6 Division of Labor between Free Innovators and Producers

In this chapter, I explain the value of a division of innovative labor between free innovators and producer innovators. As Gambardella, Raasch, and von Hippel (2016) show, both social welfare and producer profits very generally increase if producers avoid developing types of innovations that free innovators already make available "for free." Instead, as my colleagues and I argue, producers should learn to focus on developing innovations that *complement* free innovation designs rather than substitute for them. Further, innovation tasks can and should increasingly be shifted to free innovators as their capabilities increase—that is, they should be shifted to what standard economic models think of as the demand side of markets.

I will begin by reviewing four basic interactions between the free and producer innovation paradigms. Then I will explain how my colleagues and I modeled the relationships among these interactions, and the effects that we found on both producers' profits and social welfare. As we will see, under some conditions producers can profit by actually subsidizing free innovation.

Four Major Interactions between the Paradigms

Recall from chapter 1 that there are four separate types of interaction between the free innovation paradigm and the producer innovation paradigm. These were represented schematically in figure 1.1, which for convenience is reproduced here as figure 6.1. First, designs diffused from peer to peer via the free innovation paradigm can *compete with* products diffused by producers via the market, resulting in what my colleagues and I call a *free-contested market*. Second, designs diffused from peer to peer via the free innovation paradigm can *complement* products and services diffused by producers via the market, a situation we call a *free-complemented market*. Third, as is indicated by the

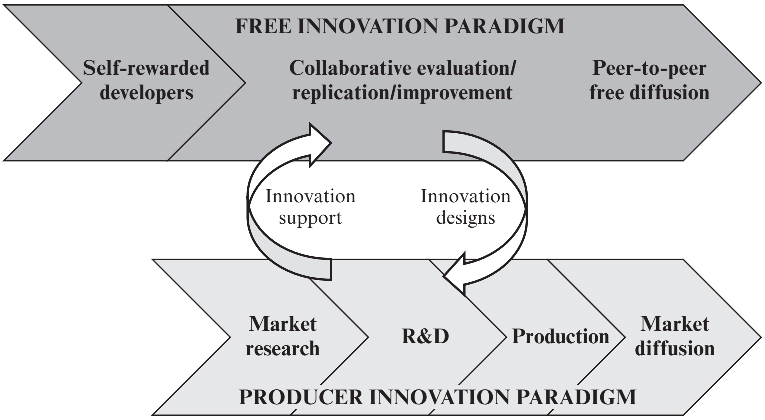

Figure 6.1
Interactions between the free innovation paradigm and the producer innovation paradigm. (Same as figure 1.1, reproduced here for the reader's convenience.)

downward-pointing arrow, free innovators "spill over" their free designs to free-riding start-up firms or incumbent producers. Fourth, as is indicated by the upward-pointing arrow, producers can supply tools and platforms to both support and shape free innovation.

In chapter 1, I briefly described the four paradigm interactions. Here I will describe what we know about each of them in more detail. This will provide a rich context for an exploration of producer strategies related to these interactions, and their effects on social welfare.

Free-contested markets

When an innovation is diffused for free to consumers via the free innovation paradigm and is a full or partial substitute for a product diffused by producers, producers face what Gambardella, Raasch, and von Hippel (2016) term a *free-contested market*. Free-contested markets involve a source of competition for producers that has not been contemplated in standard models of monopolistic or imperfect competition (see, e.g., Robinson 1933; Chamberlain 1962).

In a free-contested market, consumers as a group benefit from having access to the additional, non-market choice of free innovations and innovation designs. Some consequences of this situation have been studied in the case of competition among open source and closed source software suppliers (Casadesus-Masanell and Ghemawat 2006; Economides and Katsamakas 2006; Sen 2007). In that context, producers were found to lose profit from open source innovations distributed for free, even if those innovations were not full substitutes for producer commercial products. It was also found that consumers benefit from the existence of the open source alternative *unless* it forces proprietary firms to exit the market, leaving free, partial substitutes as consumers' only option. Loss of the producer option reduces the benefit to consumers because the two alternatives typically are not perfect substitutes—some consumers will prefer one and some the other (Kuan 2001; Baldwin and Clark 2006b; Casadesus-Masanell and Ghemawat 2006; Lin 2008).

Free-complemented markets

With respect to free-complemented markets, consider first that individual products or services are components within larger systems. For example, mountain bikes are a product that fits within a system of complements ranging from mountain biking techniques to helmets, tire pumps, navigation devices, and lights. From the perspective of the producer of any product or service within such a system, the other elements of the system are complements that range from useful to essential and that therefore add to the value of that "focal" product or service (the one I am focusing on). Thus, if I buy a specialized mountain bike and want to use it skillfully, I need the essential complement of mountain bike riding techniques. Biking techniques are largely diffused from peer to peer by free innovators rather than being sold. In other words, mountain bike producers are participating in and benefiting from a free-complemented market. The market for specialized mountain bikes would be much smaller without the free complement of mountain biking techniques.

Free-complemented markets can involve products that are separate from but complementary to producer products, as in the case of the mountain bike riding techniques just mentioned. They can also involve modifications or complements built onto or into producers' products or platforms. With respect to the latter, consider software modifications and additions that complement the value of basic commercial software products in fields ranging from music software to computer gaming software (Jeppesen and Frederiksen 2006; Prügl and Schreier 2006; Boudreau and Jeppesen 2015; Harhoff and Mayrhofer 2010). The evidence for the widespread presence of free-complemented markets runs counter to the conventional assumption that only producers provide complements, although customers are able to select and assemble them (Schilling 2000; Jacobides 2005; Adner and Kapoor 2010; Baldwin 2010).

In the case of systems of complements, producers may select the most commercially advantageous elements of a system to produce and sell. They will then prefer that the complements they do not sell will be provided to their customers in the form of free complements rather than as commercial products or services sold by other producers. The reason is that producer complementors seek to profit from the complements they provide, whereas free innovators do not. Free complementors therefore leave more profits available for the producer to extract from the system (Baldwin 2015; Baldwin and Henkel 2015; Henkel, Baldwin, and Shih 2013). For example, if free innovators provide the complement of biking techniques "for free," the value of the system of mountain bike plus mountain biking techniques to the mountain bike purchaser increases. A producer of mountain bikes that has monopoly power could extract some or all of the increased system value created by the free technique innovations by charging more for bikes.

Free spillovers of design information to producers

The third interaction between free and producer paradigms involves the spillover of free design information to producers (represented by the downward pointing arrow in figure 6.1). Producers can adopt free designs they think are likely to be profitable and commercialize them for the market at large. Research shows that such design spillovers can be highly valuable to producer firms, providing higher sales revenues, higher gross margins, and longer product life cycles for the producer (Lilien, Morrison, Searls, Sonnack, and von Hippel 2002; Winston Smith and Shah 2013; Franke, von Hippel, and Schreier 2006; Poetz and Schreier 2012); Nishikawa, Schreier, and Ogawa 2013).

Evidence for the importance of free designs to producers is illustrated by studies that explore the sources of all "important" innovations in a field. At the time of this writing I am aware of four empirical studies of this type that are focused on consumer products and services. Shah (2000) studied the source of important innovations in four sporting fields; Hienerth, von Hippel, and Jensen (2014) did the same in the specific sport of whitewater "playboat" kayaking; Oliveira and von Hippel (2011) studied the sources of important retail banking innovations; and van der Boor, Oliveira, and Veloso (2014) studied the sources of important innovations in mobile banking. These authors found that designs created by individual and collaborating users in the household sector accounted for a very significant fraction (from 45 to 79 percent) of all "important" innovations commercialized by producers in those fields. The innovative designs in the four studies were very rarely protected by their household sector developers: they were free innovations.

Cost savings for producers that adopt free designs can be estimated by first calculating producers' per-innovation design costs for innovations they *do* develop. That number can then be used to roughly estimate producer design cost savings in the case of each design adopted from free innovators. Data were collected for this calculation in the case of the whitewater kayaking study described in chapter 4. In that study, it was found that 79 percent of all important innovation designs commercialized had been developed by kayakers and revealed for free. The reduced R&D costs for kayak producers adopting those free designs were very significant: my colleagues and I calculated that development cost savings were 3.2 times larger than whitewater kayak producers' *total* product design budgets over the entire history of that sport (Hienerth, von Hippel, and Jensen 2014).

Producers' support for free innovation

In the previous section we saw that complements and commercializable product designs that spill over to producers "for free" can greatly reduce producers' internal R&D costs. Producers therefore may wish to invest in supporting the design work of free innovators to enhance their supply of free designs. They may do this by supplying free innovators with development platforms and tools that make their design and diffusion tasks easier, and that also guide free innovators' efforts in commercially profitable directions. This is the fourth form of interaction that we see between the free innovation paradigm and the producer innovation paradigm, and is represented by the upward-pointing arrow in figure 6.1.

The empirical literature describes many types of investments by producers to encourage and support innovation by free innovators. Producers may sponsor a user innovation community (West and Lakhani 2008; Bayus 2013) or a design contest (Füller 2010; Boudreau, Lacetera, and Lakhani 2011). They may provide free innovators with kits of tools to enable them to make their own designs more easily (von Hippel and Katz 2002; Franke and Piller 2004). Producers may also engage in boundary-spanning activities and may invest the working time of employees in supporting free innovators (Henkel 2009; Colombo, Piva, and Rossi-Lamastra 2013; Dahlander and Wallin 2006, Schweisfurth and Raasch 2015). Detailed examples of producer support for free innovators, and producer strategy considerations as well, will be discussed in chapter 7.

Modeling Producer Strategies to Support Free Innovation

In line with standard microeconomic modeling, the focus of Gambardella, Raasch, and von Hippel (2016) is on the implications of free innovation *for producers* as well as on the effects of free innovation and producer innovation on social welfare. I will discuss producer innovation strategies in this section and will turn to the implications for social welfare in the next section. In both sections, I will describe the model variables and modeling results conceptually rather than mathematically. The full mathematical model and findings are provided in appendix 2.

Recall from the above descriptions of four paradigm interactions that two of them are positive for the producer. First, producers' profits increase when free innovators create and diffuse complements that producers do not find it profitable to produce and sell, but that enhance the value of the products or services that producers do sell. Second, producers' costs of developing innovations are reduced when they can adopt designs from free innovators instead of developing designs in-house.

Recall too that one of the four paradigm interactions—free-contested markets—is unalloyedly negative for producers: Free peer-to-peer distribution of products or services by free innovators is a source of competition for producers trying to sell the same thing or a substitute. Just like any other form of competition, competition from participants in the free innovation paradigm decreases the size of a producer's market and/or forces the producer to lower prices. For example, in the mountain biking example discussed earlier, free innovator-developed mountain bike designs were available "for free" to mountain bikers—potential customers—just as they were to mountain bike producers. Individuals who elect to build their own bikes reduce the size of the producers' market by removing themselves as potential customers.

Finally, recall that the fourth interaction is the provision of design support by producers to free innovators. This interaction is under producer control, and it is the path by which the model of Gambardella, Raasch, and von Hippel (2016) envisions that a producer can seek to affect and shape the first three interactions to increase profits.

The model's approach to the interplay of the four interactions is to focus on the fraction of a producer's potential market that is capable of both innovation and self-supply. This is because the profitability of a decision to invest in supporting free innovation development turns out to be centrally affected by that factor. (Innovation design and innovation self-supply generally go together. If you are going to go to the trouble of designing something, you will generally build a copy too as part of the development process. If you are a user, the copy you have made will remove you from the producers' potential market—you have supplied it to yourself.)

Suppose that in a particular market very few individuals in the household sector have the capability to innovate in ways that may be of commercial value to a producer. In that case, the model finds, it would make sense for a producer to stick to in-house development and not invest in developing and supplying innovation design tools to support the efforts of just those few free innovators. The cost per additional free innovation developed would be too high. As the fraction of potential free innovators in the producer's market grows, however, investing a portion of producer R&D dollars in tools to support and increase free innovation becomes more profitable than an exclusive focus on in-house development, even if free innovators both innovate and self-supply and thereby remove themselves from that producer's potential market.

Eventually, as the share of potential innovators in a producer's market increases still further, investing in supporting free innovators again becomes unprofitable. The loss of potential market associated with self-supply by potential customers becomes so large that the producer's profits are reduced, even though more free commercializable designs are developed. The offsetting effect of customers' self-production is especially dangerous for producers when *non*-innovating potential customers also gain the ability to make very cheap copies of free innovations. This possibility is a reality today in the case of software and many other information products. Soon, with the increased availability of cheap, personally accessible production technologies such as 3D printers, it also will be a commonplace reality for many physical products.

Of course, this offsetting effect applies only to products that a producer wants to commercialize in competition with peer-to-peer diffusion. In the case of the development of valuable complements that a producer *does not* want to commercialize, the more free innovation and self-supply the better! For this reason, as we will see in the next chapter, today some producers make heavy investments to specifically encourage and support free innovators' development of complements to the commercial products they sell.

I should note that Gambardella, Raasch, and von Hippel (2016) assume that a natural level of free innovation and self-provisioning by potential customers will be present even without a producer firm making investments to support it. As national surveys show, free innovation is a very widespread phenomenon today, generally without intentional support from producers. This implies a possibility, not included in the model, that the natural level of free innovation and self-supply can already be at a point that is "too high" from the point of optimum producers' profits in some markets. Evidence shows that producers judging this to be the case may then choose to invest in frustrating free innovation rather than supporting it. They may, for example, use legal restraints and/or technical barriers to make their products more costly for potential customers to modify or copy (Braun and Herstatt 2008, 2009).

Finally, independent of the number of potential innovators in a market, a producer's best choice with respect to its corporate R&D investments is never to invest only in providing tools to support free innovators. Free designs can seldom be produced commercially just as they are. A producer therefore must invest internal funds to refine a free design and prepare it for production. In addition, a producer must invest internal funds to develop types of designs that free innovators would not be interested in developing but that are important to the market—for example, designs to make products easier for novices to use. The model therefore addresses the appropriate balance with respect to investments that *complement* the efforts of free innovators versus investments that substitute for design development activities that free innovators find it viable to make on their own.

Modeling the Effects of Free Innovation on Social Welfare

Social welfare functions are used in welfare economics to provide a measure of the material welfare of society, with economic variables as inputs. A social welfare function can be designed to express many social goals, ranging from population life expectancies to income distributions. Much of the literature on innovation and social welfare evaluates the effects of economic phenomena and policies on social welfare from the perspective of total income of a society without regard to how that income is distributed. The model presented in Gambardella, Raasch, and von Hippel (2016) takes that viewpoint.

On the face of it, free innovation should increase social welfare. It involves decisions by individuals to divert part of their discretionary unpaid time, generally assumed in economics to be devoted to consumption, to activities that produce value for the innovators themselves, and often produce value for additional peer and commercial adopters too (Henkel and von Hippel 2004).

As markets move from a traditional producer-only situation to a situation including free innovators, the modeling of Gambardella, Raasch, and von Hippel (2016) finds that both producers' profits and social welfare always increase if firms adopt a strategy of investing in complementing free innovation activity instead of competing with it. In contrast, if producers elect to compete with free innovators' designs, both producer profits and social welfare are likely to suffer.

In other words, and as I noted at the start of this chapter, the modeling and theory building my colleagues and I have done concludes that the most profitable and welfare-enhancing situation in the economy involves a division of innovation-related labor between free innovators working within the free innovation paradigm and producers working within the producer paradigm. The optimal division of labor, however, will not be arrived at without policy interventions. As the number of free innovators in markets increases steadily as a result of the technological trends described in chapter 3, our model shows that producers generally switch from a producer-only innovation mode to a mode utilizing free innovation "too late" from the perspective of overall social welfare. The reason is that overall welfare includes benefits that accrue to free innovators and increase social welfare, but that are not taken into account in private producers' calculations of returns.

Producers assess their private returns to investments in supporting free innovation by considering the value they are likely to derive from increased creation of commercially valuable free designs by free innovators. But investments by producers to support free innovation also support the creation of designs that have personal and social value but do not have commercial value. In addition, producers' investments to support free innovation induce other types of self-reward valued by free innovators but not by producers—for example, the learning and enjoyment that free innovators gain from participating in free innovation development. For these reasons, a level of investment supporting free innovation that is *higher than* the level that is optimal for producers' profits always enhances social welfare.

To bring these added sources of welfare into welfare calculations, my colleagues and I argue that calculations of social welfare should include a "tinkering surplus" component. Social welfare is conventionally calculated as profits (PS) plus a consumer surplus (CS). We suggest adding *tinkering surplus* (TS) as a third component to social welfare, consisting of all the net benefits from self-rewards that free innovators gain from developing their innovations. How significant is the omission of the tinkering surplus in conventional welfare calculations? Given the importance of self-rewards to free innovators documented earlier, the omission can be substantial.

Discussion

The most important finding of Gambardella, Raasch, and von Hippel (2016) is that both producers' profits and social welfare are generally increased if producers invest less in capabilities and innovations that *substitute for* what free innovators find it viable to do, and invest more in capabilities and innovations that *complemen*t free innovation.

For example, in the video game industry, producers should focus their own development efforts on developing game "engines"—a very complex type of software program that has been, at least so far, seldom viable for free innovator developers. In contrast, they should leave the development of simpler and cheaper game "mods" to their gamer customers. Similarly, medical equipment producers may want to leave the pioneering of some new types of medical devices to free innovator patients. (As we will see in chapter 10, free innovating patients are entirely within their legal rights to create, use, and freely share designs for novel medical devices without governmental approvals.) The producers would then focus their R&D investments on the complementary tasks of making the patients' designs better and more reliable through product engineering, and on getting the devices through costly governmental approval processes.

Recall that the modeling also found that, from the perspective of social welfare, producers tend to switch "too late" from a focus on internal R&D only to a division of labor with free innovators as the proportion of free innovators in their markets increases. This is because producers' profit calculations do not take the welfare benefits arising from free innovators' tinkering surplus into account. Novel policy measures may be needed to address this problem. Indeed, some existing policies may make the problem worse and should be reassessed. Policies to subsidize producers to develop innovations that free innovators can also develop will further retard producers' transition to an appropriate division of labor with free innovators. The net effect will be to redistribute welfare from free innovators to firms, and even to lower aggregate welfare.

Again and in summary, my colleagues and I find that both producers and society can benefit from a conscious, intelligently implemented division of innovation labor between innovators acting within the free innovation paradigm and firms acting within the producer innovation paradigm. In the next chapter, I will explore some practical steps in this direction.

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