5 Diffusion Shortfall in Free Innovation

In the preceding chapter I identified innovation pioneering as an important inbuilt difference between innovation development activities carried out within the free innovation paradigm and the producer innovation paradigm. In this chapter I identify an important inbuilt difference between the two paradigms with respect to innovation diffusion. By doing so, I further illustrate the research and practical utility provided by the free innovation paradigm.

The diffusion-related matter I will focus on is a systematic shortfall in free innovators' incentives to invest in diffusion of free innovations. I present evidence for that shortfall, and then argue that it is caused by the absence of a market link between free innovators and free-riding adopters. In a discussion at the end of the chapter, I suggest ways to address this situation.

"Market Failure" in the Free Innovation Paradigm

The value of free innovation to society comes in part from free innovators' satisfaction of their own needs via the innovations they develop. Social value is increased further 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.

In chapter 2 we saw that more than 90 percent of innovators in the household sector do not attempt protect their designs from adoption by free-riding peers or producers. We also saw that most are quite willing to have their innovations diffuse for free to others. However, simply being willing to allow free riders to adopt a design if they wish to do so is by no means the same as *investing* to support diffusion to free-riding 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 clearly, I could greatly reduce the time that perhaps thousands of adopters would require to install and use my novel code. Intuitively, it would seem that there would be a net increase in social welfare if I were to expend just that small extra effort.

To determine the optimal level of spending on diffusion in this case more exactly, it is useful to view the free innovation developer and the pool of potential free-riding adopters as a combined "system" for which we are seeking to maximize benefits. Assume that investments in diffusion of free innovations will lower adoption costs for free riders. Assume also that additional investments will lower adopters' costs at a declining rate. (For example, the first hour I spend improving my software code documentation might help clarify things a lot for free adopters, the second hour would contribute somewhat less additional clarity, and so on.) System benefit is then maximized at the point where an additional dollar of investment in diffusion by the free innovator—or anyone else in the system—reduces adoption costs by a dollar across all free adopters.

The question then is how to get to this optimal level of investment? The problem is that free innovators have to bear the costs of investments in diffusion, while free adopters get all of the benefits and do not share those costs. There is no market link that would enable a more appropriate allocation. Situations like these are described in economics under the heading of "market failure." With his evocative metaphor of an "invisible hand," Adam Smith described how pursuit of self-interest leads purchasers (whom he called "demanders") and producers jointly participating in a market to produce "always that precise quantity … which may be sufficient to supply, and no more than that supply, that demand" (1776, 54, 56). A market fails when it does not get this balance right, and when the interaction of purchasers and producers fails to allocate resources efficiently (ibid., 55). Stated in present-day terms, a market failure exists when another possible outcome can make a market participant better off without making someone else worse off (Krugman and Wells 2006). Market failures, in turn, are regarded as a form of inefficiency, especially of information and resources, that calls for government intervention and remedy (Bator 1958; Cowen 1988).

The absence of a market link and resulting market failure affect only the free innovation paradigm. In the producer innovation paradigm, in contrast, there *is* a built-in direct market connection that rewards investments in diffusion. When customers buy a product for which the producer has monopoly rights, they transfer part of the benefit they derive from adopting the innovation to the producer in the form of a price higher than marginal cost. This gives the producer a monopoly profit that both motivates and rewards investments in diffusion to gain more sales. (However, as I will note at the end of the chapter, a different diffusion problem affects the producer innovation paradigm.)

The difference in levels of diffusion incentives within the two paradigms just described is not always so stark. It can be partially or even fully offset in cases where types of self-rewards that increase with diffusion are valued by free innovators. For example, presumably the self-rewarding "warm glow" of altruism experienced by a free innovator increases as the number of people who adopt his or her free innovation increases. One could say the same for self-rewarding pride of accomplishment. Reputation enhancements can also fit: at least sometimes, the greater the diffusion of an innovation, the greater the reputational gain for the developer.

Given all these factors, is there, in practice, a general shortfall in diffusion effort by free innovators? We do not have very good data on this matter yet but, as we will next see, the available evidence does point toward such a shortfall (de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015; von Hippel, DeMonaco, and de Jong 2016).

Diffusion Performance of the Free Innovation Paradigm

There are two diffusion pathways a free innovation might follow. First, free information about an innovative design can flow directly from free innovators to peers, as figure 1.1 in chapter 1 shows. Second, as is also shown in that figure, design information can diffuse to producers for free, who then commercialize the design and sell it to adopters (Baldwin, Hienerth, and von Hippel 2006; Shah and Tripsas 2007).

In the six national representative surveys discussed in chapter 2, my colleagues and I collected data on innovation diffusion by both of these pathways. As can be seen in table 5.1, the rate of diffusion in these six countries by either pathway ranged from 5 percent to 21.2 percent of the innovation designs developed. On the face of it, this level of diffusion might seem low. However, in actuality, not all free innovations are candidates for diffusion. Recall that free innovators, motivated by self-rewards, may choose to create designs useful only to themselves. In those cases, an absence of diffusion is entirely appropriate. So, we must investigate further to see if the free innovation paradigm in fact underperforms with respect to diffusion.

Three Possible Manifestations of Diffusion-Related Market Failure

It seems to me that there is a sequence of three choices made by developers of free innovations that can each and collectively result in

Table 5.1
Development and diffusion of user innovations: results of national surveys. All studies sampled consumers aged 18 and over, with the exception of Finland (consumers aged 18 to 65).

		User innovators		Innovations	
Source	Country	Percentage of population	Number	Diffused	Protected with IPRs[a]
von Hippel, de Jong, and Flowers 2012	UK	6.1%	2.9 million	17.1%	1.9%
von Hippel, Ogawa, and de Jong 2011	US	5.2%	16.0 million	6.1%	8.8%
von Hippel, Ogawa, and de Jong 2011	Japan	3.7%	4.7 million	5.0%	0.0%
de Jong et al. 2015	Finland	5.4%	0.17 million	18.8%	4.7%
de Jong 2013	Canada	5.6%	1.6 million	21.2%	2.8%
Kim 2015	S. Korea	1.5%	0.54 million	14.4%	7.0%

a. intellectual property rights

systematic diffusion shortfalls within the free innovation paradigm. First, free innovators may not elect to *design* an innovation of value to others. Second, even if a design does have general value, free innovators may not elect to invest in *development* to an extent justified by the total value of the design to themselves *and* free-riding adopters. Third, free innovators may not elect to invest in actively *diffusing* innovation-related information to reduce the adoption costs of free riders. I next discuss each of these three choices conceptually, drawing in the relatively small amount of data currently available.

Market failure type 1: Reduced general value of free innovators' developments

Even if slight modifications could make their designs serve others better, the incentives of self-rewarding free innovators may often be to focus only on their own needs. Of course, even if this is the path taken, the resulting free innovation might still be useful to others. It depends on how similar peoples' needs are with respect to that type of development. If you and I have the same needs, it will not matter if I develop a new product or service with only myself in mind—the product or service will turn out to be useful to you too. And, of course, if our needs are different, that will not be the case (Franke, Reisinger, and Hoppe 2009; Franke and von Hippel 2003).

The proportion of free innovators who do develop innovations potentially of benefit to others as well as to themselves must be determined empirically. Accordingly, my colleagues and I collected data on this matter via questions added to the Finland and Canada national surveys of household sector innovators discussed in chapter 2. In both surveys, respondents were asked questions to determine whether they thought that others would find their innovations valuable. Their responses were grouped into the three clusters shown in table 5.2. From the table, we see that, even without a market connection to free riders, 17 percent of the innovators thought their innovations would be of value to many others, and that an additional 30-40 percent thought their innovations would be of value to at least some others.

This fraction is likely a result of both needs held in common by free innovators and potential free-riding adopters, and self-rewarding motives that increase along with diffusion of the innovation. An

Table 5.2
General value of innovations developed by free innovators.

General value	Finland (n = 176)a	Canada (n = 1,028)
Cluster I: valuable to many or nearly all	17%	17%
Cluster II: valuable to some	44%	34%
Cluster III: valuable to few or to no one except the developer	39%	43%
Did not answer	0%	6%

Sources: For Finland, de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015, table 5. For Canada, de Jong 2013, sections 3.3 a and b.

indication that the latter effect is playing a role comes from an analysis of data from Finland. Individuals who expressed *any* level of altruistic motivations (assigning at least one and at most 100 points to the innovation motive of helping others) were significantly more likely to have created a Cluster 1 innovation that could be of value to many than were individuals with no altruistic motivation at all ($\chi^2 = 9.2$, df = 2, $p = .01$) (de Jong 2015).

Market failure type 2: Suboptimal investment in design

Even if free innovators create a design of potential use to others, they may have no incentive to invest in improving the design to a level commensurate with potential value to themselves *and* free-riding adopters. For example, if fairly buggy code or roughly designed hardware will suit my personal needs, I may have no incentive to invest in refining my design, even if one thousand free riding adopters would benefit from my doing so. Free innovators will follow the viability calculations shown in chapter 3: They will invest in design only to the point that is optimal for themselves in the light of their particular constellation of self-rewards. Of course, when multiple free innovators collaborate on a project, design investment for the total project is likely to be higher than in single-developer projects.

Market failure type 3: Low diffusion effort by free innovators

The third possible manifestation of diffusion market failure is suboptimal investments to promote *diffusion* of a free innovation to free riders who might benefit from it. In table 5.3 we see evidence compatible with this third type of market failure in the case of innovations developed by individuals in Finland (de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015). In the data columns of that table we see that more than 75 percent of free innovators invested *no* effort in diffusion, even in the case of the Cluster 1 innovation designs that the developers thought had high general value. (Free innovators' self-assessments of general value may be right or wrong, but their efforts to diffuse for the benefit of others—the matter of interest here—will be a function of their own beliefs, not of the actual general value of their innovations.) Indeed, efforts to diffuse were so minimal that my colleagues and I had to use a very low threshold for our definition of active diffusion effort. Effort to diffuse an innovation peer-to-peer was deemed to exist if an innovator had simply shown the design to one or more peers. Effort to diffuse an innovation to a commercial firm was deemed to exist if an innovator had taken the initiative to show it to one or more commercial firms.

In addition to the finding of very low levels of diffusion effort in general, my colleagues and I found that in the case of peer-to-peer diffusion effort there is no significant relationship between diffusion effort exerted and the general value of the innovation ($\chi^2 = 2.5$, df = 2, $p = .285$). That is precisely what we would expect to see if there is a market failure of the type I am discussing here. Note that the pattern we see includes some free innovators making an effort to show innovations to peers that they themselves think have *no* general value (12 percent of cluster 3 in table 5.3). This can result if the free innovators have reasons to show their innovations for reasons not associated with

Table 5.3
Diffusion effort across clusters of general value in Finland.

	Diffusion effort made by free innovators	
Perceived general value	to inform peers	to inform producers
Cluster I: valuable to many	23%	19%
Cluster II: valuable to some	21%	6%
Cluster III: valuable to none	12%	0%

Source: de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015, table 6.

general value. For example, they may wish to show a "cool project" to friends independent of whether they think those individuals would find it useful.

In contrast, free innovators' efforts to diffuse information about their innovations *to producers* were significantly related to their assessment of the general value of the innovations: The more generally valuable the developer thought an innovation was, the higher the likelihood that that individual would make an effort to inform producers about it ($\chi^2 = 12.2$, df = 2, $p = .002$). Of course, it is entirely reasonable that innovators will make an effort to inform producers only if they think the producer might find the innovation commercially interesting. After all, if there is no commercial value in the innovation, efforts to bring it to the attention of producers would be wasted. Still, despite this pattern, the fact that free innovators only informed producers about 19 percent of innovations they thought had the highest value to others (Cluster 1 in table 5.3) again suggests a market failure exists in the free innovation paradigm with respect to incentives to invest in diffusing free innovations to adopters.

Discussion

We now have a strong logical case and initial empirical support for the view that free innovators' investments in diffusion may generally fall short of the social optimum. As has been discussed, in the case of free innovation, this effect is due to a market failure "built into" the free innovation paradigm—the absence of a market connection between free innovators and free adopters (de Jong, von Hippel, Gault, Kuusisto, and Raasch 2015; von Hippel, DeMonaco, and de Jong 2016).

In this discussion I first note that the free innovation paradigm is not uniquely defective in this regard. There is a diffusion shortfall built into both the free innovation and producer innovation paradigms—but different adopter types are affected. Next I briefly consider three possible approaches to easing the diffusion incentive shortfall in the free innovation paradigm: a market solution, non-market solutions, and possible government policy solutions.

Exclusion of unskilled adopters

Diffusion shortfalls afflict *both* the free innovation paradigm and the producer innovation paradigm, but the causes are different. In the case of the free innovation paradigm, as we have seen, adoption costs are higher than the social optimum due to free innovators' "too-low" incentives to invest in diffusing them. In the case of the producer innovation paradigm, a diffusion shortfall results from producers' pricing above the marginal cost of production.

Consider that intellectual property rights enable producers to charge monopoly prices. (These rights are available to both free innovators and producer innovators, but only producers have a reason to want them: free innovators, giving their innovations away, have no interest in monopoly pricing.) Although monopoly pricing can increase producers' incentives to create innovations, they also create what is called "deadweight loss" with respect to the diffusion of innovations after they have been created. That is, monopoly prices exclude customers who would purchase the innovation and benefit from it if it were priced at the marginal cost of production, but who will not buy it at the higher prices set by the producer.

An interesting contrast can be made between the characteristics of the potential adopters denied access by these two different forms of adoption barriers. Those deterred from adopting a free innovation due to free innovators' inadequate investment in diffusion will tend to be relatively deficient in technical skills. In contrast, those deterred from adopting producer innovations by monopoly prices will tend to be those with less money. This pattern has not yet been studied, but my colleagues and I think it is both logical and clearly visible in everyday life. For example, people with technical skills do not need money to go to free Internet sites to "jailbreak" their smartphones and escape phone producers' restrictions. They can then download and use the latest free features. Millions in fact do this (Greenberg 2013). In contrast, people with money, and perhaps no technical skills, are more likely to pay phone producers' monopoly prices to buy the latest products equipped with the newest commercial features.

Solution via a market connection

As we have seen, a shortfall in the diffusion of free innovations can result from a lack of a market connection between free innovators and free-riding adopters. Accordingly, a straightforward solution could be to create a market connection between them. For example, one might devise some very cheap and easy form of intellectual property protection to induce free innovators to protect and sell their designs instead of giving them away. In other words, one could try to induce free innovators to elect to become producer innovators.

There is no doubt that this approach could work to some extent. As we saw in chapter 2, about 10 percent of household sector innovators already fall into the category of "producers" and behave in ways that would reward investments in diffusion. However, I myself do not consider it a preferred approach. Addressing a failure in the free innovation paradigm by inducing more household sector innovators to become producer innovators will also decrease the individual and social advantages that we have seen that free innovation provides. For example, it might reduce the scale of free innovators' pioneering of new applications and markets.

Non-market solutions

There are ways to work *within* the framework of the free innovation paradigm to increase the amount of diffusion of generally valuable free innovations. Two general approaches are: increase the strength of self-rewards that increase with diffusion, and/or lower the costs of creating and diffusing generally valuable innovations.

Interventions to increase self-rewards associated with diffusion generally alleviate all three manifestations of the diffusion market failure that are present in the free innovation paradigm today. This is because interest in creating a generally useful product is likely to be linked with interest in designing it well, and also in promoting widespread diffusion.

How can free innovators' self-rewards for investment in diffusion be increased? "Gamification" is one generally useful approach. It is known that games played without any practical output being obtained, like solitaire, are self-motivating activities (Fullerton 2008; Schell 2008; Gee 2003). Practical methods to manipulate and enhance such self-rewards are called gamification (Zicherman and Cunningham 2011).

Gamification strategies used to promote diffusion will vary by motive type. For example, one might increase levels of altruism-related self-rewards experienced by free innovators by providing them with better information on the number of adopters who would benefit by their investment in diffusion. An example of this strategy is the non-profit site Patient-Innovation.com (2016), which, among other activities, is working on collecting data on the most important needs of underserved medical patients with rare diseases (Oliveira, Zejnilovic, Canhão, and von Hippel 2015). The goal of the site's managers is to guide engineering classes and others seeking to contribute to projects valuable to these medical patients towards especially impactful opportunities. For free innovators motivated by reputation-related self-rewards, different gamification strategies would be useful. One might, for example, increase the likelihood of reputational gains for these individuals by publicly posting information about the admirable investments they have made to diffuse socially important free innovations.

With respect to lowering the costs of free innovation and diffusion, many specific costs seem reducible in many specific ways. For example, free innovators' costs of access to design and production tools can be reduced by support for "makerspace" communities, where access to costly tools is shared, and so rendered less expensive for individuals (Svensson and Hartmann 2016). Increased emphasis on open standards for design tools can lower the costs of acquiring and learning these tools, and also lower the cost of sharing design information created on a range of tools. Open sites for posting digital designs and design information can lessen the costs of diffusion for many—and so forth.

Diffusion of free innovations can also be increased by emphasizing support for collaborative free innovation projects over those carried out by single innovators. Available evidence shows that collaboratively developed designs diffuse much more frequently than designs created by single individuals. Thus, Ogawa and Pongtanalert (2013), who studied Japanese household sector product developers, found a rate of adoption by peers of 48.5 percent when the developers belonged to collaborative communities. When the developers did not belong to such communities, the adoption rate was sharply lower at 13.3 percent. Similarly, de Jong (2013) found, in a study of Canadian household sector innovators, that for collaborative projects the probability of peer-to-peer diffusion and adoption was 38 percent, whereas for single-innovator projects it was 20 percent.

I think there are two likely reasons for this effect. First, the needs addressed by collaborative projects are likely to be more general—after all, at least several collaborators are interested. Second, the information available to free adopters from collaborative innovation projects is likely to be much richer than that from single innovator projects. This is because participants in a collaborative project must document their activities to coordinate their work, something that single innovators need not do. This richer information, created for internal project use, can then costlessly spill over to the benefit of free adopters.

The case for governmental support

Some of the measures just described, such as support for need information sites, could benefit from governmental support. But why should government pay any attention to ameliorating a diffusion failure afflicting only the free innovation paradigm? Most fundamentally the answer is that, as will be explained in the next chapter, the diffusion and adoption of free innovation designs by those who benefit from them increases social welfare. With rare exceptions, such as the design of dangerous goods, society benefits if designs are public goods, available to anyone to use or study for free. Increased social welfare is, of course, the fundamental justification for governmental interventions in general (Machlup and Penrose 1950; Nelson 1959; Arrow 1962).

By analogy, governments today invest to cure and offset defects afflicting the producer innovation paradigm, notably by creating and supporting elaborate and very expensive intellectual property rights systems. They justify these investments and policies in terms of expected increases in social welfare. Investments in the free innovation paradigm under the same justification would only level the playing field.

This is a section of doi:10.7551/mitpress/9382.001.0001

Free Innovation

By: Eric von Hippel

Citation:

Free Innovation
By: Eric von Hippel
DOI: 10.7551/mitpress/9382.001.0001
ISBN (electronic): 9780262335461
Publisher: The MIT Press
Published: 2016

The MIT Press

A hardcover edition of this text is available from The MIT Press. Copies may be ordered online at http://mitpress.mit.edu.

Set in Stone Sans and Stone Serif by Toppan Best-set Premedia Limited. Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Names: von Hippel, Eric.
Title: Free innovation / Eric von Hippel.
Description: Cambridge, MA : MIT Press, 2016. | Includes bibliographical references and index.
Identifiers: LCCN 2016009390 | ISBN 9780262035217 (hardcover : alk. paper)
Subjects: LCSH: Technological innovations--Economic aspects. | Inventors. | Innovations.
Classification: LCC HC79.T4 H557 1988 | DDC 338/.064--dc23 LC record available at https://lccn.loc.gov/2016009390

10 9 8 7 6 5 4 3 2 1