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## Into the Surge of Network-driven Innovation

### *Extending the Historical Framing of Innovation*

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## Into the Surge of Network-driven Innovation – Extending the historical framing of innovation

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**Abstract:** The ambition of this paper is to provide a better theoretical understanding of innovation by framing it in a long historical, economical, and societal perspective. The research question of the paper is: What characterize the historical surges of innovation? Based on previous works and research this is examined from the 1880's up until today. The contribution of the paper is a societal perspective on innovation, where the difference between industrial society and knowledge society leads into the surge of network-driven innovation. Network-driven innovation is unfolded on top of the known cost-driven, development-driven, and market-driven surges of innovation. Furthermore, the theoretical framing of innovation is supported by qualitative literature analyse of papers from the top 20 Technology & Innovation Management (TIM) journals.

**Keywords:** Innovation; history of innovation types; surges of innovation; network-driven innovation; network-driven organization; innovation management; driver of innovation

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## 1 Previous work on historical framing of innovation

The term “innovation” is used colloquially, and companies’ capability to be innovative is an important key to generate and sustain growth in today’s globalized economy. The phenomenon “innovation” has been studied from a wide range of theoretical perspectives. It seems that a good share have focused primarily on how to put innovation into practice (Vej 2004: 50, 52, Fagerberg et. al. 2005: 1-28, Tidd & Bessant 2009, Rosted 2003) and supplied different levels of analyses from individuals to the level of society.

One of the more thorough studies of the historical development of innovation is conducted by Jon Sundbo in the comprehensive book *Innovation theory – three paradigms* (translation of Danish title) (Sundbo 1995a) and in an important journal article (in English) by Sundbo (1995b). The work is an analysis of various types of innovation emerging during different periods beginning in the late 1880’s (Sundbo 1995a: 56). Three phases of innovation have emerged throughout time (until about 1995) with each phase based on long waves in the world economy (Kondratiev-waves). Kondratiev-waves are characterized by alternating periods of high and slow economic growth (Kondratieff & Stolper 1935), and each wave is a cycle from prosperity over recession and depression to recovery (Kondratieff & Stolper 1935). Each historical Kondratiev-wave is characterized by a particular driver of innovation when considering the level of the concrete innovation process. We supplement Sundbo with the British sociologist Roy Rothwell, who suggests a distinction between five “generations” of innovation processes from the 1950’s to 1994 (Rothwell 1994). Rothwell’s perspective, however, is the characteristics of companies’ internal innovation process and how it develops over time. Based on Sundbo and Rothwell we follow their definition of innovation. Additionally the term “surge” is used instead of “phase” or “generation”, as the last-mentioned often is characterized by a period of time with specific years defining the beginning and end. A surge is not defined as a specific period. Furthermore, as new surges of innovation emerge these add additionally types of innovation to already existing types. Thus, the innovative “tool-box” is merely growing with practices from each surge of innovation.

The first surge of innovation emerged during 1880-1892 (Sundbo 1995a: 56). The establishment of numerous new companies, often founded by single entrepreneurs, characterized this period. The founders were considered to be innovative and ahead of their time, because they industrialized in the sense that they created cost effective production machinery for non-established markets (Sundbo 1995a: 56). The companies were founded on the basis of organizational and economic perspectives, which primarily resulted in new products and establishments of new markets (Sundbo 1995a: 66, Bruland & Mowery 2005: 351-352). In the first surge the term innovation is, according to Sundbo (following a Schumpeterian perspective (Schumpeter 1934, 1939)), based on individual actions carried out by the entrepreneurs (Bruland & Mowery 2005: 355-356). Hence, we term management of the newly established companies of this surge *entrepreneur*. The term entrepreneur develops through the four surges of innovation. The type of innovation related to the first surge is termed cost-driven innovation (Rosenstand 2010, Østergaard 2009: 74).

The second surge of innovation is set from the 1930’s to 1960’s, and is characterized by rapid technical developments within large-scale industry (Sundbo 1995a: 70, Bruland & Mowery 2005: 367). Rothwell supports this as he argues that during this period (1950’s-1960’s) innovation processes are perceived as sequential and characterized by a ‘technology push’ through post-war growth (Rothwell 1994: 7, Bruland & Mowery 2009:

362). As a result of increasing established markets in the Western World, development of new products was no longer as easy to approach as during the first surge. Therefore, companies were forced to be innovative in other ways, which increased focus on technical product development (Sundbo 1995a: 71). This led the companies to implement innovation processes within R&D-departments (Bruland & Mowery 2005: 364). Thus, the second surge is characterized by encapsulated and clearly structural organizational separated innovative processes, usually conducted by esteemed engineers. As such, the innovation concept is moving from an individual endeavour to a social discipline requiring interaction of multiple employees.. Due to the focus on implementation of technical innovation, the previous way of managing companies, through intuition and the personal drive of the entrepreneurs, is gradually replaced by a more systematic and organized form of management (Sundbo 1995a: 70, Bruland & Mowery 2005: 362). Most entrepreneurs were not fit for this management type. As part of the intensive focus on technical R&D top-managers were often engineers or a person with another technical expertise.

Sundbo sets the third surge of innovation from 1980-1999. Since the 1980's, many Western markets have been saturated, which is why the growth-potential for companies lies in utilizing marginal possibilities while highly technical development in itself is no longer enough (Sundbo 1995a: 200). Previously markets were more or less controlled by companies, but since markets have become saturated, companies are increasingly forced to act according to what the markets and consumers desire. Therefore, companies change strategy and shift from a technical driven focus towards a focus on the markets' cultural and social norms (Sundbo 1995a: 107). Sundbo terms this *strategic innovation* (Sundbo 1995a: 96, 117). Thus, the third surge is characterized by companies trying to adapt their products and services to the development of markets and behavior of consumers (Sundbo 1995a: 167). Rothwell agrees to this, as the surge is driven by market needs ('marked pull') in times of more maturity and productivity of businesses. However, his second surge runs from mid 1960's to early 1970's. Furthermore, Rothwell argues that because of the oil-crisis, the third surge emerged in early 1970's to mid 1980's. The third surge 'coupled' the drivers (technology and market) of two previous surges and was more iterative and refined in order to compete in saturated markets, also termed the 'coupling'-model. Sundbo underpins this as well, but by comparison Sundbo consider Rothwell's third and fourth surge as the third surge (Sundbo 1995a: 200). Rothwell argued that a later fourth surge (early 1980's – early 1990's) further integrated and focused on the process of innovation in times of recovering from the crisis. Finally, Rothwell argued that the fifth surge (early 1990's) was concerned with time-reduction, flexibility, integration, competences and technology, essentially optimizing all aspects. In this paper the defined period for the third surge of innovation by Sundbo is followed.

During the third surge of innovation companies try to adapt products and services to markets, consequently, companies use many resources on market studies prior to product launches (Sundbo 1995a: 106). Employees – and not only engineers – are now considered an important resource for organizational development in order to sustain an innovative company (Sundbo 1995a: 104, 105, 107). Thus, during the third surge, the entire organizational culture and all employees become an important resource for innovation. The shift from focusing on a single discipline (engineering) to a focus on multiple disciplines, reflects how companies are managed. Top-manager positions are no longer held primarily by engineers. In fact, more often than not, the top-manager is superseded by a new type of manager, with a background in e.g. economics or social sciences

(Sundbo 1995a: 104). As the focus shifts to a market-aimed strategy, top-management will henceforth be termed *market analyzer* (Østergaard 2009: 73, 76).

In 1980's, a new trend within businesses slowly emerged. Companies began to create networks of strategic partnerships across multiple companies, aiming at generating more diverse processes of innovation by involving cross-disciplinary businesses. While startups of the first and second surge of innovation were founded by individual entrepreneurs and innovative departments respectively, startups of the third surge were primarily innovative in the way that they contracted with other startups – they primarily focused on external networks. As such, the process of innovation is a social process involving multiple external companies interacting across multiple external networks. In this paper, the type of innovation related to the third surge of innovation is termed *market-driven innovation* due to the companies' market-aimed strategy (Rosenstand 2010, Østergaard 2009: 75).

The framing of the three surges of innovation is illustrated in Figure 1 (\*stars marking this paper's contribution):

<b>Surge of innovation</b>	<b>First:</b> Cost-driven*	<b>Second:</b> Development-driven*	<b>Third:</b> Market-driven*
<b>Year</b>	1880 - 1892	1930 - 1960	1980 - 1999*
<b>Basis of innovation</b>	Cognitive skills*	Technology	Sociology
<b>Driver of innovation</b>	Entrepreneurship	Development of technology	Determined by the markets
<b>Innovation management</b>	Entrepreneur	Engineer	Market analyzer*
<b>Effect</b>	Societal welfare*		

**Figure 1** Illustration of the three surges of innovation and the underlying characteristics of each surge. The figure is based on a similar figure in (Østergaard 2009: 76, Østergaard, Rosenstand, Gertsen 2011: 27 and Sundbo 1995a: 201).

Based on the previous research of the historical development of innovation, we expand Sundbo's original theory of three surges of innovation (Sundbo 1995a) by suggesting four surges of innovation. Additionally, Rothwell's first 4 surges of innovation are concerned with what this paper (later) defines as industrial society (until 1990), which is similar to Sundbo's perspective. Furthermore, Rothwell's focus is on company-level 'innovation processes', which is somewhat more intra-company than the perspective of this paper. According to Rothwell, nevertheless, the nature of the fifth surge of innovation is characterized by a substantial increase in complexity with regard to iteration, networking and dynamics – all of which generally match the characteristics of the fourth surge as will be argued, when viewed in a wider perspective. Thus, the paper

includes recent developments of modern society (developments that have accelerated after Sundbo's publications in 1995, 1995a and 2001).

## **2 Portraying the fourth surge of innovation**

As accounted for, the emergence of each of the surges of innovation is based on general global societal change and market demands. In order to better understand the foundations of the emergence of the surges, it is necessary to dig deeper into societal characteristics of each surge.

We wish to widen the perspective on innovation from a business perspective to a societal perspective, where the effect of innovation is societal welfare. The societal perspective results in a framing of the surges according to different types of societies: Hunter, agriculture, industrial, and knowledge. Innovation understood as combination, prioritizing, and selection of perspectives (Rosenstand 2011) has probably existed since the beginning of verbal communication, however as argued above innovation according to specific types of innovation management is first identified around 1880. It can be discussed when to date the shifts between the surges, however as argued below the shifts are clear, so we have chosen the end of the 20<sup>th</sup> century, as the end of the industrial society. A beginning and an end of a society type does not mean that the old type disappear, it means that a new type of society is the primary driver slowly displacing previous drivers.

The shift to a societal perspective is partly based on the movement from industrial to knowledge society, which generates value through production of knowledge. According to Qvortrup (2004: 227), both input and output of a company is knowledge. Examples of businesses in its "purest" form within knowledge society are consulting, telecommunication, and search engines. In short, the knowledge society is characterized by the use of modern technologies, such as personal devices (mobile phones, tablets, computers etc.), the Internet, and wireless communication; all of which enable interconnectedness. The technology makes it possible to be in communicative contact increasingly independent of time and space, as asynchronous and synchronous communication technologies continue to develop at an ever-accelerating pace. The knowledge society makes the world communicatively interconnected. From a historical point of view, the development of communication technologies in recent decades establish our position as currently being in the early phase of the knowledge society. The knowledge society does not supersede the industrial society. Similarly, the industrial society did not supersede the agricultural society completely, although new forms of societies gradually do supersede older societies over time. Viewed from a practical perspective, the different types of societies are overlapping in time and are interconnected. For instance, today we have knowledge intensive and industrialised agriculture, which is an example of how new types of societies bring new functions to older societies in an interdependent relationship.

The knowledge society opens up new possibilities in relation to innovation and the processes of innovation, not only because of the new ways of communicating and reaching out to stakeholders, but also because of the technologies' impact on our social behaviour. Based on the changes in society it can be argued that the societal perspective

opens up a new surge of innovation, whereas the first three surges of innovation derive from industrial society.

#### *Innovation in the fourth surge*

Qvortrup (1998) argues that society has become *hyper-complex*. In essence every individual must relate to an increasing excess of information that must be reduced from different perspectives in order to understand and navigate in society. There is an inherent uncertainty in selecting one point of view: There might be a smarter point of view - perhaps not now but maybe tomorrow. Therefore, the truth is inherent in the eyes of the beholder (Rosenstand 2011). From an organizational perspective, this means that (people in) companies must be able to switch constantly between multiple points of views for many purposes and ideas for innovation purposes. Examples of points of views include, but are not limited to, an ecological, economic, environmental, political or ethical point of view (Qvortrup 2002: 262).

Companies must relate to the hyper-complex society, including the users, consumers, other external stakeholders, and of course internal actors. Furthermore, this must be done from different points of view, in order to continuously match the complexity and uncertainty of society (Powell et al. 1996). Due to the need for constantly changing points of view, companies must involve multiple numbers of people with different types of expertise in order to uphold innovative preparedness. As expertise generally is characterized by being linked to a specific point of view, it is usually not possible for a single person to change frictionless between different points of view or to uphold different points of view at the same time (Rosenstand 2008: 21). Therefore, companies acting in the hyper-complex society must uphold a variety of innovative processes consisting of multiple experts. The uncertain nature of the global market makes it unpredictable to know which type of expertise and inherent points of view tomorrow calls for. Obviously, key fields of expertise in a company can be predicted, but it would be an expensive strategy to employ professionals within all the potentially relevant types of expertise. Often it is possible to hire a professional expert, but the company can only be sure of the quality of the professional expert, if the professional expert is known in advance. However, often companies does not beforehand know which type of expertise they need in order to be innovative; so they have to uphold a social network of potentially relevant experts and organizations, that are motivated to contribute to working innovatively together with other experts. This is why innovative networks must be mutually beneficial.

As part of building and upholding a social network of potentially relevant experts, since the 1990's there have been a tendency that users have become an important part of innovation processes. Additionally, this reflects in market demands and consumer behavior, as the consumers demand unique and highly customizable services letting the individual customer stand out from the crowd. The need for individualization has increased since 1995 (Mogensen 2006: 27). The need for individualization along with development of digital communication technology has given rise to possibilities of mass customization, as when a consumer design a T-shirts, or configure and order a personal computer on the Internet, before it is processed, assembled and shipped. In short, the principles of mass customization (Pine 1999) serve as examples of user-influenced production, characterized by the way the consumers are involved in the process of configuring services. However, it is not merely a matter of consumers defining their

needs. It is also a matter of consumers supplying a great deal of the content for services generating substantial value and eventually provide the basis for co-created new business models to occur – e.g. solutions such as Wikipedia, Skype, Facebook, Twitter, YouTube, Flickr, Google, and eBay. These examples, along with concepts such as lead-user innovation (von Hippel 2005), crowd-sourcing, direct involvement of users in companies' product development, fall under the broad concept of user-driven innovation, which constitutes the initial foundation for emergence of the fourth surge of innovation. Thus, in this type of user-driven innovation, the knowledge of the users, consumers, and customers is a prerequisite, and therefore a distinctive feature of the fourth surge. Companies pursuing the principles of the fourth surge therefore broaden the framework for the involved individuals in the process of innovation to increasingly include many external stakeholders, including users/consumers.

In order for companies to uphold an innovative preparedness and navigate in the hyper-complex global society, they must be based on an open culture including users and external expertise. Thus, it becomes more difficult to uphold secret innovation processes, and at the same time be a part of a mutually beneficial network – an open culture seems more effective. This is reflected in the widespread academic concept of *open innovation* (Chesbrough 2003, 2006), which mostly takes on the corporate perspective in suggesting increasing inflow and outflow of knowledge to accelerate internal innovation, and expand the markets for external use of innovation generated by the company. However, open innovation is not the innovative driver for the fourth surge – the network is; which is why we term this type of innovation *network-driven innovation*. The importance of network in innovation is also supported by a recent investigation of 400 innovators (including a 100 inventors of revolutionary products/services) revealing 'networking' as one amongst four key-skills essential to being an innovator (Dyer, Gregersen, Christensen 2011)

#### *Towards a network-driven organization*

In order to fully support network-driven innovation companies must be organized as network-driven organizations..

There are still relatively few stories of mature companies engaging in successful network-driven innovation. The reason may be the potential benefits of networking should be related to the potential costs and setbacks of engaging in networks (Goduscheit 2009). Evidence suggests that companies working in front-end of innovation, and companies searching for more radical types of innovation, tend to apply “peripheral vision” and look beyond their current environment for linkages to widen their network (Gertsen et al 2007, Julian et al 2007, Bessant 2008, Aagaard et al 2011).

In sketching the network-driven organization, we seek inspiration in theories mainly based on studies of new innovative entrepreneurial companies. The term “network-driven organization” is inspired by Saras Sarasvathy (Sarasvathy 2001). Studies of new entrepreneurial companies show that more recent innovative entrepreneurial companies are founded on an open culture, open organizational structure, and open networks, which gives them advantages over mature companies (Sarasvathy 2001: 2-3). In general, innovative entrepreneurial companies organize as network-driven organizations consisting of dynamic working groups, involving multiple types of internal and external expertise. As the challenges and tasks of the company change, new constellations of internal and external types of expertise in networking groups will be created to uphold the innovative preparedness (Qvortrup 2002: 251). Instead of hiring new people, as it often



occurs in mature companies, innovative entrepreneurial companies focus on pulling in people from networks (Sarasvathy 2001: 3). This saves a lot of time and makes the culture much more dynamic and responsive to the fast changing markets. As innovative entrepreneurial companies are founded as network-driven organizations they can be open to a wide variety of innovation processes: Whether it is cost-driven, development driven, market-driven, or user-driven.

The fourth surge of innovation differs from previous surges, because of the companies' focus on actively using networks and its foundation of network-driven organizations. During the fourth surge, the innovative entrepreneurial companies constantly involve new resources in the network, where network in this context includes both internal and external resources.. Innovative entrepreneurial companies attempt to optimize the relationship between network resources and market opportunities. Unlike the situation of companies during the second and third surge, the nature of the hyper-complex society often makes it impossible for companies to plan from which perspective new innovative processes will occur. Instead it is possible to organize companies in a way that increases the possibilities for innovative processes to occur. In other words, the innovative entrepreneurial companies of the fourth surge draw on the different types of innovation from the first, second and third surge...

Modern innovative entrepreneurial companies tend to focus less on preceding market studies and analysis, they are proactive and get straight to action. A recent trend in Entrepreneurship literature is "Lean Start-up" (e.g., Ries 2011). This approach relates to the innovative entrepreneurial companies' focus on not letting predefined goals and aims control them, as larger and mature companies tend to do. On the contrary, as a result of the dynamic constellation of their network-driven culture, modern innovative entrepreneurial companies constantly seek new goals (Østergaard 2009: 98). This agile approach allows companies to shift between different points of view and thereby never lock themselves onto a predefined goal. Instead, it allows new goals to surface as a result of the constant renewal of resources. The ability to generate new goals constantly is paramount when navigating the hyper-complex global society (Qvortrup 2002). Furthermore this enables the innovative entrepreneurial companies to create new business opportunities. This is quite contrary to mature companies using a lot of resources on preceding market studies to predict future business opportunities. Innovative entrepreneurial companies take action based on a minimum of preceding market analysis, which allows new goals to surface as new resources from their networks get involved (Sarasvathy 2001: 4, Sarasvathy & Simon 2000). As a result of this approach, innovative entrepreneurial companies may create new markets.

The approach leaves the innovative entrepreneurial companies in uncertainty. Mature companies might have done everything in their power to avoid uncertainty, thereby using resources on preceding analysis. However, the increasing trend of networking and co-creation is also present in recent research on established innovative companies. Concepts such as "technology brokering" (Hargadon 2003) "prototyping" (Schrage 2000, Kelley 2005, O'Connor et al 2008), "open innovation" (Chesbrough 2003), "agile leadership" (Appelo 2010) and "networking" (Dyer et al 2011) are providing evidence to this movement.

As opposed to the third surge of innovation, innovative entrepreneurial companies of the fourth surge are not entirely determined by markets. Instead they focus on creating new markets. The company culture is network-driven, which makes it possible to see opportunities in markets that mature companies cannot see, with a traditional hierarchical

organization structure, where the operative and structural organization are aligned. Mature companies simply do not access the potentially relevant expertise; the potentially relevant expertise is not a part of the culture.

The ability to quickly use networks to create dynamic, innovative networking groups, and thereby be able to quickly shift between different types of innovation, is what the authors of this paper term *Network-driven innovation*. In short, network-driven innovation is (1) a professional integration of cost-driven, development-driven, market-driven, and user-driven innovation, combined with (2) the ability to switch quickly between the different types of innovation, based on the exchange of resources (Østergaard 2009: 97). Furthermore, the different types of innovation do not exclude one another, and they can be brought into play in different hybrid formats.

### *Managing network-driven innovation*

Due to the structure of network-driven organizations, and their focus on network resources, the earlier type of innovation management proves unsuitable. In the hyper-complex society the amount of information and communicative connections are practically infinite, which results in infinite perspectives or points of views. The manager needs to be able to establish contact and interaction with consumers, stakeholders and other companies without knowing from preceding market analysis what they want. Decision-making is not only based on analytical capabilities to reduce complexity, but also on experimental capabilities, with inherent uncertainty, such as reflected in classic decision-making theory on bounded rationality (Simon 1979).

It is risky for any company to navigate in the hyper-complex society, because one or even a few selected points of view are insufficient, as they will not constitute a long lasting basis for innovation. Companies will have to switch between and uphold multiple points of view simultaneously. Thus, the management must be able to constantly integrate the characteristics and skills of the entrepreneur, the engineer and the market analyzer (cf. Figure 1). Furthermore, innovation management has to integrate networks as part of the organizational structure. Hence, the management of the fourth surge of innovation is termed *Integrator*.

### *Extending the historical framing of innovation*

Based on the arguments and expositions above, the characteristics of the four surges of innovation can be organized and visualized as illustrated in Figure 2 (\*stars mark this paper's contribution).

<b>Surge of innovation</b>	<b>First:</b> Cost-driven*	<b>Second:</b> Development-driven*	<b>Third:</b> Market-driven*	<b>Fourth:</b> Network-driven*
<b>Year</b>	1880 - 1892	1930 - 1960	1980 - 1999	1999 - *
<b>Society</b>	Industrial society*	Industrial society*	Industrial society*	Knowledge society*
<b>Basis of innovation</b>	Cognitive skills*	Technology	Sociology	Hyper-complexity*
<b>Driver of innovation</b>	Entrepreneurship	Development of technology	Determined by market	Global interconnectedness*
<b>Innovation Management</b>	Entrepreneur	Engineer	Market analyzer*	Integrator*
<b>Effect</b>	Societal welfare*			

**Figure 2** Extending the historical framing of innovation (the figure is a further development of the figure of (Østergaard 2009: 76; Østergaard, Rosenstand, Gertsen 2011: 29 and Sundbo 1995a: 201)).

We set the fourth surge to begin in 1999 because of the canonical work of Qvortrup *The Hyper-Complex Society*. To accurately date the beginning of the surges of innovation, may seem both difficult and somewhat forced, as one may argue that the emergence of new surges happen over a period of years. However, the dating of the beginning of each surge, as illustrated in Figure 2, serves to provide a clear framing.

#### *Support from quantitative literature analyses*

In order to support Figure 2, a quantitative literature review was conducted. The method applied for this study followed four quick steps.

The first step was to select a number of journals, which reflect the most important journals within the field (Linton & Thongapanl 2004). Therefore the top 20 Technology & Innovation Management (TIM) journals were selected based on a thorough analysis by Linton & Thongapanl. The journals were:

Name of journal	Name of journal
Journal of Product Innovation Management	Academy of Management Journal
Research Policy	Journal of Marketing
Research Technology Management	California Management Review
Harvard Business Review	Sloan Management Review
Strategic Management Journal	Organization Science
Management Science	Technological Forecasting and Social Change
Administrative Science Quarterly	International Journal of Technology Management
R&D Management	Journal of Marketing Research
IEEE Transactions on Engineering Management	Technovation
Academy of Management Review	Technology Analysis & Strategic Management

**Figure 3** Top journals within the field of Technology & Innovation Management (TIM).

Secondly, a suitable database in which to conduct the search was selected: The Web of Science Social Science Citation Index (SSCI), mimicking the approach of Fagerberg et al. (2005).

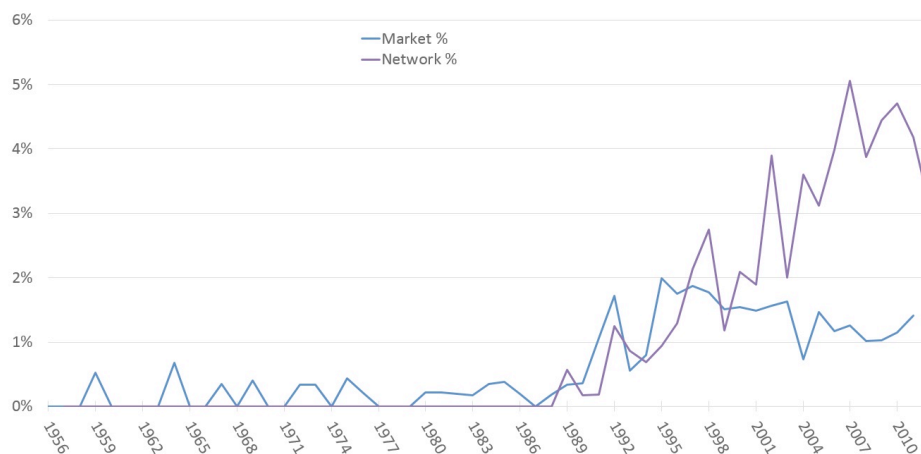
Thirdly, a number of search words were created based on their association with either Market Innovation or Network Innovation. To ensure each word was associated with the correct category, the two most cited articles of each search word were reviewed. This led to the search word Globalization being removed as the two most cited articles related mostly with international policy.

Market innovation	Network innovation
Market-driven Innovation	Network Innovation
Market Innovation	Open Innovation
Market Analysis	Research Network
Internationalization	Supply networks
Industrialization	Co-creation
Market Research	Co-Innovation
Marketing Innovation	Collaborative network
	Sourcing Innovation

**Figure 4** Search words.

Lastly, in order to ensure articles did not occur more than once when aggregating each category, the results were combined within each category and having it removed any duplicates.

Figure 5 clearly shows that network innovation becomes the most prevalent type of innovation in the selected literature around 1998-2000, supporting the fourth surge beginning here. The results are only indicative of a fundamental change in the way innovation is perceived, and more literature could be searched. In general there seems to be a sharp rise in the number of papers published around 1992



**Figure 5** The relative number of published articles of the two given categories compared to the total number of publications in the selected journals.

### 3 Conclusion

Based on the authors' interests in what causes emergence of a new surges of innovation, the paper investigates the main research question: What characterizes the historical surges of innovation? The paper conceptualizes this through theory and history of innovation, and through societal development, from industrial society to the knowledge society, which has affected the global market demands. This has, arguably, caused the emergence of four surges of innovation. Each surge is constituted by different drivers of innovation that require different innovation management skills and different organizational structures.

Given that the paper acknowledges building on the framework proposed by Sundbo (Sundbo 1995a) that covers the first three surges, the main contribution is to suggest the fourth surge of innovation reflecting the complexity and dynamics of the knowledge society

## 4 Future research

Given the ambition of the research question, the proposal of the fourth surge of innovation put forth needs further elaboration and consolidation in existing theory and analysis. Likewise, the proposal needs to be scrutinized by scholars of other disciplines in order to make the generalizations more robust. Finally, a scholarly discussion of specific industry dependent limitations, as well as other limitations to the framework, is considered necessary.

During the initial work, we found an apparent relationship between the identified surges of innovation and the end-point of societal crisis. For the sake of limitation to this paper, we have excluded this idea from the current paper, but will explore it in future research.

## 5 Acknowledgement

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## 6 References

- Aagaard, A. & Gertsen, F., 2011, *Supporting Radical Front End Innovation: Perceived Key Factors of Pharmaceutical Innovation*. Creativity and Innovation Management, 20/4: 330–346
- Appelo, J., *Management 3.0: Leading Agile Developers, Developing Agile Leaders*, Addison-Wesley Professional
- Bessant, J, 2008, *Dealing with discontinuous innovation: the European experience*. Int. J. Technology Management, Vol. 42, Nos. 1/2.
- Brulland, Kristine & Mowery, David C., 2005, *Innovation Through Time in The Oxford Handbook of Innovation*. Fagerberg, Jan, Mowery, David C. & Nelson, Richard R. (ed), Oxford University Press.
- Chesbrough, H, Vanhaverbeke, W & West, J., 2006, *Open Innovation: Researching a New Paradigm*. Oxford University Press.
- Chesbrough, Henry, 2003, *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.
- Covey, Stephen R., 2007, *The 7 Habits of Highly Effective People*. Simon & Schuster Ltd.
- Dyer, Jeff, Gregersen, Hal, Christensen & Clayton M., 2011, *Innovators DNA-Mastering the Five Skills of Disruptive Innovators*, Harvard Business Review Press.
- Fagerberg, Jan, 2005, *Innovation – a guide to the literature in The Oxford Handbook of Innovation*. Fagerberg, Jan, Mowery, David C. & Nelson, Richard R. (ed), Oxford University Press.
- Fagerberg, J., 2005. *Introduction*. In: *The Oxford Handbook of Innovation*. s.l.:Oxford University Press, pp. 1-26.
- Gertsen, F, Sloan, T, Chapman, R, Hansen, P H K, 2007, *A trilogy on discontinuous innovation*. Part I: Search. In: 21st ANZAM 2007 Conference: managing our intellectual and social capital. Canning Bridge, W.A. Promaco Conventions, p. 1-18.

- Goduscheit, R.C., 2009, *Relationships, networks and innovation – squaring the circle?*. Int. J. Learning and Intellectual Capital, Vol. 6, No. 3, pp.257–271.
- Hargadon, Andrew, 2003, *How Breakthroughs Happen*, HBS Press.
- Herbert A., Simon, 1979, *Rational Decision Making in Business Organizations*. The American Economic Review, Vol. 69/4.
- Jantzen, Christian & Vetner, Mikael, 2006, *Experiences: A Scientific Glossary in Experiences, connections and transformations*. (Danish translation). Christian Jantzen & Jens F. Jensen (editor), Aalborg University Press.
- Johnson, Steven, 2010, *Where good ideas come from*. Riverhead Books, NY.
- Julian B, Bessant J, Delbridge R, 2007, *Finding, Forming, and Performing: Creating Networks for Discontinuous Innovation*. California Management Review Vol. 49, no. 3 spring.
- Kelley, Tom, 2005, *The Ten Faces of Innovation*, Doubleday.
- Kondratieff, N. D. & Stolper, W. F., 1935, *The Long Waves in Economic Life* in The Review of Economics and Statistics. Vol. 17, No. 6 (Nov., 1935), pp. 105-115.
- Linton, J. D. & Thongpapanl, N., 2004. *PERSPECTIVE: Ranking the Technology Innovation Management Journals*. The Journal of Production Innovation Management, pp. 123-139.
- Mogensen, Klaus Æ. (ed), 2006, *Creative Man - The future consumer, employee and citizen*. The Copenhagen Institute for Future Studies.
- O'Connor et al, 2008, *Grabbing Lightning*, Jossey-Bass.
- Pine, B. J., 1999, *Mass Customization: The New Frontier in Business Competition*, HBS Press
- Powell, W.W., Koput, K.W. & Smith-Doerr, L., 1996, *Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology*. Administrative Science Quarterly, Vol. 41, No. 1, pp.116–145.
- Qvortrup, Lars, 1998, *The Hypercomplex Society*, Gyldendal.
- Qvortrup, Lars, 2002, *The Hypercomplex Society*. 2. edition, Gyldendal, NBC PrePress, Nordisk Bogproduktion A/S.
- Qvortrup, Lars, 2005, *Knowledge, Education and Learning – Hypercomplexity and knowledge*. (Danish translation).1. edition, 4. print, Gyldendal, Nørhaven Book.
- Ries, Eric, 2011, *The Lean Startup*, Penguin.
- Rosenstand, Claus A. Foss, 2008, *Innovation as a situation – Interdisciplinarity as pedagogical prerequisite for Innovation in Interdisciplinarity & Entrepreneurship – An anthology about interdisciplinarity in entrepreneurship schooling*. (Danish translation). Jacob Stolt & Christian Vintergaard (ed.), 1. edition, IDEA København og Øresund Entrepreneurship Academy.
- Rosenstand, Claus, 2010, *The Innovation Compass in U-Drive:IT – User-driven Innovation Transfer From The IT Sector To Other Sectors*. Aalborg University Press.
- Rosenstand, Claus A. Foss, 2011, *Case-based learning in Encyclopedia of the Sciences of Learning*. Seel, Norbert M. (ed.), Springer Reference.
- Rosted, Jørgen, 2003, *Three types of Innovation*. (Danish translation). Paper written for the Danish Ministry of Commerce.
- Rothweel, Roy, 1994, *Towards the Fifth-generation Innovation Process*. International Marketing Review, Vol. 11 Iss: 1, pp.7 – 31.
- Sarasvathy, Saras & Simon, Herbert, 2000, *Effectuation, near-decomposability, and the creation and growth of entrepreneurial firms*. University of Washington.

- Sarasvathy, Saras, 2001, *What makes entrepreneurs entrepreneurial?*. University of Washington.
- Schrage, Michael, 2000, *Serious Play*, HBS Press
- Schumpeter, J.A., 1934, *The Theory of Economic Development*. Cambridge, Mass.: Harvard University Press.
- Schumpeter, J.A., 1939, *Business Cycles*. New York: McGraw-Hill.
- Sundbo, Jon and Fuglsang, Lars (ed.), 2002, *Innovation as Strategic Reflexivity*. London, (Routledge).
- Sundbo, Jon, 1995a, *Innovation theory – three paradigms*. (Danish translation).1. Edition, 1. Print, Copenhagen: Jurist- og Økonomiforbundets Forlag.
- Sundbo, Jon, 1995b, *Three paradigms in innovation theory*, *Science and Public Policy*, 22(6): 399-410.
- Sundbo, Jon, 2003, *Innovation and strategic reflexivity. An evolutionary approach applied to services*. I L. Shavina (ed.): *Handbook of innovation*, Boston (Pergamon).
- Tidd, Joe & Bessant, John, 2009, *Managing Innovation*. Wiley.
- Vej, Jesper, 2004, *Innovation is what? - Innovation from thought to action*. (Danish translation). 1. Edition, 1. print, Gyldendal Boghandel, Gyldendal, Nordisk Forlag A/S.
- von Hippel, Eric, 2005, *Democratizing Innovation*. MIT Press.
- Østergaard, Claus, 2009, *Network-driven branding – The relationship between corporate branding and innovative startup companies*. (Danish translation). Aalborg University.
- Østergaard, Claus, Rosenstand, Claus & Geertsen, Frank 2012, *Five Waves of Innovation - Tracing the evolution of innovation from industrial to knowledge society*, Proceedings from EURAM 12'