whole process from early research to product development and introduction, needs to be observed to understand how industrial organizations react to environmental changes and shape their environment. Our third building block consists of tangible mechanisms that firms can utilize to accomplish foresight and industry shaping goals during different stages of the emergence of a systemic innovation.

Foresight and Industry Shaping as Resource Allocation Processes

In systemic innovation, boundary spanning serves two main purposes, to provide foresight and to shape the environment. In Figure 12.2, these two processes are depicted as two arrows spanning the different time horizons. Firms draw information about the evolution of technologies and markets but also about the resource allocation decisions of other firms by linking to multiple actors in their environment. The information derived is similar to the information that derives from strategic initiatives in the Bower-Burgelman model in that it allows the firm to define the technological and market forces and so influences internal resource allocation decisions. We refer to this process as *foresight processes* (the upper arrow in Figure 12.2). The complexity of systemic innovation means that firms need to monitor the development of multiple simultaneous innovations. Since internal resource allocation decisions need to be adjusted according to the evolution of these innovations, intense interaction with suppliers, customers, partners, developer

communities, and competitors are needed to provide rich information about the development of different elements of the systemic innovation. External contacts formed through research consortia, alliances, and other forms of cooperation provide a way for companies to gain information (Gulati 1999; Powell, Koput, and Smith-Doerr 1996), to gain understanding and make sense of this new information (Weick 1995), and ultimately to provide foresight into emerging new business opportunities.

The foresight process can be understood as passive in that it provides input into the firm internal resource allocation process but does not change the decisions of actors in the firm environment. Thus foresight does only provide limited coordination among the firms creating systemic innovation. A second process similar to the structural and context determination process for internal resource allocation is needed that provides for stronger coordination to avoid the risks that Chesbrough and Teece (1996) discuss. We refer to this process as *shaping process* (the lower arrow in Figure 12.2). Firms need to proactively influence the evolution of technologies and markets and the resource allocation decision of others in their environment. Shaping can take several forms. First, shaping can take place through providing actors in the environment with financial incentives. Focal firms frequently provide financial incentives to customers or suppliers to support a new technology or to develop complementary products or services. Other financial incentives might include investment into producers of complementary technologies. For instance INTEL has been investing in recent years millions of dollars into firms that create products based on its INTEL64 architecture (Leamon and Hardymon 2000). IBM, on the other hand, has invested significantly in companies that have built complementary innovations to enable the corporate use of the Linux platform.

Additional incentives can include sharing of firm proprietary resources, technologies or access to information. For instance, Texas Instruments has provided small and medium sized firms with access to advanced architecture information and with development support that committed to adopt its DSP technology. Sun Microsystems has sponsored the Java Platform (Garud et al., 2002). Second shaping frequently takes place through participation in standardization processes run by industry associations or standardization organizations. Important aspects of third generation wireless technologies or the Bluetooth short-range wireless standard were standardized in open standardization for a long before these technologies were ready to be introduced (Keil 2002b). Finally, shaping can also take less formal form through signaling intentions, for instance, through press announcements or in informal communications with customers suppliers, partners, or competitors.

Time Horizons and Boundary Spanning Mechanisms

To understand the mechanisms that firms can use as foresight and industry shaping mechanisms it is useful to analyze three distinct time horizons in the emergence of a systemic innovation. Since systemic innovations require multiple simultaneous innovations, coordination needs to start well before the innovation is introduced to the market place. Early technology development and standardization of technologies underlying systemic innovations frequently predate their broad commercialization by five to ten years. During this early technology development stage, the firm faces the challenge to understand the development of multiple technologies and influence their evolution and standardization. During this early stage of evolutions, focal firms frequently rely on pre-competitive cooperation mechanisms that usually take the form of research collaboration.

These might include research consortia, cooperation with universities, and participation in academic research such as presentation at a conference or publication in scientific journals. Through these research cooperation mechanisms, focal firms can gain important information about the evolution of complementary technologies but also influence early technology decisions by other actors in the value network. For instance, participation in research consortia provides firms with access to knowledge spillovers from other firms participating in the consortium (Katz 1986). These spillovers can therefore either substitute for internal research and development thereby reducing the cost of research and development or provide knowledge complementary to a firms own knowledge base through skill sharing (Sakakibara 1997). Research and development cooperation frequently takes place either in government supported consortia such as SEMATECH in the U.S. or VLSI in Japan or is related to basic research during the pre-competitive phase of technology development. During this early stage of technology development, focal firms might as well be willing to make knowledge publicly available to influence others to follow a certain technology path. For instance, the joint article on Semantic Web in the Scientific American written by Ora Lassila of Nokia with Tim Berners-Lee of W3C and James Hendler of University of Maryland has had an instrumental role in bringing the Semantic Web closer to the reality by giving a joint direction for a variety disperse research efforts. For systemic innovations that require multiple complementary innovations also the standardization of technologies frequently occurs during this early phase through formal and informal standardization bodies. For instance the standardization of 3G wireless technologies took place during the second half of the 1990s several years ahead of the release of any commercial products (Gandal, Salant, and

Waverman 2003). Participating in these standardization bodies provides the focal form with important foresight on future standards but also allows it to influence the choice among multiple standards candidates.

During early commercialization, the emphasis in tools for foresight and shaping changes from research and technology oriented mechanisms to exploratory commercialization through corporate venturing and other mechanisms. During this intermediary phase that often precedes full blown commercialization by two to five years, the focal firm participates in early commercialization efforts, however, without committing large scale resources. Early commercialization of systemic innovations usually takes place on a small scale and faces a significant risk of failure. The early commercialization efforts might involve complementary innovations, or might require experimentation with product configurations, customer groups, or business models. To control these risks and enable experimentation, the boundary spanning corporate venturing mechanisms that firms can utilize in this context include corporate venture capital investments in and alliances with start-ups involved in early commercialization, as well as small scale acquisitions.

In recent years, a large number of companies has utilized some form of corporate venture capital investments (Chesbrough 2002; Dushnitsky and Lenox 2005; Maula and Murray 2001) to participate in the early commercialization of emerging technologies. In this form of venturing, the corporation imitates the behavior of traditional venture capital firms by participating with an own investment fund in the private equity market or by participating in a fund managed by a traditional venture capital firm. By co-investing in startups the corporation gains access to information about the commercialization efforts

of these ventures allowing it to avoid resource allocation to failing products, business models or customer groups. Corporate venture capital investments also help to shape the emerging value network forming around the systemic innovation. Investments provide important resources for the start-ups such as finance, knowledge or access to distribution channels. In addition, these investments provide legitimacy to the start-ups as well as the technologies or business models these pursue. Venturing through alliances includes non-equity alliances and joint ventures to explore new business opportunities. Similarly to corporate venture capital investments, alliances and joint ventures can provide foresight into emerging technologies and support the creation of complementary innovations. In an acquisition, an independent venture or an external venture is internalized by acquiring a majority position in the venture. Acquisitions can provide control over emerging critical complementary innovations.

During the full commercialization and development stage, the emphasis of the organizational mechanisms changes once more. During full commercialization, the focal firm focuses on learning about competitive threats through business intelligence, countering competitive moves by competitors and on creating efficient value networks through shaping mechanisms. Business development mechanisms such as supplier and customer alliances, joint ventures and large scale acquisitions play an important role in providing business intelligence and developing the business system supporting the systemic innovation. Alliances and joint ventures during this stage of development are frequently used to create efficient supply chains, increase commitment compared to arms-length market transactions and to lock-in important suppliers, customers or providers of complementary products. Being embedded in a network of relationships with other

supporters of a systemic innovation reduces the risk of opportunistic behavior and provides for a mechanism of social control (Uzzi 1997). The enfolding network of partners further provides a focal firm with improved access to information (e.g., Koka and Prescott 2002). Acquisitions are frequently used to gain control of firms that own important assets in the business system, to alter the power balance between actors in the business system, and thus to manage interdependencies in the focal firm's environment (Pfeffer and Salancik 1978).

The Industry Leaders Challenge: Managing Credible Commitments to Create Systemic Innovations

The initiation of systemic innovation often poses particular problems to industry leaders. Since systemic innovation requires the simultaneous development of multiple complementary innovations, business systems often require leadership by a small group of firms that can function as anchors for coordination. Following Chesbrough (2003b), we refer to these firms as architects (See also Christensen Chapter 3). Chesbrough (2003a) describes architects as firms that develop the technical architectures of systems thereby partition the system's complexity, enabling that other companies can provide pieces of the system while guaranteeing that these pieces can be integrated. Innovation architects provide leadership to a systemic innovation by establishing the system architecture, communicating it, and enabling others to support and further develop it. This role is frequently played by large firms that can provide the emerging innovation legitimacy. The architect stands to gain significantly from the innovation since they frequently produce important components of the systemic innovation or play a central role in its commercialization. However, contrary to small and medium sized players that

can solely focus on the emerging systemic innovation, innovation shapers face a different set of challenges. Being industry incumbents, architects frequently have vested interests in technologies that are to be replaced by the emerging systemic innovation. For instance, virtually all of the central players in the emerging 3G business system have been involved in second generation mobile systems. Therefore, architects need to balance driving the emerging systemic innovation with maintaining their existing business base.

A critically important perspective particularly for architects in this expanded resource allocation equation is the perspective of credible commitments (cf. Williamson 1983). Incumbents can use their own internal resource commitments to signal their commitment to specific systemic innovations and thereby attract external complementary innovators behind them. Because of their dependence of the evolution of the innovation, the external complementary innovators constantly monitor and assess the commitment of the leading promoters to the specific systemic innovation. The signals created by the resource allocation of the leading promoters of the innovation may have big effect on the commitment of the external complementary innovators. For instance, a wrong move by SUN could easily impact the number and commitment of Java developers. The same challenge applies to Nokia concerning Symbian developers, IBM concerning Linux developers and Microsoft concerning .Net developers. Attracting and retaining the commitment of external resource pools is a critical issue for builders of systemic innovations and should be considered in internal moves made by these corporations.

A visionary leader cannot be credibly committed to all alternatives. Yet also visionary leaders need to explore and manage different time frames and prepare for multiple possible futures. Simultaneously when sponsoring a disruptive new technology

for the future, large corporations need to sell their existing products. The need to manage different time horizons may create conflicting signals and create confusing signals for the complementary innovators. The challenge is how to orchestrate so that your customers are focused on what you are offering now and so that simultaneously developers are focusing on what you are pushing forward for the 5th year (or even 2nd or 3rd year for rapidly changing industries) from now. Corporations need new tools to manage these external resources with external venturing and research collaboration becoming increasingly valuable. The credible commitments constraint limits the moving space of corporations, which forces them to think carefully what tools they can use for different purposes. E.g. IBM influenced strongly the emergence of Linux by making supportive and legitimizing CVC investments in Linux companies in 1998-1999 while at the same time they were selling fully competing products (Young and Rohm 1999; Väisänen, Maula, and Salmenkaita 2003; Maula *et al.* 2003). Too early use of wrong tools such as establishing a business division would have distracted the attention from the core business and created false signals and expectations. It is only now when setting up an internal business makes sense and does not cause too bad reactions in other partners. As seen during the recent years, Linux has grown to be a multi-billion business for IBM.

DISCUSSION AND FUTURE RESEARCH

In this chapter, we have focused on the impact of the systemic nature of innovation on the resource allocation processes. We have argued that prior resource allocation models have focused on developing the optimization of internal resources e.g. to enable the creation of disruptive innovations with the use of separate new venture divisions. However, when viewed from the perspective of creating systemic innovations,

these models fail to address important challenges faced by firms. We have argued that factors exist, which make it challenging for incumbent corporations to internalize the whole process of developing a systemic innovation that is, to create the new technology, standardize it, find relevant business models and commercialize the technology. Creation of systemic innovations often requires the use of external resources. Therefore, models focused solely on optimizing the use of internal resources may lead to suboptimization when viewed from the perspective of creation of systemic innovations. Systemic character of innovation leads to open innovation processes.

Contributions for Theory

This chapter makes three important contributions. First, we contribute to a more detailed understanding of systemic innovations and their implications. We argue that systemic character of innovation is an important underlying driver of open innovation processes. In particular, this chapter contributes to a better understanding of the constraints and challenges that incumbent corporations face in the creation and commercialization of systemic innovations. We also contribute to a more in-depth understanding of why corporations employ a variety of governance mechanisms – internal research and development, alliances, and venture capital -- in the various stages of a systemic innovation process. Our arguments suggest that in systemic innovation these open innovation mechanisms (Chesbrough 2003b) are necessary complements to ensure the successful creation of systemic innovations.

Second our chapter makes contributions to the general theme of this book – open innovation. The shift from closed to open innovation is an empirical phenomenon readily

observed in many industry contexts. Our argument that the systemic nature of innovation in industries such as information technology or telecommunications forces firms to broaden their innovation activities beyond their internal resources provides a theoretical underpinning why these changes occur. We further contribute to the open innovation concepts by identifying how architect firms (Chesbrough 2003b) accomplish the process of establishing their systems solution, communicating it, and persuading others to support it and develop it in the future. In particular, this chapter details important requirements for the architect role for a specific type of innovations systemic innovations that are particularly well suited for open innovation.

Third, our chapter contributes to theories of resource allocation in firms. While the Bower-Burgelman model (Bower 1970; Burgelman 1983a 1983b) has been the dominant model of resource allocation in the past 20 years, recently limitations and boundary conditions for the model have been identified. Our paper contributes to this discussion by suggesting that in systemic innovation, models of internal resource allocation and the optimization of internal resource allocation are insufficient and might in some cases even hamper firm success. When, as in systemic innovations, a major share of resources necessary for success is located outside the corporate boundaries, these external resources have to become an important part of the resource allocation process. Our discussion further suggests that the processes through which external resource allocation is accomplished vary dramatically from internal resource allocation since the focal firm lacks direct control of these resources and needs to devise indirect steering mechanisms.

Implications for Practice

Our results also have important implications for practice. We propose that in order to create and commercialize effectively systemic innovations, collaboration between incumbents, startups and other stakeholders should be encouraged. Our findings also show how collaboration already in the early stage of research can have critical impact on the speed of convergence in the creation of systemic innovations. Public-private partnerships and industry consortia can play a major role in facilitating the development of the new technological system. Companies need to manage their future business environment over different time horizons. Depending of the time frame, different tools can be used to create foresight of the development and to shape the development of future systemic innovations. Our framework presented in Figure 12.2 provides an overview of the tools for creating foresight and shaping to manage the business environment of the corporation over different time horizons in industries depending on systemic innovations.

Given the increasing role of systemic innovations not only in the information and communications technology industries but increasingly also in more traditional industries, understanding of the systemic innovation process and the functioning of various policy measures in supporting this type of innovative activity is becoming increasingly important. Although there is very little prior research on systemic innovations and even less on the policy measures for supporting them, several factors suggest that policy actors may play an increasingly important role in stimulating innovative activity in a systemic innovation.

First, because of typically relatively weak intellectual property protection regime in systemic innovations, innovative activity may be susceptible to different types of market failures when contrasted to traditional R&D activity. On the other hand, policy measures may have disproportionally important effects in spurring the development of important systemic innovations as evidenced for instance in the development of the Semantic Web technology significantly spurred by EU and DARPA programs that accelerated and integrated a fragmented set of research efforts. In large systemic innovations individual innovating companies rarely have incentives to invest sufficiently until they are ensured that the overall systemic innovation will materialize. This easily leads to underinvestment and delays in one ore more critical components of the systemic innovation thereby delaying the creation of the whole systemic innovation. Therefore, government R&D programs can have an important role in kick-starting and aligning the development of complementary innovations and thereby facilitate faster development of systemic innovations.

Third, many systemic innovations have important societal effects because systemic innovations commonly alter the way people and organizations work and live. The Internet is one example of such systemic innovations. Fourth, systemic innovations have significant implications also for companies who need to take a more proactive approach to research collaboration and venturing on longer time horizons to secure the future path of growth. Therefore, the increasing role of systemic innovations and adoption of proper tools for managing them are likely to have impacts on the level and type of collaboration between government, universities, and firms. Because of the special characteristics of the innovative activity in the creation of systemic innovations and the

resulting different systemic and market failures, the potentially important role of policy measures in spurring and steering the development of systemic innovations as well as the important economic and societal effects of systemic innovations, it is important for policy makers to create a through understanding of the characteristics of systemic innovations and applicable policy measures.

Future Research

The arguments made in this chapter suggest several potential avenues for future research. First our arguments have suggested on theoretical underpinning why we are observing a shift from closed to open innovation. We suggest that linking specific innovation types with the closed and open innovation processes might help to further our understanding of the applicability and boundaries of open innovation processes.

Second, our arguments have focused on the challenges for industry leaders that play the role of an industry architect. While the creation of systemic innovations is frequently steered and too some extent controlled by these industry leading firms, the question arises what role other firms in the systemic innovation process can play and what the unique challenges are for these players. For instance, future research could investigate how producers of complementary products influence the evolution of systemic innovations for instance to position their complementary innovation as centrally as possible in the system. An additional interesting question would be to which extent small and medium sized firms can play the role of architect steering the evolution of a systemic innovation. Many of the mechanisms discussed in this chapter will be unavailable for small and medium sized firms. At the same time alternative open innovation processes such as open source development (Kogut and Metiu 2001, Grand *et*

al. 2004; see also chapter 6; von Hippel and von Krogh 2003) might open alternative avenues for small and medium sized firms to steer open innovation processes but these avenues would need to be investigated further.

Third, our arguments raise important research avenues regarding resource allocation. While we have provided a framework for resource allocation in a systemic innovation context, future research should further develop and detail the mechanisms of resource allocation available to firms in an open innovation model. Studies should for instance investigate how these mechanisms are integrated into the internal decision making. Future research could also investigate how firms reconcile the at times conflicting demands, time horizons and resource allocation mechanisms between internal and external resource allocation and thereby further develop the Bower-Burgelman model (Bower 1970; Burgelman 1983a, b) to incorporate external resource allocation.

Conclusion

To sum up, innovations are increasingly systemic. This makes companies increasingly dependent on external parties and changes the resource allocation equation because a majority of the potential relevant resources are located outside the boundaries of the corporation. Successful visionary industry leading corporations are able to tap and leverage these external resources to create systemic innovations by keeping the credibility of their commitments in mind and using tools such as external venturing and research collaboration to create foresight of and to shape the business environment over different time horizons. Systemic innovations require open innovation processes.

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Figure 12.1 Impact of Systemic Innovation on Resource Allocation Process

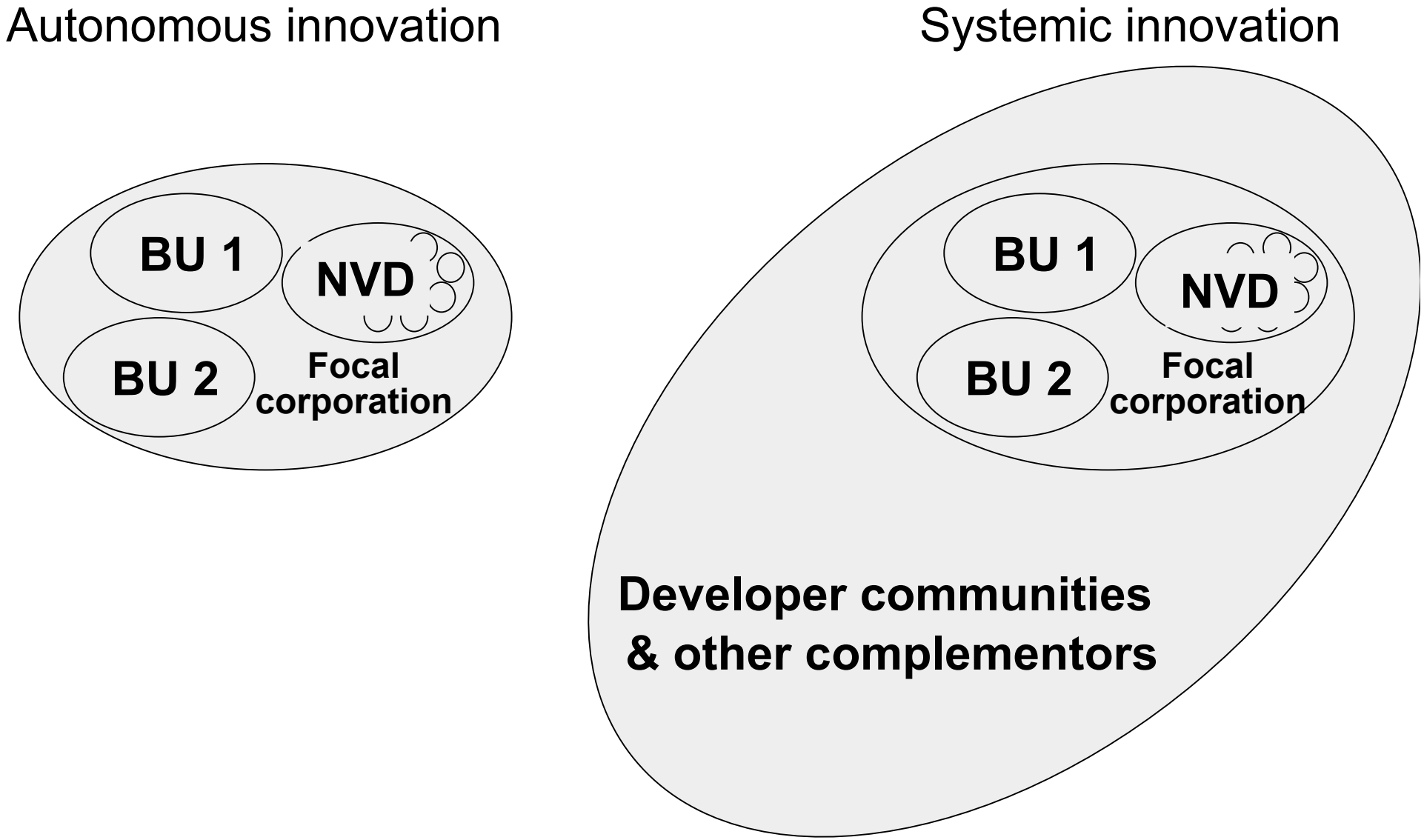

Figure 12.2 Tools for foresight and shaping to manage the business environment of the corporation over different time horizons in industries depending on systemic innovations