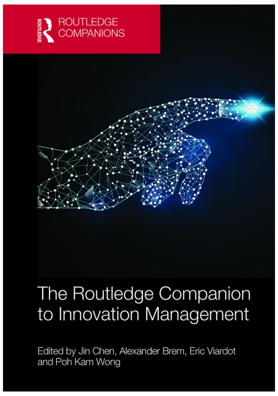

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The free innovation paradigm

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8

THE FREE INNOVATION PARADIGM[1]

Eric von Hippel

Introduction and overview

Free innovation involves innovations developed and given away by consumers as a "free good," with resulting improvements in social welfare. I define a free innovation as a functionally novel product, service or process that (1) was developed by consumers at private cost during their unpaid discretionary time (that is, no one paid them to do it) and (2) is not protected by its developers, and so is potentially acquirable by anyone without payment – for free. As we will see, free innovation has very important economic impacts, but from the perspective of participants, it is fundamentally not about money.

Examples of very important free innovation developments by consumers abound. Consider Nightscout, a system that monitors diabetics' blood sugar levels through the night. A series of product innovations and improvements addressing this very important issue are being developed and revealed for free on the Internet by a community of consumers dedicated to addressing problems associated with type 1 diabetes. Many of the participants in this community either have type 1 diabetes themselves or have children who do. The motto of the group, established out of frustration with inadequate products and introduction delays by medical device producers, is "We Are Not Waiting." Nightscout's story, as told by Linebaugh (2014) is as follows:

> Nightscout got its start in the Livonia, N.Y., home of John Costik, a software engineer at the Wegmans supermarket chain. In 2012, his son Evan was diagnosed with Type 1 diabetes at the age of four. The father of two bought a Dexcom continuous glucose monitoring system, which uses a hair's width sensor under the skin to measure blood-sugar levels. He was frustrated that he couldn't see Evan's numbers when he was at work. So he started fiddling around.
>
> On May 14 last year [2013], he tweeted a picture of his solution: a way to upload the Dexcom receiver's data to the Internet using his software, a $4 cable and an Android phone. That tweet caught the eye of other engineers across the country. One was Lane Desborough, an engineer with a background in control systems for oil refineries and chemical plants whose son, 15, has diabetes. Mr. Desborough had designed a home-display system for glucose-monitor data and called it NightScout. But his

system couldn't connect to the Internet, so it was merged with Mr. Costik's software to create the system used today. . . .

Users stay in touch with each other and the developers via a Facebook group set up by Mr. Adams. It now has more than 6,800 members. The developers are making fixes as bugs arise and adding functions such as text-message alarms and access controls via updates.

Free innovation is carried out in the "household sector" of national economies. In contrast to the business or government sector, the household sector is the consuming population of the economy, in a word all of us, all consumers. Free innovation, therefore, is a form of household production.

Nationally representative surveys conducted in six countries document that free innovation is a phenomenon of very significant scale and scope. Tens of millions of consumers annually spend tens of billions of dollars on new product development in these six countries alone (Table 8.1). The scope ranges across all categories of interest to consumers, from medical devices to toys, sports, vehicles, and improvements in dwellings.

How can individual consumers justify investing in the development of free innovations when no one pays them for either their labor or for their freely revealed innovation designs? The answer is that free innovators in the household sector are self-rewarded. When they personally use their own innovations, they are self-rewarded by benefits they derive from that use (von Hippel, 1988, 2005). When they benefit from such things as the fun and learning of developing their innovations or the good feelings that come from altruism, they are also self-rewarded (Raasch and von Hippel, 2013).

The Nightscout project described earlier illustrates several types of self-reward. From the account given, we can see that many participants gain direct self-rewards from personal or family use of the innovation they helped develop. Probably many also gain other forms of highly motivating self-rewards, such as enjoyment and learning, and perhaps also strong altruistic satisfactions from freely giving away their project designs to help many diabetic children.

Table 8.1 The extent of consumer innovation in six countries

Country (*n*)	*UK*[a] (*1,173*)	*US*[b] (*1,992*)	*Japan*[b] (*2,000*)	*Finland*[c] (*993*)	*Canada*[d] (*2,021*)	*S. Korea*[e] (*10,821*)
% of consumers who engage in consumer innovation	6.1	5.2	3.7	5.4	5.6	1.5
Number of consumer innovators	2.9 mm	16.0 mm	4.7 mm	0.172 mm	1.6 mm	0.54 mm
Amount spent on average project (time + cash in $US)	4.8 days +$125	14.7 days +$1,065	7.3 days +$397	2.6 days +$223	6.7 days +$43	5.9 days +$368
Total annual expenditures per country in $US*	$5.2B	$20.2B	$5.8B	na	na	na
% protected as intellectual property	1.9	8.8	0.0	4.7	2.8	7.0

Source: von Hippel (2017), Tables 2–1, 2.4, 2.5, and 2.7

* Total annual national expenditures include out-of-pocket expenditures for all innovation projects undertaken in a year plus total time investment calculated at average wage rate for each nation.

a. von Hippel, de Jong, and Flowers (2012); b. von Hippel, Ogawa, and de Jong (2011); c. de Jong et al. (2015); d. de Jong (2013); e. Kim (2015).

Survey questions asking about motivations support the conclusion that household-sector innovators are predominantly engaged in free innovation as I defined it earlier. About 90 percent were motivated almost entirely by self-rewards and are not significantly motivated by the prospects of selling or commercially profiting from what they had created. The remaining 10 percent of household-sector innovators, in contrast, were prospective entrepreneurs hoping to profit from what they had created. Most of the innovation protection activity indicated in Table 8.1 was pursued by prospective entrepreneurs, with 36 percent of these individuals protecting their innovations via some form of intellectual property rights (von Hippel, 2017, Chapter 2).

The free innovation and producer innovation paradigms

Due to its self-rewarding nature, free innovation does not require compensated transactions to reward consumers for the time and money they invest to develop their innovations. (Compensated transactions involve explicit, compensated exchanges of property – that is, giving someone specifically this in exchange for specifically that. See Tadelis and Williamson, 2013; Baldwin, 2008). Free innovation therefore differs fundamentally from producer innovation, which has compensated transactions at its very core. Producers cannot profit from their private investments in innovation development unless they can protect their innovations from rivals and can sell copies at a profit via compensated transactions (Schumpeter, 1934; Machlup and Penrose, 1950; Teece, 1986; Gallini and Scotchmer, 2002).

In Figure 8.1, I schematically depict these two paradigms and the interactions between them. Each describes a portion of the innovation activity in national economies. Generally, development activity in the free innovation paradigm is devoted to types of innovative products and services consumed by householders, not businesses. These represent a large fraction of gross domestic product (GDP): In the United States and many other Organisation for Economic Co-operation and Development (OECD) countries, 60 to 70 percent of GDP is devoted to products and services intended for final consumption in the household sector (BEA, 2016; OECD, 2015). In contrast, innovation development activity in the producer innovation paradigm is devoted to addressing both consumer and industrial product and service needs.

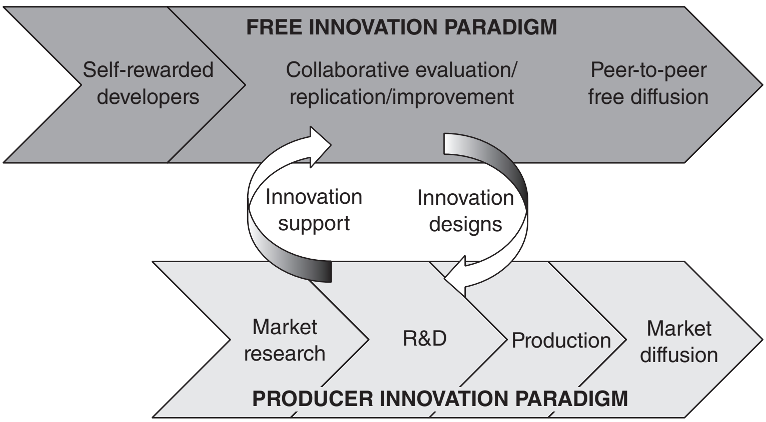

Figure 8.1 The free innovation and the producer innovation paradigms

The free innovation paradigm

The free innovation paradigm is represented by the broad arrow shown in the top half of Figure 8.1. At the left side of the arrow, we see consumers in the household sector spending their unpaid discretionary time developing new products and services. As is implied by the position of the free innovation arrow in Figure 8.1, which starts farther to the left than the producer arrow, individuals or groups of innovators who have a personal use for an innovation with a novel function generally begin development work earlier than producers do – they are pioneers. This is because the extent of general demand for really novel products and services is initially often quite unclear. General demand is irrelevant to individual free innovators, who care only about their own needs and other forms of private self-reward that they understand firsthand. Producers, in contrast, care greatly about the extent and nature of potential markets and, as the rightward positioning of the producer arrow indicates, often wait for market information to emerge before beginning their own development efforts (Baldwin, Hienerth, and von Hippel, 2006).

If there is interest in an innovation beyond the initial developer, some or many other individuals may contribute improvements to the initial design, as is shown at the center of the free innovation paradigm arrow. This pattern is visible in the Nightscout example presented earlier and is familiar in open-source software development projects as well (Raymond, 1999). Thus, in the Nightscout case, many individuals with an interest in helping children with type 1 diabetes came forward to join the efforts of the project's initiators (Nightscout project, 2016).

Finally, free diffusion of unprotected design information via peer-to-peer transfer to free riders may occur, as is shown at the right end of the free innovation paradigm arrow. (Free riders are those who benefit from an innovation but do not contribute to developing it. In that sense they get a "free ride.") Again, a pattern of diffusion to free riders is clearly visible in the Nightscout project.

Note that what is generally being revealed free for the taking by free innovators is design information, not free copies of physical products. In the case of products or services that themselves consist of information, such as software, a design for an innovation can be identical to the usable product itself. In the case of a physical product, such as a wrench or a car, what is being revealed is a design "recipe" that must be converted into a physical form before it can be used. In free peer-to-peer diffusion, this conversion is generally done by individual adopters – each adopter creates a physical implementation of a free design at private expense in order to use it.

The producer innovation paradigm

The long-established producer innovation paradigm centers on development and diffusion activities carried out by producers. The basic sequence of activities in that paradigm is shown on the lower arrow of Figure 8.1. Moving from left to right on that arrow, we see profit-seeking firms first identifying a potentially profitable market opportunity by acquiring information on unfilled needs. They then invest in R&D to design a novel product or service responsive to that opportunity. Next, they produce the innovation and sell it on the market.

The producer innovation paradigm can be traced back to Joseph Schumpeter, who between 1912 and 1945 put forth a theory of innovation in which profit-seeking entrepreneurs and corporations played the central role. Schumpeter argued that "it is . . . the producer who as a rule initiates economic change, and consumers are educated by him if necessary" (1934, p. 65).

The economic logic underlying Schumpeter's argument is that producers generally expect to distribute their costs of developing innovations over many consumers, each of whom purchases one or a few copies. Individual or collaborating free innovators, in contrast, depend only on their own in-house use of their innovation and other types of self-reward to justify their investments in innovation development. On the face of it, therefore, a producer serving many consumers can afford to invest more in developing an innovation than can any single free innovator, and so presumably can do a better job. By this logic, individuals in the household sector must simply be "consumers" who simply select among and purchase innovations that producers elect to create. After all, why would consumers innovate for themselves if producers can do it for them?

Interactions between the paradigms

There are four important interactions between the free innovation paradigm and the producer innovation paradigm (Gambardella, Raasch, and von Hippel, 2017).

First, identical or closely substituting innovation designs can be made available to potential adopters via both paradigms at the same time. For example, Apache open-source web server software is offered free peer-to-peer by the Apache development community, and at the same time a close substitute is offered commercially by Microsoft. In such cases, peer-to-peer diffusion via the free innovation paradigm can compete with products and services that producers are selling on the market. The level of competition can be substantial. In the specific case just mentioned, 38 percent of websites used Apache free web server software in 2015. Microsoft was second, serving 28 percent of sites with its commercial server software (Netcraft.com, 2015). Competition from substitutes diffused for free via peer-to-peer transfers can increase social welfare by forcing producers to lower prices. It can also drive producers to other forms of competitive responses with social value, such as improving quality or increasing investments in innovation development.

Second, innovations available for free via the free innovation paradigm can complement innovations diffused via the producer innovation paradigm. Free complements are very valuable to consumers as well as to producers. They enable producers to focus on selling commercially viable products, while free innovators fill in with designs for valuable or even essential complements. For example, a specialized mountain bike is of little value to a biker who has not learned specialized mountain biking techniques. Producers find it viable to produce and sell the specialized mountain bikes as commercial products, but largely rely on expert bikers innovating within the free paradigm to create and diffuse riding techniques as a free complement. That is, adopters generally learn new mountain biking techniques by a combination of self-practice and informal instruction freely given by more expert peers.

Third, we see from the vertical, downward-pointing arrow toward the right in Figure 8.1 that a design developed by a free innovator may spill over to a producer and become the basis for a valuable commercial product. For example, the design of the mountain bike itself and many further improvements to it were developed by free innovator bikers. These designs were not protected by the free innovator developers and were adopted for free by bike-producing firms (Penning, 1998; Buenstorf, 2003). As we will see, adoption of free innovators' designs can greatly lower producers' in-house development costs (Baldwin, Hienerth, and von Hippel, 2006; Franke and Shah, 2003; Jeppesen and Frederiksen, 2006; Lettl, Herstatt, and Gemuenden, 2006).

Fourth and finally, we see from the vertical, upward-pointing arrow at the left of Figure 8.1 that producers also supply valuable information and support to free innovators. For example, Valve Corporation, a video game development firm, offers Steam Workshop, a company-sponsored website designed to support innovation by gamers (Steam Workshop, 2016). The site contains tools that make it easier for these individuals to develop their own game modifications and improvements and to share them with other players. Investments to support free design, such as the investment in Steam Workshop by Valve, can benefit producers by increasing the supply of commercially valuable designs that free innovators create (Gambardella, Raasch, and von Hippel, 2017; Jeppesen and Frederiksen, 2006; von Hippel and Finkelstein, 1979).

The need for a free innovation paradigm

The Schumpeterian producer innovation paradigm is widely accepted by economists, business people and policy makers today. Thus, Teece (1996, p. 193) echoed Schumpeter: "In market economies, the business firm is clearly the leading player in the development and commercialization of new products and processes." Similarly, Romer (1990, S74) viewed producer innovation as the norm in his model of endogenous growth: "The vast majority of designs result from the research and development activities of private, profit-maximizing firms." And Baumol (2002, 35) placed producer innovation at the center of his theory of oligopolistic competition: "In major sectors of US industry, innovation has increasingly grown in relative importance as an instrument used by firms to battle their competitors."

Why do we need the free innovation paradigm that I proposed earlier? Recall that Thomas Kuhn defined scientific paradigms as "universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of researchers" (1962, viii). Having a paradigm in place that is widely accepted, as in the case of the producer innovation paradigm, can be very helpful to scientific advancement. Once a paradigm is in place, as Kuhn writes, researchers can engage in very productive "normal science," testing and more precisely filling in pieces of a paradigm now assumed to be correct in broad outline. However, as Kuhn also explains, a paradigm never adequately explains "everything" within a field. In fact, observations that do not fit the reigning paradigm commonly emerge during the work of normal science but are often ignored in favor of pursuing productive advances within the paradigm.

In the case of innovation research, empirical evidence related to free innovation in the household sector has been increasing during recent years. However, innovations developed and diffused without compensated transactions lie entirely outside the Schumpeterian producer innovation paradigm – and, indeed, entirely outside the transaction-based framework of economics in general. Ignoring this evidence has allowed researchers to do productive work within the Schumpeterian paradigm while deferring the work of incorporating free innovation into our paradigmatic understanding of innovation processes.

Eventually, Kuhn writes, conflicts between the predictions of a reigning paradigm and real-world observations may become so pervasive or so important that they can no longer be ignored, and at that point, the reigning paradigm may be challenged by a new one (Kuhn, 1962). I propose that this situation has been reached in the case of transaction-free innovation processes developed and utilized by free innovators in the household sector. I therefore frame the free innovation paradigm both as a challenge to the Schumpeterian innovation paradigm and as a useful complement. Both paradigms describe important innovation processes, with the free paradigm codifying important phenomena in the household sector that the producer innovation paradigm does not incorporate.

Recall that I propose that both the free innovation and producer innovation paradigms function in parallel. When Kuhn developed his concept of paradigms to explain how revolutions in understanding occur in the natural sciences, he argued that a new paradigm replaces an existing one in a "scientific revolution." However, today the idea of paradigms has expanded beyond the study of natural sciences to the study of social sciences as well. In the social sciences, Kuhn's observation that new paradigms replace earlier ones is not always followed. Multiple paradigms may coexist as complementary or competing perspectives. (See, e.g. Guba and Lincoln, 1994). It is with that view in mind that I propose the free innovation paradigm as a complement to the producer innovation paradigm rather than as a replacement. I am proposing that each usefully frames a portion of extant innovation activity.

Note that by proposing and describing the free innovation paradigm, I by no means claim that research needed to support it is complete. Indeed, I wish to claim precisely the opposite. A new paradigm is most useful when understandings of newly observed phenomena are emergent and when ideas regarding a possible underlying unifying structure are needed to help guide the new research (Kuhn, 1962). This is the role I hope the free innovation paradigm I describe will play. If it is successful, it will usefully frame and support important research questions and findings not encompassed by the existing Schumpeterian producer-centered paradigm, and so provide an improved platform for further advances in innovation research, policy making, and practice.

Major findings from research on free innovation to date

What evidence do we have to date on the value of the free innovation paradigm? First, as I described earlier, we have strong evidence that free innovation is today a large and important type and source of innovations in national economies. We also think that free innovation will only get more important over time. As Baldwin and I explain (2011), the number of innovation opportunities that are viable for individual and collaborative free innovation is increasing rapidly as powerful, easy-to-use design and communication technologies become steadily cheaper. Across many fields, radical reductions in design costs are being driven by advances in computerized design tools suitable for personal use. At the same time, radical reductions in personal communication costs are being driven by advances in the technical capabilities of the Internet. Field-specific tools are following the same trend. For example, inexpensive and easy-to-use tools for genome modification have greatly increased the number of opportunities for biological innovation that are viable for free innovators in the household sector (von Hippel, 2017, Chapter 3).

Second, as was indicated earlier, we know that free innovators play the very important role of often being pioneers with respect to new functions and markets, with producers only following later. Recall that this occurs because free innovators, being self-rewarding, are free to follow their own interests. Unlike producers, they need not restrict their development investments to projects they expect the market to reward. They therefore generally pioneer functionally new applications and markets prior to producers understanding the opportunity. Producer innovators generally enter later, after the nature and the commercial potential of markets have become clear (Riggs and von Hippel, 1994; Baldwin, Hienerth, and von Hippel, 2006).

Not only do producers enter later but they also tend to develop different kinds of innovations when they do enter. Free innovators, when they develop innovations enabling novel capabilities, may create functionality of interest to only subsections of producers' markets. This makes sense because, as was mentioned earlier, free innovators do not care about markets, they only care about their own interests and needs and their related self-rewards. Producers, in contrast, tend to care deeply about the size of markets for the innovations they create, and so tend to develop innovations that every customer will care about, even if only a little. Thus, as is shown in Table 8.2, they tend to focus on developing improvements to "dimensions of merit" that they expect all customers will value, such as improvements to convenience and reliability. As can also be seen in Table 8.2, both free innovators and producers will tend to develop innovations improving devices on performance dimensions such as sensitivity, resolution, and accuracy. These improvements can both enable new functions and improve utility for existing applications

Table 8.2 Sources of scientific equipment innovations by nature of improvements effected

Type of improvement provided by innovation	*Innovation developed by*		
	User	*Producer*	*Total(n)*
New functional capability	82%	18%	17
Sensitivity, resolution, or accuracy improvement	48%	52%	23
Convenience or reliability improvement	13%	87%	24

Source: Riggs and von Hippel (1994), reproduced in von Hippel (2017), Table 4.2.

Third, there are systematic differences between the free and producer paradigms with respect to diffusion – also a very important matter. Consider that the value of free innovation to society comes in part from free innovators' satisfaction of their own needs via the innovations they develop. However, social value can be greatly increased if others also adopt and benefit from those same developments. Of course, to realize this second form of value, free innovations must diffuse from their developers to free adopters.

Investment in diffusion by free innovators can increase social welfare because it is often the case that even relatively small investments can greatly reduce search and adoption costs for many free riders. For example, if I, as a free innovation developer, would invest just a little extra effort to document my open-source software code more fully, I could greatly reduce the time that perhaps thousands of adopters would require to install and use my novel code. Clearly, there would be a net increase in social welfare if I were to expend just that small extra effort.

However, free innovators, unlike producers, do not protect their innovations from free adoption, and they do not sell them. As a result, benefits that free-riding adopters may gain are not systematically shared with free innovators – there is no market link between these parties. For this reason, free innovators may often have too little incentive, from the perspective of social welfare, to invest in actively diffusing their free innovations – in a sense, there is a market failure affecting the free innovation paradigm. In contrast, of course, producers do have a direct market link to consumers, so there should be no similar diffusion incentive shortfall within the producer innovation paradigm. Empirical studies document this effect (de Jong et al., 2015; von Hippel, DeMonaco, and de Jong, 2017).

A proposed division of labor between free and producer innovation

The systematic and important differences between the activities of and incentives affecting free and producer innovators described earlier suggest that a division of innovation development labor between parties in the two paradigms would be of significant benefit both to actors and to social welfare.

Drawing upon modeling by Gambardella, Raasch, and von Hippel (2017), I explain that there is an opportunity for a division of innovation labor between free innovators and producer innovators that simultaneously enhances social welfare and producers' profits.

Most fundamentally, this is because there are important complementarities between the two paradigms. Thus, producers, as my colleagues and I argue, will benefit by not investing in R&D that substitutes for innovations that free innovators develop. Instead, producers will – often but not always – benefit from investing in supporting free innovator design activities. Producers should then focus their own resources on development activities that free innovators do not engage in, such as refinements needed for commercialization. Social welfare, we find, will benefit from public policies that encourage producers to transition from a focus on in-house development to a division of innovation labor with free innovators.

Specific examples of how this could profitably work can be seen from the attributes I described earlier with respect to the attributes of each paradigm and their interactions. First, it makes sense for producers of consumer products to consciously not pioneer new functions, leaving that task instead to free innovators and benefiting from the free designs they create that prove to have commercial promise. Producers will also benefit when complements to the products they commercialize are created and diffused for free to their customers by free innovators.

To illustrate both of these patterns and their value via a concrete example, consider that producers of mountain bikes regularly benefit from commercializing biker-developed free hardware designs – designs for mountain bikes and accessories that mountain bikers regularly pioneer and test in use. Note also that producers profit from the development and diffusion of mountain biking techniques that are an essential complement to mountain bikes themselves. Bike riders develop riding techniques along with novel bike designs – for example, methods of jumping. However, bike producers' ability to profit from diffusing techniques commercially (for example, by founding a mountain biking school) is quite limited. Instead, producers profit indirectly when the biker riders themselves diffuse the innovations for free peer-to-peer as a valuable complement to the mountain bike hardware the producers do sell.

Free innovator peer adopters and producers also benefit when producers adopt free designs and apply the incentives for diffusion that they have via selling and that free innovators, as we saw, themselves lack. For example, mountain bike adopters prefer – even though free designs are available – to buy mountain biking hardware from producers because producers' economies of scale in production (absent in the case of techniques) make that a lower-cost adoption option. Still, free innovators can also keep producer prices in check by being able to turn to the free option if needed. Finally, our modeling shows that it can pay producers to actually support free innovation under many conditions by providing free innovators with design tools and other support, since the benefit to producers from free designs can be quite high.

I conclude this Chapter by again noting that free innovation, free from the need for compensated transactions and intellectual property rights, represents a robust, "grassroots" mode of innovation that differs fundamentally from the prevailing Schumpeterian model of producer-centered innovation. I suggest that the free innovation paradigm described in this Chapter will enable us to understand free innovation more clearly and apply it more effectively, with a resulting increase in social welfare and human flourishing.

Acknowledgments

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Note

1 This chapter is based upon the book *Free Innovation* (MIT Press, 2017) by Eric von Hippel. Free eBook copies of the complete book can be downloaded from https://evhippel.mit.edu/

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