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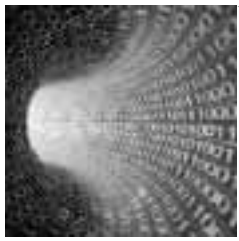

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ARTICLE

Information and communication technology innovations: radical and disruptive?

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Abstract

Information and communication technology innovations (ICT) are considered to be of central importance to social and economic developments. Various innovation theories offer classifications to predict and assess their impact. This article reviews the usefulness of selected approaches and their application in the convergent communications sector. It focuses on the notion of disruption, the comparatively new distinction between disruptive and sustaining innovations, and examines how it is related to other innovation-theoretical typologies. According to the literature, there is a high frequency of disruptive changes in the field of internet protocol-based innovations in combination with wireless technology. A closer analysis reveals that these classifications and assessments not only differ in detail but are even contradictory. The article explains these differences by highlighting delicate choices that have to be taken by analysts applying the disruption concept. It argues that its applicability is comparatively low in the convergent communications sector and generalizations of single-firm assessments are hardly valid.

Key words
communications sector • disruptive technologies • ICT • internet • innovation theory • P2P • radical innovations • VoIP • WLAN

INTRODUCTION

Rapid technological change in the information and communication technology (ICT) sector is accompanied by equally fast-changing assessments and predictions about the diffusion and impact of innovations. Long periods of technology and policy stability in communications subsectors ended in the late 20th century, when clusters of innovations, often described as radical, successively affected telecommunications, broadcasting and the rest of the copyright and publishing industries. Technological life-cycles became shorter, as did the life-cycles of predictions on the development of the sector. Visions of the dominant design of future broadband networks have changed several times over the past decades. Another example of changing expectations is the internet. The overall impact assessment of the internet changed three times within a decade, from boom to gloom and halfway back to cautious optimism. On the one hand, the end of the new economy is proclaimed – the shift from a new to the old economy, but with access to new technologies – classifying the internet merely as an enabling technology, which complements rather than cannibalizes old technologies. Accordingly, it is time to return to normality and would be appropriate to stop the currently widespread habit of placing an 'e-' in front of nearly every term (e-commerce, e-democracy, etc.; see Porter, 2001). On the other hand, the internet is conceived as the 'mother of all disruption' (see Isenberg, 1999), denoting the displacement of technologies and of respective incumbent companies. Recent academic literature, public policy documents, business and the popular press alike suggest that the combination of radical innovations and disruptive technologies is mushrooming in the 'atmosphere' of internet and wireless communication. Wireless-Fidelity (WiFi), email, wireless telephony, weblogs (blogs), Voice-over Internet Protocol (VoIP), internet protocol, mesh technologies and peer-to-peer (P2P) are not only described as radical but also disruptive, replacing technologies and incumbent firms (see Brown, 2000; Christensen and Raynor, 2003; Hiler, 2002; MeshNetworks, 2002; Schwartz, 2003; van Horn, 2002; Wikipedia, 2005). Altogether, the impression emerges that there is an era of ferment, a search for new dominant designs, and that rapid technological change in the ICT sector is leading to acronym-intensive confusion.

Social science research seeks to track technological developments and their multifaceted impacts, frequently with purely *ex-post* descriptions of

selected phenomena. It also attempts to offer orientation and strategic support for industry and politics, among other things, by offering typologies of innovations and technologies that are supposed to allow generalizations and even *ex-ante* evaluations of the impact of innovations. Confusingly, these classifications and assessments not only differ in detail, but are even contradictory, for example on VoIP and wireless local area networks (WLAN). This observation not only shows the difficulties of forcing real-world developments into helpful categories, but also the danger of overuse, oversimplification and misinterpretation. Not least, it highlights substantial shortcomings in innovation theories.

Altogether, pressing questions are emerging about what helpful concepts and theories innovation research offers, whether they are compatible and equally applicable in different sectors, and particularly whether they are applicable in the convergent communications sector. This article reviews selected innovation-theoretical approaches and their application in this sector. It focuses on the combination of radical innovations and disruptive technologies, which are considered to be particularly important for economic and social developments not only by research but also by politics, where research and development (R&D) strategies explicitly focus on the promotion of radical and disruptive technologies.

At the end of the 1990s, the concept of disruptive technologies, which introduces a new typology by distinguishing between sustaining and disruptive technologies, became popular with the publication of *The Innovator's Dilemma* by Clayton M. Christensen (1997), who claims his concept is generally applicable to all kinds of industries, technologies and companies. This bestseller led to a situation where analysts and companies were seeing disruptive threats to incumbents nearly everywhere (see Adner and Zemsky, 2003). In particular, it asserts that there is a high frequency of disruptive changes in the field of internet protocol-based innovations in combination with wireless communication. These will receive special attention in this article.

The first section puts the concept of disruptive technologies in the context of innovation theories and outlines its contribution to innovation research. The concept will be discussed against the background of dynamic, evolutionary approaches and other important typologies of technological change, with particular attention to the distinction between radical and incremental innovations. Then, the article will present results of the application of the disruptive technology concept and discuss its applicability to the convergent communications sector. Finally, it draws conclusions regarding delicate choices in the employment of the disruption concept.

INNOVATION RESEARCH: EVOLUTIONARY MODELS AND TYPOLOGIES OF TECHNOLOGICAL CHANGE

Evolutionary approaches

Various academic disciplines contribute to the understanding of innovations and technological change, particularly economics and sociology (there are influential pioneers such as Joseph Schumpeter on innovations, and Karl Marx and Werner Sombart on technological change; for an overview see Braun-Thürmann, 2005; Dosi et al., 1988; Stoneman, 1995). Communications focuses on non-economic factors of the adoption or diffusion of innovations and on media substitution (see Barnett and Siegel, 1988; Kaye and Johnson, 2003; Rogers, 2003).

Although there is not yet a comprehensive innovation theory, widely accepted innovation models can be found in the literature. Innovations can be defined and understood only in a dynamic environment. The rapidly aging new is to be understood in comparison to the old. A major contribution of Joseph Schumpeter (1934, 1942) was to address and overcome the shortcomings of the neo-classical equilibrium model, which is well equipped for modelling alternative uses of scarce resources, but rather ill-suited to modelling technological progress. Schumpeter's non-linear, dynamic innovation model, which describes the innovation process as a cycle of innovations and imitations, forms the basis for many further theoretical developments, in particular for evolutionary models. He applied a wide understanding of innovation, including products, processes and organizations, and importantly, he introduced the company and the role of the entrepreneur into the analysis. Innovations disturb the economic equilibrium, the resulting 'creative destruction' – that is, the destruction of existing and the creation of new industry structures triggered by inventors and entrepreneurs – drives the cycle of economic prosperity and recession. Christensen's (1997) concept of disruptive technologies can be understood as a special case of such creative destruction, driven by originally inferior technologies.

Evolutionary theories in the tradition of Schumpeter suggest the common basic concept, that there are two phases of technosocial change: incremental phases, interrupted by radical (discontinuous, revolutionary) innovations. The reasons for radical innovations might be functional shortcomings or scientific progress that erode existing paradigms, which are regarded consequently as having no future. For example, analogue photography might still produce better-quality pictures, but it no longer fits in with the digital era around computers and the internet (see Braun-Thürmann, 2005: 45).

Anderson and Tushman's (1990: 3) model also suggests that variation is generated by technological discontinuities and subsequent eras of ferment. Technological discontinuities, caused by radical innovations, unpredictable

technological breakthroughs or dramatic advances in price and performance, trigger a period of ferment, a design competition that is concluded by the establishment of a new dominant design. Incremental technical change then follows, which is broken subsequently by the next technological discontinuity, another radical innovation.

This common classification into alternating periods of incremental and radical innovation can be linked with findings on the common distinction regarding the type of innovation in product and process innovations. As Utterback (1994: 79) points out, product innovations are more important and more frequent in the early (fluid) phases of innovation until a dominant design emerges. Afterwards, process innovations that improve the efficiency of the dominant design become more frequent. The emergence of a dominant design is not the result of technological determinism, which would imply that the technologically best way to implement a product or process would necessarily succeed. VHS, for example, was not the best video standard from a technological perspective, and IBM personal computers (PCs) were not the fastest available. Here, institutions, norms and organizations as well as social and political processes shape the dominant design in a co-evolutionary way (on co-evolution and complexity, see Garnsey and McGlade, 2006). Most technological progress is incremental, but most of the total performance improvement over the lifetime of a technology will occur during radical changes (see Anderson and Tushman, 1990: 618). Anderson and Tushman's (1990) cyclical model suggests repeated patterns of change over time, which are linked to organizational change, and it shows the importance of dominant designs. Technological evolution calls for the specific competences of organizations, as technologies are socially driven phenomena, at least in part.

Typologies of technological change: radical/incremental

Schumpeter's work on 'creative destruction' and Kondratieff's (1926) work on 'long waves of technological change' focus only on basic innovations. They characterize economic development as a sequence of such innovations, which emerge as bundles or clusters of innovations and have both creative and destructive effects. Other authors (see Freeman and Perez, 1988: 45) have added a more detailed taxonomy of innovations by distinguishing between: incremental innovation (continuous improvement of products and processes in small steps); radical innovation (discontinuous change, e.g. transistors); new technology systems (combinations, consisting of a cluster of radical innovations that affect various sectors and are combined with new organizational forms: e.g. computers); and changes in techno-economic paradigms (revolutionary changes of societal configurations, different technological systems, economic systems and societal regulations, e.g. the industrial revolution or the information society).

Altogether, various typologies of technological change have been proposed, but no one specific typology is accepted commonly. The comparatively new distinction between disruptive and sustaining technologies adds another option for classification and differentiation. It builds on the widely used radical/incremental dichotomy, which plays a central role in the explanation of evolutionary innovation models. At the same time, differences are stressed (see Christensen and Raynor, 2003). The basic relationship between these two types of classification is that different combinations are feasible, that radical innovations, for example, are not necessarily disruptive, but also could be sustaining.

In order to understand better and assess the disruptive/sustaining dichotomy, a closer look at radical innovations is helpful. Many different definitions of radical and incremental innovations can be found in the literature. What they all have in common is that the focus is on the intensity of technological change. There are several other dichotomous classifications of innovations which roughly denote similar differences between innovations. Sometimes the following adjectives are applied synonymously with 'radical': 'discontinuous', 'architectural', 'generational'[1] and 'revolutionary'. However, these concepts differ in detail and have been proposed as a means of further differentiating the incremental/radical dichotomy.

For the purpose of this article, in assessing the concept of disruptive technologies, it will stick to the radical/incremental dichotomy and put it in the context of evolutionary models. Radical and incremental innovations alternately dominate the two phases within the above-described cyclical model of technological change (Anderson and Tushman, 1990: 3).

The widely accepted differences between these two types of innovation are summarized in Table 1.

Often, radical innovations are linked with a discontinuity compared to their predecessors, if there are any. According to Godoe (2000: 1034), this could be a novel category, species or class of technological devices, a system, process or solution. Examples from telecommunications are the communication computers used for email compared to Morse's telegraph, digital-switching technology, digital mobile radio communications, satellite communication and fibre-optic networks. These innovations were non-existent before the 1970s and 1980s, and called for re-education, reorganization and new skills and perceptions. They led to many new services and complementary innovations.

Incremental, continuous technological changes are linked to existing technologies, whereas radical, discontinuous technological changes are not. Often, radical innovations are described as being based on disruptive technologies. They may have (but not necessarily) a disruptive impact on companies employing existing technologies. Christensen (1997) describes

• Table 1 Major differences between incremental and radical innovations: constituting factors and explanations of their emergence

Incremental innovations	Radical innovations
• Continuous (linear improvement in the value received by customers)	• Discontinuous (with or without predecessor; substantial, non-linear improvement)
• Based on old technology	• Based on new technology
• Dominant design unchanged	• Leads to new dominant design
• Does not lead to paradigm shift	• Can lead to paradigm shift
• Involves low uncertainty	• Involves great uncertainty
• Feature improvements	• Entire new set of performance features
• Existing organization and qualifications are sufficient	• Need for re-education, new organization and skills
• Result of rational response, of necessity	• Attributed to chance, not to necessity; might be influenced by R&D policy
• Driven by market pull (important in late phase of technology)	• Driven by technology push (important in early phase of technology)
• To achieve economic short-term goals	• To achieve economic long-term goals

this as the innovator's dilemma: that is, when large firms are reluctant to familiarize themselves with potentially disruptive technologies quickly. Discontinuous, radical innovations permit entire industries and markets to emerge, transform or disappear.

Radical innovations may lead to a new technological paradigm and initiate development patterns that are termed, among other things, as technological trajectories, technological regimes and patterns of evolution (see Godoe, 2000: 1035). Incremental innovations are explained as the outcome of a 'rational' response to markets, dynamics of technological regimes, etc. Radical innovations are explained in terms of serendipity, chance or haphazard scientific discoveries. However, evidence of innovations in the telecommunications sector suggests that 'innovation regimes' (see Godoe, 2000) influence the capability to create radical technological innovations willingly, building essentially on R&D policy.

Traditional thinking in innovation research suggests that superior radical innovations invade the markets for existing products (see Utterback, 1994: 159). Schumpeter's notion of creative destruction is framed in s-curves (see Foster, 1986), in performance-over-time trajectories. S-curves show that technologies reach a point where improvement stops and a new technology must emerge to supplant it. There is a technology competition based on different or dramatically better product performance, or regarding essentially lower production costs. An alternative technology appears at a time when the old technology is still improving rapidly.[2] As soon as it performs better than the old technology, the new technology invades and takes over the market.

Disruptive and sustaining technologies

The major contribution of Christensen's notion of disruptive technologies to innovation theory is that he pointed to the possibility that technologies with an inferior performance can invade markets and displace established incumbents, which changed the way that scholars and managers alike approach technological competition (see Adner, 2002: 667). It eroded the dominant view in technology strategy that the displacement of established firms and technologies is driven by the superior performance offered by newcomers.

Often, technologies are commercialized in niches: some stay there while others penetrate the mainstream segments and compete with incumbent technology (see Adner and Zemsky, 2003). This phenomenon has been studied by economic historians such as Rosenberg (1976), and historians of technology such as Basalla (1988), who provides an evolutionary perspective on continuous and discontinuous developments. The emergence of technology competition, also understood as a competition of business models, has risen to prominence through the work of Christensen (1997), who in essence built his theory on case studies that he conducted on the hard-disk computer memory industry in the USA.

The impact of disruptive technologies over time is illustrated in Christensen's (1997: xvi) and Christensen and Raynor's (2003: 44) trajectory maps. The term 'inferior' in this context refers to the performance dimensions most important to the mainstream customers of the incumbent firm. The old technology overshoots, according to the performance demanded by its mainstream customers. Disruption occurs when the trajectories of performance supply and performance demand intersect. This situation is characterized by the originally underperforming (inferior) new technologies or innovations (e.g. smaller, simpler, more convenient, cheaper), in which mainstream customers are not interested. Finally, the mainstream customers shift to products based on inferior technology, and incumbent companies do not react in time. Christensen and Raynor (2003: 43) distinguish between two types of disruption. New market disruptions initially compete against 'non-consumption', as they are simple and affordable; with improving performance they can pull customers out of the low end of the original value network into the new one. Low-end disruptions do not create new markets but start at the low end of the mainstream value network. Both create a dilemma for incumbents: new market disruptions induce them to ignore attackers, and low-end-disruptions to flee the attack. Disruption is not connected intrinsically with a specific technology or a business idea. The business strategy determines how disruptive its impact is (see Christensen and Raynor, 2003: 32).

Sustaining technologies improve product performance along a trajectory that is valued already by an existing customer base, such as a mobile handset with an integrated megapixel camera compared to a mobile handset with a built-in low-quality camera. The device is used in the same way and appeals to the same set of customers. In contrast, in their early phase, disruptive technologies typically promise worse performance than existing customers expect. The problem for incumbents is that disruptive technologies do not remain in the lower tiers of the markets but move into mainstream markets, whereas old technologies overshoot with performance features that are not demanded by mainstream customers. The literature provides numerous historic examples of such low-end disruption (see Christensen and Raynor, 2003; Henten et al., 2004; Overdorf and Barragree, 2001; Steppuhn, 2003): the Digital Equipment Corporation was unable to market its PCs successfully owing to organizational failures; transistors, which initially could not be used in mainstream applications such as television because they could not handle the power requirements; voice recognition technology, which currently is not good enough for mainstream wordprocessing markets but good enough for internet chat rooms; LED flatscreen displays were used first in wristwatches and much later moved into PC and TV markets. A prominent example of a new market disruption is the telephone, which began as an inferior one-way device, was further developed into a two-way device, and finally displaced the telegraph. Western Union, the telegraphy incumbent, rejected the opportunity to buy the patent, and ultimately was overtaken by the telephone company AT&T, which originally had started up in a niche market.

In a nutshell, the disruptive principles – the major factors of disruptive innovations,[3] according to Christensen's concept – can be summarized as follows (see Henten et al., 2004; Hüsig et al., 2005: 21–2; Steppuhn, 2003:68):

- inferior performance, cheaper, fast improving;
- leading customer rejection;
- performance overshooting of established technology;
- lower profits until a new business model is found;
- emerging market success (in isolated niches);
- intersecting trajectories lead to invasion of the incumbent's market; and
- first-mover advantages.

As an important criterion for his theory, Christensen highlights the fact that technology is the infrastructure that facilitates new business models, and that new technologies would allow established companies to offer products or services that its most profitable customers cannot use. These new products may appear unprofitable relative to other possible innovations of the company, hence it is hard for the leading company to embrace the

opportunity. Further, he points out that the trajectory of technological progress almost always outstrips the ability of customers to absorb it. Technology becomes disruptive or destructive to the leading companies in the industry, which are based on the old technology, when rapidly improving technology performance intersects with customer needs:

> [D]isruptive technology is a different type of creative destruction in that it affects the business model. Like a technological solution, a business model will reach its limits to do better. So the ability to creatively destroy existing business models actually becomes the key to growth in the whole economy. (Knight, 2001: 10)

The potential effects of disruptive technologies are multifaceted. The discussion focuses on the impact on individual companies, in particular on the threat of displacement for certain incumbents in specific markets. The main question addressed is whether the displacements of old by new technologies or services are combined with the displacement of leading companies. On a more general level, the structural effects of disruptive technologies may include driving the transformation from chain structures to web structures. They may enable a broader population of less skilled or less wealthy people to do things that once required specialist services (see Overdorf and Barragree, 2001: 10). For example, with digital photography the seat of power can be seen as having moved from Kodak and Fuji to consumers rather than to other companies. Similar developments can be observed in the publishing industry for music, video and text, driven by filesharing and distributed publishing via P2P networks.

Applications of the disruptive technology concept: conflicting results

The rapid spread of Christensen's main hypothesis led to a situation where disruptive threats and effects were being detected almost everywhere. These classifications are based on evaluations with varying degrees of thoroughness, on different interpretations of disruption, and sticking more or less closely to Christensen's theory. Accordingly, with Henten et al. (2004), it makes sense to distinguish between disruptive in a *strict* way (actual disruption, displacement of incumbents) and disruptive in a *soft* way (disruptive potential). Some authors have conducted case studies on the disruptive impact of various ICT innovations, looking more or less systematically for major constituents of disruptive innovations, or at least have used the disruptive technology concept in a soft, sometimes only inspiring way. The results differ accordingly, and are even contradictory.

One of the problems is the choice and containment of the innovation to be evaluated, as most of what is called innovation consists of a bundle of innovations with different attributes regarding their disruptiveness. The perception of the internet as the 'mother of all disruptions' stems from the

perspective, that it combines disruptive technologies of many component markets. According to Isenberg (1999), the internet is not a disruptive technology per se, but like the laptop, it is a network that embraces various technologies, and depends on the trajectories of its component technologies (e.g. routing, access, computing, transport). In general, communication networks are subject to disruption as component technologies improve. Alongside the (core) components, the disruptive potential of complementary products has to be taken into account (mobile communication, scanning, databases, etc.). Results of the impact of innovations are relational: they depend on the choice of the other innovations or components to which they are compared (see Steppuhn, 2003: 27). For example, VoIP will lead to different results depending on whether it is analysed or not in combination with WLAN. Further, results are time-sensitive. Porter (2001) argues that the internet is not as disruptive to existing industries and established companies as was thought in its early phases. He sees the internet as an enabling technology that leaves the fundamentals of competition unchanged. He also points out that it seldom nullifies the sources of competitive advantage in an industry, and with generally growing internet use by companies, its advantages might be neutralized.

Innovation-theoretical classifications of WLANs such as WiFi and VoIP can be taken as examples of conflicting results regarding their disruptive potential and effects. Basically, these results are caused by different interpretations of disruption, the choice of different indicators of disruption or different performance indicators (e.g. bandwidth or radius in the case of WiFi), and by different levels of thoroughness in the evaluations.

Christensen gives VoIP as an example of disruptive technology and highlights the disruptive combination of packet switching, internet protocol and new business models (see Knight, 2001). He argues that a disintegration of long-distance telephone companies is happening with the introduction of internet-based telephony, which uses packet switching to route calls over the internet. Fast routing technology makes a routed call indistinguishable from circuit-switched calls. As a result, he expects that the business model of charging for time on long-distance calls will be replaced by flat fees for unlimited time. In contrast, Henten et al. (2004) come to the conclusion that VoIP is in essence a sustaining technology, as incumbents are not reluctant to take up the technology and because there are only minor, if any, first-mover-advantages. In a differentiated manner they argue that a new business model is conceivable only for PC-to-PC solutions of VoIP, but not for PC-to-phone or phone-to-phone applications. The position of the old voice operators is not seriously endangered, not least due to their market power in telecommunications markets. Their evaluation is based on the situation in developed countries; however, they concede that there may be regional

differences, that results could be different for less developed countries due to different starting positions for disruption. Altogether, there is no actual disruption yet (in the strict sense), and it seems unlikely to happen in the foreseeable future. Nevertheless, there is a disruptive potential: that is, disruption in a soft way.

In addition, conflicting results can be found regarding (data services via) WLAN, for example WiFi. Various sources assert its disruptive nature and potential, arguing for example that WiFi is an inferior technology due to its short operational radius compared to other mobile technologies (see Christensen and Raynor, 2003: 56). Inspired by Christensen's concept, Erber (2004: 18) highlights the clash of visions between the telecommunications and the information technology (IT) industry. He calls the combination of WLAN and VoIP the 'IT model', and foresees an end of the business model of public networks. With higher bandwidth and growing radius (e.g. with Worldwide Interoperability for Microwave Access (WiMax) compared to WiFi), allowing VoIP, pay-by-distance and pay-by-time pricing models will collapse. According to Erber (2004: 15), the second stage of WiMax will be 'disruptive', when it is embedded within laptops and other portable devices. Creative destruction might confirm Bell's Law, that a new technological trajectory also leads to a new kind of industry with different key players and new industry structures.

In contrast, the case studies that followed the Christensen concept more closely come to quite different conclusions. Steppuhn (2003) focused on data services as, due to premature technology and products, he did not see a potentially disruptive technology in the combination of WLAN and VoIP at the time of his study. He concludes that WLANs have superior bandwidth compared to other mobile network standards. Hence, the disruptive principles according to Christensen are not fulfilled. Further, he argues that the concept is rather ill-suited in this particular case, due to the important role of regulation (strong access regulation, interference by frequency policy, standardization policy), which is not covered adequately in the concept of disruptive technologies.

Similar results were derived from an *ex-ante* analysis of disruption by Hüsig et al. (2005), who identify a disruptive potential and threat, but conclude that a disruptive effect is not very likely. Their major arguments are that WLAN aims at upmarket segments which value the superior performance attributes in bandwidth, and that incumbents are willing and able to enter the market. Nevertheless, they concede that there are some limits and problems in their methodological approach, including the choice of performance criteria in their questionnaire, and the problem of adequately including network effects, incompatible standards, lock-in effects and first-mover advantages in the forecasting efforts.

It is interesting to note that in both the cases of VoIP and WLAN, the more thorough analyses according to disruptive principles show that there is no disruption in the strict sense. Further, they are both in conflict with the results regarding classifications and assessments made by Christensen.

Internet or e-commerce impact on the publishing industry

Other examples of rather vague applications of the disruption concept in the ICT sector analyse the impact of the internet or e-commerce on the publishing industry, which is in need of transformation strategies as the impact of digital media on audience and advertiser behaviour rises. The case of online bookselling, especially its most prominent representative, Amazon (www.amazon.com), is widely discussed. From the perspective of the internet as a disruptive technology, Amazon threatened conventional distributors such as Barnes & Noble with potentially disruptive e-commerce technology (low-end disruption). According to Dhillon et al. (2001), these developed a good e-commerce counter-strategy.

However, the disruptive threat is not limited to distribution markets for books; the conventional mass media such as newspapers also are affected. Picard (2003: 128) points out that the print media have been highly resistant to change for 300 years, but the pressure on the publishing industries is increasing, among other things, from mobile telephony, content provision through Short Message Service (SMS, 'texting') and internet capabilities, which are supposed to increase with Third-Generation (3G) mobile communication. Nevertheless, Picard does not foresee major shocks to the current business model for a decade or more, and in the meantime, he expects that print media companies will continue to be good investments. The print media share of total advertising is declining but real expenditures are still rising. However, there is low or no real growth in advertising and sales revenues and profits per title will continue to decline, hence, there are other growth mechanisms: vertical integration into distribution and supply chains, horizontal diversification (other print products) and diversification into other types of media and non-media companies are possible. With new media activities, new uses for existing materials are being sought. The major strategic challenge is to find the right moment for 'turning the cash cow into entrecote before its productive life is over' (Picard, 2003: 134). AOL and Vivendi may have done so too soon (see Picard, 2003) and the management had to resign, but when is the right time to slaughter the cow?

Altogether, there is an impetus to structural change in mature publishing industries characterized by rising cost and declining revenues and profits per title. Companies face a timing problem for the transformation. They are seeking new media business opportunities built on the print core. Currently, consumer behaviour is preventing short-term destruction of publishing

companies. The effects of disruptive technology on companies are not uniform – it depends on individual companies' response strategies. Overdorf and Barragree (2001) argue that companies have made ill-conceived ventures into electronic publishing, which raises the strategic question of whether they should stay in their traditional business. Building on Christensen's theory, they outline the disruptive landscape in the publishing industry, distinguishing between the industry's different tiers. Further, they point to the transformation of the industry from a traditional chain structure to a web structure and at the importance of the organization's ability to exploit the opportunities offered by new technologies.

In general it should be borne in mind that entrenched companies' negative reactions to technological innovations are not a surprising or new phenomena. The copyright industry has reacted negatively to the introduction of every previous innovation in copying technology. The publishing industry has complained about photocopying, although it ultimately turned out to be beneficial to the industry; the movie and television industry tried to stop video recorders, although it finally led to a new market, not just a substitute market (see Liebowitz, 2005).

DISCUSSION AND CONCLUSION

This article has analysed the relatively new concept of disruptive technologies in the context of other innovation-theoretical concepts, in particular the concept of radical innovations, and applications of the disruption concept in the ICT sector. Without doubt, the concept touches upon a highly relevant issue for industries and policymakers alike. It sensitizes to the possibly displacing effects of (initially) inferior technological innovations, to the important connection between technological innovations and business models or strategies, and to the threat and dilemma that innovations may pose for incumbent companies.

The original purpose of the disruptive technology concept is to support managers of incumbent companies in their long-term strategic decisions, to help them to find management strategies that pursue innovation opportunities:[4] 'Business units and their business models just mature and die. By using the lens of the disruptive model, strategic leaders can learn how to cause their organizations to evolve successfully' (Knight, 2001: 15). The concept takes a company perspective, not a user perspective, which means that the classification is disruptive or not does not tell us if there are strong impacts on users or on socio-economic factors in general. In other words, innovations can cause immense changes for users without being disruptive, or innovations (for example, the digitalization of the telephone) can be perceived as radical by companies but not by users (see Godoe, 2000: 1036). In the disruption concept, the micro-perspective of incumbents is chosen.

Nevertheless, the results are important for public policy regarding changing industry structures and growth perspectives.

A review of various applications of the concept highlights the danger and the practice of oversimplification and overstretching of the theory. Different interpretations and (over)usage of the theory necessarily lead to confusion (for a critique of Christensen's theory, see Danneels, 2004; Markides, 2006). On the one hand, the concept is applied in a soft way, as inspiration for a specific angle and direction in research, or in a metaphoric manner, which basically focuses on the general meaning of the term 'disruption'. On the other hand, it is used in a strict way, trying to follow Christensen's theory closely. Both approaches have their merits and shortcomings. Based on the review of strict applications of Christensen's theory it can be concluded that, in addition to the basic 'disruptive principles', for example inferior performance, leading customer rejection, performance oversupply and first-mover advantages, other factors require adequate attention. In general, it should be borne in mind that the theory as presented by Christensen has a very limited scope, that it covers only a small or medium range. It is intended to be applied under restrictive pre-conditions, and acceptable generalizations of results are very limited and should be treated with care. Delicate choices in the process of its application, which are summarized below, lead to very different results.

First, it is a model that analyses the relation between two distinct products. Hence, these products have to be defined and isolated as far as possible. For example, VoIP as a subject of research regarding its disruptiveness seems to be too undifferentiated. The choice between different VoIP modes (PC-to-PC, phone-to-phone) will lead to different results regarding disruption. Moreover, if analysed in combination with WLAN, VoIP will produce different results than VoIP combined with fixed lines. Technologies can be both disruptive and sustaining, as inkjet printers are disruptive to laser jet printers and sustaining to the dot-matrix printer (see Christensen and Raynor, 2003). Therefore, the results regarding the disruptive potential or impact of technologies have a narrow scope, being valid only for two specific technologies or innovations and their respective business strategies. As argued below, they are valid only for a specific incumbent in a defined regional environment.

Second, the concept is thought of originally as an individual company assessment: the same potentially disruptive innovation may have different effects on different companies, so the assessment cannot be generalized. The assessment that a technology is potentially disruptive has to be distinguished from the assessment that actual disruption occurs in a specific case. For example, according to Christensen and Raynor (2003) the potentially disruptive internet is actually disruptive for Compaq but sustaining for Dell;[5] further, the internet proves to be disruptive for music companies

but not for the pharmaceutical industries. In addition, it should be noted that Christensen's examinations of disruption chose only well-managed companies. Altogether, an individual company perspective is taken, excluding the possibility of mismanagement.

Third, the choice of different performance criteria for the analyses could lead to different results. For example, if bandwidth is chosen as the decisive criterion, then Wifi is a superior technology compared to the Universal Mobile Telecommunications System (UMTS), but it is inferior if geographical range is chosen.

Fourth, socio-economic and cultural factors make a difference. Technologies might prove disruptive in one region but not in another. There are different regional effects from the same technology or innovation. Chesbrough (1999), for example, argues that the disruptive effects described by Christensen in the US hard-disk drive industry did not occur the same way in Japan, and Henten et al. (2004) claim that the results of VoIP might be different for poor and rich countries, depending on the different supply conditions of old technologies.

Fifth, the results are valid only for a specific point in time and development. Criticism focuses on the static nature of the Christensen model, not giving enough consideration to the timeframe. The results of disruption (both *ex-post* and *ex-ante* evaluations) might differ within a month, not least because of rapid improvements due to increasingly shorter life-cycles. P2P technology is already considered to be disruptive for music distribution companies, to a lesser degree for video, and not yet for publishing companies. This means that the time horizon is another important factor to be considered in application of the theory.

Finally, the degree of applicability and usefulness of the concept differs between (and within) sectors. Its applicability in the convergent mediamatics sector, combining telecommunications and the media, is limited heavily by the regulation of market access, by the fact that incumbents in service markets also own the infrastructure. Further, it is limited by the situation that standardization processes are dominated by incumbents, that complementary products (e.g. handsets) exhibit different conditions for disruption and that there are scarce essential resources, such as frequencies, which limit the options for market entry (see Hüsig et al., 2005; Steppuhn, 2003). Only well-managed companies in sectors which do not show these characteristics are well suited to the application of Christensen's model.

Other factors to be taken into consideration are that Christensen's focus is on the combination of business model and technology, not on offering a general judgement on technologies or innovations. For example, most internet start-ups have used the internet as a sustaining innovation relative to business models of established companies. eBay (www.ebay.com) is a notable

exception and pursued a disruptive strategy, as it allows collectors to sell things (Christensen and Raynor, 2003: 59). This implies that e-commerce is basically a sustaining and continuous innovation. It is not radical if the internet is only an additional distribution channel, keeping more or less the same business model. Accordingly, Christensen (1997: 209) considers disruption to be a marketing challenge, not a technological challenge.

The disruption concept might lead one into an interpretation in line with technology determinism to a monocausal interpretation, that certain technological innovations necessarily lead to disruption, that technology has certain impacts on business models, and so forth. A different, co-evolutionary view on the impact of technology on society holds that sociotechnological systems have a potential impact that creates pressure for change. Hence, potentially disruptive technologies need to be distinguished from actual disruption in certain cases, which depends on the interplay of the various technological, social, economic and political factors discussed above, and can be governed to a certain degree by companies' strategic behaviour.

There are various strategies for incumbents to react to disruptive threats, to the emergence of potentially disruptive technologies. One would be to set up new organizations to pursue a disruptive business opportunity and later shut down or sell off the old business. This would be a form of proactive cannibalization in reaction to innovations. As Cravens et al. (2002: 258) point out, *Encyclopaedia Britannica* failed when threatened by CD-ROM, whereas Kodak successfully reinvented itself in reaction to the discontinuous, radical innovation of digital photography. On the one hand, there is the need to be open to (self-)cannibalization, on the other hand, a major challenge for companies is to avoid destructive cannibalization (see Cravens et al., 2002). Christensen et al. (2004: 48) identify four incumbent response strategies to disruptive threats: incumbents could leave the market to the entrants (ceding), fight the attack by acquiring disruptive innovations (co-opting), target the entrants' customers with modified versions of their core product (growth-driven), or concentrate on keeping their existing customers and preventing the entry of other companies (defensive).

Regarding the compatibility and combination with other innovation-theoretical classifications, in particular with the differentiation in radical and incremental innovations, it should be noted that different combinations between these two classifications are feasible – that, for example, radical innovations could be either disruptive or sustaining at the same time. Despite the possibilities of neatly distinguishing between radical and incremental and between disruptive and sustaining innovations, problems remain in introducing these and other classifications of innovations into economic theory: it is hard to distinguish economically between radical/incremental or disruptive/sustaining, in particular in a formalized, mathematical manner.

Further developments of the disruption theory are proposed. Adner (2002) argues that the constituent factors of the phenomenon of disruption are well documented: basically, the innovation starts in isolated niches, then matures and expands into the mainstream market. However, as in the case of radical innovations, the drivers of disruption have not been equally well analysed yet. He draws attention to the demand conditions for disruption, and proposes a model of how to take them into consideration better. Hüsig et al. (2005) tackle the problem that companies and public policymakers need to identify the disruptive potential of technologies *ex-ante*. They propose a method, based essentially on a detailed questionnaire on disruption factors, that is intended to allow companies to assess possible disruption *ex-ante*. They also try to include so-far neglected factors such as the existence of complementary goods and standards, and of lock-in situations and network externalities, which are of special importance in the telecommunications sector.

To conclude, the disruption concept can be judged as helpful and inspiring, but also as easily misleading. Its application yields hardly comparable results due to the many delicate choices to be made in the process. These choices on the containment of research subjects, performance indicators, regional market conditions, sector-specific characteristics, individual or company performance and so forth, lead to conflicting results. In other words, there is a very limited range of validity of research results, so generalizations of individual or company assessments are hardly valid. Moreover, the concept is not equally well suited to different markets with different institutional characteristics. For telecommunications and electronic media markets its applicability is comparatively low, which calls for even more cautious application and interpretation of results.

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Notes

1 'Generational' was the predecessor of 'architectural', both introduced by Henderson and Clark (1990).

2 As Utterback (1994: 160) points out, a radical innovation (e.g. wordprocessing) may lead to a burst of improvement in the old technology (e.g. typewriter), which delays the replacement.

3 In his 1997 book, Christensen does not distinguish technology and innovation systematically. Later he defines technology as the infrastructure that facilitates new business models. In an interview, Christensen said that he would not use the words 'disruptive technologies' if rewriting his 1997 book (Knight, 2001: 10). To minimize misinterpretations, Christensen and Raynor (2003: 66) substituted the term 'disruptive innovation' for the term 'disruptive technology'.

4 For a blueprint to help managers reap the benefits of disruptive innovations, see for example Christensen et al. (2002).
5 Dell already sold computers by mail and over the phone before the introduction of internet-based e-commerce; this was already a low-end disruption, hence the internet did not have a disruptive effect (see Christensen and Raynor, 2003: 42).

References

Adner, R. (2002) 'When are Technologies Disruptive? A Demand-based View of the Emergence of Competition', *Strategic Management Journal* 23(8): 667–88.
Adner, R. and P. Zemsky (2003) 'Disruptive Technologies and the Emergence of Competition', CERP Discussion Article No. 3994. London: Centre for Economic Policy Research.
Anderson, P. and M. Tushman (1990) 'Technological Discontinuities and Dominant Designs: a Cyclical Model of Technological Change', *Administrative Science Quarterly* 35(6): 604–33.
Barnett, G.A. and G. Siegel (1988) 'The Diffusion of Computer-assisted Legal Research Systems', *Journal of the American Society for Information Science* 39(4): 224–34.
Basalla, G. (1988) *The Evolution of Technology*. Cambridge: Cambridge University Press.
Braun-Thürmann, H. (2005) *Innovation*. Bielefeld: Transcript Verlag.
Brown, M. (2000) 'Embracing Disruptive Technology: Storage of Data over IP', *Computer Technology Review* 4: 60–7.
Chesbrough, H.W. (1999) 'The Organizational Impact of Technological Change: a Comparative Theory of National Institutional Factors', *Industrial and Corporate Change* 8(3): 447–85.
Christensen, C.M. (1997) *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston, MA: Harvard Business School Press.
Christensen, C.M., S.D. Anthony and E.A Roth (2004) *Seeing What's Next: Using the Theories of Innovation to Predict Industry Change*. Boston, MA: Harvard Business School Press.
Christensen, C.M., M.W. Johnson and D.K Rigby (2002) 'Foundations for Growth: How to Identify and Build Disruptive New Businesses', *MIT Sloan Management Review* 43(3): 22–31.
Christensen, C.M. and M.E. Raynor (2003) *The Innovator's Solution*. Boston, MA: Harvard Business School Press.
Cravens, D.W., N.F. Piercy and G.S. Low (2002) 'The Innovation Challenges of Proactive Cannibalisation and Discontinuous Technology', *European Business Review* 14(4): 257–67.
Danneels, E. (2004) 'Disruptive Technology Reconsidered: A Critique and Research Agenda', *Product Innovation Management* 21(4): 246–58.
Dhillon, G., D. Coss and R. Hackney (2001) 'Interpreting the Role of Disruptive Technologies in e-Businesses', *Logistics Information Management* 14(1–2): 163–70.
Dosi, G., C. Freeman, R. Nelson and L. Soete (eds) (1988) *Technical Change and Economic Theory*. London: Pinter.
Erber, G. (2004) 'Disruptive versus Incremental Innovations in Broadband Communication: What's Going to Happen Next?', paper presented at the International Telecommunications Society conference, Berlin, 4–7 September.
Foster, R. (1986) *Innovation: The Attacker's Advantage*. New York: Simon & Schuster.

Freeman, C. and C. Perez (1988) 'Structural Crises of Adjustment: Business Cycles and Investment Behaviour', in G. Dosi, C. Freeman, R. Nelson and L. Soete (eds) *Technical Change and Economic Theory*, pp. 38–66. London: Pinter.
Garnsey, E. and J. McGlade (eds) (2006) *Complexity and Co-evolution: Continuity and Change in Socio Economic Systems*. Cheltenham: Edward Elgar.
Godoe, H. (2000) 'Innovation Regimes, R&D and Radical Innovations in Telecommunications', *Research Policy* 29(9): 1033–46.
Henderson, R. and K. Clark (1990) 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly* 35(1): 9–30.
Henten, A., D. Saugstrup and R. Tadayoni (2004) 'VoIP: A Disruptive Technology?', paper presented at the Center for Information and Communications Technolgies conference, Lyngby, 4–5 November.
Hiler, J. (2002) 'Blogs as Disruptive Tech. How Weblogs Are Flying Under the Radar of the Content Management Giants', URL (consulted January 2008): http://www.webcrimson.com/ourstories/blogsdisruptivetech.htm
Hüsig, S., C. Hipp and M. Dowling (2005) 'Analysing Disruptive Potential: the Case of Wireless Local Area Network and Mobile Communications Network Companies', *R&D Management* 35(1): 17–35.
Isenberg, D.S. (1999) 'Mother of All Disruptions. The Internet Combines Disruptive Technologies of Many Component Markets', *America's Network*, 15 July, p. 12.
Kaye, B.K. and T.J. Johnson (2003) 'From Here to Obsurity? Media Substitution Theory and Traditional Media in an On-line World', *Journal of the American Society for Information Science* 54(3): 260–73.
Knight, D.J. (2001) 'Making Friends with Disruptive Technology: An Interview with Clayton M. Christensen', *Strategy and Leadership* 29(2): 10–15.
Kondratieff, N. (1926) 'Die langen Wellen der Konjunktur' ['The Long Waves in Economic Life'], *Archiv für Sozialwissenschaft und Sozialpolitik* 56(3): 573–609.
Liebowitz, S.J. (2005) 'File-sharing: Creative Destruction or Just Plain Destruction?', Working Paper, School of Management, University of Texas at Dallas, March.
Markides, C. (2006) 'Disruptive Innovation: In Need of Better Theory', *Product Innovation Management* 23(1): 19–25.
MeshNetworks (ed.) (2002) *Fostering Disruptive Technologies*. Maitland, FL: MeshNetworks.
Overdorf, M. and A. Barragree (2001) 'The Impending Disruption of the Publishing Industry', *Publishing Research Quarterly* 17(3): 3–18.
Picard, R.G. (2003) 'Cash Cows or Entrecote: Publishing Companies and Disruptive Technologies', *Trends in Communication* 11(2): 127–36.
Porter, M.E. (2001) 'Strategy and the Internet', *Harvard Business Review* 79(3): 63–78.
Rogers, E.M. (2003). *Diffusion of Innovations*. New York: Free Press.
Rosenberg, N. (1976) *Perspectives on Technology*. Cambridge: Cambridge University Press.
Schumpeter, J. (1934) *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.
Schumpeter, J. (1942) *Capitalism, Socialism and Democracy*. New York: Harper & Brothers.
Schwartz, E. (2003) 'Defining Disruption', *InfoWorld*, 6 January, p. 1.
Steppuhn, T. (2003) *Die Bedeutung von Wireless LAN in der Mobilfunkbranche: eine Analyse auf Basis des Disruptive Technology Frameworks* [*The Importance of Wireless LAN in the Mobile Communications Industry: an Analysis Based on the Disruptive Technology Framework*]. Regensburg: Diplomarbeit, Universität Regensburg.

Stoneman, P. (ed.) (1995) *Handbook of Innovation and Technological Change*. Oxford: Blackwell.
Utterback, J.M. (1994) *Mastering the Dynamics of Innovation*. Boston, MA: Harvard Business School Press.
van Horn, R. (2002) 'Disruptive Technology', *Phi Delta Kappa* 83(7): 492–4.
Wikipedia (2005) 'Disruptive Technology', URL (consulted January 2008): http://en.wikipedia.org/wiki/Disruptive_technology

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