Chapter 14
Spreading Innovations: Models, Designs and Research Directions

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14.1 Introduction

Diffusion models describe local change processes that lead over time to a spread of particles or information in a topological space. Metric spaces are the most common examples of topological spaces, but there are other examples, too. Any kind of space in which the notion of proximity can be formed, mathematically addressed by the term ‘neighbourhood’, allows the application of diffusion models. This does not only include standard Euclidean spaces as they are frequently used in physics or geography, but also formal networks describing interconnected social or technical entities (see e.g. the contribution by Shekhtman et al. in this volume). Diffusion models have therefore not only proven to be quite useful in the natural sciences, but also in research on the connections between individual human behavior and the economic, cultural or technical development of a society as a whole. For example, they have helped to gain a better understanding of the way how the effects of technical inventions, scientific discoveries and artistic genius evolve in time and space and how society and economy are able to take advantage of it.

One of the first scientists who addressed this issue systematically was the French sociologist and psychologist Gabriel Tarde at the turn to the twentieth century [1]. Tarde, a contemporary and competitor of Émile Durkheim, subsumed the adoption of novelty among humans under the term imitation and looked specifically at the effects of blind obedience, explanation and training and their sequential combination. He made clear that the spread of innovations in society cannot be left to themselves. They have to be actively managed and require a lot of effort, which is widely neglected in simple histories that focus exclusively on the dates of discovery

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and invention, implicitly assuming that the results will spread more or less automatically in society.

Inspired by Tarde, the thesis of this contribution is that such management activities go further than the search for the most important factors of influence of the diffusion process. They can more likely be described as design efforts which organize the spread of novelty in a way that makes it possible to conceptualize it as a predictable diffusion process and exploit it accordingly. At the same time, the subject matter of the diffusion process must be considered by itself as a designed artefact, too (see also Chap. 15.4.1 on social construction). The notion of an innovation is a social construct that can be gained in different ways, adding further complexity to the discussion.

Every scientific discipline has its idiosyncrasies, and a book that discusses diffusion across many disciplinary boundaries therefore provides many opportunities for misunderstandings, caused by different ontological assumptions, epistemological interests or deviating nomenclature. In this chapter, for example, an artefact is understood in its literal sense as an object made by man, whereas physics uses the term to address systematic errors due to deficiencies in experimental procedure. Further problems arise from the limited comparability of the subject matter to which the diffusion models are applied. The intuition of a natural scientist is rather guided by phenomena like the diffusion of molecules in porous solids (Chap. 10) or the diffusion of plants and animals in their habitats (Chap. 3), which can be described with reference to conventional metric spaces by the Eqs. (2.1)–(2.18) in the chapter on "Spreading Fundamentals". Social scientists are confronted with a different kind of reality, in which proximity is not exclusively depending on physical distance, but also on personal acquaintance and technical connectedness. Individuals can accordingly feel closer to family members on a different continent than strangers in the next building.

The chapters by Brockmann and by Shekhtman et al. in this book discuss the notions of distance and network which provide the foundation for the understanding of space and proximity used in diffusion studies by the social sciences. It illustrates the wealth of information attainable from solely the topological structure of such networks: the paths existing between its entities. As it will be explained, society is built on numerous overlaying networks that connect individuals with one another, provided by different technologies, roles and relationships. The fact that these networks can be actively changed contributes largely to the specific way diffusion is treated on the following pages.

14.2 Diffusion Models in Innovation Research

14.2.1 Conceptual Approaches

The term technology does not describe a homogeneous entity. Technology rather has to be understood as an embodiment of any kind of instrumental action that occurs repetitively in the world [2, 3]. This definition of technology makes it possible to treat any kind of innovation as technical. At the same time, however, it creates the need for numerous different operational measures for the diffusion of innovations, depending on the given context. In many cases, such measures can be gained through sales figures for technical artefacts. This, for example, is the case in Griliches' seminal work on the economics of technical change [4]. For Gort and Klepper [5], "diffusion is defined as the spread in the number of producers engaged in manufacturing a new product" which would economically be described as the net entry rate in the market for a new product. Rogers, on the other hand, describes diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system" [6], independently from any business operation. The spread of the internet requires yet another approach that takes the availability and, ideally, also the bandwidth of internet access into consideration [7]. In order to measure the actual adoption of a technology in daily routines, it is furthermore necessary to collect data on the frequency or intensity of usage.

In any case, innovations need a carrier medium to spread. This medium is provided by society, in terms of interrelated individuals, groups, corporations or other institutions that can be described as actors who hold certain information, are in possession of certain material goods, show certain behavior or have certain attitudes that entail certain decisions, which can then be empirically accessed. Regarding these actors, two important questions have to be asked: how are they connected and what resources do they have available to act? The connectedness determines the paths on which innovations can spread and thus induces a spatial structure on which diffusion can be observed. The availability of resources determines if and in what way the actors can make use of a technology, describing the capacity of the actors in their function as carriers of innovation.

The role of connectedness and resource availability for the diffusion of innovations is illustrated by the following examples:

- Innovative data processing algorithms can spread very quickly over the internet, if there is no further effort necessary for their installation. This effect is very well known from computer viruses. Their distribution is to a large extent a question of connectedness. One of the most popular ways of securing sensitive data is therefore to keep them isolated from the internet. Knowledge about new mathematical algorithms or construction methods in engineering spreads among sufficiently trained experts in a similar way.
- Expensive product innovations spread very slowly, even if many dealers keep them in stock. For example, this is currently the case for cars with electric engines, which need to be strongly subsidised to be sold. Connectedness does not matter, if people do not have the resources at their disposal to adopt them. Such resources do not only include financial means, but also qualification, time, space and the ability for habitual change.

As a general rule, one can say that connectedness matters most when innovations add novelty to an existing repertoire and are in this sense complementary to whatever is there already, whereas resource availability has to be considered whenever innovations entail a substitution process.

Inasmuch as the connections between the actors determine the paths on which innovations can travel and the available resources determine the potential for the adoption of an innovation, connectedness and resource availability both have to be considered in the design of a topology on which the diffusion of innovation is depicted as a formal process (illustrated by Brockmann in Chap. 19). Even if the transport infrastructure between the actors constitutes a small or an ultra-small network (see the contribution by Shekhtman et al. in Chap. 20), the actual travel times of innovations can be quite long, if their adoption requires an intensive substitution process. Furthermore, it is often necessary to take path dependencies during communication into account. Depending on the source of an innovation, actors can be more or less inclined to adopt it. Similar effects also have to be considered in the comparison of different communication channels such as internet blogs, e-mails, telephone calls, business gatherings or private meetings. Innovations, one can say, travel on very rough terrain and multi-dimensional surfaces.

Due to the increasing dynamics of technical, social and political development, the question of the durability of the change caused by the diffusion of innovations currently emerges as a new research topic for innovation studies. The switch to a new technology does not necessarily have to be permanent. Innovations often require a continuous flow of energy supply, consumer goods or regular expert maintenance. If the surrounding infrastructure breaks down, innovations can therefore disappear again. With the current discussion on the protection of critical social infrastructures against disruptive events, questions of technical robustness and resilience receive increased attention (e.g. [8]), and they are likely to become more important for innovation research in the future as well.

What can be learned for all this is that formal models to describe the diffusion of innovations have to be very specific about the subject matter they are concerned with and the social, technical and economic conditions under which the diffusion process is assumed to take place.

14.2.2 Mathematical Models

As a quantitative measure with reference to the diffusion of innovation, it stands to reason to consider the percentage of the target group who has adopted the innovation. Figure 14.1 shows this (in terms of the “fraction of the carrier medium that has adopted the innovation”, f) schematically as a function of time.

Early studies found that the increase in innovations as shown in Fig. 14.1 followed the typical pattern of constrained exponential growth [4, 9], visualized by an S-shaped curve with asymptotic behavior at the outer limits and a central inflection point (see arrow in figure). The curve shown in Fig. 14.1 corresponds with the

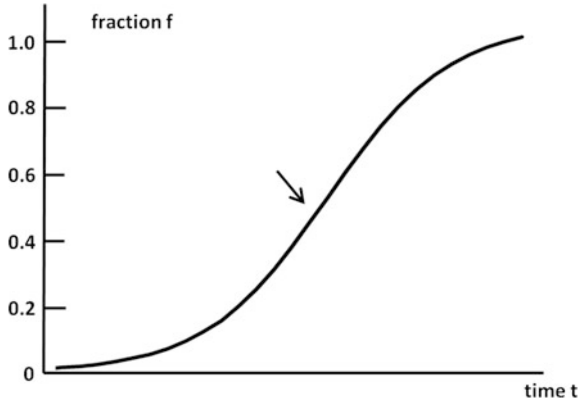


Fig. 14.1 Sample plot of constrained growth over time in a logistic function

so-called uptake curve indicating the relative number of molecules entering a nanoporous particle upon pressure increase in the surrounding atmosphere. It is illustrated in Chap. 10 that it is this type of information which over decades served as the main source of experimental evidence for the prediction of the diffusion characteristics in porous media, with all deficiencies of an "indirect" technique of measurement since evidence of such type of experiments concerns the effect of diffusion rather than the process of diffusion itself.

As this curve is characteristic for the logistic function (see Chap. 3, Sect. 3.4.1), Griliches [4] proposes that the diffusion of innovations be described by the according differential equation of the type

$$\frac{df}{dt} = af(1-f) \tag{14.1}$$

where f is the fraction of the carrier medium that has adopted the innovation, t is time, and a is a growth parameter.

This equation was introduced by Verhulst [10] in the discussion of limited population growth, without any data on the maximal population size that can actually be reached [11]. Innovation researchers are usually in a more comfortable situation, since they can estimate the maximal distribution of an innovation by the size of the current population or by referring to an older technology that is expected to be substituted by the innovation [12]. This approach is frequently used to forecast the progress of the diffusion of innovations, illustrated by the example of smartphones in Fig. 14.2.

Due to the conceptual challenges mentioned before, satisfactory explanations of this behaviour are hard to give. A common assumption is that differences in connectivity and resource availability cause adoption times t for innovations in society to follow a normal distribution $p(t)$. For each innovation, there are accordingly a few early adopters and laggards with exceptionally short or long adoption times, while the majority of the population stays within a smaller interval around the average adoption time (Fig. 14.3).

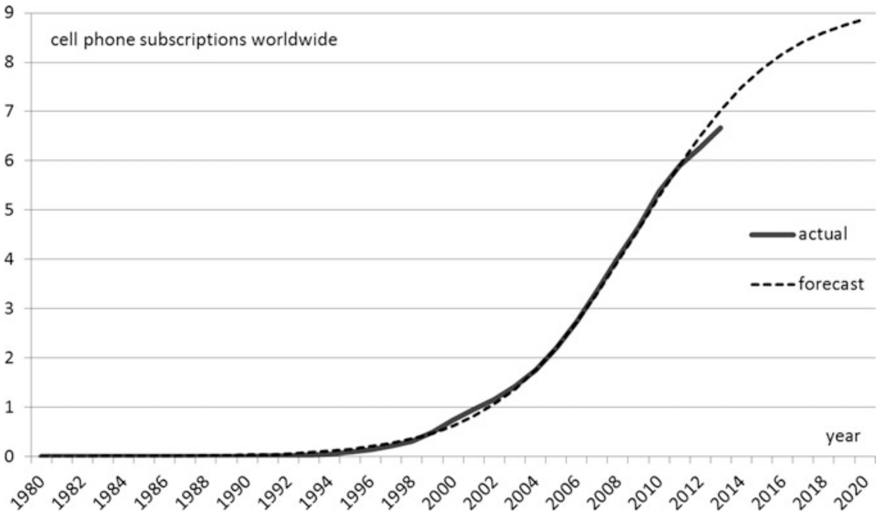


Fig. 14.2 Actual figures and forecast with logistic function for cell phone diffusion worldwide [13]

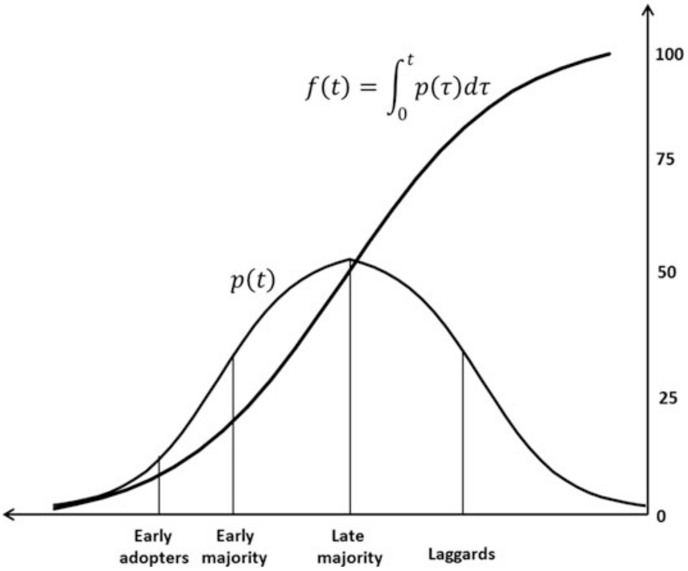


Fig. 14.3 Normal distribution of adoption characteristics in a population

Over the years, various modifications of this model have been suggested, in particular regarding the parameter a, which is not any more treated like a constant, but rather depending on changes in manufacturing and marketing [14]. In the course of the diffusion process, technology producers are expected to become more efficient, reduce prices and connect better to their audience, which accelerates the spread of the innovation.

While some data sets support this model, others raise questions about the general applicability of the logistics function to the diffusion of innovations. In a large survey on data sets about the diffusion of various technologies in different countries, Comin et al. [15] identify numerous cases in which logistic functions approximate the actual data very poorly and calculate unrealistic saturation times. While some of these findings may be caused by disruptive changes in the general setting (political change, economic crisis etc.), there is good reason to assume that there are also other internal dynamics at work which affect the diffusion process, in particular with respect to individual adoption behavior. These dynamics have become one of the major fields of study in innovation research.

14.3 Individual Adoption Behavior

14.3.1 Acceptance Models

Innovation research uses various different approaches to capture the causal relationships regarding the adoption behavior among social actors. A particularly high number of studies are based on the technology acceptance model, which looks at two different factors that influence the intention of an actor to use a technology [16]:

- the perceived ease of use refers to the complexity experienced by users in operating a technology and directing it to the outcome which they intend to achieve
- the perceived usefulness refers to the advantages that the users expect to result from applying the technology

These two factors reflect a distinction between costs and benefits of a technology in the ease of use expressing the effort necessary to handle it and the usefulness expressing the value generated by it. The perceived usefulness is by itself subject to various different influences, such as the quality of the output and its quality or the image of a technology in public and the social treatment of its users. Empirical evidence suggests that the perceived usefulness has a higher relevance for decision making process than the perceived ease of use [17]. As it seems, potential adopters expect a learning process over time that will make the technology easier to use in the future, while the perceived usefulness is considered as an attribute of the technology which cannot be influenced by them.

Another finding that has attracted a lot of attention during the last years is the contrast between personal acceptance and social acceptability of a technology. Public transportation may be taken as an example for a technology with higher social acceptability than personal acceptance: although most people agree that busses, subways and railroads are valuable means of transportation, many of them nevertheless prefer to drive by car for themselves. Smoking is an example of the opposite: despite all public concerns about it that they may share, many people still think that it is okay to have a cigarette for themselves.

In order to capture these differences, it is necessary to distinguish other factors influencing human behavior according to psychological theories [18, 19]:

- the personal attitude toward a certain act
- the social norms referring to its performance and outcome
- the perceived level of control over its execution

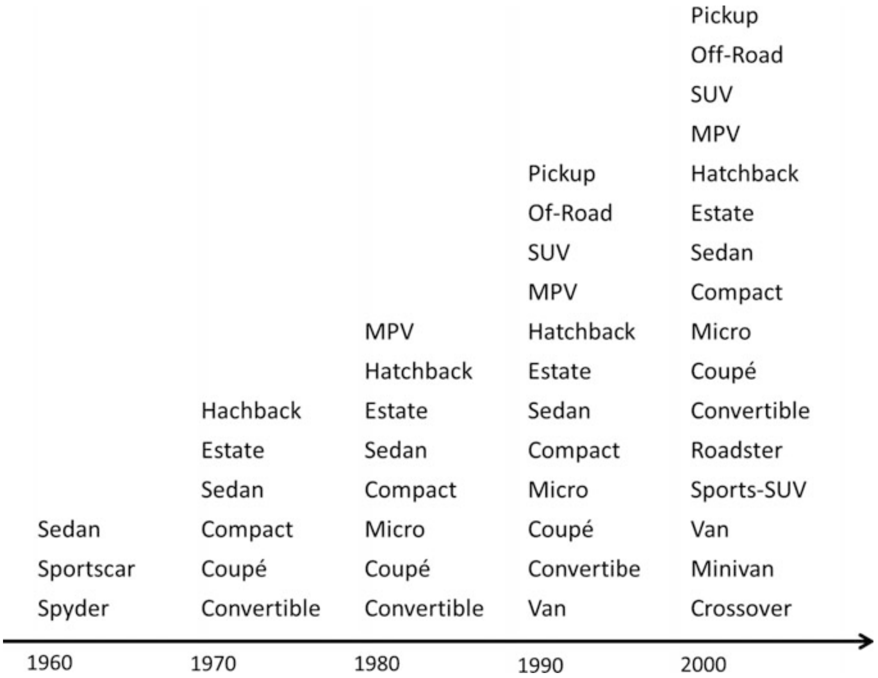
These factors evolve differently over time. They also react differently to specific forms of external interference.

The adoption behavior of individuals that provides the foundation for the spread of innovations must accordingly be considered as a result of a superposition of different cognitive processes. These processes are subjected to various influences which are unlikely to affect every person in society in the same way. With increasing social diversity, the carrier medium for the diffusion of innovations therefore becomes highly inhomogeneous. Even if the overall diffusion process indicates a high adoption rate, special focus groups might actually react differently. The automotive industry, for example, is lately confronted with the phenomenon that young people show significant differences in their adoption behavior from others. This fact remains invisible in general sales figures, since they only account for a small fraction of the market. Nevertheless, this phenomenon raises concerns about future sales opportunities [20, 21].

This is a rather unsatisfactory development for the manufacturer, since it indicates that the product does not find acceptance in an important part of society, no matter how successful it is elsewhere. As a consequence, the manufacturer is advised to action against this development. This, however, must be considered highly dangerous. Growth processes are known to react very sensitively to parameter change. In a diverse society, manufacturers have to expect chaotic reactions to change which are hard to predict or control. Many companies have therefore turned to strategies that relate innovation to specific target groups in the overall population which can be expected to show a more homogeneous behavior.

14.3.2 The Shifting Locus of Innovation

Figure 14.4 illustrates the development of product strategies in the automotive industry over the past decades, leading away from the idea of a single product that fits everyone's need towards a highly diversified family of different models which are designed according to specific application patterns that can be expected to meet the needs of certain social groups. In this example, the diversification is described in terms of the body shapes of the car. Diversification also proceeds with respect to



1960	1970	1980	1990	2000
				Pickup
				Off-Road
				SUV
				MPV
			Pickup	Hatchback
			Of-Road	Estate
			SUV	Sedan
			MPV	Compact
		MPV	Hatchback	Micro
		Hatchback	Estate	Coupé
	Hachback	Estate	Sedan	Convertible
	Estate	Sedan	Compact	Roadster
	Sedan	Compact	Micro	Sports-SUV
Sedan	Compact	Micro	Coupé	Van
Sportscar	Coupé	Coupé	Convertibe	Minivan
Spyder	Convertible	Convertible	Van	Crossover

Fig. 14.4 Increasing diversification in German automotive industry based on body shape [22]

such different aspects as engines, colors etc. Larger corporations such as General Motors or Volkswagen also diversify by differentiating brands according to specific lifestyles and personal values, from practicality over sports to comfort and luxury.

Product diversification allows companies to pursue different strategies to support the adoption of their products, depending on the respective target group. In addition to the technical features of the products, these strategies also address other aspects of business activity, including the pricing methods, the distribution network, and the communication channels to approach potential or existing customers. Companies can thus circumvent a large part of the complexity which they would have to face if they had to look at diffusion processes in the whole population. The separation of different target groups and the selection of different ways to approach them make it possible to differentiate separate diffusion processes on parts of the population which are, as carrier media of innovation, once again, largely more homogenous.

As a result, however, innovation also takes on a different quality. Although a larger notion of the term technology allows us to still think of innovation as technical change, this change is not focused on engineering solutions any more. Innovation now concerns the whole set of business operations that generate value for the customer. This is addressed in the current discussion on business model innovation [23, 24].

The shift towards value generation has various implications for the practice of modelling diffusion processes. There are now two different kinds of items which can be considered to spread: the overall business model and the offerings of the company that it contains. Business models spread among companies as a carrier medium; popular examples are leasing models, mobility packages, or flat rates in telecommunication. Offerings in the company remain more closely connected to the intuition of technical change; with the focus on value generation, however, the attention is drawn away from quantities of sales as means to make profit. What becomes more important is the control of the diffusion process that allows companies to plan the revenue and optimize the workload on their resources over time. In many respects, this also applies for larger attempts to spread innovations as they are undertaken by governments or other political institutions who want to ensure steady development.

Figure 14.5 provides a simplified visualization of this idea for a sequence of diffusion processes for single innovations appearing regularly over time, such as new model series that are produced.

Ideally, the diffusion of innovations should happen in a way that the capacities in manufacturing and logistics continue to have the same workload over time. Such conditions simplify the planning process and the operation of a company's facilities and reduce volatility in pricing. A company would accordingly use its influence on the diffusion of innovations through pricing, communication and distribution to ensure that the accumulated spread of subsequent innovations can be described by the simple and therefore easily manageable equation

$$\frac{df}{dt} = a \tag{14.2}$$

where a is constant or at least increasing in rare steps or very slowly in comparison to f, if the production capacities are expanded. More likely than this expansion, however, is an increase in the prices for which innovations are sold, based on the

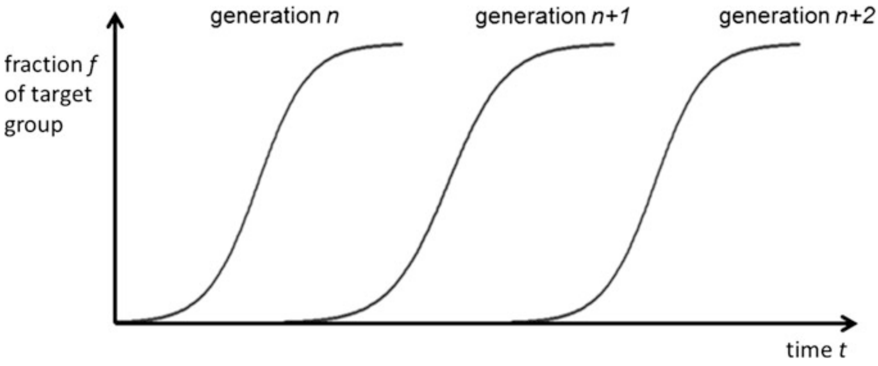


Fig. 14.5 Idealized sequence of innovations for optimal resource planning (see Fig. 14.1)

assumption that each new innovation will better meet the requirements of its target group and generate more value.

It seems reasonable to assume that innovation by value follows the pattern of novelty (at least inasmuch as the economic notion of value is concerned). In this sense, one could talk about a spread in terms of value which, excluding seasonality effects, follows the pattern of exponential growth, as many pricing schemes in innovation-driven industries illustrate. Monetary developments, however, lead back to the field of global phenomena in the whole population with all their complexity and require a wider investigation that goes beyond the boundaries of diffusion studies.

14.4 Diffusion and Co-creation

14.4.1 Platform Technology

So far, the adoption of innovations has been understood as a reactive process in which a new technology triggers certain behavior among actors according to their personal dispositions. This corresponds with the image of innovation as a rational problem-solving process (consisting of different stages with subsequent "control gates" to evaluate the success) in which the diffusion of innovations forms the last step. At this point, artefacts with a determinate function are already created and can now be introduced to the public (Fig. 14.6).

The shift towards individualized offerings can in many respects be interpreted as an expansion of the range that early process phases cover, because decisions about individual application patterns are already anticipated in the design phase and thus taken out of the hands of the adopters. With increasing data about usage behaviors, companies can further expand their reach into the personal lives of the adopters. At the same time, however, it can also be observed that the reach of the adopters also expands into the opposite direction with more opportunities to contribute to the design process.

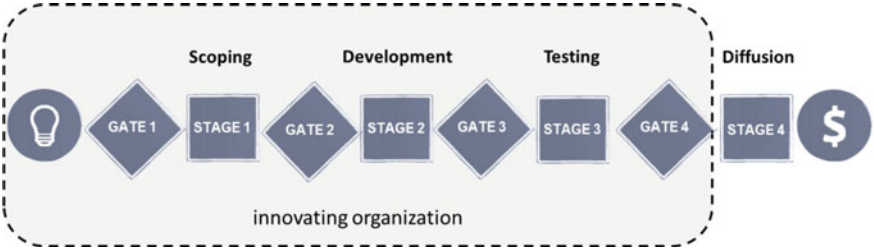


Fig. 14.6 Standardized "stage-gate"-innovation process with final diffusion [25]

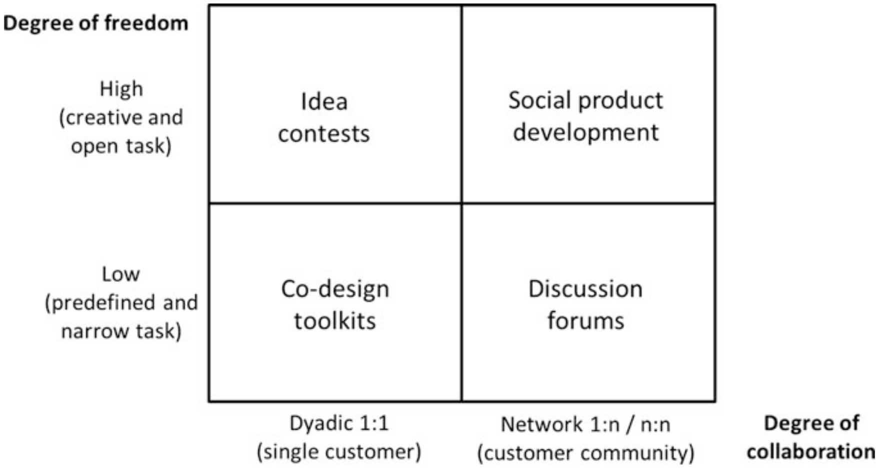


Fig. 14.7 Two-dimensional classification of contributions by participants in open innovation processes according to Piller and Ihl [26]

Figure 14.7 shows a classification of different contribution options that are offered during innovation processes. Popular examples include product configurators in which customers can choose from large lists of different options, contests in which participants can submit their own functional or aesthetic design, and numerous voting options and discussion groups on different aspects of innovation.

To allow such contributions from the user perspective, the technical architecture of the offerings in question must be modularized, so that different combinations and extensions become possible. In such cases, it seems doubtful whether the offerings that are brought to the market already constitute innovations or whether they just provide building blocks for further innovation activities which are executed by customers. In the latter sense, companies must be considered only to mediate innovation without accomplishing it themselves.

This is very prominently the case for many offerings in the field of information technology, such as smartphones or tablets, but also community platforms on the internet when they are stripped from further functions. They are widely celebrated as innovations, although they only provide operational platforms which, in order to generate value, have to be complemented through the installation of application software. When looking at the spread of such items in the population, one therefore has to ask to what extent this can be accounted for as a diffusion of innovation by itself and to what extent it rather has to be addressed as a spreading infrastructure for innovation.

Considering all this, there are apparently two different types of protagonists which nowadays have to be considered in the context of innovation: the engineer-innovator and the user-innovator. Both decide together about the meaning of an innovation in a communicative process (cf. [6]). While this process has previously been approached as a unidirectional transfer of matter and information, many researchers are nowadays interested in the bilateral exchange between engineer-innovators and user-innovators during the design and manufacturing processes. Since this exchange means that institutional boundaries are frequently crossed, it is customarily described as open innovation [27]. In an extreme form of open innovation, users might be able to propel the development of new technical solutions on their own, without any further involvement of companies [28].

Open innovation requires a fundamental change of perspective in the study of diffusion processes. Instead of assuming that there are predetermined points of origin from which innovations start to spread across the population, any kind of exchange between different actors in a societal network must now be expected to be a potential initiation point for innovations. While there is so far no systematic research agenda in this field, current research on open innovation can give a first impression of the directions that might be taken.

14.4.2 Innovation Incubators

While previous research on the diffusion of innovation allowed allusions to particle movement in various dimensions, open innovation rather seems to call for references in biology in order to give account of the continuous change of diffusion subjects and their carrier media, a general problem that is also addressed in Chap. 10 where in Sect. 10.6 guest molecules in porous materials are considered to undergo chemical reactions and where the last paragraph of Sect. 10.4 deals with guest-induced changes of the host material.

In that sense, a population and its practices of technology usage would be subjected to continuous change, caused by the replacement of its individual members over time with the possibility of mutation and recombination in every single case. Innovations could accordingly be assumed to originate and spread like successful genetic patterns, or, following a virological approach, like infectious diseases.

Similar to these references, it is interesting for research on diffusion from the perspective of open innovation to look for ways to anticipate, recognize and control "outbreaks" of innovation. Instead of fighting such "outbreaks", however, the ultimate goal of innovation research from a managerial perspective is obviously to provoke them and guide them into promising directions. In order to gain more transparency about the overall situation, innovation research requires scouting and scanning techniques which are able to identify occurrences of innovation. Such techniques have already been discussed for a long time in trend research. Currently, big data analysis adds further sophistication with advanced algorithms for pattern recognition.

Regarding the management of diffusion from the perspective of open innovation, research has been specifically attracted by the question how so-called incubators for open innovation can be set up and how they perform. Generally speaking, any kind of infrastructure that supports boundary-crossing interaction among innovators with

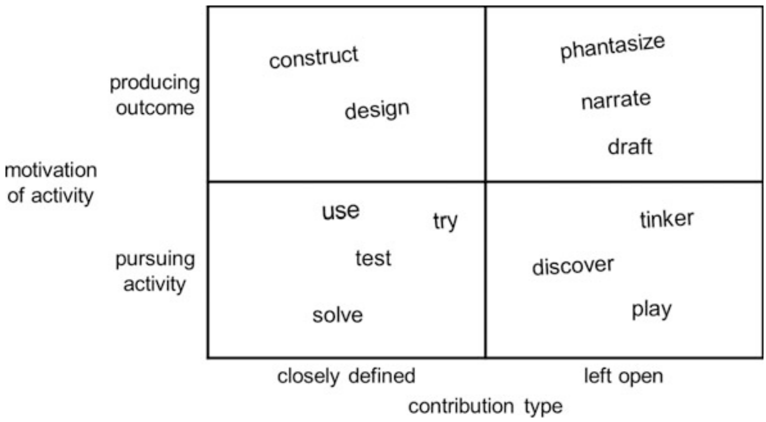


Fig. 14.8 Forms of collaboration in open innovation incubators, adapted from [29]

a positive effect on its outcome can be considered as an incubator for open innovation. This includes innovation communities and other platforms on the internet, but also physical spaces in which people come together. The types of interaction that are supported by the incubators can be quite diverse (Fig. 14.8). In particular, physical meeting spaces allow exchange in a large variety of ways. Among these spaces, two different kinds of incubators have lately been studied quite extensively: science parks and open innovation laboratories.

Science or technology parks are areas in which research institutions and companies with a strong focus on innovation are assembled to foster exchange and joint activities. Silicon Valley is usually considered as the archetype of such a park, although it exceeds most parks in size. In addition, most parks are intentionally planned by governmental organizations and strongly supported by different methods of financing: Science parks can thus be considered as public investments; research on science parks focusses on their performance on fostering innovation and the exchange between its inhabitants [30, 31]. Implicitly, science parks are assumed to be sources for innovation that can subsequently spread to other locations. However, this spread is expected to follow institutional structure. In that sense, innovation activities within the parks may be considered open, but the results are then redirected to conventional economic players.

Open innovation laboratories follow a different logic. They provide spaces for different people to come together for the purpose of problem solving and exploring novelty [32]. Such laboratories are usually established in central areas of larger cities or in the vicinity of universities or industrial districts where many people with higher education pass through. In order to use the equipment in the laboratories, visitor may have to pay a fee. Otherwise, there is no general entrance restriction. People join the activities in the laboratories whenever they want. Afterwards, they leave again and take their experiences with them to other places. Institutional actors can be involved in open innovation laboratories in different ways: as hosts of the facilities, organizer of events, or counterpart in the collaboration with other visitors [33]. Nevertheless, the interaction in the laboratories must be considered as a public exchange on innovation, since the visitors from the outside remain independent from internal company regulations and specifically designed contractual agreements.

While incubators in a biological or medical sense mainly serve the purpose of providing a hospitable environment for growth or reproduction, incubators for innovation can also influence the quality of the processes that are taking place by attracting certain people and providing special tools for innovation [34]. Some laboratories, for example Tech Shops, Fab Labs or Lego Stores, rely strongly on machinery to support the physical construction of new devices on site; others, like the Living Labs, the Fraunhofer Open Lab JOSEPHS or the Maker Faires focus their attention rather on the mode of social interaction [33]. Furthermore, the ratio between diverging, explorative activities and converging, exploitative activities is also different for each single laboratory concept. While some emphasize the construction of fully operative solutions, others give precedence to the clarification of goals and strategies in an open debate.

Each open laboratory accordingly defines its own constructive pattern of innovation. This does not only determine the possible outcomes; it also anticipates the path of the diffusion process, since it allows some persons or institutions to relate more easily to the innovations than others. First experiences during the last years suggest that explorative, discourse-oriented laboratories play an important role in social innovation that needs a high grade to public acceptance to spread; exploitative, engineering-oriented laboratories rather seem to serve as incubators for innovations that convince adopters by their technical function. These findings, however, have to be called preliminary. Until now, research has not had much time to study the impact of open innovation laboratories on broad range and there is still a lot to be learned in the future.

14.5 Conclusions

Diffusion models play an important role in innovation research—not only because of their descriptive capacity for the analysis of the processes that are taking place, but also because they provide the basis for the economic exploitation of the spread of novelty in society. Similar to different energetic potentials that initiate electric currents, an intentional design of the diffusion process of innovations to manage demand and supply can be used to gain revenue. Natural scientists create laboratory conditions to isolate certain effects from the environment; economic decision makers use the normative means of social organization to customize innovations with specific attributes for certain groups of people. This increases their control over the events that are taking place and enables them to focus their interferences on the effects that they intend to provoke. The design activities in the context of the diffusion of innovation therefore mostly take place on a detailed level, regarding individualized offerings for smaller groups of people, opposed to grand stories about technical progress that capture the long-term development of societies.

Grand stories on innovation rely on vague notions of objects: cars, planes, telephones—assuming that they remain the same during all the time that it takes for them to spread through society. With increasing detail, it becomes clear that technical devices and the conditions under which they are used change quite frequently; and in many respects, each of these changes can be referred to in terms of a small innovation, because it brings a new practice of using technology with it. For a long time, institutional centralization and formal standardization have made it possible to focus on the grand stories and neglect the details. Today, however, the situation has changed. Grand stories of innovation only continue to make sense where they refer to a platform technology: a solution that is by itself only an empty shell and requires further input to become meaningful in practice. As it turns out, this input is highly individual. Technology is customized with personal information which makes each single instance of a device different from all others. The study of diffusion processes for innovation consequentially become highly difficult.

Most companies have reacted to this difficulty by turning the focus towards the adoption of innovations among social groups with similar practices of technology usage and towards the design of solutions that are customized specifically for their needs and communicated accordingly. Comprehensive diffusion models for the whole population are traded in for a multitude of extremely simple diffusion models for many different artefacts and target groups, which avoid the effort necessary to address the complexity of general social dynamics. Mathematical models of diffusion as they are applied in industry remain accordingly comparably simple. At the same time, additional effort is created elsewhere. In order to cluster society in sufficiently homogeneous user groups that can then be addresses separately, it is necessary to collect more and more information about the users. Where companies are not able to do this, they integrate the users themselves in the design process in ways that allow them to organize themselves autonomously according to their interests. Users thus take over an active part in the creation of innovations, before it has reached maturity.

There is still a lot to learn about the consequences of opening up innovation procedures for user participation. Nevertheless, it seems clear that they will require a revision of the current diffusion models in innovation research. Inspiration can be drawn, for example, from biology. The image of a continuously changing population of individuals in which novelty can occur everywhere seems to provide a suitable background for research on open innovation, in particular where incubators are concerned that bring different people together under suitable conditions to foster innovation. Although first attempts into this direction have already been started, further conceptual and empirical work will be necessary to find out how much can actually be gained from it.

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