# COMPANY INNOVATION SYSTEM: A CONCEPTUALIZATION

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## ABSTRACT

We conceptualize the company as an innovation system that consists of components, relationships and attributes, with the purpose to produce innovation. The systems approach to innovation has received limited attention at the company level. While it is widely accepted for nations, sectors, regions and technologies, and while some company-level foundations and building blocks have been proposed, the dominant approach at company level is to regard innovation as a process.

*Components* of a company innovation system are actors or resources. *Relationships* refer to the configuration of these components: an innovation process now becomes one of the possible configurations of components in a system. *Attributes* of a company innovation system are capabilities and other system properties, such as innovative culture or infrastructure.

We explore the concept of company innovation system by analyzing and comparing case examples of ABB Group, Adobe Systems, Amazon.com, eBay, Hitachi, HTC, Lockheed Martin, Philips, Qualcomm, Salesforce.com and Southwest Airlines.

We find that using the company innovation system approach, we can map innovation systems at the company level. We can identify the *components*, such as R&D departments, labs, venture organizations, teams, employees, C-level offices and facilitating tools. We can identify *relationships* such as single or multiple configurations, simple or complex configurations, technology-driven, market-driven or interactive configurations, and open or closed configurations. We can identify *attributes* such as creativity versus efficiency emphasis, systematic versus non-systematic approaches, adaptiveness of the system, and large project-focus versus experimentation focus.

The findings indicate that companies design, configure and coordinate their innovation systems in different ways. Our current findings are tentative and preliminary and only provide descriptive insights of the case examples. A well-conceptualized and validated company innovation system approach may give managers relevant insights to address the problems of designing, configuring and coordinating their company innovation systems. Academically, the company innovation system approach provides complementary insights to the existing company-level innovation approaches.

**Key words:** Company Innovation System; Corporate Innovation System; Innovation; Systems approach

## INTRODUCTION

We conceptualize the company as an innovation system that consists of components, relationships and attributes, with the purpose to produce innovation. The systems approach to innovation management has received limited attention at the company level. Innovation systems approaches have been successfully applied to countries as National Innovation Systems (Lundvall, 1992), to regions as Regional Innovation Systems (Cooke et al., 1997), to sectors as Sectoral Innovation Systems (Malerba, 2002), and to technologies as Technological Innovation Systems (Carlssson & Stankiewicz, 1991). In each of those fields, the innovation systems approach is widely accepted.

We propose the company innovation system approach as a relevant addition to the existing innovation system approaches and to the innovation process approach. We base the company innovation system approach on foundations provided by Van de Ven (1986), who addressed the question of part-whole relationships in innovation management, by Granstrand (2000), who first coined the term corporate innovation system, by Carlsson et al. (2002), who laid out a methodology to conceptualize innovation systems, and by O'Connor (2008), who used the systems approach for making propositions about major innovation in firms. We use many of the building blocks that have been proposed in the literature (Teece, 1996; Granstrand, 1998; 2000; Sigurdson & Cheng, 2001; Coriat & Weinstein, 2002; O'Connor, 2008; Steiber & Alänge, 2013; Taylor & Wagner, 2014; Chen et al., 2015).

At the company level, the dominant textbook approach is to regard innovation as a process (see, e.g., Trott, 2011; Tidd & Bessant, 2013). The introduction of the Stage-Gate system by Cooper (1985) greatly contributed to the acceptance of the process view. Initially, many companies regarded innovation processes as linear, with sequential steps, but soon they recognized that using cross-functional mechanisms and parallel and non-linear processes enhanced effectivess (see, e.g., Cooper 1990). Cooper (2008) himself debunked many of the myths that the Stage-Gate system would be rigid and sequential, while still recognizing that many companies implement it as such.

With the advent of open innovation, companies and researchers have increasingly adopted an innovation network approach in addition to the process approach (Chesbrough, 2003). Researchers who use a network approach emphasize the structure of a system, counting the numbers of nodes and links and the connectedness between the nodes. Researchers who developed the concepts of business ecosystems and platforms (e.g., Moore, 1993; Iansiti & Levien, 2004; Gawer & Cusumano 2014) have extended this network approach into a systems approach, in which the company is one of the actors within a technological (eco)system or platform. Researchers who use a systems approach look beyond systems structure, emphasizing the exchange relationships between the actors and the emergent properties at the system level. A systems approach to innovation emphasizes interaction, learning, and knowledge creation (Edquist, 1997). It allows inclusion of a wide array of institutional attributes that may be important in explaining innovation, such as innovative culture, top-down versus self-organized coordination, or an open versus closed mindset.

The scope of this paper is limited: we only look inside the company, we use strictly a systems approach and we only aim to describe. First, we only look at the company level, and we do not venture into the links that clearly exist between the company and wider innovation systems or networks (cf., Sigurdson & Cheng, 2001). Second, we do not make international comparisons of company innovation systems in different national innovation or policy contexts (cf. Granstrand, 2000; Sigurdson & Cheng, 2001). Third, we do not aim to explain why a company is successful in innovation or why some companies are more successful than others (cf., Steiber & Alänge, 2013). We believe that the components, relationships and attributes of the company innovation system are among the factors that influence innovation success, but any attempt to include the company innovation system concept to explain innovation success will have to wait for the development of a body or empirical research.

Empirically, too, our scope is limited to descriptive case analyses and a cross-case analysis of the company innovation systems of ABB Group, Adobe Systems, Amazon.com, eBay, Hitachi, HTC, Lockheed Martin, Philips, Qualcomm, Salesforce.com and Southwest Airlines. The only aim of these analyses is to show that the concept can be used to describe company innovation systems and that there are differences between companies. We recognize that further conceptual work is necessary to flesh out the concept and its sub-concepts, to enable testing and falsifying the concept, and to clarify the connections with related concepts. Further empirical work is necessary to test the usefulness of the approach for analyzing innovation in companies.

## COMPANY INNOVATION SYSTEM

### Foundations and methodological aspects

Granstrand (2000) coined the concept of corporate innovation system and defined it as "…the set of actors, activities, resources and institutions and the causal interrelations that are in some sense important for the innovative performance of a corporation." (p.14), a definition that is in line with the concepts of national, regional, sectoral and technological innovation systems. He studied such systems in different county contexts, on an aggregate country level, identifying a number of important characteristics and developments, such as the growing importance of external technology acquisition and the increasing diversification of companies' technology base. He also investigated implications for growth and performance. Grandstrand's (2000) is the most comprehensive study on this topic to date, but results are presented at an aggregate level, and could be more informative for developing the concept at the company level.

Van de Ven (1986) provided a foundation for company innovation systems in his discussion on 'problems in the management of innovation'. One of the main problems in innovation, he argues, is the management of part-whole relationships. A tempting and much-used approach for achieving maximum productivity is to segment innovation into a sequence of stages and to divide the labor among specialist departments, like R&D, production or marketing. Such approaches have turned out to be inadequate for complex, interdependent activities like innovation because the efficiency of the micro-structures too often leads to macro nonsense (Van de Ven, 1986). An alternative, he proposes, would be to use simultaneous coupling of business functions, based on the hologram/brains metaphor of Morgan (1986). This requires radically different design principles for the organization of innovation, specifically:

i. allowing the collection of actors responsible for innovation to self-organize
ii. creating redundant functions, rather than narrow specialisms

iii. assuring requisite variety (Ashby, 1962), meaning that the complexity of the internal system should be large enough to deal with the complexity of the environment
iv. using temporal linkage, meaning that actors can configure into groups, change configurations, eliminate configurations and reconfigure into different groups, based on the demands of their innovation task.

For these principles to work, Van de Ven (1986) continues, the system needs the governance, institutional characteristics and infrastructure that enable it to learn. This requires network-building inside and outside the organization.

O'Connor (2008) used a similar approach to make propositions about how firms could organize and build capabilities for generating major innovations. She proposes four requirements for the various aspects of a company innovation system to be defined as a 'system':

i. the system should be identifiable and its elements should be interdependent
ii. the whole should be greater than the sum of the parts
iii. there should be internal and external relationships for the system to be in dynamic balance
iv. it should have a clear purpose in the larger system in which the system is embedded

Carlsson et al (2002), in their paper on analytical and methodological issues for innovation systems, indicate that systems consist of components, the relationships among them, and their characteristics or attributes. Components are actors, artifacts (cf., the resources mentioned by Granstrand, 1998), and institutions (such as laws, traditions and norms). The relationships between the components are essential for the formation of a system: the parts influence each other; the parts influence the whole; and the whole influences the parts. Such relationships, Carlsson et al. (2002) argue, can be market-based on non-market based. The feedback loops in the relationships provide the dynamics of the system. Attributes are properties of components and relationships, such as capabilities for selecting markets, technologies and organization modes, organizational capabilities for coordinating and integrating activities, functional capabilities for executing tasks efficiently, and adaptive capabilities that allow the system to learn from success and failure. Next to this, the system has dynamic properties, such as robustness, flexibility, the ability to generate change and the ability to respond to changes. Such changes, they argue can be endogenously or exogenously induced. Carlsson et al. (2002) define three major methodological issues to resolve for conceptualizing a system:

i. what is the level of analysis?
ii. what is the definition of the system boundary?
iii. what constitutes system performance?

First, the *level of analysis* for a company innovation system is fairly clear: it will be either the corporate or the business unit level. We need to be careful not to mix the levels, although they can be analyzed together as long as it is clear on which level we are. Second, we define the *system boundary* for the moment very straightforward as the legal boundary of the company. A possible alternative would be to use a stakeholder-based definition that would include, for example, subcontractors working within the company or temporary laborers. Furthermore, as argued by Coriat & Weinstein (2002) and as shown in the concepts of Sigurdson & Cheng (2001) and Chen et al. (2015) the company innovation system may be strongly intertwined with wider ecosystems or regional, sectoral or national systems of innovation, and it may in practice not be so easy to define what is ‘inside’ and what is ‘outside’. The dynamics of the system mean that the company boundary may evolve over time. Next to organic evolution of the company, this may be the result of mergers or acquisitions, or of all kinds of spin-out and source-in modes that result from open innovation. Third, we define *system performance* or *purpose* of a company innovation system in a broad sense: its outputs include different types of innovation (product, technological, business model, organizational) with different rates of innovativeness (e.g., incremental, radical), different rates of success or failure and different rates of impact on the company, the market or the world.

**Components**

Following the ‘template’ for innovation systems as put forward by Carlsson et al. (2002), we define a company innovation system as *‘the system of components, relationships and attributes within the boundary of a company, that has the purpose of producing innovation.’*

Starting with the components: these can be actors, such as individuals, teams, departments or business units, business or corporate decision makers (executives such as Chief Technology Officers or Chief Innovation Officers) incubators, central or decentral R&D departments, laboratories or facilitating groups. Granstrand (1998, p.475), in his conceptualization of the technology-based firm, views a firm as “… a legally defined, dynamic human system, consisting of a set of heterogeneous resources in an institutional setting …”. He identifies resources as the most important components of the system and he provides a detailed discussion of these resources, namely physical capital, financial capital, intellectual capital, relational capital and human embodied capital. The latter, is, of course, embedded in the actors and their relationships.

**Relationships**

The components of the innovation system can be configured, by top-down coordination or by self-organization, into configurations that address specific tasks. For example, one configuration focuses on coming up with new ideas, another configuration focuses on developing and launching new products (see figure 1). We argue that these configurations will normally match the complexity of the company’s environment (‘requisite variety’). We further argue that these configurations can range from temporary to permanent (‘temporal linkage’). Successful configurations around recurring tasks are expected to be more permanent, reflecting the company’s exploitation of existing resources, activities and capabilities. Configurations meant to discover new combinations or unsuccessful configurations will be more temporary and reflect a company’s exploration activities and the building of new resources and capabilities (see also O’Connor, 2008). At the system level, we will therefore see identifiable structures and interfaces with the main organization and the environment (O’Connor, 2008).

Not all the system’s actors and resources need to be involved in every configuration. Indeed, different configurations can exist simultaneously, partly overlapping and using the same actors and resources, while perhaps leaving other actors and resources unused (‘reducndancy’). The use of actors and resources for different tasks, or the (temporal) lack of use of some actors and resources align with Van de Ven’s (1986) design principle of ‘redundancy of functions’: the capacity of the system is larger than what it actually needs for any specific configuration, but prepares it for wider needs.

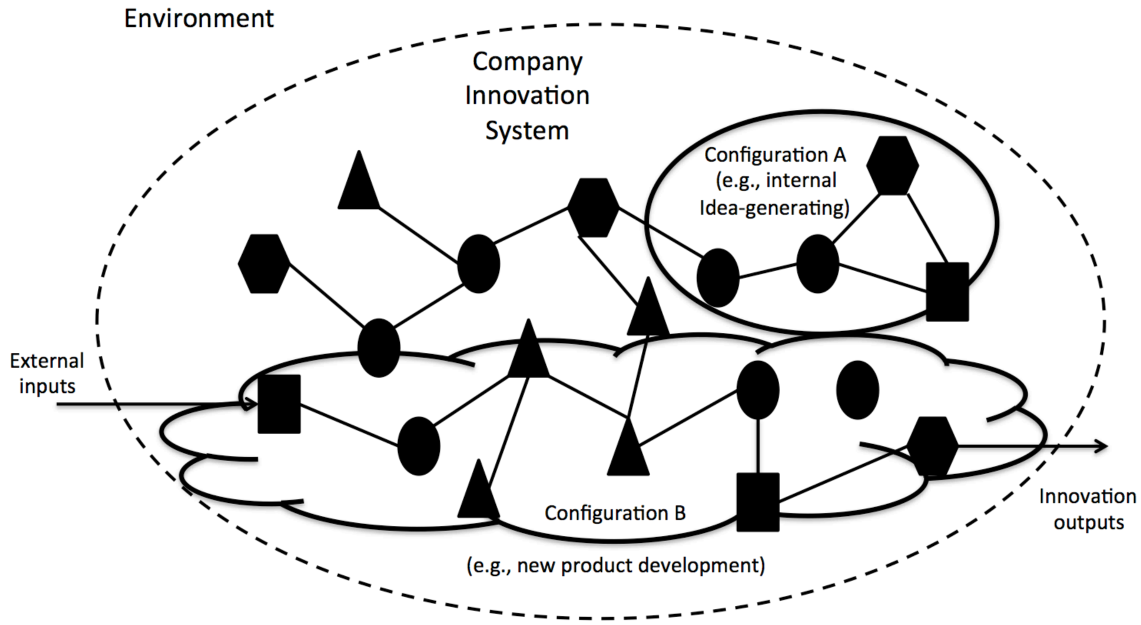


*Figure 1: Company Innovation System*

We know from innovation process literature that process structures can range from linear and simple (in a limited interpretation of Stage-Gate), to nonlinear and involving complex coordination mechanisms. Looked at in this way, an innovation process becomes a specific configuration mode of components of the innovation system. The company innovation system approach does therefore not replace or compete with the process approach, but complements and generalizes it. According to Ortt & Van der Duin (2008), a company may choose a different configuration of its innovation process, contingent upon the type of innovation, the type of business, the resources available, or the external environment. Different configurations may exist side by side. Some configurations are successful and will be more permanently linked, meaning that the company will use them over and over. Other configurations may be more temporary linked. This also points to the coordination function in a company innovation system. A more permanent configuration, once in place, may require relatively less central coordination. Temporal configurations and reconfigurations will require continuous coordination, either self-organized and centrally facilitated or centrally managed and controlled.

What do such configurations look like? Different concepts have been proposed. Teece (1996) identified different archetypes of system relationship governance based on the institutional characteristics of external linkages, hierarchical decision making, change culture (which he equates with informal structure), scope (multi- or single product), and vertical integration. As archetypes Teece (1996) identified the multiproduct integrated hierarchy, the high flex Silicon Valley type, the virtual corporation and the conglomerate. Each archetype facilitates specific types of innovation and the creation of or access to specific types of capabilities.

Chen et al. (2015) use Rothwell's (1994) five innovation generations as a starting point to identify a number of archetypes of innovation systems. The use of Rothwell's (1994) generations also implies a generic evolution in how companies structure and lead their innovation systems over time. Specifically, Chen et al. (2015) identify:

i. the internal R&D-oriented innovation system, with a dominant technology-push role of internal R&D
ii. the internal and external collaborative innovation system, with interconnected R&D, marketing and manufacturing functions
iii. the highly strategy-oriented innovation system, led from the business strategy by the CEO or Chief Innovation Officer
iv. the ecological innovation system, which departs from the company level and sees the company as an actor in a business ecosystem

Coriat & Weinstein (2002) identify two main questions regarding such configurations. The first is “How can one understand both the diversity of organizational patterns and the existence of dominant modes of organization?” (p.276). This question is related to Van de Ven’s (1986) design principle of requisite variety - different environments require different levels of system complexity - and to the principle of temporal linkage - some organization modes are successful across environments and over time, and will tend to more permanent linking, exploiting existing resources and capabilities. Coriat & Weinstein’s (2002) second question is “How can organizational patterns evolve to give birth to new principles and organizational systems?” (p.277). This question is related to Van de Ven’s (1986) design principle of self-organization (given a new and unknown task, the system will reconfigure to try and solve the task) and also to the principle of temporal linkage (unsuccessful modes or modes that are not continually required will dissolve and be replaced by other modes, exploring new routines and building capabilities). Coriat & Weinstein (2002) warn against treating the company as a closed system, explaining that the company - and, consequently, its dynamics - is a part of the wider institutional environment. They interpret this institutional environment mainly as the national or sectoral systems of innovation that the company belongs to.

Like any system, a company innovation system has an environment, i.e., that which is outside the company, and it interacts with this environment, exchanging inputs and outputs with it. Like the system’s own resources, such inputs and outputs can be physical, financial, intellectual, relational and human. External innovation systems such as platforms, business ecosystems, technology systems, regional, sectoral and national innovation systems and the public sector are important parts of that environment (cf., Sigurdson & Cheng, 2001). Company innovation systems can be more or less open to that environment (Chesbrough, 2003).

**Attributes**

Finally, we can identify system attributes. The list of possible attributes is long and involves every characteristic that potentially influences system behavior and performance. Sigurdson & Cheng (2001) provide ten elements of corporate innovation systems, of which seven can be characterized as attributes: organizational ability and strategy, arrangements for advanced learning, human resource management, competitive strategy, management of intellectual property rights, networking ability and strategy, and financing strategy. O’Connor (2008) proposes requisite skills and talent development, governance and decision-making mechanisms, performance metrics, and culture and leadership context. Steiber & Alänge (2013), in an in-depth case analysis of Google’s innovation system, identify seven system characteristics that are core to continuous innovation: innovation-oriented culture, selection of individuals, leaders and facilitators, organizational infrastructure, performance and incentives, organizational learning, and external interaction. Apart from the external interaction, which is an aspect of system relationships, all are system attributes.

Many of these attributes have in common that they are difficult to measure, something that Steiber & Alänge (2013) for example do by interviews with company employees. Based on the attributes proposed and taking measurability into account, we identify five attributes of company innovation systems:

i. innovation as an exception versus innovation as day-to-day business; this is related to innovation culture
ii. non-systematic versus systematic innovation; this is related to organizational infrastructure for innovation
iii. dramatic turnarounds versus adaptable organization; this is related to innovation culture
iv. large breakthrough projects versus (massive) experimentation; this is related to mechanisms of learning (see, e.g., Thomke, 2001; Taylor & Wagner, 2014)
v. the ability to combine creativity and efficiency; this is related exploration-exploitation, to mechanisms of learning and to organizational infrastructure (see, e.g., Reeves et al., 2013)

**METHOD**

We explore the concept of company innovation system by analyzing case examples of ABB Group, Adobe Systems, Amazon.com, eBay, Hitachi, HTC, Lockheed Martin, Philips, Qualcomm, Salesforce.com and Southwest Airlines. To construct the case examples, we used a case protocol that contains relevant aspects of the company innovation system (see table 1). For the analyses, only publicly available data was used, such as the company website and its annual reports, press releases, media coverage, academic articles and other available case studies. This data puts limits on what we can measure; it is near impossible, for example, to measure innovative culture, leadership or human resource management practices.

*Table 1: Case protocol*

| Question | Aspect of CIS |
|---|---|
| Analyze the company according to the characteristics of “modern innovation management” (use a semantic differential scale): | |
| i. Innovation as exception versus Innovation as day-to-day business | Attributes |
| ii. Nonsystematic versus Systematic | Attributes |
| iii. Dramatic turnarounds versus Adaptable organization | Attributes |
| iv. Large breakthrough projects versus Massive experimentation | Attributes |
| v. Closed, within company versus open, in networks | Relationships |
| vi. Innovation as the business of R&D versus Innovation as everybody’s business | Components |
| Did this innovation appear from a technology-push model, from a market pull model, from an interactive model, or from open innovation? | Relationships |

| Describe the *internal* innovation system of the company: | |
|---|---|
| i. Is innovation represented at the executive level? Does the company have a 'chief innovation officer' or 'chief technology officer'? | Components |
| ii. What are the main components (actors, departments, units, incubators, central or de-central R&D departments or laboratories, etc.) involved in innovation? | Components |
| iii. How do these components work together to create innovation? | Relationships |
| iv. Draw a picture of the components of the innovation system and how they work together | Components<br>Relationships |
| Analyze which mechanisms the company uses to combine creativity with efficiency | Attributes |

Based on this case protocol junior researchers, i.e., senior undergraduate students, analyzed 152 cases of large companies. We checked these initial cases for quality and completeness, for internal consistency and for mutual consistency. We selected the 11 best and most complete cases and did a cross-case analysis of those, making additional interpretations where necessary.

**RESULTS**

We present the results of the case analyses in the tables 2, 3, and 4 below.

*Table 2: Cross-case analysis of coordination and system components*

| **Company** | **Overall character** | **Principle of coordination** | **Components: actors** | **Components: C-level** | **Components: R&D vs everybody** |
|---|---|---|---|---|---|
| ABB Group | Complex, linear, technology-driven | Key individuals connecting R&D with business; collaborations facilitated through software systems | R&D global and division level, ventures department | Chief Technology Officer overseeing all aspects | R&D is core |
| Adobe Systems | Individual-based, decentralized, rule-based | Informal, complex, highly de-centralized, but strictly rule-based | All employees (individual) | Chief Technology Officer and a Chief innovation and creativity officer | Everybody's business |
| Amazon.com | Many small teams, informal, complex, decentralized | Informal, complex, highly de-centralized | Many small, independent teams; Lab 126 | Chief Technology Officer overseeing key projects | Everybody's business |

| **Company** | **Overall character** | **Principle of coordination** | **Components: actors** | **Components: C-level** | **Components: R&D vs everybody** |
|---|---|---|---|---|---|
| eBay | Multi-incubation, decentralized, technology driven | Self-organizing under strong C-level leadership | Incubation programs worldwide; hackatons; Innovation demo expo; R&D department | Chief Technology Officer leading technology vision and strategy | Everybody's business, but technology driven |
| Hitachi | Complex and holistic; project-based | Project-based and rule-based | Sister companies; de-central business development; technology strategy office; centers for social and for technological innovation; center for exploratory research | Chief Technology Officer and many decentral business development executives | Moderate, leaning toward everybody's business |
| HTC | Technology-driven and open | Self-organizing under strong C-level leadership | Developers (internal and external); HTC Design studio; Incubators; Business partners | No, but innovation is integral part of C-level responsibilities | Internal R&D and external partners |
| Lockheed Martin | Multi-modal | Depends on the type of innovation | Specialized R&D departments; Skunk works; de-centralized business; 'lighthouse' for open innovation | No; C-level officers of the business are responsible | Specific departments for specific breakthroughs combined with everybody's business for improvements |

| Company | Overall character | Principle of coordination | Components: actors | Components: C-level | Components: R&D vs everybody |
|---|---|---|---|---|---|
| Philips | Interactive, systematic, complex | Collaboration between various departments | Decentral country-based and business-based; central group innovation department; Incubators; Design center | Chief Technology Officer | Decentral: not everybody, but also not a single department: multiple departments are leading |
| Qualcomm | Linear, technology push | R&D driven, linear process | R&D facilities around the world: labs and incubators; decentralized units, each with own unique knowledge | Chief Innovation Officer | Mainly R&D |
| Salesforce.com | Simple, customer data-driven | Initiation de-central; implementation centralized; more impactful innovation coordinated by executive level | Individual employees; tools and labs | No, but innovation is integral part of C-level responsibilities | Mostly business development, driven by the business |
| Southwest Airlines | Lean and flexible; decentralized yet efficiently coordinated | Strategy and innovation department initiates and coordinates | Multiple functional business departments | Chief Technology Officer and Chief Strategy & Innovation Officer | No R&D department: multiple departments involved |

We find that using a company innovation system approach we can map the main components of companies' innovation systems, such as executive level representation, central innovation departments, de-central departments in regions or attached to the business units and business teams. Companies differ in their centralization of innovation efforts, in the emphasis they put on innovation by departments (mostly the older, industrial ones) versus innovation by individuals and small teams (mostly the younger, IT-based ones), and in seeing innovation as the business of R&D versus the business of everybody in the company. Executive representation is remarkably uniform, with either specific C-level innovation or technology officers or clear innovation responsibilities with general C-level officers.

Large differences can be seen in coordination mode: from top-down via R&D driven to self-organizing. We added an overall characterization of the company innovation system, which also shows considerable differences and which does not immediately show any archetypes as proposed by Teece (1996) or Chen et al. (2015).

*Table 3: Cross-case analysis of system relationships*

| **Company** | **Relations: innovation generation** | **Relations: closed versus open** | **Relations: single or multiple configurations** | **Relations: simple, linear versus complex** | **Relations: fixed versus reconfigurable** |
|---|---|---|---|---|---|
| ABB Group | Interactive model, leaning toward technology-driven | Mostly closed; working with universities on R&D | Single: combining technology with customer input | Complex with interdisciplinary cooperation | Reconfigurable in idea and testing stage; fixed in development stage |
| Adobe Systems | Market pull | Open or closed when and where necessary | Many parallel processes | Moderate complexity (small teams) | Extremely configurable |
| Amazon.com | Interactive | Mostly closed | Many teams ('pizza teams') working parallel on different projects | Moderate complexity (small teams) | Extremely configurable |
| eBay | Open innovation, but technology is core driver | Leaning toward open | Multiple processes (internal and external paths) | Simple process (technology-driven), but with complex coordination | Reconfigurable within limits |
| Hitachi | Between interactive and technology push | Moderate: not open but working with many alliances and partners | Multiple processes (project-based) | Complex, continuous collaboration for holistic solutions (project-based) | Project-based reconfigurable |
| HTC | Open innovation, but technology is core driver | Open, with partners and external developers (open source) | Single | Linear process, but complex coordination | Depending on the project different actors involved |
| Lockheed Martin | Contextual: technology push, interactive and semi-open all exist | Multiple: closed and semi-open | Multiple processes: technology-driven and combining technology with customer input | Linear for breakthrough projects; complex for other projects | N/A |

| **Company** | **Relations: innovation generation** | **Relations: closed versus open** | **Relations: single or multiple configurations** | **Relations: simple, linear versus complex** | **Relations: fixed versus reconfigurable** |
|---|---|---|---|---|---|
| Philips | Interactive | Moderate not open but working with many alliances and partners | Single, combining technology with customer input | Very complex, many departments and units involved | Reconfigurable within limits: depending on the project different actors involved |
| Qualcomm | Technology-push | Mostly closed, but cooperation with universities in early stages | Single | Simple linear | Fixed |
| Salesforce.com | Between demand-pull and interactive | N/A | Multiple: data analytics-driven and customer insight-driven | Cross-functional teams | Fixed |
| Southwest Airlines | Demand-pull | Moderate: open to input from networks, but innovation internal | Dual: initiation and implementation | Dual: initiation is more complex, implementation is more linear | Reconfigurable for implementation ('relaxed structure') |

We find that we can indicate the relationships between the components of the company innovation systems. This is no surprise with the innovation generations concept (Rothwell, 1994; Chen et. al, 2015), although here we see companies that are in between generations and companies that use multiple generations in parallel.

Internal and external innovation systems are intertwined (Sigurdson & Cheng, 2001; Coriat & Weinstein, 2002; Chen et al., 2015), hence we should be careful to include the effects of external innovation systems on the company innovation system. The open versus closed aspect captures part of these relationships, and here, too, we see differences that transcend a simple one-dimensional scale: some companies use multiple modes, being open for some innovation problems while closed for others.

We find that many companies use multiple configurations, either multiple processes or multiple networks or subsystems, within their company innovation systems. This shows the value of company innovation system concept versus the innovation process approach. Processes exist, but they are a specific type of configuration of the system, even if some companies limit their system to a single configuration.

Single or multiple configurations does not equal simple, linear versus complex configurations. There are companies with single, yet complex configurations and companies with multiple yet simple configurations.

Another insight from the case examples is emphasis on reconfigurations and 'new combinations' (cf., Edquist, 1997). We can detect where new configurations come from, e.g., from individuals, from teams, from central offices, or from projects. In the innovation systems approach, the mechanism of how new combinations happen is built into the analysis rather than externally assumed. Admittedly, a lot of conceptual and empirical work needs to be done to clearly demonstrate this principle.

*Table 4: Cross-case analysis of system attributes*

| **Company** | **Attributes: combining creativity and efficiency** | **Attributes: exception versus day-to-day** | **Attributes: systematic versus non-systematic** | **Attributes: turnarounds versus adaptable** | **Attributes: breakthroughs versus experimentation** |
|---|---|---|---|---|---|
| ABB Group | Multiple approaches: separation; scientist initiative with business selection criteria; local business to use global resources | Day-to-day | Systematic | N/A | N/A |
| Adobe Systems | Self-organization and self-selection | Day-to-day | Moderately systematic | Adaptable | Massive experimentation |
| Amazon.com | Multiple approaches: massive experimentation combined with quick learning from market feedback; separation (Lab 126) | Day-to-day | Moderately systematic | Adaptable | Massive experimentation |
| eBay | Internal and external ecosystem (eBay innovation demo expo; incubators and hackatons) | Day-to-day | Systematic | Adaptable | Regular major adaptations (e.g., Paypal, Skype integration) |
| Hitachi | Self-organization delivers ideas and experiments; central management sets boundaries | Day-to-day | Systematic | N/A | Experimentation |

| Company | Attributes: combining creativity and efficiency | Attributes: exception versus day-to-day | Attributes: systematic versus non-systematic | Attributes: turnarounds versus adaptable | Attributes: breakthroughs versus experimentation |
|---|---|---|---|---|---|
| HTC | External ecosystem | Day-to-day | Systematic | Adaptable | Experimentation |
| Lockheed Martin | Multiple approaches: separation (Skunk works); within business self-organization and external ecosystem | Day-to-day | Systematic | Both adaptable and turnarounds | Breakthroughs |
| Philips | Multiple approaches: separation (Philips Research); self-organization through complex cooperation; ecosystem with partners | Day-to-day | Systematic | Adaptable | N/A |
| Qualcomm | R&D generates idea in cooperation with universities; then linear process to select and implement | Day-to-day | Systematic | Continuous adaptation | N/A |
| Salesforce.com | Culture supports idea generation; very selective in implementation | Day-to-day | Systematic | Moderate, leaning toward adaptable | Regular well-functioning changes; no radical changes |
| Southwest Airlines | Separation and self-organization | Moderate, not day-to-day, but also not exceptional | Systematic | Moderate: standardized processes not adaptable, but regular updates | Toward experimentation and fast learning; no radical changes |

We find that we can identify company innovation system attributes. The combination of creativity and efficiency (exploration-exploitation) shows different approaches taken by companies: from having separate units for creativity/idea generation and efficiency/implementation modes; via self-organization, where the individuals, teams or departments themselves decide which mode to focus on and/or when to make the switch between the modes; to the use of external ecosystems, where external networks are configured for generating ideas or for efficient collaboration (Reeves et al, 2013). The attributes of day-to-day innovation versus innovation as exception, systematic versus nonsystematic innovation, and adaptable organization versus large turnarounds do not show a lot of variance. This may be because our selection is biased to innovative and larger companies, or because these attributes are not sufficiently differentiating. Further conceptual development and empirical testing seems necessary here. The last attribute, breakthroughs versus experimentation – a learning mechanism (e.g., Thomke, 2001) – again shows differences from one end of the scale to the other.

## CONCLUSION

### Objective and findings

The objective of this paper was to conceptualize the company as an innovation system and to explore this concept using descriptive case examples. The company innovation system approach builds on existing theoretical foundations and some relevant building blocks have been proposed in the literature. It provides additional and complementary insights to existing approaches, specifically to the innovation process approach.

We find that using the company innovation system approach, we can map innovation systems at the company level and show the differences between them. We can identify the components, such as R&D departments, labs, venture organizations, teams, employees, C-level offices and facilitating tools. We can identify relationships such as single or multiple configurations, simple or complex configurations, technology-driven, market-driven or interactive configurations, and open or closed configurations. We can identify system characteristics such as creativity versus efficiency emphasis, systematic versus non-systematic approaches, adaptiveness of the system, and large project versus experimentation focus.

### Academic and practical implications

This research has academic and practical implications. Academically, we propose that innovation management can be analyzed using the company innovation system approach. We also propose that certain problems and characteristics, such as cross-functional cooperation, learning and knowledge, the emergence of new combinations, and coordination of the innovation functions, can be better analyzed and deeper understood by using a company innovation system approach than by using an innovation process approach.

Practically, companies need to address problems of innovation system design (who or which part of the company innovation system is responsible for what), innovation system structure (how do the different parts of the company innovation system work together) and innovation system coordination (how to ensure that the company innovation system is productive, fulfills its objectives, and is stable). A well-conceptualized and validated company innovation system approach may provide managers with insights to address those problems. Which brings us to future research.

### Scope for future research

The implications stated above are, at this moment, tentative and preliminary. The current paper provides merely an initial conceptualization and descriptive exploration of the company as an innovation system. Further conceptual work is needed to flesh out the concept and its sub-concepts, to integrate relevant additional concepts (e.g., various attributes), to ensure the ability to test and falsify these concepts, and to clarify the connections with and distinction from related concepts. All the analytical and methodological aspects of innovation systems as identified by Carlsson et al. (2002) should be further addressed and clarified. Specific issues that come to mind are:

i. the system definition/boundary, e.g., a strictly legal definition of the company versus a stakeholder involvement definition, embedding in environment and larger systems (e.g., Sigurdson & Cheng, 2001; O'Connor, 2008)
ii. the role of the system design principles (e.g., Van de Ven, 1986; Morgan 1986; O'Connor, 2008)
iii. the possible configurations of the system, archetypical, permanent, or temporary (e.g., Teece, 1996; Chen et al., 2015)
iv. the governance and institutional characteristics of the system (e.g., Van de Ven, 1986; Teece, 1996; Sigurdson & Cheng, 2001; Steiber & Alänge, 2013)
v. a definition of the elementary units of the system (e.g., Granstrand, 1998)
vi. the role of resources (Granstrand, 1998) and capabilities (Coriat & Weinstein, 2002)
vii. the dynamic and evolutionary aspects of the concept (Carlsson et al., 2002)

Further empirical work is needed to do the actual testing and to demonstrate the usefulness of the approach for analyzing innovation in companies. Such empirical work could start with mapping the innovation systems of companies using the case method, making cross-sectional comparisons between companies, or following the evolution of specific company innovation systems over time. Specifically, due to the continuous feedback in the system produced by its interactions, we should be careful with 'snapshots' (Carlsson et al., 2002). Longitudinal research is therefore strongly preferred.

Upon availability of a sufficient basis of empirical observations, further questions could be empirically tackled, such as the contingency between system structure, governance and the environment, or the relationship between system structure, governance and innovative performance.

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