

Chapter 2

Convergence

After this short introduction of the motivation for a concept of anticipating converging industries this chapter will focus on the phenomenon to be anticipated. Only few studies have thus far participated in laying a solid theoretical foundation to the industry convergence construct. To partly heal this major shortcoming the present study will try to contribute to this foundation in so far as it is relevant for anticipating convergence. First the term's historic applications will be discussed followed by its fundamental aspects a review of definitions by preceding researchers then its definition delineation in the present study. Second an array of different triggers drivers is derived from literature before compiling them into a comprehensive classification scheme. Third in a case study approach different examples of industry convergence are characterized on the basis of the derived classification. Finally this chapter is concluded by a brief analysis of the convergence process itself its individual steps. In summary this chapter will address the questions:

- What is convergence?
- Why does convergence happen?
- Where does convergence happen?
- How does convergence happen?

In doing so, this chapter will introduce delineations and definitions for the central aspects of this study, while at the same time providing a literature review of the thus far rather scarce and scattered literature on convergence.

2.1 Definition and Delineation of Convergence

2.1.1 Concept of Convergence

Although ‘convergence’ has been attested “broad implications for economic welfare” [1, p. 1079], it has at the same time been coined “an often used but rarely defined”¹ [3, p. 5] buzzword [cf. 4, p. 2; or 5, p. 13] by authors aiming at developing a comprehensive definition for it. This section will focus on uses of and definitions for this term and delineate it from other terms used in the same context. The use of ‘convergence’ in the English language dates back to the seventeenth century. It is of Latin origin “convergere” (inclining together) and its dictionary definition encompasses basic definitions like “(of lines) tend to meet at a point” or “(of a number of things) gradually change so as to become similar or develop something in common” [6, p. 378]. Furthermore, individual disciplines use it in more specialized meanings. Biologists speak of convergence when talking about unrelated organisms that “develop superficially similar characteristics under similar environmental conditions” and meteorologists think of meeting airflows or ocean currents [6, p. 378]. It is used as well in mathematics, natural and social sciences as in computing and economic sciences. More generally it describes the concept of at least two discernible items moving towards union or uniformity or the merging of distinct technologies, devices or industries into a unified whole. A common point in all of these definitions is the emphasis on convergence being a process rather than a steady state. The converging items are ‘inclining’, ‘meeting’, ‘developing’, ‘moving’ or ‘merging’. This longitudinal dimension will also be highlighted in Chap. 3, where the concept for an anticipation of convergence is developed.

Historically it had been applied in mathematics and natural sciences first, before describing a convergence of US and Soviet systems in the political sciences in the middle of the twentieth century [cf. 7, p. 58]. Stieglitz argues the term’s application in so different environments lead to structurally different definitions [cf. 3, pp. 21ff.]. In mathematics ‘convergent’ is defined as “(of a series) approaching a definite limit as more of its terms are added” [6, p. 378]. Thus, it is easily measurable or quantifiable. Consequently, Stieglitz speaks of a **quantitative-exact convergence** definition, which is also applicable to macroeconomics. There it is used in connection with growth rates in productivity or *per capita* income in different societies that are supposed to tend to a common number, based on the influences of exogenously determined parameters. These definitions all share the quantitative perspective, where convergence can be objectively identified and even measured, as it is solely based on numbers and facts. Contrastingly, biology and the social sciences employ a **qualitative-heuristic convergence** term. In biology, exogenous factors influence initially genetically different organisms to develop

¹ Amongst those who criticize the lack of a clear definition are also [2, p. 2224], who mention a wide range of definitions from “easily understood to scientific approaches”.

similar physiological characteristics in a similar environment. As these characteristics are present in completely distinct organisms and may be structurally different, they cannot be measured in a mathematical sense. The same holds true for the social sciences, where convergence is being discussed as a result of similar problems in similar environments leading to similar solutions in different societies or groups [cf. 3, p. 22]. Accordingly, Sorokin argues that the US and the Soviet systems would be beginning to exhibit institutional similarities due to the necessities and the influence of a growing degree of industrialization [cf. 3, p. 22]. Stieglitz sees a central difference between the quantitative and the qualitative convergence definitions in respect to the degree of forecastability of developments. Whereas the quantitative-exact view implies a high degree of determinism, this would be a lot less the case in respect to the qualitative-heuristic view. There, serendipitous reactions to environmental impacts make a precise forecast impossible [cf. 3, p. 23].²

The first use of convergence in a managerial context is attributed to Rosenberg, who in his article on technological changes in the machine tool industry in the second half of the nineteenth century coins the expression of “technological convergence” in contrast to “sequences of parallel and unrelated activities” [8, p. 423]. He employs the phrase to describe processes that are commonly used by different (unrelated) industry sectors and different stages of tool production. While pre-industrial economies had seen a necessity for rather specialized skills to assemble any final product, these techniques had become more and more generic during industrialization. Thus, completely different machinery and metal-using sectors—from firearms to bicycles—had begun to share a common technological basis. 8 years later, Oettinger for the first time invented a hybrid term to describe an area of convergence between computers and telecommunications—“communications” [cf. 9, p. 74], claiming that both areas had become so inseparable that it was time to fuse their names as well. Farber and Baran, in their 1977 Science article, add to the evolving talk about convergence in computers and telecommunication and predict “a large number of new industries” to emerge [cf. 10, p. 1166]. This academic viewpoint was at the same time complemented by a growing industrial awareness for convergence. The Nippon Electric Company (now NEC) estimated a convergence between computers and communications to occur by 1990 [cf. 11, p. 26]. In 1978 MIT (Massachusetts Institute of Technology) researcher Negroponte became the pioneer in depicting convergence. He used three circles labeled with the three industries and technologies of computers, broadcasting and printing that he described to be overlapping nearly completely by 2000 [cf. 7, pp. 58f.; 11, p. 25; 12, p. 25]. Shortly afterwards, Apple’s then CEO (Chief Executive Officer) Sculley

² Consequently, this study largely follows the quantitative-exact approach, with limitations regarding the degree of determinism. Convergence within the present study is not viewed as an unavoidable result of outside impacts. Even when taking an industry insider perspective, managers and other stakeholders can exert substantial influence on the course of events. See Sect. 2.2 for an overview of triggers and drivers as well as Sects. 2.3 and 4.3 for a discussion of the role of individual actors within possible cases of convergence.

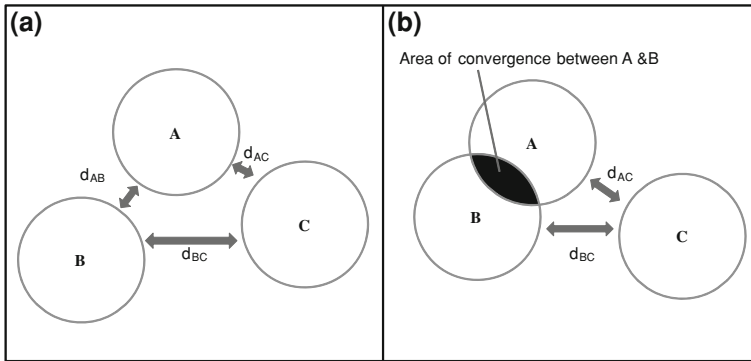


Fig. 2.1 The process of convergence, depicted in two states (time t_0 and t_1). **a** *Status quo* at time t_0 . **b** *Status quo* at time t_1 (Source Adapted from [13, p. 28])

used a similar figure to embed his idea of Apple’s future position. He used boxes to illustrate seven individual industries from media/publishing to computers, office equipment and distribution representing the situation in 1980. For the year 2000 he expected overlaps between these seven areas, with new industry segments like “Interactive News” where the old ones had overlapped. He labeled the whole figure “convergence” [cf. 7, p. 59]. Figure 2.1 depicts a similar concept. Areas A, B and C (Fig. 2.1a) represent different and initially disjoint fields like science disciplines, technologies, markets or industries. Their circular geometry is only an arbitrary illustration; others have used other forms such as ellipses. Each area contains all the items belonging to this particular field. Depending on the level of analysis, such an area might be seen from an individuals’ perspective and thus be constituted by all the scholars conducting research in the respective field. Or it might be regarded as a field in the sense of all the scientific publications in it. Consequently, the distance between each of the areas cannot be calculated on a general basis.³ But basically Fig. 2.1b shows a difference in the distances between the three areas. Whilst A&B have begun to overlap, the distances between A&C (d_{AC}) and B&C (d_{BC}) are more or less unchanged.

Besides any needs for further specification, Negroponte’s illustration is an easily comprehensible way to graphically explain what happens in converging fields. This is of even greater interest, as the breadth of what is to be understood as convergence varies greatly by author [cf. 3, p. 5]. Some limit their definitions to just one industrial field [cf. 14, p. 9]. Nyström, e.g., in her study on convergence in the Finnish telecommunication industry, initially defines it as the “merging of the three sectors of telecommunications, media and information technology” [12, p. 8].⁴ Only later in her text she acknowledges the fact that this would be too

³ Chapter 3 will provide a more detailed discussion of possible measures to calculate the size of each of the areas and the distances between them.

⁴ Nyström in her definition refers to a green paper by the European Commission [15, p. 1].

narrow an explanation and that convergence is affecting other industries as well [cf. 12, p. 25]. Accordingly, Stieglitz criticizes that the market-oriented strategy stream views technological convergence solely in connection with developments in the ICT (information technology, consumer electronics and telecommunication⁵) industries [cf. 3, p. 15].⁶ This concentration on ICT is being driven by three factors. First, in many studies industry convergence—or even convergence in general—is equaled with technological convergence. Possibly the most prominent technological convergence is the digitization of information in any form. And the momentum of the digitization has been a central enabler of changes in the ICT industries. Second, it has seen huge mergers and acquisitions which in turn caught the attention of scholars and the general public. Third, the changes that are happening around devices, services and technology in ICT affect everyone. People realize that their phones have changed as much as the way in which they communicate with other people, buy their goods or conduct their daily business. Thus it appears to be quite natural to focus on developments around these industries. It is reflected by the number of studies on convergence in ICT. In contrast to this ICT-focused approach, other scholars are discussing convergence with respect to different industries and on a more general level.⁷ Section 2.3 will delve deeper into ICT and other examples of converging industries.

But if convergence does not refer to one single case, a concrete definition becomes even more necessary. In Rosenberg's early seminal work a foundation for the commonplace (mis-)understanding of industry convergence equaling technological convergence is laid. While in many cases like the ICT industries, technological convergence and industry convergence will be strongly related, they are still not interchangeable [cf. 12]. The OECD (Organisation for Economic Co-operation and Development) in a 1992 report on developments in telecommunications and broadcasting acknowledged that “the term ‘convergence’ has become something of a buzzword in the information industry” and that processes on a further three levels would need to be taken into account: networks, services and corporate organization [cf. 5, p. 13]. But it entails even more facets, including science convergence, demand convergence and convergence in regulations. Consequently, definitions mirror these different levels of convergence. And even ‘levels’ might be a misleading word. While some of the different forms of

⁵ A plethora of different definitions exists for the abbreviation ‘ICT’. Within this study, it is used to encompass the three broad sectors of computers and information technology (I), consumer electronics and media appliances (C) and telecommunication devices and technology (T). They have in common the generation, processing and storing of (by now) digital information. On a more content-related note, also media and broadcasting should be taken into account when discussing developments in ICT (see, e.g., [16]). Other abbreviations describing similar developments include TIME (telecommunications, information technology, media and entertainment) and TMC (telecommunications, media and consumer electronics).

⁶ Others, like [14, 17, p. 9], share this criticism.

⁷ These include but are not limited to [4, 7, 14, 16, 18–26].

convergence are clearly inclusive of some others, a few are somehow detached from most forms. The present study is conducted on the basis of an understanding of a sequential structure of science, technology, market and industry convergence.⁸

To develop a comprehensive definition as a foundation for the analyses in this study, it is important to delineate prior works regarding these facets. One part is representing different *loci* of convergence⁹:

- **Science** Different scientific disciplines or areas
- **Technology**¹⁰ Central technologies of different application areas
- **Market** Markets for different sets of demands
- **Corporate organization** Companies being unattached to each other and active in different markets
- **Industry** Set of companies with (partly) different technology bases, different application fields and different target groups

All of them are possible answers to the question *On what level is convergence happening?* and are partly related or dependent on each other. The nature of their hierarchical interdependencies is the starting point for the sequential process of convergence, which is being introduced in Sect. 2.4. An additional part of facets is answering the question *What is the result of convergence?* concentrating on the type of convergence result:

- **Product** Combination of hitherto disjoint products functionalities
- **Service** Different services combined into one
- **Demand** Customers' demands traditionally being met by different companies/industries
- **Regulation** Regulation for different services or products in their respective applications

Traditionally, convergence has mainly been discussed in connection with products or services, but some papers also address the demand type of

⁸ See Sect. 2.4 for a detailed discussion of this sequential structure.

⁹ A short description for the pre-convergence status of each of the *loci* is given in parentheses.

¹⁰ As a convergence of networks (e.g., networks for cellular phones, cable television and broadband) represents only a form of technological and/or market convergence, it is not included in the selection of *loci*. Müller [27, pp. 40ff.], distinguishes further between technology convergence and functional convergence as sub-types of market convergence. In his view technological convergence describes a merger of different technologies hitherto used. Following his line of argument, functional convergence leads to a combination of different functions (and mostly products) into one new device. As this study is aiming at developing a concept for the anticipation of convergence, only a clear distinction between different *loci* of convergence will enable a stepwise employment of the concept (see Sect. 2.4 for a more detailed argumentation for this sequential structure).

convergence. The European Commission speaks vaguely of “interacting with society” [15, p. ii]. Pennings and Puranam label it “demand side convergence” and discern between two archetypes. The first refers to converging customer demands in different parts of the world. This, in their view, leads to a “uniform set of needs” and global markets [cf. 25, p. 6]. The second describes demand convergence as it is understood within the present study, as a growing tendency of customers towards ‘one-stop shopping’—the wish to buy products or services satisfying multiple needs. This **demand-side convergence** is complemented by what Pennings and Puranam call **supply-side convergence** [cf. 25, pp. 6ff.]. Following a similar perspective, Bröring concludes that only the co-occurrence of technology-driven input side convergence and demand-driven output side convergence leads to the emergence of new inter-industry segments between or instead of at least two distinct industries [cf. 20, p. 80]. Bröring also stresses the importance of convergence in regulation [cf. 20, pp. 79f]. She views it as a possible trigger as well as a possible outcome of convergence processes. On the one hand, changes in regulation can lead to changes in industry structure.¹¹ On the other hand, new areas of convergence may make changes or even an initial introduction of regulation inevitable.¹² Products are probably the most naturally accepted outcome of convergence. Smartphones, e.g., have reached a status where they incorporate not only phone and text message functionalities, but also commonly cameras, radios, web browsers, e-mail and even GPS (Global Positioning System). Thus, consumers can conduct an array of different tasks with their smartphone, instead of carrying about a dozen different devices. Such a convergence outcome is present in peoples’ everyday life as well as very physically graspable. So, a large share of the limited amount of literature on convergence contains product convergence examples cf., e.g., [1, 3, 4, 7, 12, 14, 20, 24–26, 28–33]. But additionally to products as outcomes, new services may also be a result of convergence. This tendency to underestimate the importance of the service sector is somewhat similar to discussions within the broader innovation management literature [cf. 34, p. 1]. For instance, Tidd and Hull criticize that we know “comparatively little” about organization of new ‘product’ development in service sectors [cf. 35, p. 3]. And this is the case, although an increasing amount of the real economy is based on services rather than products [cf. 36, pp. 1f.], especially in the so called ‘developed nations’. Statistics for the USA, the UK or Australia list a

¹¹ An example for such a convergence-enabling change in regulation is the ICT area. Privatization of formerly state-owned companies led to a reshuffling of companies and their portfolios in most countries. See Sect. 2.3 for more details on this.

¹² Biotechnology is a good example for such a regulation-demanding convergence. New technological possibilities may lead to a myriad of legal and moral questions and challenges. This is especially the case when dealing with gene technology and issues such as embryonic stem cells or the cloning of animals or humans. Differing from country to country, policy makers have set up more or less tight guard railings. See Sect. 2.3 for more details on this.

share of nearly 80, 75 or 70 %, respectively, of the gross domestic product (GDP)¹³ provided by the service sector [cf. 37].¹⁴ Hence, new ideas, insights or combinations may lead to either new products or services—or even both. Staying with examples from ICT, phone calls may be placed through more traditional means like landline phones or cell phones, but may also be conducted via VoIP (voice over internet protocol) services. The service of letting two or more people talk to each other is increasingly being detached from certain, dedicated devices. Consequently, many of the studies and reports on convergence have acknowledged the importance of service convergence cf., e.g., [1, 5, 7, 12, 14, 15, 20, 24, 32, 33].

2.1.2 Literature Review on Definitions of Convergence

As briefly mentioned in Sect. 2.1.1, most of the papers and books on convergence use their own definition—if the term is defined at all. A rough selection of the most important ones will be provided in the following before developing a comprehensive one on their basis. Included will be also the term ‘fusion’ or ‘industry fusion’ that has been used by some scholars to describe similar ideas. This overall definition will serve as the foundation for the development of an anticipation concept in Chap. 3.

Amongst those that define convergence, there are those that focus solely on ICT. Accordingly, Fransmann describes convergence as “paradigmatic changes [...] in the information, communication and entertainment areas” [33, p. 35]. Similarly, Borés et al. restrict their delineation to ICT, but are apparently less convinced that it actually happens. They view convergence as “a process by which the telecommunications, broadcasting, information technologies and entertainment sectors [...] may be converging towards a unified market” [38, p. 1]. Interestingly, the breadth or scope of definitions does not show any clear trend over time. Neither a generalization nor a specialization tendency can be extrapolated from the different contributions over time. For example Yoffie employs a broader definition earlier than Fransmann or Borés et al. He emphasizes the importance of a shared functionality as well as a set of base technologies: “the unification of functions—the coming together of previously distinct products that employ digital technologies” [39, p. 2]. This output-oriented take on functionality is shared by Gill, who

¹³ GDP = gross domestic product; value of all final goods and services produced within one nation (or group of nations) in one given year.

¹⁴ Interestingly, there are some noteworthy exceptions to this general rule. For example, Norway’s service sector share amounts only to about 54 % and Ireland’s to 49 %. Whereas most countries with high per capita GDP exhibit a share of the agricultural sector somewhere between 1 and 2 %, this number is 5 % for Ireland. For the whole world, the distribution is 4 % agricultural sector, 32 % industrial sector and 64 % services sector. Many poor nations are a lot more dependent on the agricultural sector, with Liberia marking the highest number of nearly 77 % (5 % industry and 18 % services).

views convergence as “the addition of disparate new functionalities to existing base products” [cf. 40]. According to Stieglitz, a distinction should be made between convergence as a state and convergence as a process. [cf. 3, p. 23]. After discussing a selection of market convergence types, he concludes with his definition of market convergence as a process of qualitative change leading to the combination of two or more formerly disjoint markets [cf. 3, p. 32]. Most studies inherently deal with convergence as a process, but only few acknowledge the decisive difference. This perspective also has important implications for measuring convergence. If it is a process, it does not make much sense to try to assess a degree of convergence at one point in time. Only when following a longitudinal approach, differences in the degree of overlap between the involved areas can be calculated. Section 3.4 will discuss possible measures for estimating degrees of convergence. It will be followed by a more comprehensive concept for measuring and anticipating convergence, based on longitudinal data collection.

Bally sums up earlier works to a quite comprehensive definition of technological convergence: “the growing together of technologies, which fundamentally alters the boundaries of previously distinct industry or market sectors and merges them into a new competitive environment” [14, p. 13]. In contrast to this, Lind defines it within his study only with respect to market convergence as being “a confluence and merging of hitherto separated markets, removing entry barriers across the market and industry boundaries” [16, p. 1]. He emphasizes the difference between his definition and the widespread belief that industry convergence would lead to separate industries merging into one big converging industry [cf. 4, p. 2; 16, p. 1]. In a later paper he adds an alternative, very broad definition: “a market/industry definition generated by technological change” [4, p. 1]. Complimentary to technology and market convergence, Bröring focuses on industry convergence leading “to an overlap of two formerly separated industries starting to produce similar products” [20, p. 76]. In the following she also incorporates fusing technologies that form [4] new products or product categories. Albeit adding to this industry perspective, Choi and Valikangas broaden it to a blurring of “boundaries between industries by converging value propositions, technologies and markets” [41, p. 426]. Although the OECD report on telecommunications and broadcasting brands convergence a buzzword “which is high on concept, but low on content” [5, p. 13], it defines it simply as the “blurring of technical and regulatory boundaries between sectors of the economy” [5, p. 13]. Thus it follows the line of industry convergence, while at the same time stressing more unusual influencing factors such as regulation.

Another group of scholars detaches its definitions from too industry- and technology-focused viewpoints. Pennings and Puranam emphasize that “convergence between previously disjointed markets can be viewed as the erosion of boundaries that define and isolate industry-specific knowledge” [25, p. 3]. But they do not specifically define convergence. Hacklin follows this approach and defines (besides other forms of convergence): “Knowledge convergence denotes the emergence of serendipitous co-evolutionary spillover between previously unassociated and distinct knowledge bases, giving rise to the erosion of established boundaries that isolate industry-specific knowledge” [11, p. 57]. Interestingly, knowledge is already a

broader term than technology and leads to the question of convergence on levels uncoupled with commercial activities. While most definitions focus on markets, industries and technologies in connection with their application in new products or services, some scholars also see the importance of extending this construct to changes in knowledge bases or scientific disciplines. Accordingly, Guilhon sees convergence as “the process by which the application of the same scientific concept allows the putting together of two or many fields of activity” [42, p. 33]. Here the independence of technological aspects plays a crucial role. The notion of science convergence will be discussed further in [Sect. 2.4](#).

Finally, while stating that convergence “eludes precise definition”, a Green Paper of the European Commission describes it as “the ability of different network platforms to carry essentially similar kinds of services, or the coming together of consumer devices such as the telephone, television and personal computer” [15, p. 1]. This is an example for the kind of definitions provided in most texts on convergence. Most of them are either rather fuzzy (like the OECD definition) or they explicitly focus on a rather limited scope. Most likely Nyström’s final definition is the one closest to the scope of this study. After a detailed overview of different definition approaches she concludes: “Convergence is a change process initiated by technological, socio-economical and organizational forces, removing or changing traditional industry borders, framing and enabling new resource constellations and eventually leading to industry convergence in the form of sub-industries, new business ecosystems and new markets” [12, p. 52]. Against this background, this study considers convergence on all levels (e.g. science, technology, market or industry), in respect to all results (product/service, demand, regulation), all application fields,¹⁵ and inclusive of what has been termed ‘fusion’.

2.1.3 Delineating Convergence from Fusion

Bierly and Chakrabarti refer to a state of ‘industry fusion’ as “industries that are without clear boundaries and are continually combining with other industries” [19, p. 35]. They argue that while many industries have not yet entered the “industry fusion stage”, they will in the near future. Other industries, like the ICT, the pharmaceutical or the financial services sectors are already in the middle of this process. They further develop their concept of managing a company affected by industry fusion and thus add to the aforementioned definition. Such companies will have to employ new knowledge from different areas, will have to face new and very strong competitors from different sectors and hence will engage in mergers, alliances and licensing deals. Especially the challenge to deal with “so many knowledge areas” [19, p. 41] and to successfully integrate new knowledge in the company is nearly unimaginable—if not done in connection with close collaboration of any form with other companies [cf. 18, pp. 10f.; 19, pp. 35ff.].

¹⁵ For an overview of fields prominently affected by convergence see [Sect. 2.3](#).

While Bierly and Chakrabarti do not delineate fusion from convergence, Adner and Levinthal do. To them convergence is a process, “in which the common domain is an application domain in which one of two antecedent technologies is already applied” [43, p. 64]. Fusion is something that two technologies undergo, with “the resulting technology” being “applied to a new domain” [43, p. 65]. In contrast to their opinion, ‘fusion’ has etymologically a slightly different meaning. Just like ‘convergence’ it is of Latin origin (“fundere”—pour, melt), but fusion is defined as “the process or result of joining two or more things together to form a single entity” [6, p. 704]. Whereas the earlier is mainly being used for objects that move towards each other and form one single entity somewhere else, the latter is covering complete melts of objects in the very same spot. Adding to a basic perception of fusion, Kim distinguishes between two main types of technology fusion. First, fusing across technologies (either basic and applied or applied and applied), relating mainly to the employment of a different technology base within a given technology. Second, fusing across industries (either among neighboring or non-neighboring sectors), which describes technology fusion in the sense of blurring industry boundaries. Whereas the first definition would not be coined technology fusion by most, it is easily understandable against the background of Kim’s study. Discussing different possibilities to reflect fading boundaries in university education, technology fusion according to his definition still requires universities to set up blended teaching schemes with courses from a wider array of disciplines [44, pp. 222f.].

2.1.4 Defining Convergence and Fusion

A definition within this study should entail convergence as well as fusion, as both are grounded on a similar idea—the blurring or fading of boundaries. When identifying early warning signals, every possible point of information should be taken into account. Thus, all *loci* of convergence will be included, whereas drivers and triggers are only an additional feature of the definition. They will be added at the end of Sect. 2.2. Furthermore, as will be discussed in Sect. 2.4, convergence does not necessarily imply the development of a new industry. In some cases industry areas or, e.g., scientific disciplines may create a new area of collaboration, without changes in the antecedent areas and even nothing more than loosely coupled to them. In addition to Fig. 2.1, these areas will in most cases be heterogeneous forms with some of the tentacles beginning to move towards each other (Fig. 2.2). This may mean a movement from both¹⁶ areas, but as well only one of the fields may be evolving their expertise further in such a direction.

¹⁶ When speaking of ‘two areas’ or ‘both’, this is only the smallest possible number. Convergence may as well happen between three or more areas, of course. But for increased legibility ‘two’ will always represent ‘at least two’.

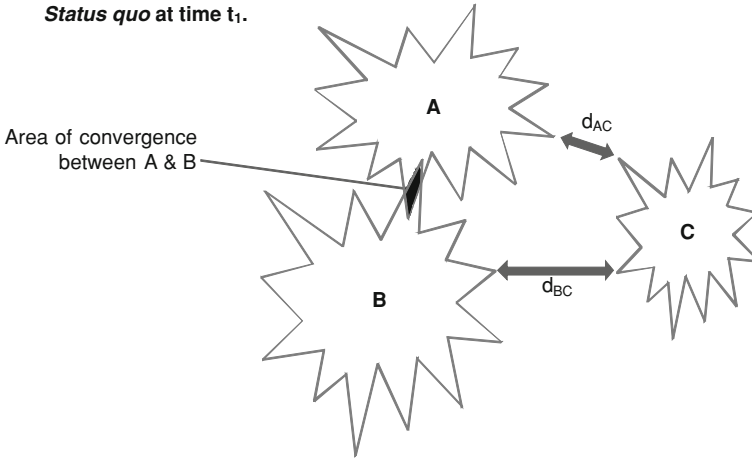


Fig. 2.2 Convergence of non-circular areas A&B, still completely distinct from area C (Source Own figure)

To differentiate convergence from fusion this study delineates the terms as follows:

Convergence describes a process, where objects move or stretch further from their prior and discrete spots, to a new and common place.

Fusion describes a process, where objects begin to merge with each other in the very same place of at least one of the objects.

Hence, the difference lies in the movements of the objects. For example, industries would be labeled ‘converging’, if they (or parts thereof) began to merge with each other in a new field. This field would have to not have been part of any of the hitherto distinct industries. In contrast to this, industries would be labeled ‘fusing’, if the new replacing segment or sub-segment would substitute (parts) of the prior segments.

Accordingly, Nutraceuticals and Functional Foods can be interpreted as an example of convergence, as they are replacing neither the demand for nutrition nor the demand for full-scale medication.¹⁷ On the other hand, smartphones are a fusion¹⁸ product of cameras, cellular phones and portable computers (etc.). All of the attached demands had been fulfilled prior to the fusion process. Afterwards a new sub-segment of the established industries was created in the spot of the hitherto disjoint devices. Figure 2.3 depicts the difference with an illustrative example. Figure 2.3a (at time t_0) consists of the two disjoint areas A&B separated

¹⁷ See Sect. 4.3 for a more thorough explanation of NFF as an example for convergence.

¹⁸ This delineation is not reflected in other researchers’ works. As discussed, most appear to not discern between both terms at all. For studies explicitly dealing with fusion see, e.g., [18, 19, 44–46].

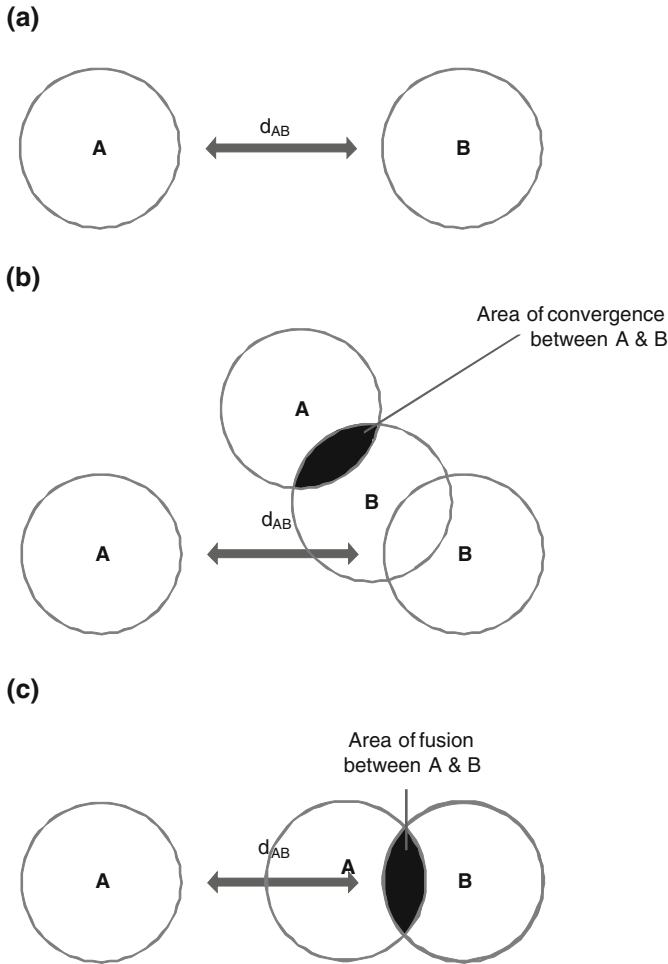


Fig. 2.3 The process of convergence (a/b) graphically delineated from the process of fusion (a/c). **a** Status quo at time t_0 . **b** Status quo at time t_1 -convergence. **c** Status quo at time t_1 -fusion. Source Own figure

by the distance d_{AB} . Upon reaching a convergence status at time t_1 , both areas (or parts thereof) have moved to a common new spot, demonstrated by their old positions, depicted in the background (Fig. 2.3b). Contrasting this situation, Fig. 2.3c shows a fusion scenario. B has not moved at all, but is rather merging with A in its own spot.

Consequently, building on the notion of Nyström and the aforementioned convergence/fusion¹⁹ delineation, this study defines convergence in a managerial context as:

***Convergence [fusion]** is a blurring of boundaries between at least two hitherto disjoint areas of science, technology, markets or industries. Through this convergence [fusion], a new (sub-)segment is being created in a new spot [the same spot] as a merger of (parts) of the old segments. It is marked by an increase of interchangeability and connectedness between the respective areas, as can be seen in collaboration, licensing, patenting or publishing behavior.*

2.2 Triggers and Drivers of Convergence

2.2.1 Differentiating Between Triggers and Drivers

After arriving at a definition for convergence and fusion within this study and before looking at examples of convergence and its progress, it is imperative to question what causes it.²⁰ Causes of convergence are commonly referred to as drivers or triggers. First of all, it should be distinguished between triggers and drivers. Incidents and developments may be seen as clear **triggers** of convergence, but they may not necessarily **drive** its further development. Whereas literature tends not to discern between the two,²¹ this chapter will try to delineate the one from the other. The Oxford Dictionary of English lists as one definition for ‘driver’ “a factor which brings about or sustains a particular phenomenon” [6, p. 531], even though its original Germanic meaning is “urge (a person or animal) to go forward” [6, p. 531]. In contrast to this, ‘trigger’ is listed to mean “an event that is the cause of a particular action, process, or situation” [6, p. 1884]. Hence, within this study a distinction will be made between:

¹⁹ As the present study aims at developing a monitoring concept for a blurring of boundaries, both cases are of high interest—convergence as well as fusion. As the concept will not discern between convergence and fusion, fusion will always implicitly be addressed when convergence is mentioned—if not stated otherwise.

²⁰ Barriers for convergence processes could be discussed together with the triggers and drivers. But this will not be explicitly done within this study. Most barriers mentioned in literature thus far are somewhat inverted drivers, if addressed at all see, e.g., [12], including organizations’ inability to adjust to convergence effects or regulation stopping firms from entering new markets. Thus, potential barriers are to a large extent inherently addressed when talking about triggers and drivers. Furthermore, this study does not view convergence as a kind of natural force happening if not stopped. On the contrary, it interprets convergence as something that has to be actively driven in order to finally prevail.

²¹ Pennings and Puranam, for example, even combine both terms to: “We attempt to identify a range of drivers that trigger the onset of convergence.” [25, p. 3].

A **trigger** *denominates an event or situation that sets off a certain sequence of reactions.*

A **driver** *denominates a series of events or a situation that sustains a certain sequence of reactions.*

For instance, when looking at the launch of a rocket, the **trigger** would be the ignition spark, whereas the launch would be **driven** by the constant burning of the propellant. Following this delineation, triggers of convergence include inventions, instant regulation changes or demand shifts, the unavailability of necessary raw materials and other sudden events. Drivers of convergence can be seen in slower and more constant developments. These can be based on technological changes, modifications of business *foci* and *loci*, policy alterations or changes in customer structures. It can be argued that the convergence processes in ICT are triggered (amongst others) by inventions on the technological side, rather bold moves of single companies—like Apple’s decision to enter the cellular phone market—and policy shifts such as the privatization of hitherto state-owned telecommunication monopolists. But what drives the ICT convergence is much more a constant digitization, miniaturization and the tendency of customers to buy multi-purpose devices. [Section 2.3](#) will shed more light on triggers and drivers for convergence in individual cases.

2.2.2 Literature Review on Triggers and Drivers

Concentrating on a classification of triggers and drivers, most scholars have mentioned a comparable set of triggers/drivers.²² But nearly all of the contributions have thus far only very briefly addressed the question of antecedents of convergence [cf. 11, p. 38], if at all. A clustering of prior research into streams of literature proofs especially difficult in this context as most authors use their own terminology and classification schemes. Notwithstanding this challenge, the remainder of this chapter will try to reflect the most important contributions to literature’s discussion of influences on convergence. Starting with rather simple and mono-causal views, it will become more complex before channeling the different works into one more comprehensive perspective. On a general level, the listed examples include causes based on:

- Technology
- Business models
- Market structure
- Regulation and legal issues
- Societal developments

²² As most researchers do not discern between triggers and drivers, this chapter will start with listing examples from the literature without a further classification. At the end an overview will be provided, delineating the mentioned triggers from the potential drivers of convergence.

A first part of the literature provides rather narrow, nearly mono-causal drivers/triggers. While most articles feature possible gains from the convergence phenomenon, Bainbridge's work on scientific convergence stands out for its particularly positive tone towards fading boundaries and even "unifying science". This may as well be rooted in a neglect to discuss possible negative effects as in the focus on (far from commercialization) fundamental research. Consequently, he speaks of mathematics as a universal language and new tools 'helping' researchers to turn to adjacent fields for possible solutions to their challenges [cf. 47]. Similarly positive are Yasunaga et al., working for the Japanese Ministry of Economy and examining ways to promote and further technology convergence. Whilst not really providing further insight into potential triggers and drivers, they are discussing possibilities to sustain convergence through the use of grants and road-mapping [cf. 48].

As the first to use convergence in a managerial context, Rosenberg focused solely on technology as a cause for convergence. In his view, the increasingly ubiquitous use of machinery and metal working technologies led to a close relationship of industries hitherto completely distinct [cf. 8, p. 423]. Von Tunzelmann attributes trends of convergence in telecommunications and computing to the similarities between hardware and function. Computers began to be as much connected through networks as the telecommunications sector switched from analogue technology to computerized processing [cf. 28, p. 125].²³ Taking a little broader perspective, Kim lists three reasons for fusion on industry level: constantly growing complexity of customer demands, surmounting demand limits and blending manufacturing with advanced services (such as renting or consulting). Interestingly, all of these are rooted in the demand sphere [cf. 44, p. 223].

A second part of the literature introduces also a second set of causes. For instance, Bierly and Chakrabarti list the increasing rate of technological diffusion (caused by easier and wider access to information) as well as the globalization of markets (leading to shorter product life cycles and a need for more effective innovation activities) as the main reasons for convergence [cf. 18, p. 7; 19, p. 35]. Concentrating on developments affecting the computer games industry, Ip identifies drivers of convergence to increasingly stem from market convergence and the complexity of content [cf. 49, p. 220]. Interestingly, most researchers who see changing demands as a main driver for convergence do not differentiate between B2B (business to business) and B2C (business to consumers) customers.²⁴ A deviant approach is voiced by Myring. In his opinion—due to differing economies of scale and technological expertise between both groups—technological developments are often driven by businesses first and only later by consumers [cf. 32, p. 7].

²³ Also, Duysters and Hagedoorn, argue in a similar fashion [cf. 30, p. 356].

²⁴ Business-to-business (B2B) delineates business transactions between businesses (e.g., wholesaler/retailer or manufacturer/wholesaler) from transactions between businesses and consumers (B2C) or governments (B2G).

Gambardella and Torrisi see technological convergence being prompted by an increasing importance of “generic technologies”. In spite of their applicability in different markets or products, the authors identify the problem of many companies to be able to get used to new “value networks”. They further emphasize the role of the individual company in highlighting companies’ influences. According to their line of argument, more complex products are not always the result of inevitable changes in technological knowledge bases, but sometimes rather a way to generate more income through selling multi-technology devices [cf. 50]. Finally, Bally classifies the influencing factors as either being internal or external factors. In this classification, technologies, innovation and management constitute internal factors, whereas technological change, regulation and customers’ demands represent the main external factors. As compelling as this dichotomy is, the delineation of ‘technologies’ from ‘innovations’ and from ‘technological change’ remains somewhat unclear [cf. 14, pp. 9f.].

Yoffie as a representative of the third group of authors focuses his explanation of the convergence phenomenon on three main drivers. Next to the widely accepted drivers (de-)regulation and technological change, he puts large emphasis on what he calls “managerial creativity”. Against the background of a strong impetus of technological change in computers and communications, large multinational corporations like Sony or International Business Machines (IBM) had still failed in “forcing convergence” due to missing creative products or services. In contrast to this, smaller start-ups were more successful in off-setting convergence through innovative products [cf. 2, 39]. Although Kaluza et al. follow Yoffie’s introduction of three main drivers, they discern between drivers and triggers. According to them, the effects of dramatically reduced telecommunication costs were “triggered by the breakup of AT&T (American Telephone and Telegraph Company)” [2, p. 2225], leading to further convergence in ICT. In spite of largely adhering to Yoffie’s classification and acknowledging the particular importance and acceptance of “digital technology” as a driver, they criticize the lacking consent among scholars on the central drivers behind convergence [2, p. 2245]. Contradictory to this assessment is Rikkiev and Mäkinen’s take, who see external environmental forces as well as internal company actions as consistently listed by several authors [31, p. 375].

Pennings and Puranam differentiate between “sudden surges of convergence”, such as those caused by deregulation and delayed convergence developments. In their opinion, socio-economic developments and changing demographics are particularly slow triggers/drivers. Technological drivers’ pace is depending on the structural parameters and the characteristics of the technological innovation [cf. 25, p. 3]. Again, Katz identifies three classes of drivers: technological developments, “evolution of business thinking” and regulatory changes. For the blurring of boundaries in ICT, technological change (especially digitization) is one of the central drivers. But in his view, convergence in ICT has moved from being mainly supply-side driven to a more demand-side phenomenon. Convergence started on the basis of a mere possibility to change technology before being a lot more dependent on users’ interests. Katz discusses regulation not so much as a

driver but rather as a barrier to convergence. In ICT, e.g., regulation distinguished for a long time between telecommunication and enhanced services, forcing their separation. Furthermore, mono- or at least oligopolizing the telephone market barred other possible service providers from entering the market [cf. 1, pp. 1082ff.].

In conclusion, developing further this notion of three classes, Nyström discerns between organizational, technological and socio-economic drivers. According to her line of argument, firms have the possibility to cause convergence by seeking new knowledge and new solutions and combining them into something innovative across technological boundaries. Additionally, firms will in most cases be more likely to engage in developments outside their traditional fields of expertise, if their recent past has not been as successful as that of competitors. Technological drivers are said to consist of technological change, digitization and the growing importance of the internet. Finally, Nyström lists socio-economic drivers, including liberalization, regulation and globalization. Interestingly, she does not discuss regulation as only a barrier to convergence (with de-regulation or liberalization as drivers), but also as a driver. Regulations may also be aimed at fostering convergence developments (such as promoting internet services or multi-purpose devices) [cf. 12, pp. 29ff.; 51, p. 1]. Similar to this more complex discussion, Choi and Valikangas regard convergence as one of ten strategic innovation themes, caused not only by deregulation and new customer demands, but also by a “ubiquity of information”. While this is part of other researchers’ discussion about globalization, it adds another perspective to it [cf. 41, pp. 425f.]. It is a combination of globalization (borders become less important and economic systems are becoming more equal), digitization (information flows are increasingly dependent on the flow of bits and bytes) and also changes in consumers’ perception of information. New developments in the information business are concentrating on providing basically all the information at anytime and anywhere.²⁵

The last stream of the literature develops and discusses multi-causal concepts, classifying triggers/drivers along different parameters. Accordingly, Hacklin draws in several works the conclusion that drivers are to be found inside and outside of the respective industries. As one of the scholars dwelling most intensively on triggers and drivers, he argues that “convergence occurs when innovations emerge at the intersection of established and clearly defined industry boundaries, thereby sparking off an evolutionary development with much broader impact” [52, p. 723] (pointing at a trigger). A combination of technological trajectories leads to outcomes with improved performance when compared to the sum of the performance of each part. He also sees a cause for technology as well as industry convergence in the “discontinuity in a globalized industry” [53, p. 317], resulting from a global market, new innovation opportunities due to more and more intersections between technologies, opportunities to establish innovation collaborations, amendments in

²⁵ See also Sect. 2.3.1 for a more detailed description of changes around information technology, media and communication.

regulation and customers' need for more complex solutions and problem solving [cf. 11, pp. 36ff.]. Referring to Theilen, he lists possible triggers as “new technologies, societal change, globalization, liberalization, deregulation, legal change and market-implied changes of existing value chains²⁶” [53, p. 318], but also better opportunities for product-bundling. He delineates technological drivers (the evolution of underlying technologies) from economic drivers (deregulation) in the field of ICT [cf. 53, p. 317]. In his nomenclature—and similar to Bally's classification—endogenous drivers on the firm level are to be separated from exogenous drivers on industry level.

Malhorta and Gupta discern between demand-side and supply-side convergence. Whilst the first is set off by customers identifying substitutive or complementary linkages between products from different industries, the second is initiated by companies delivering goods to two industries. Both the drivers may occur alone or in a combination of both [cf. 24, p. 1]. Although there is arguably a dichotomy between supply- and demand-side drivers, especially their elucidation of what is to be understood as supply-side drivers is rather weak. Taking a more holistic approach, Weaver in his work on the security industry acknowledges technological drivers as being amongst the most important. At the same time, he argues that these are complemented by other causes, such as regulation, standards, business models, demand shifts and the structure of industry channels, which all “tend to be overlooked” a little [cf. 26, pp. 2ff.]. He follows the dichotomy of demand- and supply-side convergence drivers and elaborates further on them. At the same time, he is caught in a ‘chicken and egg’ problem, mixing antecedents and phenomena of convergence [cf. 55, 56]. In spite of these inconsistencies, he adds a few more aspects to the current discussion. As part of technological drivers, there are also the results of ‘Moore's Law’,²⁷ leading to more and more functionalities on an ever smaller chip and the setting and adoption of universal standards. Compellingly, Weaver sees internet protocols as examples for a *de facto* communication standard. Furthermore, he adds firms' internal factors, including entrepreneurial activities and strategic actions [cf. 26, p. 8; 55, p. 5].

Finally, Bröring further refines Malhorta and Gupta's classification and divides drivers into two different groups. First, “**technology-driven input-side convergence**” [20, p. 81] evolves from new technologies, which are applied across different industry sectors. Accordingly, one of the industries may develop a new

²⁶ See also [54].

²⁷ Moore's Law describes a historical trend in computing and is named after Intel co-founder Gordon E. Moore. In his seminal 1965 paper “Cramming more components onto integrated circuits” and later works he predicted that the number of transistors on one single computer chip would double about every 2 years. This forecast has proven to be correct for more than 40 years and is expected to be still valid for the next years. In 1965 an average chip would hold approximately 50 transistors. This number has now reached 2 billion with Intel's newest Itanium processor range “Tukwila”. Closely related to the number of transistors are also related parameters like the size of chip components, the number of calculations per time, memory capacities and the number of pixels on an average digital camera chip [cf. 57, 58].

technology and then this is employed in other industries as well. In this case a new technology **substitutes** an incumbent technology in a different industry. It is referred to as **complementary**, if both industries are developing individual technologies that are combined only later, to form new solutions or products. Second, “**market-driven output-side convergence**” [20, p. 82] is said to occur once customers start to “treat products of different industries in the same way, i.e. products which originally do not stand in any competition to each other start to become substitutes” [20, p. 82]. Just as regarding technology-driven input-side, the output-side convergence can be classified further into substitutive or complementary, depending on the reaction of customers [cf. 21, p. 489; 22, pp. 165f.]. Third, another dimension is added with respect to regulations. Changes in regulations can be triggers or outcomes of convergence. Contrastingly, existing regulation may actually block or slow down convergence. Interestingly, Bröring argues that complete industry convergence will only happen when both input- and output-side occur [cf. 60, pp. 275f.].²⁸ In one paper she introduces different *loci* of convergence as triggers and drivers in their own right. Consequently, she voices her opinion that technology convergence is the “ultimate trigger for industry convergence, whereas market convergence is reinforcing it” [60, p. 276].²⁹ This concept of input-side and output-side bears analogy to the discussion about technology push or market pull as drivers for innovation by Mowery and Rosenberg or Howells [cf. 61, pp. 102ff.; 62, pp. 1209ff.]. While technological developments enable firms to supply the market with new or enhanced products, changes in customer structures and behavior may lead to demand-driven output-side convergence. Reasons for a decisive change on the demand-side include a growing interest in satisfying multiple needs with one transaction as well as socio-demographic developments [cf. 25, pp. 3ff.].³⁰

2.2.3 Classification of Triggers and Drivers

To summarize the prior literature review, Table 2.1 represents a classification of triggers and drivers and their respective sources in literature. Most of the above-mentioned literature focused on individual cases and specific industry settings, largely parts of the greater ICT sector. Bearing in mind that it is not always easy or at all possible to sharply distinguish between triggers and drivers, this is supposed to be a more generalized approach.

²⁸ This is in line with Hauschildt and Salomo’s argument that it takes technology push and market demand for successful innovations [cf. 59].

²⁹ See Sect. 2.4 for an introduction into different *loci* of convergence and their interconnectedness.

³⁰ These encompass developments such as growing customer bases in thus far developing countries, relatively free and global trade or a “homogenization of customer segments due to changing demographics”.

Concentrating on the meta-level, four different clustering schemes appear to be reasonable. As discussed at the beginning of Sect. 2.2, a first distinction should be made between triggers and drivers. While it should be possible in most cases to judge on the pace and stage of an impact (sudden and early = trigger; slower, longer-lasting and later in the process of convergence = driver), this dichotomy alone seems to rough of a classification. Nevertheless, each cause should be assessed in respect to its positioning. The same holds true for the next two schemes. As compelling as the distinction between endogenous (or internal) and

Table 2.1 Classification of triggers and drivers in converging industries

	Triggers	Drivers
Technological	• Combination of technological trajectories yields increased performance [53] • Similarity between hardware and function [28]	• Ubiquitous use of technology [8] • Digitization [1, 2, 12, 41, 51] • Technological developments [1, 14, 20, 26] • Generic technologies [50] • Increased rate of technological diffusion [18, 19] • Ubiquity of information [41] • Technological change [14, 38, 39, 55, 56] • Complexity of content [49] • Growing importance of the internet [12] • More intersections between technologies [11]
Managerial	• Managerial creativity [39] • Management’s actions [14, 26, 55] • Entrepreneurial activities [26, 55] • Rather unsuccessful past of company [12, 30]	• Evolution of business thinking [1] • More complex products as means to generate more income [50] • Innovation [14] • Blending manufacturing with advanced services [44] • Business models [26] • Establishing innovation collaborations [11]
Industrial	• Breakup of companies [2] • Standards (introduced by industry) [26] • Innovations emerging at intersection of different industries [52]	• Companies delivering goods to two industries [24] • Market-implied changes of value chains [53] • Internet protocols as quasi standards [26, 55] • Structure of industry channels [26] • Market convergence [49]
Political	• De-monopolizing markets [1] • Deregulation [25] • Legal changes [11, 54] • Standards (imposed by governments) [26]	• (De-)regulation/liberalization [1, 11, 12, 14, 20, 26, 38, 39, 41] • New regulations aimed at fostering convergence [41] • Grants promoting convergence [48]

(continued)

Table 2.1 (continued)

Triggers	Drivers
Societal	• Customers’ demands [1, 14, 26, 41] • Globalization of markets [18, 19, 41, 53] • Changing demographics [25] • Consumers’ perception of information [41] • Customers identifying linkages between products from different industries [20, 24] • Socio-economic developments [25] • Growing complexity of customer demands [1, 11] • Surmounting demand limits [44]

Source Own table. For sources of individual triggers and drivers the aforementioned studies are listed. They are grouped with a common terminology, if a comparable stance can be assumed. Where no reference is provided, it is an additionally identified trigger/driver. Individual bullet points are sorted by year of oldest reference. The delineation between drivers and triggers is not always provided by original authors. Where no difference was made, it was conducted by this study

exogenous (or external) drivers³¹ is, this only makes sense if it is defined in greater detail. Is the internal perspective that of an industry, an individual firm, or even a specific technology? For instance, following Bally’s classification, technologies, innovation and management would constitute internal factors (similar to Hacklin’s endogenous, firm level drivers). Whereas management actions may convincingly be seen as completely firm-dependent, technology and innovation should also include an outside perspective. Following increasing trends towards “Open Innovation” cf., e.g., [63], this would largely neglect the importance and also the direct influence of innovation partners beyond the factory gate. While these differentiations add an important level of analysis to any discussion on drivers of convergence, their general applicability remains questionable.

Malhorta and Gupta as well as Bröring discuss a differentiation between supply-side (or input-side) and demand-side (or output-side) drivers. Again, it is necessary to specify the entity receiving input or producing output. As convergence is a phenomenon not to be expected on the level of individual companies, it seems to be more appropriate to apply this classification on industry level. First, reducing drivers to be either input- or output-related would leave the industry and company influences unacknowledged. Second, especially when looking at more complex value chains, it could prove to be difficult to generalize across all participants in that industry. The value chain of chemical products, e.g., starts with oil-drilling and cracking before oil is being transformed into base chemicals, specialty chemicals and then eventually final products, such as fast moving consumer goods

³¹ For increased legibility, ‘driver’ will be used for the remainder of this study to describe both, triggers and drivers, if not stated otherwise.

(FMCG). Depending on the parameters, a ‘chemical industry’ perspective would mostly contain the producers of base and specialty chemicals [cf. 63, pp. 123ff.]. Within the chemical industry the use of renewable resources instead of petrochemicals is increasingly being discussed.³² A specialty chemicals producer could switch to renewable feedstocks through either purchasing base chemicals made from renewable or through purchasing them from outside the chemical industry (e.g., from companies in the agricultural sector). In the latter case this would have to be coined an input-side driver, whereas in the earlier case it would come from within the industry. Accordingly, an analysis of output-side drivers would pose similar problems—in spite of the same underlying trend and thus driver. Thus, these dimensions add an important angle to analyses of convergence drivers but appear to fall short of a generalizable and comprehensive classification of causes.

Building on the five areas introduced at the beginning of Sect. 2.2.2, this study proposes to ask where possible drivers can evolve. Building on the fact that all developments within economic systems are somehow set off by human individuals (or groups of individuals) this translates into the question: “Who is the source of this particular convergence driver?” Adhering to the five areas these drivers are:

- Technology: scientists/researchers (**technological drivers**)
- Business models: managers (**managerial drivers**)
- Market structure: companies (**industrial drivers**)
- Regulation and legal issues: governments (**political drivers**)
- Societal developments: societies/consumers (**societal drivers**).

2.2.3.1 Technological Drivers

Technological developments are grounded on new technological possibilities (such as miniaturization) or evolutions (e.g., digitization). These developments are not a somehow unavoidable result of technology but rather the outcome of research and development activities. They are conducted mainly in academia, semi-academic research labs or governmental agencies and industry. Furthermore, especially in areas like software development, unaffiliated individuals with good expertise may be another important source.

2.2.3.2 Managerial Drivers

Several authors emphasize the role of individual business action. Yoffie calls it “managerial creativity” [39, p. 9], Katz “evolution of business thinking” [cf. 1, pp. 1082ff.], Weaver “business models” [cf. 26, pp. 2ff.] and Bally simply “management” [cf. 14, pp. 9f.] (to name only a few). Strategic actions driving

³² Cf., e.g., Nordhoff et al., who critically discuss the influence of raw material prices (renewable as well as petrochemical) on their selection in the chemical industry [64, pp. 1505ff.].

convergence are sometimes massive corporate mergers like that of Time Warner and America Online (AOL) or IBM and Rolm,³³ but at the same time they can be much more silent developments. The decision of Apple's managers (and probably particularly Steve Jobs) to introduce Apple's design and functionality stance to the mobile phone industry, has certainly fortified a blurring of boundaries around smartphones. As most managers' decisions are rather short- to medium-term oriented cf., e.g., [65, pp. 1469ff.], managerial drivers will in most instances really be drivers rather than triggers. Only if a company is already facing a possible convergence will most managers be prepared to make bold moves to engage in it.

2.2.3.3 Industrial Drivers

The differentiation between managerial and industrial drivers may be a little difficult, as developments on industry level will often be initiated by individual companies' decisions. But at a certain point in time (where industry structure and positioning is a given fact, for the time being), the parameters of the respective industries will determine their scope of decisions and actions. For example, the interest of food companies to sell Functional Foods is to a considerable extent based on their higher margins compared to conventional food products. Rather slim margins in food production are a characteristic that only a whole industry sector could try to change.³⁴ This leads to the conclusion that certain enablers of convergence are rooted on an industrial level and thus also pose challenges to the concerned companies.

2.2.3.4 Political Drivers

Political drivers encompass regulation, liberalization (or de-regulation), standardization (if not conducted on industry level), legislature, government funding and the way governmental authorities deal with debated issues.³⁵ Without the decision in most countries to open the telecommunication markets to non state-owned companies, the initiation of a convergence between the communication sector and the computer sector would not have been possible. On a similar note, regulation around NFF plays a substantial role in the question whether they can successfully compete with conventional foods and pharmaceutical industry's drugs.³⁶

³³ See Sect. 2.3.1 for a more thorough discussion of these activities within ICT.

³⁴ See Sect. 4.3 for an overview of the situation in the NFF industry.

³⁵ Especially when it comes to disputed new technologies, governmental practice can be even more important than legislature. This is even more so the case, where non-governmental organizations (NGOs) or the society at large may be opposing new developments and where decisions are of a particularly long-term orientation.

³⁶ This will also be discussed in greater detail in Sect. 4.3 on the NFF industry.

2.2.3.5 Societal Drivers

Societal drivers are probably the broadest selection of different impacts. They include changing demographics, trends of global thinking and flexibility and changes in public's values and political views. At least in the so-called developed nations people's life-span is constantly increasing. On the one hand, people in these ageing societies may have another 20 years of average life expectancy (and thus of buying products and services) after retiring from their jobs. On the other hand, reaching 80 or 90 years leads to a sharp increase in illnesses caused by the shear age of the body.³⁷ Accordingly, the demand for products and services targeted at older age consumers increases, including medical devices, pharmaceuticals and functional foods [cf. 66, pp. 125ff.].³⁸ This trend is strengthened further by a more dominant desire to be healthy, young and beautiful.³⁹ A possible antagonistic trend in the food industry, rooted in people's values and beliefs, may be seen in the purchase of organic food products. And at the intersection between both trends is a market for "natural functional foods" [cf. 66, pp. 125ff.]. Societal drivers also include developments caused by society as a group of consumers, leading to demand shifts. For example, consumers' tendency towards one-stop shopping leads to unified systems in cellular phones. A rise in the share of people living alone and spending a high percentage of their time in front of computers leads to a different attitude towards what, where and how to buy, providing a strong commercial basis for internet stores or auctioning platforms like eBay.

After discussing the classification of triggers and drivers on a more theoretical level, Table 2.1 gives an overview of the developed matrix and possible examples. As most authors do not discern between triggers and drivers, the classification has to be based on this study's understanding of their respective line of argument. But although they have been freely moved between both classes, the majority of causes can be regarded as being rather drivers than triggers. This is easily understandable on the basis of the extent of changes initiated by convergence. In most cases they will be much too massive to be caused by one "once in time" trigger and will need other drivers to sustain the impetus of change. In any way, convergence has thus far never been caused by just one trigger or driver, but rather a broader selection. Strikingly, in contrast to other scientific fields, there is no increasing specialization visible in the discussion of causes for convergence. When looking at the use of different drivers over time no clear pattern is identifiable. Rather specified terms like 'more complex products as means to generate more income' (Gambardella

³⁷ While the overall process of ageing and its relation to an increased mortality is very complex, major factors include cells being lost without replacement and mutations in our chromosomes. This organismal senescence is characterized by a declining ability to mitigate stress results and unhealthy conditions, to a considerable part caused by environmental factors.

³⁸ Demand shifts caused by an ageing society will also be briefly discussed in the context of developments at the intersection of nutrition and pharmaceuticals in Sect. 4.3.

³⁹ While the content of this desire and its implications could well be discussed in a study of its own, the mere existence is as undisputed as the massive effects on buying behavior and leisure.

and Torrisi) have been introduced in 1998, whereas the way more generic ‘technological change’ seems to have been introduced by Bally in 2005. To shed some more light on real cases of convergence and the way in which they happen, [Sect. 2.3](#) will discuss a selection of examples from different industries and initiated by different triggers and drivers.

2.3 Examples of Converging Industries

The preceding paragraphs have provided the terminology and definitions for the most important individual aspects of convergence. In a case study approach, this chapter will substantiate the largely theoretical discussion in the preceding paragraphs with an analysis of the blurring of boundaries in the prototype of converging industries—the ICT sector. This is supposed to shed some more light on the practical relevance of industry convergence. Additionally, the influence of the different triggers and drivers and the degree of convergence realization are briefly discussed.⁴⁰ Exemplary company examples are included in this discussion, where applicable. Followed by a few more exotic manifestations,⁴¹ this chapter is specifically aiming at elaborating different parameters of convergence.

2.3.1 *The ICT industry*

As discussed earlier, most scholars have thus far concentrated on media-, information technology- or electronics-related industries for studying effects of industry convergence. Most of the remaining works employ developments in the ICT industry at least as one of their examples. But as also other sectors have experienced their fair share of convergence-related activities, why should so many researchers focus on the intersection of computers, communication and consumer electronics? Partly, this may be due to the strong technological focus, the search for signs of industry reactions and the necessity of comprehensible and illustrative examples, marking a considerable portion of the literature.⁴² But also the extent of influences on peoples’ every-day life is probably unrivalled by other occurrences of convergence. First, a decisive customer surplus is often a result of new combinations of products or services. Second, the omnipresence of (digitalized) information in the form of text, pictures, sounds, or a combination of these is

⁴⁰ Especially the degree of convergence in NFF will be discussed in-depth in [Chap. 6](#) after the presentation of results of the measuring of convergence.

⁴¹ Being the second major example of convergence and the basis of the present study, developments in NFF will be discussed in greater detail as the research setting in [Sect. 4.3](#).

⁴² See [Sect. 2.1.1](#) for a discussion of reasons of literature’s (over-)representation of ICT examples. See also [Chap. 6](#) for an assessment of the state of convergence in the ICT industry.

altering the global economy. Third, for some developments even new economic measures need to be developed. Products like Google's search engine (or any of its competitors, for that matter) or the Adobe Reader experience nearly unlimited market dissemination, partly due to apparently being free of charge. Thus, the only way in which their importance for metrics such as GDP can be measured is due to their indirect effects in enabling Google to sell advertising or Adobe to sell other connected software tools [cf. 67, p. 165].

When looking at convergence possibilities at the outskirts of the ICT cluster, there is a myriad of boundaries to be faded. The industry sectors consist of a broad array of different segments. While the information technology sector is about computers and their production, software and service providers play a significant role as well. In consumer electronics, e.g., developments regarding (digital) cameras, music storage and reproduction, television sets and radios are involved. Communication deals with landline phones, cellular phones and access to the internet as well as other forms of modern communication. Finally, there are other sectors affected, like the media industry, publishing and printing and to some extent completely different sectors: biotechnology, nanotechnology or chemistry.

Strikingly, convergence involving the computer and the communication sector has been discussed at least since the early 1970s. As early as 1971 Oettinger spoke of "computers and communications [having] long since become inseparable" [9, p. 74].⁴³ Retrospectively, this was a time at which a merger between both sectors was far from being finalized (if it had really begun at all). Indeed, while some classify it as a clear trend observed by many and as a well suited example [cf. 53, p. 318], others question the connection between an undisputed technological convergence in ICT and blurring market boundaries [cf. 50, p. 445]. Notwithstanding this discussion, many areas have in the meantime merged into common markets. In addition to the emergence of smartphones, voice and data streams are increasingly managed by the same providers and delivered through one single line to the end customer.

In 1965, at the time of Intel-cofounder Moore's groundbreaking paper on the expected evolution of integrated circuits, most processes were still based on analog technologies. In his article he envisions a future with "such wonders as home computers [...] and personal portable communications equipment" [57, p. 1] and discusses different approaches to miniaturize and reduce the costs of electronics equipment. In the remainder of the paper he derives time-dependent cost curves for the number of components per integrated circuit and predicts the number of components (at minimum costs) to be exponentially rising for at least a decade.⁴⁴ Two decisive technological drivers of convergence in ICT are listed here. First, digitization enables a free transfer of information (no matter whether pictures, sounds or text) through various transport mechanisms. Second, miniaturization

⁴³ See also Sect. 2.1.1.

⁴⁴ With a few alterations this prediction has been named "Moore's Law" after him. See also Sect. 2.2.2.

secures the applicability of integrated circuits in a wide array of increasingly small equipment. Digitization most likely plays the central role [cf. 2, p. 2224]. It could even be classified a prerequisite for convergence in ICT, instead of just one of many triggers and drivers. Without the switching from analog to digital means of information transportation, the different branches would have had no common ‘language’ to use. To that extent, grounding products and services on bits and bytes may be regarded a ‘generic technology’ See, e.g., [68, p. 228], as it can be employed similarly across different industry boundaries. Indeed, digital technology probably is a generic technology. And much more, as the notion ‘language’ would suggest. Consequently, it is not only a technology to send information from A to B in certain settings. As a result, these products or services have now been replaced into a competitive environment, addressing similar demands and markets.

Furthermore, digitization actually changed underlying paradigms of, for instance, telecommunication and computers. When the internet began to receive increased attention during the 1990s, people used their telephone lines and analog modems to connect to it. Nowadays, more and more consumers and companies use their digital broadband access to administer their telephoning activities. Also, VoIP handsets have been introduced by mobile device vendors and the underlying technology is being switched to packet-switched data transmission [cf. 14, pp. 14ff.; 52, p. 728; 53, p. 321]. This technology in combination with efforts to grant free access to “Wireless Local Area Networks” (WLAN) or even “Wireless Metropolitan Area Networks” (WMAN), could lead to substantial losses for telecommunication providers concentrating on established airtime business models. Next to free and wireless internet access in many hotels, restaurants and shops, several cities and even countries around the world have free WLAN access in place. For instance, all of Estonia’s 45,000 km² are covered by WLAN, partly financed through advertisement, partly through a kind of levy on purchases [cf. 69]. Also, cities like Swindon (UK) [cf. 70] or Milpitas (USA) [cf. 71] provide free WLAN access to their population. On the other hand, some very ambitious projects have been called off due to a lack of investors or sponsors, such as in San Francisco (USA) [cf. 72] and New York (USA), where all parks were supposed to be free WLAN zones [cf. 73].

Miniaturization, on the other hand, is part of a larger set of technological developments making the process of convergence more likely and easier, but this convergence was beginning to speed up already at a time when ‘mobile phones’ would still fill the trunk of a car. Miniaturization definitely plays a central role when it comes to the performance of microprocessors as well as the possibility to assemble devices with multiple functionalities. The calculation power of any microprocessor-containing device, from dish washers and cars to telephones and personal computers is still exponentially rising. And accordingly are the possibilities for computer-aided applications [cf. 2, p. 2223]. Modern more luxurious cars, for example, use them for a plethora of functionalities from engine control to navigation, adaptive cruise controls, blind spot detection or even automatic parking. Moreover, miniaturization of all components has enabled devices such as smartphones with their bundle of functions. And with these technological

developments, also production technologies and material properties became more and more equal [cf. 30, p. 355].

After a ground was thus laid for a blurring of boundaries by technological change, another important driver was the deregulation of the telecommunications markets [cf. 38, p. 1; 53, p. 318]. In the USA, e.g., the “Telecommunications Act of 1996” aimed at letting anyone compete in any market with any communications business [cf. 74]. This act was the first amendment to the Communications Act of 1934 and opens with the pledge “To promote competition and reduce regulation in order to secure lower prices and higher quality services for American telecommunications consumers and encourage the rapid deployment of new telecommunications technologies” [75, 110 STAT. 56]. Another good example is Europe, where the “Commission Directive 90/388/EEC on competition in the markets for telecommunications services” was introduced in 1990 to progressively introduce competition to the telecommunications sector [cf. 76, p. 10], followed by further legislation in the years afterwards [cf. 12, p. 33]. 12 years later a series of directives (including 2002/77/EC) was trying to introduce a common regulatory framework for “all electronic communications services and/or networks which are concerned with the conveyance of signals by wire, radio, optical or other electromagnetic means (i.e. fixed, wireless, cable television, satellite networks) [77, p. 21]. It even mentions a convergence phenomenon having “shaped the information technology, media and telecommunications industries over recent years” [77, p. 21]. Similar developments have taken place in most countries, opening the hitherto monopolized telecommunications sector (and related sectors) to competition and thus furthering convergence. Bierly and Chakrabarti argue that deregulation has fuelled industry fusion in the ICT sector and forecast companies from the different telecommunication (long-distance and local), the computer and the computer software industries to be competing against each other in the future [cf. 19, p. 36].

Next to technological (especially digitization) and regulatory aspects [cf. 2, p. 2223], a third trend has propelled developments in this industry—the trend for one-stop shopping or multi-purpose devices See, e.g., [2, p. 2228; 26, p. 9]. In this context, Kaluza et al. highlight increased pressure from substitutive products during the process of convergence [cf. 2, p. 2241]. This can be well observed in the domain of internet service providers (ISPs), cable and satellite television providers and telephone providers. Each of them has faced competition from other providers in his area since deregulation. But today, all of them are directly competing with each other. In the German market, for example, telecommunication companies like the Deutsche Telekom offer broadband, telephone and television access, just like cable providers such as Unitymedia or ISPs like 1&1. Thus, convergence leads to intensified competition and results in decreasing prices for these services.⁴⁵

⁴⁵ The prospect of diminishing prices is actually one of the reasons for the deregulation activities of the past two decades see, e.g., [75, 110 STAT. 56].

Firms from the initial ICT sectors were among the first and most obvious to react to the blurring or reorganization of industry boundaries.⁴⁶ According to an estimate by the European Commission in 1997, 15 % of the total value of worldwide M&A activity of US\$ 1 trillion was rooted in ICT [cf. 15, p. 6]. One of the most prominent examples is probably the merger of AOL and Time Warner in 2000,⁴⁷ bringing together internet and more traditional media competencies [cf. 78]. At the beginning their merger was dressed in very optimistic wording, aiming at creating the “[...] World’s First Internet-Age Media and Communications Company” [78].⁴⁸ They acclaimed the uniqueness of this all-stock combination valued at US\$ 350 billion. According to the board’s statements, they had expected to be able to build on a range of growth opportunities, from music and entertainment to broadband and telephony. Although supposedly a merger between equals, many saw it as rather a takeover of Time Warner by the (revenue wise) much smaller AOL. This was reflected in the name of the new company (AOL Time Warner), in the distribution of shares (55 % of AOL Time Warner was held by former AOL shareholders) and the fact that AOL’s chairman was also chairman of the combined board. And the basic idea behind it was preparing for convergence [cf. 78–80]. But somehow this merger, which has even been called “the worst deal of the century” [81] and “one of the largest blunders in corporate history” [82], never really delivered on its promises. Most likely, this was more due to the outdated AOL business model of dial-up internet access combined with the provision of own content than to a serious misjudgment of the convergence phenomenon. Today AOL’s business spans dial-up and VoIP telephony, but increasingly more important—advertisement (for that reason the majority of services is now offered to customers for free).⁴⁹ Ironically, a company that set out to spearhead convergence-related industry changes has been immensely affected by the increase in broadband-access, a prerequisite for convergence in other services. Whatever the reasons were, the stock market value of the combined company fell by about 80 % since the merger [cf. 84]. In 2003, “AOL” was dropped from the name [cf. 85] and finally in 2009 Time Warner spun off AOL [cf. 83].

But even long before them, other firms tried to harden themselves against increased competition from new fields of business [cf. 2, p. 2225]. In 1984, IBM wanted to strengthen its position through acquisition of telecommunication equipment maker Rolm [cf. 30, pp. 356f.], while AT&T purchased, e.g., 25 % of

⁴⁶ Actually, some attribute convergence as a major impact to M&A activities, especially in ICT see, e.g., [68, pp. 227f.].

⁴⁷ The deal was announced on January 10th, 2000. The merger was then completed after gaining approval from the Federal Trade Commission and the Federal Communications Commission on January 11th, 2001. Hence parts of the literature list the merger as happening in 2000 or 2001, respectively.

⁴⁸ Capitalization is according to original text.

⁴⁹ The shift in focus is also reflected in revenues. The share of subscription income in total revenues is down from 74 % in 2006 to 46 % in 2008, including an increase of 11 % in advertising revenues and a decrease of 67 % in subscription revenues [cf. 83, pp. 42ff.].

computer maker Olivetti in 1983 [cf. 50, p. 449; 86] and in 1991 acquired NCR (National Cash Register). Rolm was a small Silicon Valley company specialized in PBX (private branch exchange, i.e. routing calls within offices) [cf. 50, 87, p. 449]. Olivetti and NCR were supposed to open up the personal computer market to AT&T as well as a specific distribution channel into the financial services market (in the case of NCR). But all three maneuvers were later reversed [cf. 1, p. 1082; 19, p. 36; 28, p. 145; 50, pp. 448ff.], just as Matsushita Electric's takeover of MCA (Music Corporation of America) and Universal Pictures in 1990. IBM sold Rolm to Siemens after yearly losses of more than US\$ 100 million [cf. 14, 87, p. 4]. AT&T sold their stake in Olivetti in 1989 [cf. 88, p. 9] as well as spinning off NCR in 1996 [cf. 89]. Markoff refers to experts who had by the late 1980s changed their opinion on ICT convergence. Initially they had awaited a blending of data and voice streams but had later acknowledged that the massive integration of both services would not be due for a longer time [cf. 87].⁵⁰ Additionally, others have criticized the way and the propositions under which many of these early years' convergence-driven alliances and M&As were conducted. Despite possible economies of scope, many of these strategic actions lacked the necessary inner fit. Large companies, incumbents in their own sectors, often underestimated the differences between selling personal computers and providing telecommunications services, for example. Disillusioned by their experiences, this has led some of the players to question the underlying logic in general. IBM is said to have realized "that convergence between computer and communications technologies was difficult to achieve" [50, p. 450, based on *Electronic Business*, June 15th, 1988, p. 63] and AT&T's top management that "the concept of converging communications and computer markets, which drove the NCR deal, is an illusion" [cf. 50, pp. 448f., based on *Business Week*, October 2nd, 1995, p. 28]. One of the rather few who stayed with their enlarged portfolio is Sony with its stake in the media market [cf. 16, p. 7].⁵¹

Whilst most scholars report M&A activities caused by convergence (or expect it for the future),⁵² only few try to analyze the ex or even the results of it. Bower introduces a conceptual framework for five different types of M&A activities and their strategic triggers. One of those is a scenario of industry convergence, which in his analysis of 1997–1999 deals in the USA above US\$ 500 million is the reason for 4 % of M&As [cf. 90]. Typical examples would include the 2000 deal of AOL/Time Warner or 2001 Allianz/Dresdner Bank takeover [cf. 91, pp. 36ff.].⁵³ Gambardella and Torrisi add to the discussion by questioning the performance

⁵⁰ Thus it seems to be of critical importance to have the proper timing. When firms act to hastily, this can result in costly adventures. On the other hand, waiting for too long may prove to be as detrimental [cf. 12, p. 237].

⁵¹ See also the more thorough discussion of Sony's activities around convergence in ICT later in this chapter.

⁵² For authors discussing M&A activities as a reaction to convergence cf., e.g., [38, 50, 90, 91]. For an overview and short discussion of prior literature see also [12, pp. 41f.].

⁵³ See also Sect. 2.3.5 for a brief discussion of convergence between insurance and banking.

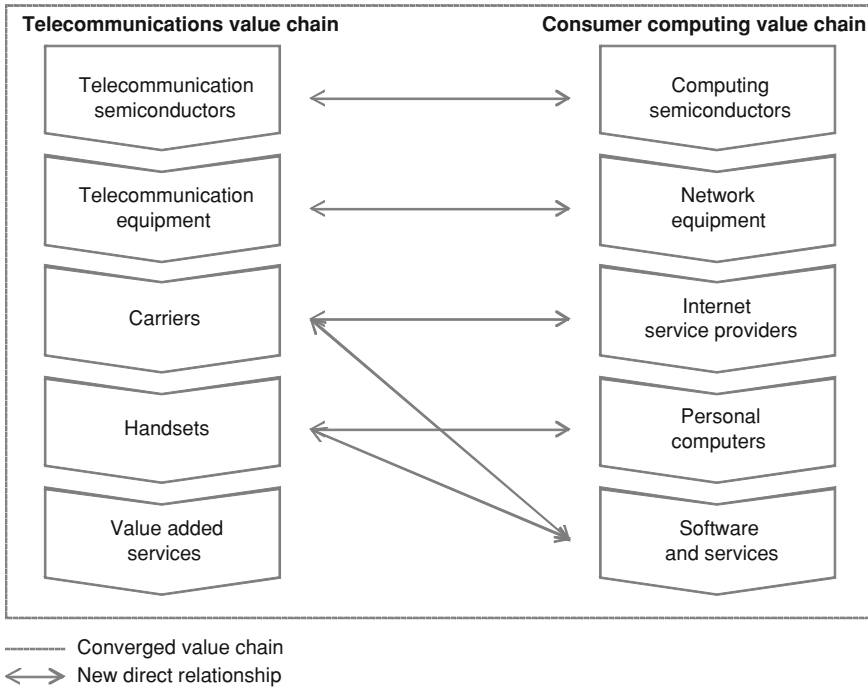


Fig. 2.4 Converging value chains in ICT (Source Adapted from [11, pp. 85ff.])

level after such a strategic change. In their analysis of 32 companies from Europe and the USA (all ICT companies listed in 1990s Fortune 500), they find that firms with stronger focus actually performed better [cf. 50, pp. 450ff.].

The blurring boundaries in ICT have also led to fundamental changes in value chains [cf. 12, pp. 48f.]. Figure 2.4 depicts these changes resulting in heavily increased competition between companies active in telecommunications and those in consumer computing.⁵⁴ Whereas originally both sectors had separate value chains with separate players for each of their steps, connections increased and lead to faded boundaries between the two. As a result, firms active as semiconductor or equipment providers, are now able to offer their goods and services also in the respective other area, as their technological and customer bases are merging into one larger, unified area. On the downside, this also means competition from their counterpart, of course. But these connections are not only established on similar levels of the value chain. Accordingly, telecommunication handset manufacturers are also offering software or services from the domain of computing.⁵⁵

As can be seen when looking at the example of Apple, it is of little importance today, in which sector a firm was originally active. Apple is a good example for a

⁵⁴ [Cf. 11, pp. 84ff.].

⁵⁵ See Footnote 54.

company starting with computer devices and software offerings. In 1976 it was founded as “Apple Computer, Inc.”, stressing its focus of building and selling computers. For the next decades it concentrated on the development of computers, peripherals and specialized software. Specifically, its inclusion of a graphical user interface (GUI) had a great influence on other operating systems’ providers. It was initiated by an agreement between Xerox (who had invented the GUI with their system “PARC”) and Apple,⁵⁶ allowing Apple to study Xerox’s GUI and Xerox to invest US\$ 1 million in Apple.

The first real move away from the computer industry value chain can be seen in the production (and licensing) of the Apple Bandai “Pippin” multimedia platform in 1995. It was supposed to be an inexpensive network computer with computer games functionality, but mainly perceived as a games console, inferior to its competitors like Sega Saturn or Sony PlayStation [cf. 92].⁵⁷ The final move into the consumer electronics market was the introduction of the portable digital audio player “iPod” in 2001, complemented by the 2003 launch of the strongly intertwined “iTunes Store” (offering online music downloads) [cf. 93, 94]. On January 9th, 2007, a Form 8-K was filed with the United States Securities and Exchange Commission (SEC) announcing its renaming to “Apple Inc.” [cf. 95]. The name change was supposed to reflect Apple’s strategic move away from just personal computers and software to the addition of media offerings (iTunes Store), consumer electronics (iPod range and Apple TV) and mobile phones (iPhone range) [cf. 96, p. 1]. This could be interpreted as the desire to have its name also reflect its claiming convergence ground in ICT. On the same day Apple’s first smartphone “iPhone” and its digital media receiver “Apple TV” were presented to the public [cf. 97], marking the inclusion of a further foreign value chain element—the production of telecommunication handhelds. Being a smartphone from the very beginning, the latest iPhone model also contains a mobile navigation system.

But Apple is not the only company incorporating the ICT convergence in its fields of activities. Sony Corporation is another very prominent example. Founded in 1946, it (including subsidiaries and joint ventures) nowadays sells a wide array of products, from audio and television devices, cameras, batteries and semiconductors to personal computers, music, motion pictures and telephones.⁵⁸ Originally it developed audio devices, like magnetic tape recorders and transistor radios. Later adding television sets and semiconductors, Sony teamed with CBS in 1968 to form the 50:50 joint venture CBS/Sony Records, which is nowadays the completely owned Sony Music Entertainment. So, already more than 40 years ago, the company moved away from just hardware manufacturing to producing content as well. Next to selling further different consumer electronics (like the portable

⁵⁶ This was in advance of Apple’s initial public offering (IPO) in 1980.

⁵⁷ Game consoles themselves are today seen as convergence products by some researchers. They can be used as gaming devices, DVD (or Blu-ray Disc) players or even to access the internet [cf. 49, pp. 202ff.].

⁵⁸ Today through Sony Ericsson Mobile Communications, a 50:50 joint venture between Sony Corporation and Telefonaktiebolaget LM Ericsson [cf. 98–100].

music playing device “Walkman” and photo cameras), Sony began to sell personal computers in 1982 and phones in 2001 [cf. 101]. Hence, it is another suitable example of a company trying to mirror convergence trends in the whole industry within its own organization. In contrast to Apple, Sony has not only broadened its in-house capabilities, but also reacted to developments in ICT by collaborating with other players in the form of joint ventures (e.g. initially CBS Records, Prudential Insurance or Ericsson) or by acquiring them (e.g. Columbia Pictures Entertainment or AIWA) [cf. 101]. Strikingly, the company is not only reacting to this phenomenon, but also explicitly addressing convergence. In 1998, Sony and Microsoft issued a joint press release announcing plans to create convergence of personal computers and consumer audio-visual electronics by several collaboration activities [cf. 102]. Today, they describe themselves as being focused on electronics, game, entertainment and financial services. Amounting to a “globally unique” setup, Sony wants to “aggressively [carry] out [their] convergence strategy” [103].

In contrast to AOL/Time Warner, Apple and Sony can be viewed as convergence examples grounded on a broader foundation. Their development is not only pushed by outside events such as technological change, demand shifts or deregulation, but also decisively by managerial triggers and drivers (see Table 2.1). Similarly, Nyström discerns between the four drivers organizations, technology, deregulation and demand in the ICT domain. To the common factors of technological change in general and digitization in particular, she also emphasizes the role of a transition to IP (Internet Protocol, a protocol for the transfer of packet-switched data) technology [cf. 12, pp. 29ff.]. Due to this technology’s indifference to the type of transferred data, it can and does serve as a platform for all different types, mainly texts, photos, sounds and video. Nyström also emphasizes the necessity of a combination of different drivers for convergence to happen. According to her line of argument, ICT boundaries would not have blurred if it was not for technological **and** regulatory developments [cf. 12, p. 35].

Albeit all the decisive changes in ICT related industries, it is still being debated how much convergence actually has happened in this area. Lind stresses that while telecom, computer, media and consumer electronics industries were substantially transformed by the events of the last decades, they are still around as largely separate industry sectors. He sees manifestation of changes in their value propositions and business models, but thus far no challenging of their actual existence. Furthermore, in his assessment the number of industry sectors or at least markets has increased, with entry barriers in these markets as high as they had been in traditional settings [cf. 4, pp. 13f.]. Regarding convergence on the media edge of ICT, Gordon summarizes the status quo in the year 2002 to be far from finalized, but with convergence’s outlines taking shape. The vision had been for all media content to be stored and distributed digitally and via the same distribution lines to multi-purpose devices. But while he rightly analyzes that this is not the case in his book chapter published in 2003, many of those have changed in the meantime. Gordon identifies major obstacles in limited transmission speeds and differing formats [cf. 7, pp. 60ff.]. Although there is still a broad selection of file formats,

compatibility has probably improved as much as connection speeds. In their 1998 study on strategic alliances and technological competencies in a convergence setting in the ICT industry, Duysters and Hagedoorn find that despite technological convergence firms appear to sustain their original technological base. Analyzing strategic alliances and patent data of “leading” computer and telecommunication equipment manufacturers, they discuss this concentration on their traditional respective technology areas as probably the most efficient approach. This is accompanied by a tendency of (at least initial) inertia to change. The authors still expect this single focus approach to alter in the future [cf. 30, pp. 359ff.].

Another reason for a much slower realization of convergence in ICT may lie in the fact that most developments in the earlier phase were focused on just the technological or the regulatory side and only to a lesser extent meant to address the end-customer. Tarjanne argues that people need to be the focus of attention if convergence is supposed to be successful [cf. 12, pp. 43f.; 104, pp. 41ff.]. Similarly, Katz sees drivers of convergence in ICT to be twofold—supply-side digitization drove convergence at the beginning, before demand-side effects took over. In his opinion this is due to a re-thinking of corporate customers [cf. 1, p. 1084].⁵⁹ But this insinuation of each driver happening sequentially over a course of time is probably over-simplified. It appears to be not so much a question of one driver necessarily being the off-setter before another driver takes over, but rather the co-existence of different drivers at the same time. In contrast to smartphones⁶⁰ or triple play⁶¹ services which provide benefits for the consumer and address his tendency towards one-stop shopping, earlier developments evolved without a clear added benefit. For instance, a shift from analog to digital telephony may be scientifically fascinating or resulting in cost reduction possibilities for the providing firms. But only if this leads to cheaper connection charges, better sound quality or added functionalities, it is of interest to consumers as well. Hence, it could be expected that full industry convergence will only happen if companies are successful in transforming technology convergence⁶² into customers’ perception of improved products or services.

⁵⁹ In this approach to emphasize the influence of the customer base Katz also predicts that “within a decade, many people will take multimedia ‘phones’ for granted”, driven by the wish to engage in one-stop shopping [cf. 1, p. 1086].

⁶⁰ Nyström relates to smartphones (or in her wording mobile phones) as the point of convergence, with influences and inputs from the areas of communication (e.g., speech, messaging, e-mail), broadcast media (e.g., TV, radio) and mobile data (e.g., internet, mobile services) [cf. 12, pp. 221f.].

⁶¹ ‘Triple play’ is a term used in marketing and referring to the simultaneous provision of data, voice and television streams. Sometimes it is even extended to ‘quadruple play’, including mobile phone access as well. In most cases it is administered through the networks of either broadband service providers or cable providers see, e.g., [49, p. 214].

⁶² This study views convergence as happening sequentially, based on different levels. See Sect. 2.4 for a detailed discussion of different phases of convergence.

Furthermore, convergence may also lead to divergence. Kaumanns et al. describe changes in customers' perception and usage of products and services to be marked by a growing diversity of offerings, media consumption patterns, target groups and consequently business models [cf. 105, p. 29]. Based on their representative survey of 1,000 German consumers between 14 and 69 years of age, they discern between different 'usage modes', depending on the type of activity. Most people consume more traditional audio-visual media in a 'lean back-mode', whereas they largely switch to a 'lean forward-mode' when accessing the internet. Recent developments enable consumers to turn into 'ProSumers' and actively influence or even produce media content [cf. 105, p. 2]. In their assessment those companies are profiting from convergence that combine devices with services and content, such as Apple's iPod [cf. 105, p. 30].

This convergence/divergence dichotomy (or at least its perception) changed from the time of the first discussion of convergence in ICT. In the 1980s companies appeared to be able to use their core technologies to produce a broadening range of products, whereas in the 1990s they were expected to include more and more different technologies into one product. Today companies need to do both and balance convergence in technologies/products with divergence in the respective other [cf. 28, pp. 126ff.]. Only companies aware of changing market dynamics and with the capability to address those will be able to use a convergence setting to their advantage. In many cases this will not be the more established and path-dependent large companies, but rather small and more flexible ones.⁶³

Furthermore, when assessing developments in ICT different levels and patterns of innovative activity need to be considered. Patent growth rates, technological pervasiveness or share of self-citations may vary greatly even within the ICT sector [cf. 106].⁶⁴ Because of all these characteristics in ICT, Bröring concludes "[...] there is no total substitution of hitherto separate sectors, but rather a fragmentation into different sub-segments and value chains" [60, p. 280].⁶⁵ Accordingly, the International Engineering Consortium (IEC) is expecting a realignment of the five traditional information industries photography, publishing, telecommunications, computing and entertainment into the three new sectors information content, information appliances and information highways. In contrast to the traditional boundaries along the different forms of information (images, text, voice, data and audio/video), the new sectors are expected to be based on the functions of information (create/collect, display/store and process/distribute). Governmental

⁶³ See, e.g., [60, pp. 280ff.] for a discussion of efforts undertaken by AT&T, Palm and Research in Motion (RIM) developing the market segment of PDAs and later smartphones. While AT&T withdrew quickly because of their failure to successfully market their PDA 'EO 440', Palm and RIM were highly successful in transporting the added benefits of their handhelds/BlackBerrys to the end-customer.

⁶⁴ Corrocher, Malerba & Montobbio discern between different "Schumpeterian patterns of innovative activity in the ICT field". Section 3.3 will discuss differences in, e.g., the propensity to patent and how this may influence patent analyses in greater detail.

⁶⁵ See also, e.g., [16, p. 11] for a similar assessment.

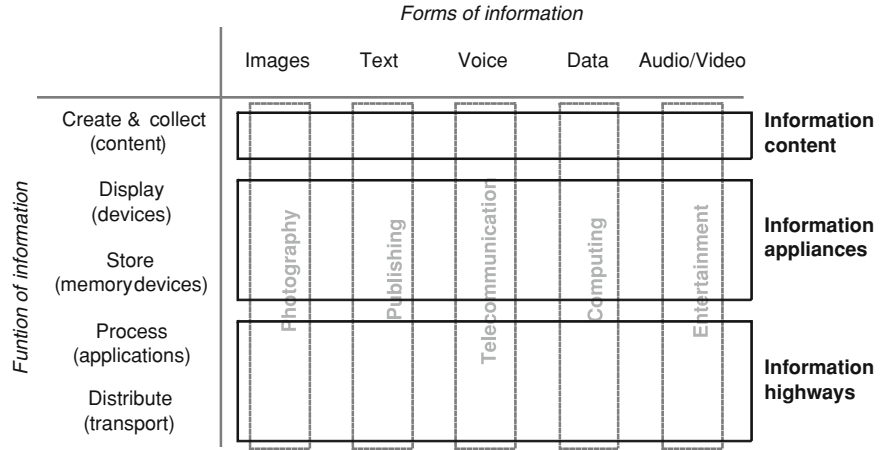


Fig. 2.5 Convergence in ICT based on a shift of focus from forms of information to functions of information (*Source* Adapted from [107, pp. 7ff.])

deregulation of barriers between the different forms on the one hand and the technological ability to carry out any of the function irrespective of the form of data to be used on the other hand, are believed to be leading to this reshaping of the information industry (Fig. 2.5) [cf. 107, pp. 3ff.]. Initially, the IEC has proposed this fading of boundaries in 1999 and anticipated it for ten to fifteen years later [cf. 107, p. 3; 108, p. 305]. Table 2.2 depicts this change in industry structure and the related core competencies. In spite of companies that are trying to bridge the gap between these three functional sectors (like Apple or Sony), recent developments have indeed led to a concentration based on functions rather than forms of information. Section 5.2.6 will also briefly address manifestations of this new structure in patent literature.

Table 2.2 Convergence in ICT with new industry sectors and their relation to traditional sectors

New industry sector	Examples of needed core competencies/ expertise	Traditional industry sectors linked to it
Information content	• Fostering and managing creativity • Information gathering • Programming skills	• Publishing • Entertainment
Information appliances	• Global presence (economies of scale) • Strategic sourcing • Design and manufacturing expertise • Concurrent engineering and marketing	• Consumer electronics • Personal computers
Information transport	• Network management • Interactive communications • Billing systems • IT platforms	• Telecommunication • Cable TV • Broadcast media • Private networks

Source Adapted from [107, pp. 18f.]

2.3.2 *The IT and Electronics Industry with Other Industries*

Constituting a largely generic technology with broad applications in virtually any field of modern life, IT has been discussed to be converging with many different other fields as well. An often employed example is the area of “intelligent buildings” [cf. 11, p. 3] or “smart homes” [cf. 109, pp. 158ff.]. Here building technologies, especially regarding temperature control and intrusion and fire safety, are expected to merge with information technology [cf. 11, p. 3]. The employment of information technology to control household appliances as well as the abovementioned building technologies can be accepted as a given fact. In contrast to this, more far-fetching visions of houses completely managed by a home computer system that would signal a finished turn of the washing machine on the television set and would consist of completely intertwined and ‘intelligent’ systems, have thus far proven to be overoptimistic. Notwithstanding these drawbacks, the promoters of smart homes appear to be just increasing the level of ‘smartness’ in homes since the first discussions in the 1980s. Today they are still talking about fridges connected to the internet and automatically restocking their content as well as the possibility to access all the control systems from wherever the homeowner would be in the world [cf. 109, pp. 158ff.]. Certainly, many of these functions are technically possible today, but still most homes are built rather ‘unintelligent’. Independent of the degree of realization of these predictions, smart homes can hardly be interpreted as an area of converging industries. As much as architects, builders and producers of household appliances are increasingly using information technology, as little are their industry sectors likely to converge into one common sector. Even more, following the definition of convergence within this study they would not even been characterized as converging at all (not even on the technology level) but rather the one technology using the other.

Furthermore, the IT industry is part of a reported convergence with the security industry. As security services are largely shifting away from analog technologies to digital technologies, IT companies enter security industry’s market [cf. 55, pp. 1ff.; 56, pp. 1ff.].

The intersection of the packaging and paper industry on the one hand and the chemical industry on the other hand is another increasingly intertwined area largely based on the development of nanotechnology competencies. Printable electronics are a product range that is part of this possible convergence area. They include OLEDs,⁶⁶ RFID⁶⁷ tags and other (semi-)conducting modules that can be printed onto substrates and serve a broad array of purposes. Their functionalities include displays, sensors and indicators [cf. 11, p. 3; 60, pp. 282ff.; 110, pp. 396ff.]. Whereas the products are competing with other products from the electronics and the packaging and paper industry, they are to a high degree only an example of technological convergence and not of market convergence. Especially the chemical

⁶⁶ Organic light emitting diodes.

⁶⁷ Radio frequency identification.

industry collaborates with players from the electronics domain to develop printable electronics solutions consisting of the chemical ingredients and the machinery equipment needed to actually print and sell these products [cf. 60, p. 282].

2.3.3 *The Chemical Industry*

The chemical industry, in the middle of a paradigm shift, is full of further examples of blurring boundaries. First, most firms have closed down their huge central laboratories and redeployed their researchers to smaller units managed by the individual business unit. This set up is aiming at less basic research and more customer-oriented development, with customers altering their demands and buying behavior substantially. Second, this traditionally technology-driven industry has realized that most impulses for innovations have in the recent past come from its neighboring disciplines. While their substantial R&D budgets for the assessment of inventions used to be spent on experimental trial and error, the so-called ‘innovation scissors’ (the difference between the increasing development time and decreasing commercial exploitation time), became a serious problem since the 1960s [cf. 111, p. 57]. Most companies tried to battle the fact that they were developing fewer really new molecules that often only showed incremental changes in properties, compared to existing materials, by increasing the speed of their trial and error approach. These ultra high throughput screening methods⁶⁸ are still industry standard today, but they are supported by methods developed in neighboring fields, especially informatics (leading to computational chemistry and molecular modeling) and biotechnology. Working with informatics allows for fewer physical experiments and thus increased turnover and methods developed by researchers in biotechnology make a directed approach possible. Through understanding of physiological mechanisms within a plant or the human body, researchers can start to look for a specific key to a lock much more target-oriented. Consequently, (partial) convergence has happened particularly between chemistry and biotechnology in science and technology. But lacking a real industry of its own, there is no real biotechnological industry that could converge with the chemical industry. Biotechnological companies are characterized as such due to their technological base and not because of independent markets or customers. Their products serve as substitutes for either chemically derived products or pharmaceutical products.

Further drivers of convergence tendencies within the chemical industry structure include the alteration of the raw materials base. For about half a century almost all chemicals for the different kinds of applications were synthesized from

⁶⁸ UHTS (ultra high throughput screening) is based on fully automated testing of tens of thousands of substances from a company’s substance library on single targets, especially in the development of new pharmaceutical drugs or chemicals to be used in crop protection.

oil. But while the demand for oil has surged for decades, the world's reserves are definitely limited. Additionally, environmental awareness has increased in most countries and led to an increasing interest in products derived from renewable raw materials. This has led to the blurring of boundaries between the incumbent materials manufacturers and new competitors with access to renewable raw materials. Hence, chemical companies like Dow or Bayer are today competing with agricultural companies like Cargill or Archer Daniels Midland. This could lead to an industry convergence of parts of the chemical industry and parts of the agricultural industry [cf. 112, pp. 1ff.].

2.3.4 *The Pharmaceutical Industry*

In contrast to this competition between similarly sized firms, the pharmaceutical industry has in the past mainly taken over considerably smaller biotechnological firms to fill its product pipeline or to broaden its technological knowledge base [cf. 18 pp. 8ff.]. This has to be seen in the light of a setting, where on the one hand one active ingredient alone may account for over US\$ 1 billion p.a. in sales. However, on the other hand, companies have to deal with extremely high failure rates of lead compounds tested in the discovery phase: the estimated success rates are about 0.01–0.02 % [cf. 113, p. 20]. Hence, many firms experiencing backlashes with predicted blockbusters⁶⁹ have turned to biotechnological firms to fill their drying product pipelines. While this often results in acquisition of the biotech firm (e.g. Roche buying Genentech, Merck KGaA acquiring Serono, or AstraZeneca's US\$ 15 billion takeover of MedImmune), building alliances with others outside the firm's boundaries may often be preferable in regard to costs, flexibility and broadness of cooperation possibilities.

In the pharmaceutical industry's relation with biotech firms, often not convergence but mere utilization of technologies or even whole companies plays the decisive role. But at the borders of this segment two clear examples of industry convergence have earned some considerable attention—the emerging sectors of NFF and of Cosmeceuticals. The NFF sector has been emerging since the early 1990s at the intersection of pharmaceutical and food industry sectors cf., e.g., [20–22], starting in Japan, which is still a very strong market for NFF [cf. 114]. The NFF sector is marked by input-side convergence as well as output-side convergence. Food technology competencies are converging with LDL-cholesterol lowering technologies. Regulations regarding pharmaceutical products are increasingly transferred also to food products with enhanced characteristics. And finally, customers are seeking to purchase foods with added health-benefits in an attempt of one-stop shopping [cf. 20, p. 83]. Thus firms do not only need knowledge and technological

⁶⁹ Blockbusters are pharmaceutical products that account for at least US\$ 1 billion in annual sales.

skills formerly unimportant to them, but also find themselves competing with one another in one unified market of nutrition and disease prevention [cf. 115, pp. 11ff.].

A similar setting can be found in the sector of Cosmeceuticals [cf. 11, p. 42], a term coined by Klingman in the 1970s [cf. 116]. It is reported to be the fastest growing segment of the “natural personal care industry” with cosmetic-pharmaceutical hybrids aiming at enhancing both “beauty” and health. [cf. 117, p. 155] While health benefits appear to be more disputed than for most products in the NFF sector,⁷⁰ some experts are calling for a harmonized regulation through bodies like the FDA (US Food and Drug Administration) [cf. 117, p. 158]. The broader the health claims marketed with the Cosmeceuticals, the more likely they will have to undergo scrutiny by drug administration bodies, leading to a convergence of regulations and standards. As examples from the area of Cosmeceuticals and especially NFF constitute the prime empirical base for the analyses conducted in this study, they will be analyzed in greater detail in Sect. 4.3.

With “many of the innovations that have transformed health care [having] come from the combination of progress in seemingly unrelated areas” [118, p. 34], the pharmaceutical industry is also affected by developments involving nanotechnology, biotechnology, information technology and cognitive science (NBIC), which are aiming at the “improvement of human performance” [cf. 11, pp. 187ff.; 119, pp. 281ff.; 120, pp. 35f.]. With possibly far-reaching implications, Roco and Bainbridge speak of the world standing “at the threshold of a New Renaissance in science and technology, based on a comprehensive understanding of the structure and behavior of matter from the nanoscale to the most complex system yet discovered, the human brain” [119, p. 281]. Similarly, Hacklin argues that nanotechnology will act as a kind of catalyst or platform for a range of existing scientific disciplines, including mathematics, physics, chemistry, biology and engineering sciences [cf. 11, pp. 188f.]. The combination of these different disciplines and technological fields⁷¹ will lead to products like biosensors, nanosensors or biological nanoscale chips which could be employed in drug delivery or other areas to overcome human illnesses and ‘limitations’. Roco & Bainbridge report on six visionary topics in combination with NBIC:

- Overall potential of converging technologies
- Expanding human cognition and communication
- Improving human health and physical capabilities
- Enhancing group and societal outcomes
- National security
- Unifying science and education.

⁷⁰ See, e.g., [116] who also cites Dr. Nicholas Perricone, founder of NV Perricone MD Cosmeceuticals, opposing accusations of Cosmeceuticals’ low credibility: “Cosmeceuticals are science-based rather than marketing-driven, giving the customer results and value for their investment.”

⁷¹ Other authors describe similar developments but limit them to only nanotechnology and biotechnology cf., e.g., [121, pp. 105ff.].

These topics are largely related to anticipated alterations in basically any function of the human mind and body, including communication, thinking, sensory and physical strength. Through a massive increase in human performance, they expect not only enhanced national productivity but also an improvement of societal outcomes and quality of life [cf. 119, pp. 281ff.]. While these developments could certainly lead to massive changes in the underlying technologies and the way products and processes are constructed, industry convergence would need distinct industry sectors, which could then begin to converge. As discussed above, it remains arguable whether these are existent in connection with the respective scientific disciplines.

2.3.5 *Service Sector and Other Industries*

Certainly, convergence is mainly a phenomenon discussed in connection with research-intensive industries. Following the line of argument in most studies (including the present one), this is also rightly so as it is mainly driven by substantial changes in the underlying technology and knowledge bases. In contrast to this, convergence may also be driven by political or societal developments.⁷²

One of the largest sectors affected by convergence trends is the health care system. Health insurers are said to engage more in health care management and health information management, aiming at reducing their expenses. Hospitals and physicians spend more effort in delivering non-directly health-related services, such as wellness, nutritional and fitness consulting [cf. 122, pp. xxiiff.]. Some even discuss a convergence of health care and the internet, with more and more information searched on the internet and sometimes even online discussion of possible treatments [cf. 123, pp.8ff.]. Despite several further (and probably to a certain extent unknown) parameters influencing the path of the health care system, Pierce concludes: “Convergence will be gradual and the impact may not be immediately obvious, but the long term outcome will dramatically reshape the industry” [122, p. xxx].

Part of this reshaping is a blurring of boundaries between traditional health insurers and banking institutions. Especially in the USA new legislations are expected to lead to a convergence of both sectors [cf. 124, pp. 3ff.]. The predicted merger of banking and insurance institutions (termed ‘bank assurance’) is not necessarily limited to health insurers. Furthermore, banks are experiencing more turmoil from other angles. For example, car manufacturers are offering customers more and more banking services. While potential buyers used to ask their local bank for a loan, they nowadays often turn to the banking affiliate of their car maker. And those banks do not only offer services in direct connection with the

⁷² See Sect. 2.2.3 for an overview of different triggers and drivers of convergence and their possible classification.

purchase of cars, in the meantime they have established quite a vast array of regular banking services [cf. 125, p. 348].

These examples share a market perspective rather than a technological perspective driving their convergence. This is different with the final example. Rosenberg's technological convergence is focusing on developments in all "machinery and metal-using sectors" [8, p. 423]. Due to the employment of a common set of technologies, previously unrelated industries (because of the characteristics and the applications of the products) converge technologically. He uses the examples of firearms, sewing machines and bicycles [8, pp. 423ff.]. Undoubtedly, these industries witnessed technological convergence. As markets and companies did not really begin to merge, industry convergence (as defined earlier) did not occur on the basis of metal-using technologies.

2.4 Process of Convergence

The examples presented in Sect. 2.3 exemplify the variety of convergence phenomena in different industrial settings. This is in part caused by different triggers and drivers and, of course, varying strategic responses by different firms. To another part this is due to diverse parameters and characteristics of the respective industries. But the underlying logic is in most cases similar. For the anticipation of convergence, it is of particular relevance to consider the level at which convergence is supposed to be measured. Thus, this chapter will analyze the sequence of events and the modules on which convergence is usually build upon. A few of the aforementioned authors have tried to categorize convergence on separate levels, on the basis of different points in time or different breadths of actions. Prior to the introduction of an idealized sequence of levels of convergence, three approaches to categorization are briefly discussed.

As well the European Commission as Tarjanne discriminate three levels from each other: (1) technology, (2) industry and (3) services/markets. Following their delineation, convergence on the *technology* level addresses different products/services fulfilling similar needs [cf. 12; 15; 33, p. 37]. So, e.g., NFF would (for a part of the customer base) have medical effects similar to those caused by pharmaceutical drugs. On *industry* level, convergence leads to a higher degree of direct interaction between distinct firms, resulting in the formation of alliances, joint ventures or even M&A activities. Convergence on the level of *services* tries to classify the establishment of new services at the intersection of the formerly disjoint industries. In their opinion, convergence on one of these levels does not necessarily transpire to similar events on the other two levels [cf. 15, pp. IVff.].

Fransman employs a rather comprehensive distinction between five areas⁷³: (1) networks (representing infrastructure), (2) industries/markets, (3) products/

⁷³ Although Fransman uses the term 'areas', it is strongly connected to the discussed 'levels'.

services, (4) firms and (5) technologies. An overview of these five areas, their explanation and examples are provided in Table 2.3. Basically, convergence in *network infrastructure* represents the offering of similar access to one point. One example would be the possibility to connect to the internet via dial-up services over telephone landlines, access through mobile phone networks, broadband, or cable services. Internet telephony is his example for convergence of *industries* and *markets*, with separate industries beginning to compete with each other on the basis of similar products/services. Accordingly, *products/services* convergence reflects the merger of different functionalities afterwards combined into one single product, as can be seen in smartphones (in comparison to cellular phones, digital cameras and portable audio players etc. as separate devices). As a fourth area *firms* are introduced, describing any form of strategic partnerships between companies from different industries. Finally, convergence in *technologies* is sub-divided into three further cases. First, generic technologies for different applications, such as digitization in ICT are mentioned. Second, technologies as a sort of umbrella technology, such as the internet protocols are listed. Third, Fransman identifies competition between distinct technologies providing similar benefits as a sub-division, such as the technologies behind mobile telephony competing with those enabling fixed telephony [cf. 33, pp. 35ff.].

The probably most detailed taxonomy is discussed by Hacklin. He employs four stages of convergence in his “evolutionary and sequential perspective”: (1) knowledge convergence, (2) technological convergence, (3) applicational convergence and finally (4) industrial convergence [cf. 11, pp. 56ff.]. According to his definition the first is marked by (to an individual firm) serendipitous *knowledge* spillovers between previously disjoint knowledge bases and leading to a new combination of knowledge sets, initiated by a large scale erosion of isolated industry specific-knowledge [cf. 25, p. 3]. Accordingly, the ability to enrich conventional food with substances that reach the desired area in the human body and can thus trigger a physical reaction, could be viewed as such a combination of distinct knowledge bases. In Hacklin’s line of argument this knowledge would not only relate to the technological knowledge sets of food processing and of drug delivery, but also to the related market knowledge. [cf. 11, pp. 56f.] Consequently, he describes *technological* convergence as a “transition of knowledge convergence into a potential for technological innovation” [11, p. 60]. Again, it is not viewed as a conscious-driven act, but rather as a partly serendipitous evolution, based on the combination of different knowledge sets. Digitization would be an example of a technological convergence that in his reasoning would not necessarily lead to convergence in the higher hierarchies of convergence. It could also be seen as just a creation of some sort of widely used, generic technology.

On the next step, the *applicational* convergence, managers’ will becomes a decisive factor. Here they need to spot opportunities for a realignment of their business activities, going further than just the creation of new products/services. Such realignment can be seen in the food industry, where many companies have realized and utilized the potential of the new knowledge and technological capabilities and transformed those into new fields of activity. The final step,

Table 2.3 Fransman's classification of convergence areas and their examples

Interrelated convergence areas	Kind of convergence	Examples of convergence
Networks	• Interconnection/interoperability between networks	• Telecom^a (PSTN,^b ISDN,^c fixed and mobile) and data and broadcasting (cable, terrestrial and satellite) networks
Industries/ Markets	• Previously separate industries based on separate markets now offering similar products/services to the same customers	• Telephony, fax transmission, video conferencing and internet access offered by information processing and software companies and telecom companies
Products/ Services	• Products/services incorporating some of the functionalities of other products/services previously sold in disjoint markets	• Television (TV) sets becoming Personal Computer (PC)-like • PCs becoming TV-like • Hybrid PCTVs • Computer-telephony integration • VoIP
Firms	• Firms, previously in separate industries/markets, converging in terms of markets, products/services and technologies	• Joint ventures/strategic alliances between computer hardware and software, telecom, broadcasting companies
Technologies	(a) Digital technology providing a 'common currency' (b) Technologies integrating other technologies (c) Technological competition as a result of and response to convergence	(a) Computing, switching, transmission and broadcasting now all digital (b) TCP/IP^d Internet protocol or Platform-independent Java programming language (c) Fixed versus mobile telephony or VoIP versus telecom networks or broadband versus cable modems versus satellite

Source Adapted from [33, p. 37]

^a Telecommunication

^b Public switched telephone network (PSTN), originally network of fixed-line analog telephone systems, today mostly digital

^c Integrated services digital network (ISDN), telephone network system that can transmit voice, video and data streams at the same time over PSTN

^d Transmission control protocol/internet protocol (TCP/IP), two central parts of the Internet Protocol Suite that are often used synonymously for the whole set of communication protocols necessary to communicate through local area networks (LANs) or the internet

termed 'industrial convergence' denotes a degree of convergence, where firms from previously distinct industries are increasingly competing with each other as the industries' boundaries blur. This is set off by changing business models and value chains and will in many cases lead to increased strategic alliances and M&A activity [cf. 11, p. 61f.]. The ICT setting serves well as an example for industry convergence. Undoubtedly, different knowledge sets had to be combined to be able to stretch technological developments such as digitization across industries as diverse as camera manufacturers, state-owned telecommunication monopolists and

personal computer manufacturers. New business models have been developed by many companies in ICT and several firms have tried to conquer new markets by siding with firms from other industry sectors.⁷⁴ Summing up, Hacklin views convergence as an “evolutionary process” [11, p. 65], with each of the steps triggering the next sequential convergence. In his perception these are preceded by distinct knowledge bases, unassociated technologies, intersected technologies and integrated technologies, respectively [cf. 11, p. 103].

According to the short explanations of the three levels by the European Commission and Tarjanne, it remains unclear what is exactly included on each of the levels and where their borders run. Furthermore, their approach does not entail an explanation of how convergence—in general—evolves. As comprehensive as Fransman’s categorization is, it poses the challenge to clearly distinguish between the individual areas. For instance, technologies and networks would appear to be closely related, as competition of different networks could also be viewed as competition between underlying technologies. Similarly, the delineation of industries/markets, firms and products/services seems to be rather arbitrary. It is not clear why products/services should not be part of either the firm perspective (as they are offering them) or the market perspective (as that is where they will be competing against each other). Similarly, although Hacklin’s distinction between four sequential stages of convergence is rather convincing, it bears the problem of differentiating between knowledge/technological convergence as well as between applicational/industrial convergence. This is also reflected in his own use of the terms. Several tables in his book, discerning between the four stages, list common results for each of the two pairs.⁷⁵ Following his delineation, it is particularly difficult to grasp the concept of knowledge convergence and to decide where knowledge convergence would end and technological convergence would begin. The term ‘knowledge’ itself is, despite its ubiquitous use, very complicated to define.⁷⁶ Hacklin’s examples for a merging of knowledge sets tend to be rather intertwined with technological developments [cf. 11, pp. 56ff.]. Thus, a differentiation between (patentable) technological knowledge and technologies themselves appears to be rather complex. Especially when assessing the degree of convergence on different levels, it is important to select distinct proxies for each of the convergence steps. Hence, the present study needs to build its concept on sharply distinguishable sequences and their related indicators.

Convergence has been discussed mainly in connection with industries that are to a high degree science and technology driven. In the ICT as well as the chemical sector and their neighboring industries shortened lifecycles and up to two-digit R&D spending have resulted from pivotal developments in the respective scientific fields. Thus, in most cases a convergence of technologies or even whole industries

⁷⁴ For a thorough discussion of convergence in ICT see [Sect. 2.3.1](#).

⁷⁵ See, e.g., [11] or [Table 3.11](#).

⁷⁶ For a thorough definition of knowledge and its delineation from terms such as ‘data’, ‘information’ and ‘wisdom’ see a comprehensive discussion in, e.g., [126, pp. 52ff.].

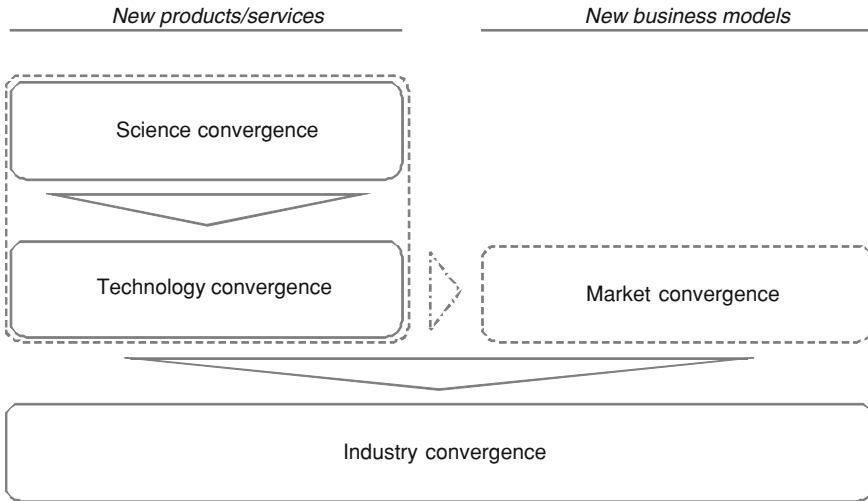


Fig. 2.6 Sequential process of industry convergence. *Dashed lines* indicate facultative dependencies, whereas *solid lines* represent obligatory connections between individual sequences (Source Adapted from [127], p. 259)

will succeed a growing overlap of scientific disciplines. The hierarchical nature of these interdependencies is the starting point for the sequential convergence process, which is depicted in Fig. 2.6.

When looking at further cases of convergence, there is mostly a similar pattern of events. At first, different scientific disciplines realize that their research is of interest to or affected by other disciplines. Once they begin to use more and more research results of one another [cf. 47], a scientific convergence will start with cross-disciplinary citations and eventually develop further into closer research collaborations. After the distance between basic science areas has been decreasing for some time, applied science and technology development should follow [cf. 128, 129], leading to technology convergence. This can trigger market convergence, with new product-market combinations. Finally, firms begin to merge with each other, completing the convergence process with industry convergence. Whilst in most cases convergence will thus build up over each of the steps, on some occasions industry convergence may evolve as a direct result of just one of both developments—either new business models or new products/services. For example, convergence of the banking and the insurance sectors has not been driven by technological developments, but rather by new business models. Hence, the idealized time series of events introduced earlier [cf. 130, pp. 386f.; 131, pp. 640f.], has been developed further to also include such phenomena. Also, convergence does not necessarily imply the development of a new industry. In some cases industry areas or, e.g., scientific disciplines may create a new area of collaboration, without changes in the antecedent areas and even nothing more than loosely

coupled to them. This may mean a movement from both areas, but as well only one of the fields may be evolving their expertise further in such a direction.

Being aware that this is a simplified and idealized process, this sequential model is still deemed useful to discuss different means for anticipating and (later in the time series) realizing occurrences of convergence. Independent of which of the parts of this process will be part of any case of convergence, it can still be used as a theoretical basis. Naturally, caution has to be exerted when deriving conclusions from such measurements, as it has to be borne in mind that not all steps need to show a tendency towards convergence. [Chapters 3](#) (concept) and [6](#) (discussion) will discuss this study's approach in anticipating convergence and limitations to the interpretation of accordingly derived results in greater detail.

References

1. Katz, M.L.: Remarks on the economic implications of convergence. *Ind. Corp. Change* **5**(4), 1079–1095 (1996)
2. Kaluza, B., Blecker, T., Bischof, C.: Implications of digital convergence on strategic management. In: Dahiya, S.B. (ed.) *The Current State of Economic Science*, vol. 4, pp. 2223–2249. Spellbound Publications, Rohtak, India (1999)
3. Stieglitz, N.: *Strategie und Wettbewerb in konvergierenden Märkten*. Deutscher Universitäts-Verlag, Wiesbaden, Germany (2004)
4. Lind, J.: Ubiquitous convergence: market redefinitions generated by technological change and the industry life cycle. Paper presented at the DRUID Academy Winter 2005 PhD Conference, Aalborg, Denmark, 27–29 Jan 2005
5. OECD: Telecommunications and broadcasting: convergence or collision? No. 29. In: *OECD Digital Economy Papers No. 5*. OECD Publishing (1992)
6. Oxford Dictionary of English: In: Oxford University Press, Oxford, UK (2006)
7. Gordon, R.: The meanings and implications of convergence. In: Kawamoto, K. (ed.) *Digital Journalism: Emerging Media and the Changing Horizons of Journalism*, pp. 57–73. Rowman & Littlefield, Lanham (MD), USA (2003)
8. Rosenberg, N.: Technological change in the machine tool industry, 1840–1910. *J. Econ. Hist.* **23**(4), 414–443 (1963)
9. Oettinger, A.G.: Communications in the national decision-making process. In: Greenberger, M. (ed.) *Computers, Communications, and the Public Interest*. Johns Hopkins Press, Baltimore (MD), USA (1971)
10. Farber, D., Baran, P.: The convergence of computing and telecommunications systems. *Science* **195**(4283), 1166–1170 (1977)
11. Hacklin, F.: *Management of convergence in innovation—Strategies and capabilities for value creation beyond Blurring Industry boundaries*. Physica-Verlag, Heidelberg, Germany (2008). Contributions to Management Science
12. Nyström, A.-G.: *Understanding change processes in business networks—A study of convergence in Finnish telecommunications 1985–2005*. Åbo Akademi University Press, Turku, Finland (2008)
13. Curran, C.-S., Leker, J.: When two worlds collide—Measuring industry convergence. In: 2009 Academy of Management Annual Meeting, Chicago (IL), USA, 07–13 Aug 2009
14. Bally, N.: Deriving managerial implications from technological convergence along the innovation process: a case study on the telecommunications industry. In: *MEMO-STENCIL, Preliminära Forskningsrapporter*, vol. 223. Åbo Akademi School of Business, Åbo, Finland (2005)

15. European Commission: Green paper on the convergence of the telecommunications, media and information technology sectors, and the implications for regulation—Towards an Information Society Approach. In., vol. COM(97)623. Brussels, Belgium (1997)
16. Lind, J.: Convergence: history of term usage and lessons for firm strategists. In: 15th Biennial ITS Conference, Berlin, Germany, 2004
17. Balthasar, A., Bättig, C., Thierstein, A., Wilhelm, B.: “Developers”: key actors of the innovation process: types of developers and their contacts to institutions involved in research and development, continuing education and training, and the transfer of technology. *Technovation* **20**, 523–538 (2000)
18. Bierly, P.E., Chakrabarti, A.K.: Managing through industry fusion. In: Brockhoff, K., Chakrabarti, A.K., Hauschildt, J. (eds.) *The dynamics of innovation: strategic and managerial implications*, pp. 7–26. Springer, Berlin, Heidelberg, New York (1999)
19. Bierly, P.E., Chakrabarti, A.K.: Dynamic knowledge strategies and industry fusion. *Int. J. Manuf. Technol. Manage.* **3**(1/2), 31–48 (2001)
20. Bröring, S.: The front end of innovation in converging industries: The case of Nutraceuticals and functional foods. DUV, Wiesbaden, Germany (2005)
21. Bröring, S., Cloutier, L.M., Leker, J.: The front end of innovation in an era of industry convergence: evidence from Nutraceuticals and functional foods. *R&D Manage.* **36**(5), 487–498 (2006)
22. Bröring, S., Leker, J.: Industry convergence and its implications for the front end of innovation: a problem of absorptive capacity. *Creativity Innov. Manage.* **16**(2), 165–175 (2007)
23. Fai, F., von Tunzelmann, N.: Industry-specific competencies and converging technological systems: evidence from patents. *Struct. Change Econ. Dyn.* **12**(2), 141–170 (2001)
24. Malhorta, A., Gupta, A.K.: An investigation of firm’s strategic response to industry convergence. In: *Academy of Management Proceedings*, 2001, Best Paper Series: G1 (2001)
25. Pennings, J.M., Puranam, P.: Market convergence & firm strategy: new directions for theory and research. In: *ECIS Conference, The Future of Innovation Studies*, Eindhoven, Netherlands, 20–23 Sept 2001
26. Weaver, B.: Industry convergence: driving forces, factors and consequences. Paper presented at the 19th NFF conference, Bergen, Norway, 9–11 Aug 2007
27. Müller, K.: *Strategieprozess und Marktkonvergenz—Der Zusammenhang zwischen unternehmensstrategischem Handeln, Unternehmensstrategie und konvergierenden Märkten aus der Perspektive der Strukturtheorie—Mit einem Beispiel aus dem Bereich Mobile TV.* (2008)
28. von Tunzelmann, N.: “Convergence” and corporate change in the electronics industry. In: Gambardella, A., Malerba, F. (eds.) *The organization of economic innovation in Europe*, pp. 125–157. Cambridge University Press, Cambridge, UK (1999)
29. Kern, T.: Convergence makes a comeback. *Broadcasting & Cable* (2005)
30. Duysters, G., Hagedoorn, J.: Technological convergence in the IT industry: the role of strategic technology alliances and technological competencies. *Int. J. Econ. Bus.* **5**(3), 355–368 (1998)
31. Rikkiev, A., Mäkinen, S.: Success factors for technology integration convergence collaboration: empirical assessment. In: XXXX (ed.) *PICMET ‘09 Conference: “Technology Management in the Age of Fundamental Change”*, pp. 374–382, Portland (OR), USA 2009
32. Myring, J.: Industry convergence is good news for users. *NMA* 24 Aug 2006, p. 7 (2006)
33. Fransman, M.: Convergence, the internet and multimedia: implications for the evolution of industries and technologies. In: Bohlin, E., Brodin, K., Lundgren, A., Thorngren, B. (eds.) *Convergence in Communications and Beyond*. North Holland, Amsterdam, The Netherlands (2000)
34. Gallouj, F.: *Innovation in the Service Economy: The New Wealth of Nations*. Edward Elgar Publishing, Cheltenham, UK (2002)

35. Tidd, J., Hull, F.M.: Managing service innovation: variations of best practice. In: Hull, J.T.F.M. (ed.) *Service Innovation: Organizational Responses to Technological Opportunities & Market Imperatives*. Series on Technology Management, vol. 9, pp. 3–34. Imperial College Press, London, UK (2003)
36. Quinn, J.B., Guile, B.R.: Managing innovation in services. In: Quinn, B.R.G.J.B. (ed.) *Managing Innovation: Cases from the Services Industries*. Series on Technology and Social Priorities, pp. 1–8. National Academy Press, Washington (DC), USA (1988)
37. Central Intelligence Agency: The CIA World Factbook—GDP Composition by Sector. <https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html?countryName=United%20Kingdom&countryCode=uk®ionCode=eu&#uk> (2009). Accessed 17 Nov 2009
38. Borés, C., Saurina, C., Torres, R.: Technological convergence: a strategic perspective. *Technovation* **23**(1), 1–13 (2003)
39. Yoffie, D.B.: CHES and competing in the age of digital convergence. In: Yoffie, D.B. (ed.) *Competing in the Age of Digital Convergence*, pp. 1–36. Harvard Business School Press, Boston (MA), USA (1997)
40. Gill, T.: Convergent products: what functionalities add more value to the base? *J. Mark.* **72**(2), 46–62 (2008)
41. Choi, D., Valikangas, L.: Patterns of strategy innovation. *Eur. Manage. J.* **19**(4), 424–429 (2001)
42. Guilhon, B.: The emergence of the quasi-markets for knowledge. In: Guilhon, B. (ed.) *Technology and Markets for Knowledge: Knowledge Creation, Diffusion and Exchange within a Growing Economy*, pp. 21–40. Kluwer Academic Publishers, Norwell (MA), USA (2001)
43. Adner, R., Levinthal, D.A.: Technology speciation and the path of emerging technologies. In: Day, G.S., Schoemaker, P.J.H., Gunther, R.E. (eds.) *Wharton on managing emerging technologies*, pp. 57–74. Wiley, New York (NY), USA (2000)
44. Kim, J.: Will technology fusion induce the paradigm change of university education? *Int. J. Technol. Manage.* **38**(3), 220–234 (2007)
45. Kodama, F.: Technology fusion and the new R&D. *Harvard Bus. Rev.* **70**(4), 70–78 (1992)
46. Fujimoto, M., Miyazaki, K., Tunzelmann, N.V.: Technological fusion and telemedicine in Japanese companies. *Technovation* **20**, 169–187 (2000)
47. Bainbridge, W.S.: Transformative concepts in scientific convergence. *Ann. N. Y. Acad. Sci.* **1093**, 24–45 (2006). doi:[10.1196/annals.1382.003](https://doi.org/10.1196/annals.1382.003)
48. Yasunaga, Y., Watanabe, M., Korenga, M.: Application of technology roadmaps to governmental innovation policy for promoting technology convergence. *Technol. Forecast. Soc. Chang.* **76**, 61–79 (2009)
49. Ip, B.: Technological, content, and market convergence in the games industry. *Games Cult.* **3**(2), 199–224 (2008)
50. Gambardella, A., Torrisi, S.: Does technological convergence imply convergence in markets? Evidence from the electronics industry. *Res. Policy* **27**, 445–463 (1998)
51. Nyström, A.-G.: What is convergence? Perceptions from the Finnish telecommunications Sector. Paper presented at the 18th European Regional ITS Conference, Istanbul, Turkey, 02–04 Sept 2007
52. Hacklin, F., Marxt, C., Fahrni, F.: Coevolutionary cycles of convergence: an extrapolation from the ICT industry. *Technol. Forecast. Soc. Chang.* **76**, 723–736 (2009)
53. Hacklin, F., Raurich, V., Marxt, C.: Implications of technological convergence on innovation trajectories: the case of ICT industry. *Int. J. Innov. Technol. Manage.* **2**(3), 313–330 (2005)
54. Theilen, F.: Geschäftsmodellbasiertes Konvergenzmanagement auf dem Markt für mobile Financial Services. Diskussionsreihe Bank & Börse. Springer, Wien, Austria (2004)
55. Weaver, B.: ‘Convergence’ in the security industry—Definitions, drivers and consequences. In: LUSAX Memos., vol. LXM-BW2—Convergence, pp. 1–6 (2008)

56. Weaver, B.: Security industry convergence - bridging the knowledge divide. In: LUSAX Memos., vol. LXM-BW1—Knowledge Gap, pp. 1–5 (2007)
57. Moore, G.E.: Cramming more components onto integrated circuits. *Electronics* **38**(8) (1965)
58. Intel Corporation: World's First 2-Billion Transistor Microprocessor. http://www.intel.com/technology/architecture-silicon/2billion.htm?id=tech_mooreslaw+rhc_2b (2009). Accessed 03 Nov 2009
59. Hauschildt, J., Salomo, S.: *Innovationsmanagement*, 4th edn. Vahlen, München, Germany (2007)
60. Bröring, S.: Developing innovation strategies for convergence—Is 'open innovation' imperative? *Int. J. Technol. Manage.* **49**(1/2/3), 272–294 (2010)
61. Mowery, D.C., Rosenberg, N.: The influence of market demand upon innovation: a critical review of some recent empirical studies. *Res. Policy* **8**, 102–153 (1979)
62. Howells, J.: Rethinking the market-technology relationship for innovation. *Res. Policy* **25**, 1209–1219 (1997)
63. Herzog, P.: Open and closed innovation—Different cultures for different strategies. Gabler, Wiesbaden (2008)
64. Nordhoff, S., Höcker, H., Gebhardt, H.: Renewable resources in the chemical industry—Breaking away from oil? *Biotechnol. J.* **2**(12), 1505–1513 (2007)
65. Narayanan, M.P.: Managerial incentives for short-term results. *J. Finance* **40**(5), 1469–1484 (1985)
66. Yu, L., Slavin, M.: All natural whole-wheat functional foods for health promotion and disease prevention. In: *Functional Food and Health*. ACS Symposium Series, pp. 125–142. American Chemical Society, Washington, DC (2008)
67. Gilbey, J.: Valuing the digital economy. *Nature* **462**(7270), 165 (2009). doi:[10.1038/462165a](https://doi.org/10.1038/462165a)
68. Athreye, S., Keeble, D.: Technological convergence, globalisation and ownership in the UK computer industry. *Technovation* **20**, 227–245 (2000)
69. Basu, I.: Estonia Becomes E-stonia. *Government Technology* (2008)
70. de Bruxelles, S.: Swindon to become first UK wi-fi town. *Times Online* (2009)
71. City of Milpitas: Information services—Citywide free public WiFi internet service. http://www.ci.milpitas.ca.gov/government/is/wifi_service.asp (2009). Accessed 22 Nov 2009
72. Reardon, M.: Free San Francisco Wi-Fi project dies. *cnet news* (2007)
73. Chan, S.: Deal collapses for free Wi-Fi in parks. *The New York Times* (2009)
74. Federal Communications Commission: Telecommunications Act of 1996. <http://www.fcc.gov/telecom.html> (2008). Accessed 22 Nov 2009
75. Anonymous: Telecommunications act of 1996. In: 104th US Congress, vol. Public Law No. 104-104, pp. 110 Stat. 156–161. Washington (DC), USA, (1996)
76. Anonymous: Commission directive 90/388/EEC of 28 June 1990 on competition in the markets for telecommunications services. In: The Commission of the European Communities (ed.), vol. 90/388/EEC. Official Journal L 192, 124/107/1990 P. 0010–0016. Brussels, Belgium (1990)
77. Anonymous: Commission Directive 2002/77/EC of 16 September 2002 on competition in the markets for electronic communications networks and services. In: The Commission of the European Communities (ed.), vol. 90/388/EEC. Official Journal L 249, 217.209.2002, pp. 2021–2026. Brussels, Belgium, (2002)
78. AOL Time Warner: America online and time warner will merge to create world's first internet-age media and communications Company. <http://www.timewarner.com/corp/newsroom/pr/0,20812,667602,00.html> (2000). Accessed 23 Nov 2009
79. McCullagh, D.: AOL, Time Warner to Merge. *Wired.com* (2000)
80. Glasner, J.: Why AOL wants time warner. *Wired.com* (2000)
81. Rushe, D.: AOL and time warner split after 'deal of the century' goes bad. *Times Online* (2008)
82. Musgrove, M., Ahrens, F.: Time Warner, AOL to Split by Year-End. *The Washington Post* (2009)
83. Bewkes, J.: AOL information statement. In: Time Warner & AOL shareholders (ed.), pp. 1–240. New York (NY), USA (2009)

84. Smith, A.: Time warner to split off AOL. CNNMoney.com (2009)
85. AOL Time Warner: AOL time warner to rename company 'Time Warner'. <http://www.timewarner.com/corp/newsroom/pr/0,20812,670030,00.html> (2003). Accessed 25 Nov 2009
86. Spekman, R.E., Bolon, M.: AT&T and Olivetti: Analysis of a Failed Strategic Alliance (2008)
87. Markoff, J.: I.B.M. to Sell Rolm to Siemens. *The New York Times*, 14 Dec 1988 (1988)
88. Spekman, R.E., Bolon, M.M.: AT&T and Olivetti: Analysis of a Failed Strategic Alliance (1993)
89. NCR Corporation: NCR History Timeline. http://www.ncr.com/about_ncr/company_overview/history.jsp (2009). Accessed 25 Nov 2009
90. Bower, J.L.: Not all M&As are alike—and that matters. *Harvard Bus. Rev.* **2/2001**, 93–101 (2001)
91. Sodeik, N.: Projektmanagement wertorientierter Mergers & Acquisitions, vol. 124. Planung, Organisation und Unternehmensführung. Josef Eul Verlag, Lohmar, Germany (2009)
92. Snow, B.: The 10 worst-selling consoles of all time. [http://www.gamepro.com/article/features/111823/the-10-worst-selling-consoles-of-all-time-page-2-of-2/\(2007\)](http://www.gamepro.com/article/features/111823/the-10-worst-selling-consoles-of-all-time-page-2-of-2/(2007)). Accessed 20 Nov 2009
93. Foljanty, L.: The apple museum. <http://www.theapplemuseum.com> (2009). Accessed 20 Nov 2009
94. Sanford, G.: Apple history. <http://www.apple-history.com> (2009). Accessed 20 Nov 2009
95. United States Securities and Exchange Commission: Form 8-K: Apple Inc. In: vol. Commission File Number 000-10030, 09 Jan 2007. Washington (DC), USA, (2007)
96. Yoffie, D.B., Slind, M.: Apple Inc., 2008. In: vol. Case Study No. 9-708-480, pp. 1–32. Harvard Business School (2008)
97. Anonymous: Apple Inc. http://en.wikipedia.org/wiki/Apple_inc (2009). Accessed 20 Nov 2009
98. Sony Corporation: Affiliated Companies. <http://www.sony.net/SonyInfo/CorporateInfo/Subsidiaries/index.html> (2009). Accessed 22 Nov 2009
99. Sony Corporation: Annual Report 2009. In. Tokyo, Japan (2009)
100. Sony Ericsson Mobile Communications: Sony Ericsson. <http://www.sonyericsson.com/cws/corporate/home> (2009). Accessed 22 Nov 2009
101. Sony Corporation: Corporate history. <http://www.sony.net/SonyInfo/CorporateInfo/History/history.html> (2009). Accessed 22 Nov 2009
102. Sony Corporation: Microsoft and Sony to collaborate in creating the convergence of personal computer, digital television and consumer audio-visual platforms. Press Release, 07 Apr 1998 (1998)
103. Sony Corporation: About Sony Group. [http://www.sony.net/SonyInfo/\(2009\)](http://www.sony.net/SonyInfo/(2009)). Accessed 22 Nov 2009
104. Tarjanne, P.: Convergence and implications for users, market players and regulators. In: Bohlin, E., Brodin, K., Lundgren, A., Thorngren, B. (eds.) *Convergence in Communications and Beyond*, pp. 39–43. Elsevier Science, Amsterdam, The Netherlands (2000)
105. Kaumanns, R., Neus, A., Pörschmann, F.C.: Konvergenz oder Divergenz? Erwartungen und Präferenzen der Konsumenten an die Telekommunikations- und Medienangebote von morgen. In: *IBM Global Business Services—Strategy & Change*. IBM Corporation, Stuttgart, Germany (2007)
106. Corrocher, N., Malerba, F., Montobbio, F.: Schumpeterian patterns of innovative activity in the ICT field. *Res. Policy* **36**(3), 418–432 (2007)
107. International Engineering Consortium (IEC): The new information industry. White Papers (2007)
108. Rhéaume, L., Bhabra, H.S.: Value creation in information-based industries through convergence: A study of U.S. mergers and acquisitions between 1993 and 2005. *Inf. Manage.* **45**(5), 304–311 (2008). doi:<http://dx.doi.org/10.1016/j.im.2008.03.002>

109. Schnaars, S., Thomas, G., Irmak, C.: Predicting the emergence of innovations from technological convergence: lessons from the twentieth century. *J. Macromarketing* **28**(2), 157–168 (2008)
110. Karvonen, M., Lehtovaara, M., Kässi, T.: Managing technological convergence: evidence from printed intelligence industry. In: Kocaoglu, D.F., Anderson, T.R., Daim, T.U., Jetter, A., Weber, C.M. (eds.) *Proceedings of PICMET '09, Technology Management in the Age of Fundamental Changes*, pp. 396–408, Portland (OR), USA, 2–6 Aug 2009
111. Gassmann, O., Reepmeyer, G., von Zedtwitz, M.: *Leading Pharmaceutical Innovation: Trends and Drivers for Growth in the Pharmaceutical Industry*, 2nd edn. Springer, Berlin/Heidelberg, Germany (2008)
112. Preschitschek, N., Curran, C.-S., Leker, J.: Are plastics turning Organic? Antecedents of Convergence in the Chemical Industry. Paper presented at the The XXI ISPIM Conference—The Dynamics of Innovation, Bilbao, Spain, 06–09 June 2010
113. McNamara, L.: Market dynamics in search of double-digit revenue growth: Can big pharma hit its numbers? *Int. J. Med. Mark.* **4**, 18–26 (2004)
114. Cole, M.: When food meets medicine. *Int. Rev.* **June/July**, 15–17 (1991)
115. Donnelly, W.J., Fenelon, M.A., Giblin, L., Stanton, C.: Obesity. The food research agenda. *Int. J. Dairy Technol.* **61**(1), 11–15 (2008)
116. Crompton, S.: Hype or beautiful science? *Times Online* (2007)
117. Dureja, H., Kaushik, D., Gupta, M., Kumar, V., Lather, V.: Cosmeceuticals: An emerging concept. *Indian J. Pharmacol.* **37**(3), 155–159 (2005)
118. Wilkinson, J.M.: Cultivate technology convergence for product innovation. *Med. Device Technol.* **17**(3), 34–36 (2006)
119. Roco, M.C., Bainbridge, W.S.: Converging technologies for improving human performance: integrating from the nanoscale. *J. Nanopart. Res.* **4**(4), 281–295 (2002)
120. Loveridge, D., Dewick, P., Randles, S.: Converging technologies at the nanoscale: the making of a new world? *Technol. Anal. Strateg. Manage.* **20**(1), 29–43 (2008). doi:[10.1080/09537320701726544](https://doi.org/10.1080/09537320701726544)
121. Thomas, T.C., Acuna-Narvaez, R.: The convergence of biotechnology and nanotechnology: Why here, why now? *J. Commer. Biotechnol.* **12**(2), 105–110 (2006)
122. Pierce, M.E.: Convergence of the health industry. *Leadersh. Health Serv.* **18**(1), xxii–xxxi (2005). doi:[10.1108/13660750510578402](https://doi.org/10.1108/13660750510578402)
123. Frank, S.R.: Digital health care—The convergence of health care and the internet. *J. Ambul. Care Manage.* **23**(2), 8–17 (2000)
124. Weinstock, P.G., Kalahurka, S.E.: Health savings accounts and the convergence of healthcare and banking. *Bank. Law J.* **125**(1), 3–48 (2008)
125. Fahrni, F.: Konvergenz als Herausforderung für neue Wertschöpfungsketten und Geschäftsmodelle. In: Klumpp, D., Kubicek, H., Roßnagel, A., Schulz, W. (eds.) *Informationelles Vertrauen für die Informationsgesellschaft*, pp. 347–356. Springer, Berlin/Heidelberg, Germany (2008)
126. Niedergassel, B.: *Knowledge sharing in collaborative R&D Projects*. University of Münster (2009)
127. Curran, C.-S., Leker, J.: Patent indicators for monitoring convergence—examples from NFF and ICT. *Technol. Forecast. Soc. Chang.* **78**(2), 256–273 (2011). doi:[10.1016/j.techfore.2010.06.021](https://doi.org/10.1016/j.techfore.2010.06.021)
128. Meyer, M.: Does science push technology? Patents citing scientific literature. *Res. Policy* **29**(3), 409–434 (2000)
129. Murray, F.: Innovation as co-evolution of scientific and technological networks: exploring tissue engineering. *Res. Policy* **31**(8–9), 1389–1403 (2002)
130. Curran, C.-S., Bröring, S., Leker, J.: Anticipating converging industries using publicly available data. *Technol. Forecast. Soc. Chang.* **77**(3), 385–395 (2010)
131. Curran, C.-S., Leker, J.: Employing STN AnaVist to forecast converging industries. *Int. J. Innov. Manage.* **13**(4), 637–664 (2009). doi:[10.1142/S1363919609002455](https://doi.org/10.1142/S1363919609002455)

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