2 Evidence for Free Innovation

In this chapter I present evidence that free innovation is a very substantial phenomenon with respect to the development of products consumed within the household sector. As we will see, today tens of millions of consumers annually spend tens of billions of dollars creating and modifying products to better serve their own needs. In fact, aggregate household sector product development expenditures rival the scale of business sector expenditures by producers developing products *for* consumers. Next, we will see that more than 90 percent of the developers of product innovations in the household sector meet both of the criteria for free innovation specified in chapter 1: the innovators develop their innovations during their unpaid, discretionary time; and they do not actively protect their designs from free adopters. The remainder are aspiring entrepreneurs. Finally, I explore the nature of transaction-free self-rewards central to the viability of free innovation, and discuss why it can make economic sense for free innovators to reveal their innovations for free.

Six National Studies

At the time of this writing, six national surveys have explored the scale and scope of household sector product innovation by product users. I begin with a very brief overview of the methods all these studies used. Full details will be found in the published reports on each. The six national surveys were carried out in the United Kingdom by von Hippel, de Jong, and Flowers (2012), in the United States and Japan by Ogawa and Pongtanalert (published in von Hippel, Ogawa, and de Jong 2011), in Finland by de Jong, von Hippel, Gault, Kuusisto, and Raasch (2015), in Canada by de Jong (2013), and in South Korea by Kim (2015). All six study samples included only new products and product modifications that had been developed by household sector individuals for personal or family use. To qualify for inclusion in our studies, we required that the developments provided useful functional improvements over products already available on the market, and that they had been developed within the three years prior to data collection. Aesthetic improvements were not included. Innovations that individuals developed at home for their jobs, rather than for personal or family use, were also not included in the study samples.

All six surveys utilized what are called nationally representative samples. A sample of this type is designed to mirror the demographic composition of a nation's population. For example, if a population contains a specific percentage of technically educated individuals, the sample will have a similar "representative" percentage of respondents with that characteristic. Because of this feature, we can project the findings derived from a nationally representative sample onto a nation's population at large. Data were collected by means of a questionnaire administered by telephone interviewers in the United Kingdom, Finland, and Canada and by means of Internet sites in the United States, Japan, and South Korea. Questions used in four of the six national studies were identical (UK, US, Japan, and South Korea). New questions were added to the fifth and sixth studies (Finland and Canada) to address additional issues. The full questionnaire used in the most recent study (Finland) is published in appendix 1 and also in de Jong (2016).

The scale of product innovation in the household sector

Recall that in the producer innovation paradigm, consumers are not expected to innovate—they are expected to consume. However, quite contrary to this conventional assumption, the data my colleagues and I collected found that 24.4 million people had developed or modified products for their own use in just the six countries surveyed to date (table 2.1). This quite large number is likely to be a very conservative measure of total household sector innovation development activities. As I noted above, the national six surveys included only *product* innovations developed for personal or family use. Service and process development activities in the household sector were not included, and are likely to also be of significant scale when measured.

Table 2.1
Fraction of individuals developing products for their own use in six countries.

	UK (*n* = 1,173)	US (*n* = 1,992)	Japan (*n* = 2,000)	Finland (*n* = 993)	Canada (*n* = 2,021)	S. Korea (*n* = 10,821)
Percentage of consumer innovators in the population aged 18 and over[a]	6.1%	5.2%	3.7%	5.4%[b]	5.6%	1.5%
Number of consumer innovators aged 18 and over[a]	2.9 million	16.0 million	4.7 million	0.17 million[b]	1.6 million	0.54 million

a. In all six surveys individuals under age 18 were excluded due to youth privacy considerations.
b. In Finland, the age range was 18–65.

The scope of consumer product innovation

The products developed by consumers addressed a wide range of household sector activities (table 2.2). Areas showing high levels of innovation mapped well upon major categories of unpaid time activities reported by consumers. For example, in the United Kingdom, sports, gardening, household chores, caring for children, and using computers were significant activities (Lader, Short, and Gershuny 2006).

A few brief descriptions of innovations reported by respondents for each of the innovation categories listed in table 2.2 will illustrate both the nature and the broad scope of product development by consumers (table 2.3).

Spending on Innovation Projects

In the household sector, individual projects typically were developed using relatively modest, “person-sized” expenditures. As can be seen in table 2.4, spending by individual innovators on their most recent projects in the six countries averaged from a few hundred dollars to a little

Table 2.2
Scope of product development by household sector users in various innovation categories.

	UK[a]	Japan[b]	US[b]	Finland[c]	Canada[d]	S. Korea[e]
Craft and shop tools	23.0%	8.4%	12.3%	20%	22%	16.4%
Sports and hobby	20.0%	7.2%	14.9%	17%	18%	17.9%
Dwelling-related	16.0%	45.8%	25.4%	20%	19%	17.9%
Gardening-related	11.0%	6.0%	4.4%	na[f]	na	na
Child-related	10.0%	6.0%	6.1%	4%	10%	10.9%
Vehicle-related	8.0%	9.6%	7.0%	11%	10%	6.5%
Pet-related	3.0%	2.4%	7.0%	na	na	na
Medical	2.0%	2.4%	7.9%	7%	8%	5.5%
Computer software	na	na	na	6%	11%	na
Food and clothes	na	na	na	12%	na	na
Other	7.0%	12.0%	14.9%	3%	3%	23.9%

a. Source: von Hippel, de Jong, and Flowers 2012
b. Source: von Hippel, Ogawa, and de Jong 2011
c. Source: de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015
d. Source: de Jong 2013
e. Source: Kim 2015

more than a thousand dollars in time and materials combined. (In these calculations, time was converted to a money equivalent by using the average per-hour wage rate in each nation surveyed.) The range of project expenditures by respondents was wide, varying from almost nothing—projects accomplished very quickly using only materials on hand—to levels much higher than average. Other research on other innovation samples finds that individuals who spent significantly more than average are likely to be lead users—individuals at the leading edge of important market trends having a strong need for their creations. Lead users are also more likely than average users to develop products with potential commercial value (von Hippel 1986; Urban and von Hippel 1988; Franke, von Hippel, and Schreier 2006; Hienerth, von Hippel, and Jensen 2014, table 3).

Table 2.3
Examples of household sector product innovations in various categories.

Craft and shop tools	I created a jig to make arrows. The jig holds the arrow in place and turns at the same time, so I can paint according to my own markings. Jigs available on the market do not rotate.
Sports and hobbies	I developed luminous paduk (go) stones, so that you can play the game in the dark. Compressed glossy material on the surface of the stones looks identical to normal ones, and the feeling is also similar.
Dwelling related	Due to the weather, I wanted my washing machine to spin only. I modified it by changing the way the timer worked to give a spin-only option. I bridged one of the circuits and inserted a switch. I used a GPS system that can be operated by computer and small tags to create a mechanism for immediately finding objects that have become lost in the house. I used a microwave oven to create a half-pressure rice cooker. I drilled holes in a plastic container and used a large rubber band and small board to adjust pressure within the container so that the resulting rice tasted as good as that cooked with other sources of heat.
Gardening related	I made a device for trimming the tops of trees. It's a fishing rod with a large metal hook at the end. This enables me to reach the top of the trees, bend them down, and cut them.
Child related	I colored the two halves of a clock dial with different colors, so a child can easily see which side is past the hour and which before the hour. I used it to teach my kids to tell the time. I created a cloth expansion panel to enable me to fasten my Winter coat while wearing a baby carrier underneath. Helps keep me and my baby warm. Adapts to all my conventional zippers.
Vehicle related	I installed a display on my car key remote controller for parking location positioning. When unable to remember where I parked in a large parking lot or a parking lot with several floors, it can help save time and the effort in finding my car.
Pet-related	My dog was having trouble eating. I used a flat piece of laminated wood and put an edge around it like a tray to stop her bowl from moving around the kitchen. It is a successful innovation.
Medical	My mother had a stroke and became unable to use her limbs. I created a coat that was easy for her to put on and take off while in a wheelchair. The areas under the sleeves were cut open so that the sleeves could be opened and closed with special tape.
Computer software related	I am colorblind. I developed an iPhone camera app that identifies the colors of objects in a scene, and codes them for easy recognition.

Small expenditures on individual projects add up to quite large amounts in aggregate, simply because so many householders innovate. In the case of the United Kingdom, the United States, and Japan surveys, my colleagues and I were able to estimate total annual expenditures on product development in the household sector. In those three countries only, the national surveys included a question asking respondents how many projects they had carried out per year. That information, together with the data we had on the costs of innovators' most recent projects and the total number of innovators in each nation, enabled us to make the calculations.

Table 2.4
Individual expenditures on most recent user innovation project

	UK	US	Japan	Finland	Canada	S. Korea
Time spent on most recent project (person-days)	4.8	14.7	7.3	2.6	6.7	5.9
Average materials expenditure on most recent project	£101	$1,065	$397	207€	$58 (Canadian)	$368

Source*:* von Hippel, Ogawa, and de Jong 2011, table 1. Total expenditures include out-of-pocket expenditures for the specific project plus time investment calculated at average wage rate for each country.

As can be seen in table 2.5, multiple billions of dollars are spent annually by household sector innovators in the United Kingdom, the United States, and Japan in aggregate. Interestingly, as can also be seen in table 2.5, this level of expenditure is not so different from annual expenditures by consumer goods firms on developing products *for* consumers in those countries (von Hippel, Ogawa, and de Jong 2011). Again, this is an indicator that product development by householders is an activity of substantial scale.

Table 2.5
Total individual innovation expenditures per year on products for own use.

	UK	US	Japan
Average number of projects per year	2.7	1.9	2.6
Estimated total expenditures[a] by consumer innovators on consumer product development per year	\$5.2 billion	\$20.2 billion	\$5.8 billion
Estimated consumer product R&D expenditures funded by producers per year[b]	\$3.6 billion	\$62.0 billion	\$43.4 billion

a. Total expenditures include out-of-pocket expenditures for the specific project plus time investment calculated at average wage rate for each nation.
b. Calculated from national input-output tables.
Source*:* von Hippel, Ogawa and de Jong 2011, table 1.

Single vs. Collaborative Innovation

Recall from chapter 1 that innovators may develop their innovations either as single individuals or collaboratively with others. In the six surveys, most individuals reported having developed their most recent innovations alone, and 10-28 percent reported having innovated collaboratively (table 2.6). As I will discuss in chapter 3, this pattern makes good economic sense. Collaborative development can produce major cost savings for participants in larger projects, where substantial costs are being shared. For relatively small projects, however, such as the typical household sector projects documented here, it can be more efficient to innovate alone, and in that way avoid the costs of coordinating development work with others.

Table 2.6
Modes of innovation.

	UK	US	Japan	Finland	Canada	S. Korea
Innovation by single individual	90%	89%	92%	72%	83%	72%
Collaborative innovation	10%	11%	8%	28%	17%	28%

Is It Free Innovation?

Recall from chapter 1 that I defined free innovation as having two characteristics. First, no one pays free innovators for their development work, they do it during their unpaid, discretionary time. Second, free innovation designs are not actively protected by their developers—they are potentially acquirable by anyone for free. From the data in the six national surveys, we can directly conclude that more than 90 percent of the innovators surveyed fulfill these two criteria. With respect to the first, all six surveys asked respondents whether they had developed their innovations during their unpaid, discretionary time, and included data only from individuals who said this was the case. With respect to the second criterion, all six surveys provided a list of possible means of preventing free adoption, ranging from secrecy to patenting, and asked innovating respondents whether they had used any of these to protect their innovations. As can be seen in table 2.7, efforts to protect innovations by secrecy or intellectual property rights of any kind were quite rare.

Table 2.7
Household sector innovations protected by intellectual property rights.

UK	US	Japan	Finland	Canada	S. Korea
1.9%	8.8%	0.0%	4.7%	2.8%	7.0%

Of course, a general absence of investment in protection could mean simply that efforts to protect were seen as impractically costly by household sector innovators (Baldwin 2008; Blaxill and Eckardt 2009; von Hippel 2005; Strandburg 2008). If that were the case, these innovators might wish they *could* protect their innovations, and would do so if a low-cost way (say, very inexpensive forms of patenting) were to become available. Such a situation would render free innovation a fragile phenomenon, at risk of vanishing if a cheaper way to protect innovations emerged.

To test this possibility, my colleagues and I asked participants in the Finland and Canadian national surveys about their *willingness* to reveal their innovations freely. In Finland, 84 percent said they were willing to freely reveal their innovations to at least some people. Of these, 44 percent were willing to reveal their innovations to anyone and everyone, and an additional 40 percent were willing to freely reveal their innovations selectively to friends and others in their personal networks (de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015). In the Canadian study, de Jong (2013) found that overall willingness to freely reveal was also 88 percent, with 66 percent of respondents willing to freely reveal to everyone, and an additional 22 percent willing to freely reveal selectively to their networks. In both Finland and Canada, in other words, it appears that free revealing is not simply an artifact of high costs of protection—a large fraction of household sector innovators are *willing* to freely reveal their innovations to some or all.

The Nature of Household Sector Innovators' Motivations

Earlier, I reasoned that innovation project opportunities can be "viable" for free innovators—those with benefits exceeding costs—only if those innovators are self-rewarded. After all, by my definition no one pays free innovators to innovate, and no adopter pays them for their designs. To assess this matter, in the Finland national survey respondents were asked about the types *and the relative strength* of the motives that drove them to innovate. Specifically, they were asked to distribute 100 percent of their motivations across five specific types of rewards. In addition, they were offered an "other" option to list any additional types of rewards that were important in their case.

Four of the five types of rewards asked about were known to be important motivators for contributors to open source software projects (Hertel, Niedner, and Herrmann 2003; Lakhani and Wolf 2005): personal use of the innovation (von Hippel 2005; Stock, Oliveira, and von Hippel 2015); personal enjoyment of innovation development work (Hienerth 2006; Ogawa and Pongtanalert 2011; von Hippel, de Jong, and Flowers 2012), personal learning and skill improvement (Bin 2013; Hienerth 2006; Lakhani and Wolf 2005), and helping others (Kogut and Metiu 2001; Lakhani and von Hippel 2003; Ozinga 1999). The fifth type of motivation measure was "to sell / make money." This motive does not fit within the free innovation paradigm: It is the main motivation of innovators within the producer innovation paradigm, and was included for that reason.

In the Finland study only, my colleagues and I had collected data from a sample of 408 household sector innovators that included both those who said they had developed innovations primarily for their own use (the 176 individuals represented in the tables in this chapter that refer to the Finland study) *and* those who made no such claim but filled out the full questionnaire nonetheless. My colleague Jeroen de Jong and I subjected this larger sample to a cluster analysis in order to group innovators with similar motivational profiles together (Green 1977; Schaffer and Green 1998). A four-cluster solution was found which was both in line with theoretical considerations, and had good stability (Cohen's kappa = 0.80) (source: de Jong 2015).

In figure 2.1 I report the fraction of the overall sample falling within each of the four clusters and also the distribution of motive types within each. As can immediately be seen, innovators in the household sector are generally driven by a mixture of motives rather than one pure type. Indeed, it was rare to find someone who was driven only by a single motive.

Each cluster in the figure is labeled with the name of the most important type of private benefit expected by household sector innovators in that cluster. "Participators" (43 percent of all the household sector innovators in the sample) expected the largest fraction of their innovation-related benefits to come from the self-reward of enjoyment and learning from participating in the innovation process itself. "Users" (37 percent of the sample) expected their largest fraction of benefit to come from personal use of the innovation they had developed. "Helpers" (11 percent) were those whose strongest motivation in the list of five asked about was to innovate in order to help others—altruism. "Producers" (9 percent of the sample) were most strongly motivated by the prospect of sales.

Next note that four of the five motives asked about involved expectations of *self-rewards*—compensated transactions were not required to obtain them. That is, when individuals say they use an innovation they have developed, they are self-rewarded—no one else is required to reward them. Similarly, if free innovators enjoy or learn from the process of developing their innovations, they are

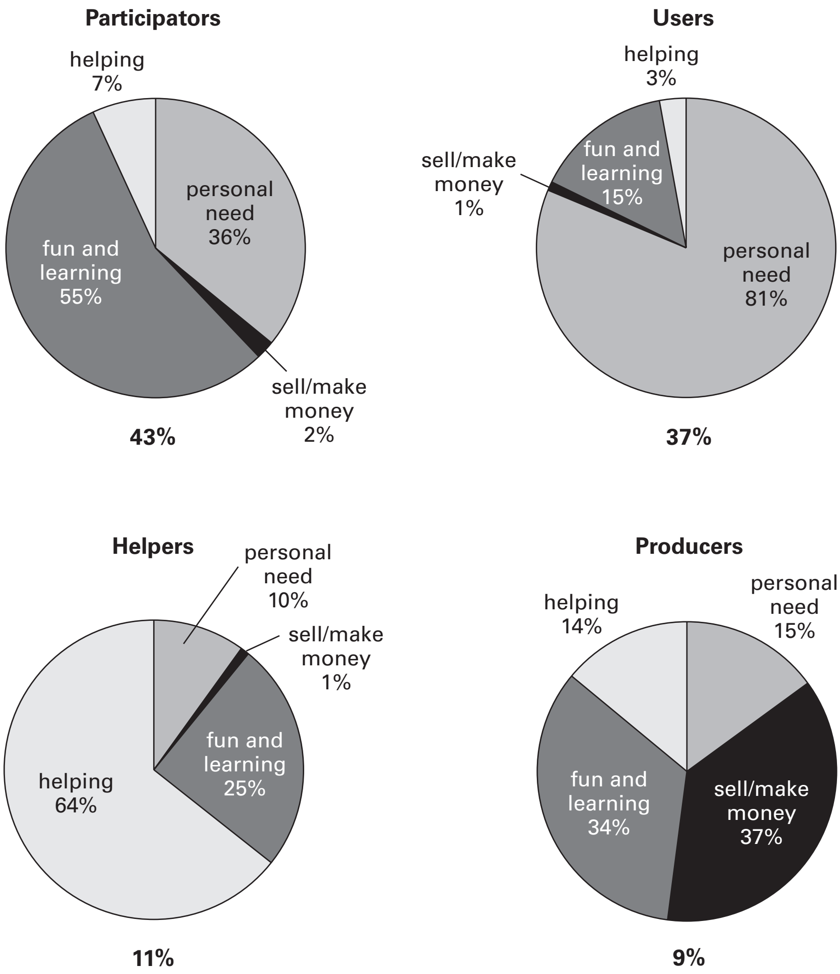

Figure 2.1
Household sector innovators in Finland clustered by mix of private benefits expected (*n* = 408).

self-rewarded—consuming those types of benefits also does not depend on transactions with others (Stock, von Hippel, and Gillert 2016; Stock, Oliveira, and von Hippel 2015; Raasch and von Hippel 2013; Franke and Schreier 2010; Hars and Ou 2002; Füller 2010). Also, as will be discussed further below, altruism too is a form of self-reward, not dependent upon compensated transactions. Only the last of the listed motives, the motive to "sell / make money," requires a compensated transaction with others.

From the findings shown in figure 2.1 we may conclude that innovators in three of the four clusters were free innovators—motivated by self-rewards almost entirely, and therefore finding it viable to invest in their innovation even if no one would pay them to obtain a copy. In sharp contrast, innovators in the producer cluster *were* significantly motived by the prospect of selling their creations. "Selling / making money" represented 37 percent of their total motivation. Of course, it is reasonable that a household sector survey will identify some individuals who are developing innovations to sell. Global Entrepreneurship Monitor (GEM) surveys find a similar fraction of individuals in the household sector (8.54 percent in advanced, "innovation driven" economies) to be in the early stages of entrepreneurial activity, with about half of these seeking to bring something novel to the market (Singer, Amorós, and Moska 2015, table A.3 and figure 2.14).

Individuals in the producer cluster differ from individuals in the three free innovator clusters with respect to behaviors as well as motivations. If one is seeking to sell, then developing designs likely to have value to many, investing in executing those designs very well, and protecting them from free adopters are all reasonable things to do. In line with these expectations, de Jong (private conversation, 2015) found that innovations developed by individuals in the producer cluster had significantly higher general value than innovations developed by individuals in the other three clusters. In addition, individuals in the producer cluster spent more developing their innovations (1,228 euros vs. an average of from 100 to 300 euros for the other three clusters). They also were also far more likely to protect their innovations via intellectual property rights (36 percent of innovators in the producer cluster did this vs. 3 percent or less in the other clusters).

Self-Rewards and Transaction-Free Activities

The concepts of self-reward and transaction-free activities, as I use them to describe the functioning of the free innovation paradigm, are connected: I define self-rewards as those private benefits that can be obtained without compensated transactions. A compensated transaction involves explicit or implicit arrangements to provide a specific party with "this" thing—perhaps a good, a service, or a financial instrument—in exchange for "that" thing. Therefore, when I say activities in the free innovation paradigm are transaction free, I mean that no compensated exchanges of this nature occur within it.

Compensated transactions are not involved when I gain personal use value from an innovation I develop and/or gain enjoyment and learning from engaging in the process of developing it. All of these reward types can be reaped without any requirement of related actions by or effects upon others—they are self-rewards. But what about the rewards associated with altruism that were asked about in the Finland survey? After all, others must adopt or benefit from my innovation before I can legitimately feel I have done something altruistic. Similarly, when I display or freely offer an innovation to others—reveal it without protections as the definition of free innovator requires—I may be hoping for a reward in the form of an increase in my personal reputation in the eyes of others (Lerner and Tirole 2002). In both of these instances, others have to do or experience something before I am rewarded. Why is this not a compensated transaction? The reason is that these hoped-for reactions are not an exchange of "this" for specifically "that" with a specific exchange partner. Instead, the freely revealed innovation is a casting of bread upon the waters, perhaps with expectations or hopes of return gifts in the form of "generalized reciprocity."

To clarify, let me digress briefly into the nature of gifts. First, note that compensated transactions, fitting the criterion of "specifically this for specifically that," can exist even without money or precise accounting as social transactions (Benkler 2006). Social transactions, Benkler explains, differ from economic transactions not in the absence of obligations for exchange, but in the precision of exchange. A market transaction has greater precision that "derives from the precision and formality of the medium of exchange—currency" (Benkler 2006, 109). In contrast, social exchanges are less precisely calculated. Benkler (ibid.) illustrates with a quote from Godelier in *The Enigma of the Gift*: "The mark of the gift between close friends and relatives … is not the absence of obligations, it is the absence of 'calculation.'" Still, as Mauss (1966, xiv), quoting from the "Havamal" in his book *The Gift*, put it, "a gift always looks for recompense." Examining the elements of any gift, Mauss discusses the three obligations involved—giving, receiving, and repaying—within which "the obligation of worthy return is imperative" (ibid., 41). As illustrated by Benkler, Godelier, and Mauss, when a gift is between specific known givers and recipients, it is a social transaction involving a compensated exchange of property, and such a gift is thus not "transaction free."

Second, note that gifts—such as those motivated by altruism in the case of our free innovators—*can* be transaction free when the givers expect generalized reciprocity rather than compensation from specific others. Generalized reciprocity, according to Sahlins (who first specified the term), is characterized by transactions that are generally accepted to be "altruistic," a "pure gift," and with expectations of recompense or direct material return being "unseemly" and at best "implicit" (Sahlins 1972, 193–194). It refers to "the return of a gift only indefinitely prescribed, the time and amount of reciprocation left contingent on the future needs of the original donor and abilities of the recipient; so the flow of goods may be unbalanced, or even one-way, for a very long period" (ibid., 279-280). Some have called generalized reciprocity "'helping a person backward,' where there is no chance of reciprocation by the person helped" (Ladd 1957, 291) or "paying it forward," described as the principle of "'I help you, and you help someone else'" (Baker and Bulkley 2014, 1493), but Sahlins expresses the essence, stating that "failure to reciprocate does not result in the giver of stuff to stop giving" (1972, 194).

Benjamin Franklin (1793, 178–179) made his important inventions available to all without patent protections. He explained his motives in terms of generalized reciprocity, saying "that, as we enjoy great advantages from the inventions of others, we should be glad of an opportunity to serve others by *any* invention of ours; and this we should do freely and generously." A smaller and more ordinary example of generalized reciprocity is the telling of the time to a stranger who stops one on the street to ask for that favor. You do not expect to see that individual again, nor to receive a return favor from precisely him or her. However, by contributing to a culture of generalized reciprocity, you can confidently expect that in the future some stranger will be willing to tell you the time if you ask. Very importantly, expectations of generalized reciprocity associated with a gift are transaction-free because, as was noted above, "failure to reciprocate does not result in the giver of stuff to stop giving" (Sahlins 1972, 194).

Within our context of free innovation, then, expectations of rewards in the form of generalized reciprocity such as gratitude or reputational enhancements evoked in the minds of others may motivate free innovators, and still not be compensated transactions made with specific others. However, there clearly can be a gray zone between transaction-free behaviors and transaction-based behaviors. For example, the number of active developers in an open source software development project may range from many to just a few. In the case of many developers, the situation contributors face might be most accurately called one of generalized reciprocity. However, as the number dwindles, awareness may grow that some specific person is developing and contributing X useful innovation to the commons and is doing so *because* another specific member will develop and contribute Y. In that case, the situation becomes one involving a compensated transaction.

To conclude, let me note that idea of transaction-free behaviors may seem odd, but in fact these are common in life—and justifiably so, in view of the costs and complexities that can be associated with arranging and executing compensated transactions (Tadelis and Williamson 2013). Baldwin (2008) points out that collaborative innovation projects, such as open source software development projects, are transaction free by design. She also points out that families and communities, when engaging in the activities of daily life, generally also engage in transaction-free interactions, often within a framework of generalized reciprocity. One can be confident, for example, that almost any adult will immediately rush to protect any young child from danger. According to Ladd (1957, 254), such help is offered "without the thought or expectations of reciprocation; and the reciprocation, when it does come, isn't considered a return but a new act of goodwill."

Discussion

Findings presented in this chapter show clearly that household sector innovation is significant in scale and scope. They also show that about 90 percent of household sector innovators fit the two criteria I have set for free innovation. That is, the innovators were motivated almost entirely by self-reward as compensation for their innovation-related investments, and they also did not protect their innovations from free-riding adopters.

In this section, I explain more richly *why* free innovators are willing to freely reveal their innovations. Although useful to us here, this topic has been explored in detail in previous work (e.g., Allen 1983; Harhoff 1996; Lerner and Tirole 2002; Harhoff, Henkel, and von Hippel 2003; von Hippel 2005, chapter 6). For this reason, I will provide only a brief summary of the main arguments.

The first fundamental point to note is that household sector innovators who are not rivals, and who do not plan to gain from having a monopoly on their innovations, generally do not lose anything by freely revealing their designs. For example, if I develop an innovation to help my diabetic child and have no interest in selling it, my own interests are in no way damaged if you adopt my design to help your diabetic child without paying me. This is true even if you did not contribute to the development work—that is, if you are a free rider. The same is true even if you are a producer who will make a great deal of money commercializing my free innovation, and who will not share any of the profits with me. After all, my self-reward—sufficient to induce me to develop the innovation—was to help my child. (Of course, there can be special reasons to restrict free revealing even in the case of non-rivalry. For example, free innovators who create medical devices that are complex or dangerous to use may freely reveal their designs only very selectively, wishing to avoid any health risk to adopters with lesser skills. See Lewis and Liebrand 2014.)

Second, given that one does not lose anything by free revealing, a passive absence of efforts to protect innovation-related information is the lowest-cost option for innovators. This is so because active exclusion requires investment to prevent revealing of design-related information that would otherwise leak out in the natural course of events (Benkler 2004; von Hippel 2005). For example, if you use an invention in public—say, if you ride an innovative bicycle in public—its design is to some extent "naturally self-revealing." That is, unless you invest in shrouding your bicycle's working parts, observers can to some extent understand its functioning via simple observation as you pass by (Strandburg 2008). Investments in protection can take the form of measures to maintain secrecy, as just described, and/or investments to prevent use of information that has been revealed via contracts or intellectual property rights.

Third, freely revealing rather than hiding an innovation can provide valuable, transaction-free rewards to free innovators well beyond the four types of self-rewards listed in earlier tables. For example, innovators who freely reveal their new designs may find that others then elect to improve their innovation, to mutual benefit (Allen 1983; Raymond 1999). Commercialization by producers also can create a source of supply for innovators that is cheaper than do-it-yourself production. For example, I might be pleased if a producer adopts my innovative medical device. Commercialization of my development would give me the convenience of buying copies I might need in future rather than having to make them for myself (Allen 1983). And, of course, revealing innovations for free can enhance innovators' reputations, sometimes leading to valuable personal outcomes like job offers (Lerner and Tirole 2002).

Despite the benefits of free revealing listed above, the option to protect one's innovation is open to all. Indeed, recall that many household sector innovators in the "producer" cluster in figure 2.1 do exactly that in pursuit of profit. Why do not more innovators, since the opportunity is open to all, opt for protection and commercialization instead of free revealing? A major reason, I surmise, is that even if an effort to commercialize might yield some profit in the end, investing time and money to realize that profit has opportunity costs associated with it. (An opportunity cost is the loss of potential gain from other alternatives when one alternative is chosen.) All household sector innovators—and all of us—have many things that compete for our time and attention. Household innovators in the producer cluster appear to have decided that commercialization is worth pursuing under their particular circumstances (Shah and Tripsas 2007; Halbinger 2016). In contrast, household sector innovators who choose the path of free innovation may simply prefer devote their time and money to following other opportunities.

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