Free Innovation

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3 Viability Zones for Free Innovation

In this chapter I explore the conditions under which innovation *pays* for both free innovators and producers. Drawing heavily upon research carried out with Carliss Baldwin (Baldwin and von Hippel 2011), I first define and describe three basic innovation modes: free innovation by single individuals, collaborative free innovation by multiple individuals, and producer innovation. I then explore the conditions under which each of these modes is "viable"—that is, will provide a net benefit to innovators engaging in it.

Building upon innovation mode viability calculations, we will see that continuing improvements to free innovators' design tools and communication capabilities are making free innovation viable for an increasing range of innovation opportunities. As a result, it is reasonable to conclude that free innovation will steadily grow in importance relative to producer innovation.

Three Innovation Modes

The thinking and the analyses that I will describe in this chapter were first developed in a paper analyzing the viability of user and producer innovation modes (Baldwin and von Hippel 2011). In what follows, I apply this work, with slight modifications to definitions, to analyze the viability of free and producer innovation modes.

Recall from chapters 1 and 2 that free innovation involves innovations developed at private cost by individuals during their unpaid discretionary time and also involves innovation designs that are not protected by their developers and so are potentially acquirable by anyone "for free." Recall also from chapter 1 that two different modes of innovating occur within the free innovation paradigm: free innovation by single individuals, and free innovation by groups of collaborating individuals. Together with producer innovation, this gives us three basic "modes" of innovation:

- A *single free innovator* is an individual in the household sector of the economy who creates an innovation using unpaid discretionary time and does not protect his or her design from adoption by free riders.
- A *collaborative free innovation project* involves unpaid household sector contributors who share the work of generating a design for an innovation and do not protect their design from adoption by free riders.
- A *producer innovator* is a single, non-collaborating firm. Producers anticipate profiting from their design by selling it. It is assumed that, thanks to secrecy or intellectual property rights, a producer innovator has exclusive control over the innovation and so is a monopolist with respect to its design.

Viability of an Innovation Opportunity

A mode of innovation is *viable* with respect to a particular innovation opportunity if the innovator or each participant in a collaborative effort finds it worthwhile to incur the costs required to gain the anticipated value of the innovation (Arrow 1962; Simon 1981; Langlois 1986; Jensen and Meckling 1994; Scott 2001). This definition of viability is related to the contracting view of economic organizations (Alchian and Demsetz 1972; Demsetz 1988; Hart 1995), the concept of solvency in finance, and the concept of equilibrium in institutional game theory (Aoki 2001; Greif 2006).

In terms of benefits, we define the *value of an innovation*, denoted by v, as the benefit that a party expects to gain from converting an innovation opportunity into a new design—the recipe—and then turning the design into a useful product, process, or service. As was discussed in chapters 1 and 2, free innovators and producers benefit from innovations they develop in different ways. Free innovators benefit from self-rewards and do not protect their innovations from free adoption by others. Their self-rewards may include benefits from using the innovation, benefits from participating in the innovation process, such as fun and learning, and benefits from helping, such as the "warm glow" associated with altruism (Raasch and von Hippel 2013; Stock, Oliveira, and von Hippel 2015; Franke and Schreier 2010; Hars and Ou 2002). In sharp contrast, producers benefit from profitable sales, which may take the form of sales of intellectual property (a patent or license) or sales of products or services that embody the design. Ultimately, a producer's benefit derives from customers' willingness to pay for the innovative design.

With respect to *innovation-related costs*, the model of Baldwin and von Hippel (2011) includes four basic types:

- *Design cost*, d, is the cost of creating the design for an innovation. It includes the cost of specifying what the innovation is supposed to do. These instructions can be thought of as a "recipe" for the innovation that when implemented will bring the innovation into reality (Baldwin and Clark 2000, 2006a; Suh 1990; Winter 2010; Dosi and Nelson 2010).
- *Communication cost*, c, is the cost of transferring design-related information between project participants during the design process and of communicating design information to others to accomplish diffusion.
- *Production cost*, u, is the cost of carrying out the design instructions to produce the specified good or service. The inputs include the design instructions—the recipe—and the materials, energy, and human effort required to carry out those instructions. The output is the innovative product or service—the design converted into usable form.
- *Transaction cost*, t, is the cost of establishing property rights and engaging in compensated exchanges of property.

For any innovation opportunity, the condition for viability for any innovation process participant is straightforward: The value of the innovation to any individual or firm i (expressed as v_i), must be greater than the costs that innovator incurs in design, in communication with others, in production, and in transactions. That inequality is

$$v_i > d_i + c_i + u_i + t_i. \tag{1}$$

To simplify discussion of the viability of the three modes of innovation, Baldwin and I first focus only on design and communication costs. This allows visualizing the zones of viability for each innovation mode in two-axis charts. Later, when the bounds on viability for all three innovation modes with respect to design and communication costs have been established, we will reintroduce the other two dimensions of cost and show how they affect the results. Therefore, for now consider that, for a given innovation opportunity, a particular mode of innovation is viable if and only if, for each necessary contributor to that mode, design and communication costs are less than the value that contributor expects, i.e., that

$$v_i > d_i + c_i. \tag{2}$$

When is an innovation opportunity viable for a single free innovator? Figure 3.1 illustrates the innovation opportunity viability zone for a single free innovator. Project design costs (d) are represented on the horizontal axis, project communication costs (c) on the vertical axis.

The pattern we see is simple but interesting. Recall that the effort of innovation is worthwhile for a single free innovator in the case of a specific design opportunity if v_i is greater than the individual's cost of design plus cost of communication: $v_i > d_i + c_i$. Recall also that Baldwin and I defined communication cost as the cost of transferring design-related information among project participants during the design process, or to accomplish diffusion.

Under this definition, communication cost is zero in the case of design development by a single free innovator because that individual "does not have to talk with anyone" to benefit from developing and using the innovation. For example, if I have the capability to develop a

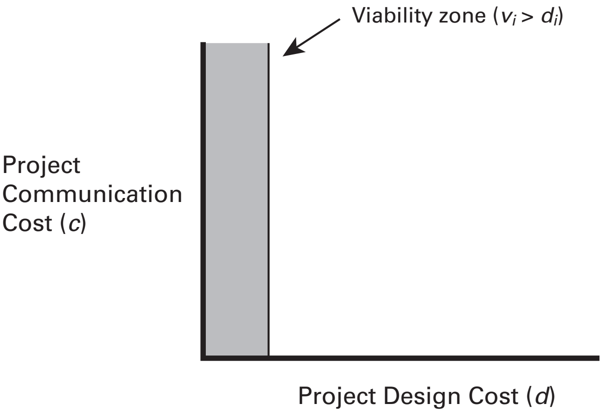

Figure 3.1
The viability region for an individual free innovator.

medical device or a type of sporting equipment to meet my own needs, I can "just do it," not communicating with anyone as I work on the project. I can then also use my improved equipment, again without the need to incur communication costs. In other words, our viability equation is reduced to $v_i > d_i$ in the case of design development and use by single free innovators. Because communication costs are zero, these individuals can find innovation development viable even if communication technology is very primitive, or if the costs of communication are very high for other reasons. This is why the shaded viability zone for single developers shown in figure 3.1 extends upward to include areas of high communication costs.

Note that single free innovators can choose to incur communication costs by investing in actively diffusing information about their innovation to potential adopters. However, they need not do this. Our definition of free innovation requires only that free innovators do not protect their design-related information—a choice that does not require investment in communication.

Even though single free innovators have no communication costs, they do have to expend time and money on design. An innovation project, therefore, will be viable for a single free innovator inside the vertically striped zone in figure 3.1, where $v_i > d_i$, but will not be viable outside that zone. That is, I would be willing to spend only up to d_i to respond to a specific innovation opportunity to improve my medical device, in view of the benefit of v_i that I expect. Of course, these values may be different for different individuals. If you need the same medical device somewhat more than I do, your v_i, and therefore your d_i, would be somewhat higher than mine.

When is an innovation opportunity viable for a collaborating free innovator?

Recall next that a collaborative innovation project is carried out by individuals who share the work. Open source hardware design projects, such as the Nightscout project described in chapter 1, and open source software projects are examples of collaborative innovation projects. In these projects, the participants are not rivals with respect to the innovative design they are creating. (If they were, they would not collaborate.)

Like single free innovators, collaborating free innovators need not invest in communicating with potential adopters. However, they must invest in communicating with others who are also contributing to the project. They must inform one another of ongoing design work, and they must coordinate to create a well-integrated full design. For this reason, communication costs in the case of collaborative free innovation projects are *not* zero, and so we are back to our viability inequality of $v_i > d_i + c_i$.

A collaborative innovation project offers two major advantages over innovation projects carried out by individual free innovators. The first major benefit from a participant's perspective has to do with output value obtained: Each individual participant incurs the design cost of doing a fraction of the project work but, if intending to use it, obtains the value of the entire design, including additions and improvements generated by others (von Hippel and von Krogh 2003; Baldwin and Clark 2006b). For example, if you and I have the shared goal of improving the design of a medical device used by diabetes patients, you may decide to design improvements to the electronics and I may decide to design improved hardware. In the end, if we both reveal our improvements, each of us gets to use the designs for *both* improvements while personally paying the design costs for only one of them.

Since designs are non-rival goods (both you and I can use a design at the same time—I am not competing with you for access), non-rival individuals considering creating an innovation should always prefer participating in a collaborative project to going it alone if a collaborative project is viable *and* the added costs of communication involved in a collaborative project do not exceed the savings individual participants gain by sharing design costs.

A second major advantage of collaborative projects over single innovator projects is that collaborative projects greatly expand the range of innovation opportunities that are viable for free innovators. This is because overall project costs are no longer limited to a level of design costs that are viable for a single individual.

Figure 3.2 shows how both of these factors play out. The horizontal extent (i.e., the width) of the rectangles in the shaded area at the bottom of the figure represents the viable amount of design costs for each individual participant in the collaborative project (d_i). (In the example

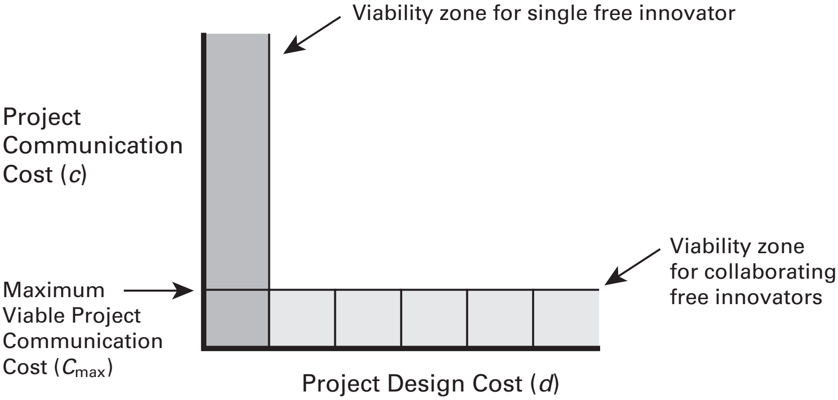

Figure 3.2
Adding a viability region for a collaborative free innovation project.

given above, one rectangle might represent the effort of the contributor improving the diabetes device's electronics and another the effort of the person improving the hardware. The rectangles reflect the situation of individual contributors, and need not be of equal width.) The width of the shaded area across the bottom of the figure shows the scale of the design that can be undertaken by a collaborative free innovation project. As can be seen, the scale can be quite large— project costs can total to the aggregate willingness of many to pay for a portion of the design, and contribute their portion to the collaboration. If there are *N* contributors to a project, and each contributes his or her own part, the total design investment will be the sum of their individual design costs.

The top horizontal line in figure 3.2 (more specifically, the distance between that line and the horizontal axis, i.e., the height) represents the maximum viable communication costs for the project. It is calculated as the sum of the maximum communication cost that each contributor is prepared to bear, given the benefits they individually get from the collaboration. Conceptually, it should be clear that the lower the cost of communicating with the group, the lower the value threshold other members' contributions must meet to justify an attempt to collaborate. This means that low communication costs, as recently enabled by the Internet, are critical to the range of innovation opportunities for which the collaborative free innovation model is viable.

Lower communication costs affect the inequality $v_i > d_i + c_i$ in two ways. First, they decrease the direct cost of contributing, and so they increase the likelihood that an individual contributor will find joining the project and contributing to it worthwhile. Second, they increase the probability that others will contribute to the project. At a cost above $C_{\max}$, demarked in figure 3.2, a collaborative project simply cannot get off the ground. But if communication costs are low for everyone, it is rational for each member of the group to contribute designs to the general pool and expect that others will contribute complementary designs or improve on his or her design. Again, this result hinges on the fact that the innovative design itself is a non-rival good. Each participant in a collaborative effort gets the value of the whole design, but incurs only a fraction of the design cost (Baldwin and Clark 2006b).

As makes economic sense, collaborative free innovation projects are generally “open” (that is, the innovation design information is freely revealed to all), because the cost of screening or other protective measures to exclude free riders would raise costs, and because free riders do not exert any negative effect on the free innovators. (Recall that free riders are those who benefit from a project design without making any contribution to it—they get a “free ride” when they adopt the innovation without paying or otherwise contributing.) Protective measures would shrink the pool of potential contributors, and so shrink the overall scale of the project. The network properties of the collaborative innovation model (the fact that the value to everyone increases as the total number of contributors increases) mean that this reduction in the contributor pool would reduce the value of the project to the contributors who remain as well as to free riders (Raymond 1999; Baldwin and Clark 2006b; Baldwin 2008).

Of course, any potential contributor might also decide to *not* develop and contribute an addition that could be viable for that contributor, hoping that someone else will do the work. This is the well-known incentive to free ride. But considerations such as urgency and self-rewards from performing the work can override such considerations for enough individuals to make a project viable.

When is an innovation opportunity viable for a producer?

Next, let us consider the space of innovation opportunities for which producer innovation is viable. Recall that a *producer innovator* is a single, non-collaborating firm that creates an innovation in order to sell it. Often producers can economically justify undertaking larger designs more easily than single individuals can, because they expect to spread their design costs over many purchasers.

Even though they are single organizations, producers, unlike single individuals, are affected by communication costs. They may use developers outside the firm, and then have to communicate with those outside individuals or organizations in order to coordinate. In addition, in order to justify investing in an innovation, they have to sell it. For that reason, they must invest in making potential buyers aware of what they have to sell via marketing communications. Such investments are often substantial, as the size of many producers' marketing budgets clearly attests.

Let us assume that a producer knows the development costs (d_p) and communication costs (c_p) that will be required to create the innovation and diffuse information about it to potential adopters. Let us also assume that the producer knows the value v_i that each potential adopter places on that innovation, as well as the number of potential adopters who would drop out of the producer's list of potential customers because they can self-supply more cheaply—in other words, that the producer knows each customer's willingness to pay for the producer's version of the innovative product or service. Following standard reasoning in microeconomics, the producer innovator can convert this knowledge about customers into a demand function, $Q(p)$, that relates each price it might charge to the number of units of the product or service it will be able to sell at that price. From the demand function, the producer innovator can solve for the price (p^*) and the quantity (Q^*) that maximize its expected revenues (net of production and transaction costs). Next, it can subtract its design (d_p) and communication (c_p) costs from this net revenue to calculate its expected maximum profit, P^*:

$$P^* = p^*Q^* - d_p - c_p. \tag{3}$$

If the producer anticipates positive profit for a specific innovation opportunity, then, as a rational actor, it will enter the market to supply the innovation. In other words, for that opportunity, the producer innovator model is viable. Conversely, if its anticipated profit is negative, the producer will not enter, and the producer model of innovation is not viable. As figure 3.3 shows, the zero profit line is a negative 45° line in the space of design and communication costs: $p^*Q^* = d_p + c_p$. For innovation opportunities within the triangle created by that line, the producer can expect profits. Those opportunities are therefore "viable" for the producer. Outside that triangle, innovation opportunities are not viable (Baldwin and von Hippel 2011).

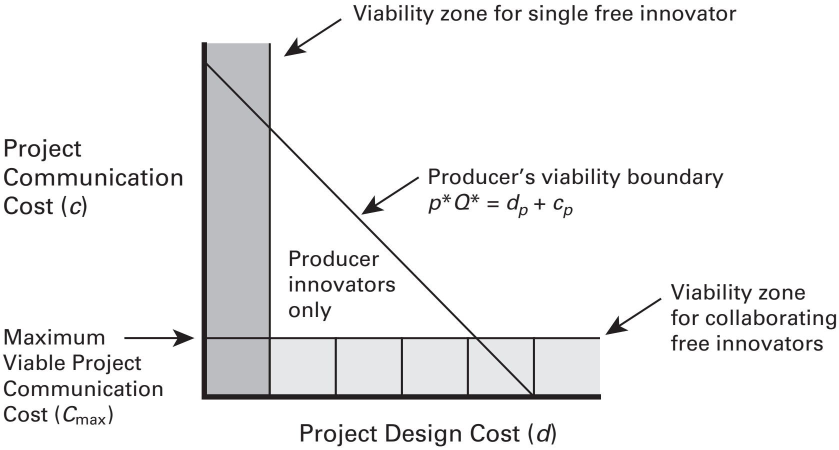

Figure 3.3
Adding a viability region for producer innovation.

Bringing Back Production Costs and Transaction Costs

Recall that at the beginning of this chapter, in order to focus on the contrasting effects of design and communication costs on the three modes of innovation, we made the simplifying assumption that production costs and transaction costs were similar across all three modes, and so had no effect on any mode's viability relative to the other two. I now bring these two costs back into consideration and discuss whether there are systematic differences in production or transaction costs across the three modes. In effect, we now will include all four cost variables—design costs d_i, communication costs c_i, production costs u_i, and transaction costs t_i—in our assessment of the viability of innovation opportunities:

$$v_i > d_i + c_i + u_i + t_i.$$

This discussion will show that production cost considerations may favor producers over free innovators in many cases today, but that production cost considerations are trending toward neutrality over time. Transaction cost considerations, on the other hand, favor free innovators over producers.

Production costs

Recall that a design is the *information* required to produce a novel product or service—the "recipe." For products that themselves consist of information, such as software, the production cost is simply the cost of making a copy of the design—essentially zero. For physical products, however, the design recipe must be converted into a physical form before it can be used. In such cases, the input consists of the design instructions—the recipe—plus the materials, energy, and human effort required to carry out those instructions. The output is a product—the design converted into usable form.

One of the major advantages producers have historically had over single free innovators and open collaborative innovation projects is economies of scale with respect to mass production technologies. Mass production, which became widespread in the early twentieth century, is a set of techniques whereby certain physical products can be turned out in very high volumes at very low unit cost (Chandler 1977; Hounshell 1984). The economies of scale in mass production generally depend on using a single design (or a small number of designs) over and over again. In classic mass production, changing designs interrupts the flow of products and incurs setup costs and switching costs, which reduce the overall efficiency of the process.

Can single free innovators or open collaborative innovation projects convert their various designs into physical products that will be economically competitive with the products of mass producers? Increasingly, the answer is Yes. Consider that today mass producers can design their production technologies to be independent of many of the specifics of the designs they produce. Such processes are said to provide “mass customization capabilities.” Computer-controlled production machines can adjust to create a single unique item at a cost that is not different from producing a stream of identical items on those same machines (Pine 1993; Tseng and Piller 2003). When mass customization is possible, producers can, in principle, make their low-cost, high-throughput factories available for the production of designs created by single individuals and collaborative free innovation projects. Also, and increasingly, individuals can purchase production equipment designed for personal use such as personal 3D printers, and thereby have a low-cost production capability of their own that is entirely independent of the factories of commercial producers.

Of course, for a long time to come, there will continue to be instances in which the economies of mass production depend significantly upon careful and subtle co-design of products and product-specific production systems. In such instances, producer innovators will continue to have an advantage in designing and producing goods and services for mass markets.

Transaction costs

If producer innovators have a production cost advantage for some (but not all) production technologies, single and collaborative free innovators have an advantage with respect to costs for compensated transactions. By definition, they have none.

Consider that the ordinarily assumed transaction costs of innovation include the cost of establishing exclusive rights over the innovative design—for example, through secrecy or by obtaining a patent. Also included are the costs of protecting the design from theft—for example, by restricting access or by enforcing non-compete agreements (Teece 2000; Marx, Strumsky, and Fleming 2009). Finally, the costs of selling and receiving payment and the costs of protecting both sides against opportunism also are included in transaction costs and may be substantial. These may involve the cost of bargaining and writing contracts (Hart 1995), plus costs of accounting for transfers and compensation, and finally the costs of policing and enforcing agreements made (Williamson 1985).

Producer innovators *must* incur these transaction costs. By definition, they obtain revenue and resources from compensated exchanges with customers, employees, suppliers, and investors. A considerable amount of analysis in the fields of economics, management, and strategy considers how to minimize transaction costs by rearranging the boundaries of firms or the structure of products and processes. (For reviews of this literature, see Williamson 2000 and Lafontaine and Slade 2007.) For producer innovators, transaction costs are an inevitable cost of doing business.

Individual free innovators do not incur transaction costs. By definition they do not protect their innovation designs. Collaborative free innovation projects also do not sell products, nor do they pay members for their contributions. Transaction costs can creep in, of course, if individuals or groups decide not to fully relinquish claims on their intellectual property rights. For example, open source software projects generally assert a copyright over the software code created by their projects, doing so in order to preserve open access rather than limit it. The General Public License (GPL), based on copyright law, was explicitly designed to protect the rights of all to view, modify, and distribute open source software code bearing that license (Stallman 2002; O'Mahony 2003). The costs of enforcing the GPL are like classic transaction costs in that they assert and enforce property rights. Notwithstanding this minor exception, it is clear that free-revealing single free innovators and open collaborative innovation projects have a transaction cost advantage over producer innovators.

Hybrid Models of Innovation

Theory development is often best served by simplicity, such as in the three polar models of innovation Baldwin and I describe. In contrast, the world is often hybrid. A hybrid innovation model combines elements of the three polar models analyzed in previous sections of this chapter. Hybrids of the three basic models thrive in the real world. This is because the architecture of a design intended to achieve a certain function can often take a number of forms suited to development by combinations of our three basic models. For example, producers or free innovators can choose to modularize a product architecture into a mix of large components viable for development by producers only, plus many smaller components viable for development by single free innovators or open collaborative innovation projects (Baldwin and Clark 2000). As illustration, consider that Intel develops expensive and complex central processing unit (cpu) chips for computers, a design task that today may be viable for producers only. Complementary smaller software and hardware design opportunities are then viable for profit-seeking producers, and/or for free innovators, working singly or collaboratively.

Large indivisible design projects, which have traditionally been in the producer-only zone of figure 3.3, may become hybrids as a result of re-architecting and (often) modularization of traditional, producer-centered design approaches. For example, the costs of clinical trials of new drugs are commonly argued to be so high that only a producer innovator, buttressed by strong intellectual property protection for the drug to be tested, will find this development task viable. Increasingly, however, we are learning how to subdivide clinical trials—a large cost traditionally borne by drug producers—into elements suitable for voluntary, unpaid participation by collaborating individuals. This possibility has recently been illustrated in a trial of the effects of lithium on amyotrophic lateral sclerosis carried out by ALS patients themselves with the support of a website developed by the firm PatientsLikeMe (Wicks, Vaughan, Massagli, and Heywood 2011).

Discussion

Fundamentally, in a free economy, the organizational forms that survive are ones with benefits exceeding their costs (Fama and Jensen 1983a,b). Costs in turn are determined by technology and change over time. Chandler (1977) argued that the modern corporation became a viable form of organization (and the dominant form in some sectors) as a consequence of the decline in mass production costs due to technological advances, together with declines in transportation and energy costs. Adopting Chandler's logic, we should expect a particular organizational form to be prevalent when its technologically determined costs are low and to grow relative to other forms when its costs are declining relative to the costs of other forms.

To understand that the zones of viability for single and collaborative free innovation are growing over time requires only that one understand that design and communication costs for individuals have been decreasing due to exogenous technical trends, and that this is likely to continue.

Very generally, reductions in the cost of design in many fields are being driven by the rapidly declining cost and the increasing quality of personally accessible computer-based design tools. In fields where design is not implemented by digital methods, rapid progress in the development of field-specific tools is having the same effect. For example, in do-it-yourself biology, simple and powerful techniques to manipulate the genome are enabling individuals with little training to engage in genetic engineering and innovation (Delfanti 2012).

Reductions in communication costs for free innovation projects have been largely Internet-enabled. As in the case of design tools, "virtual reality" tools, and other new communication-related tools not yet envisioned, will extend the scale and scope of free innovation and diffusion. The central technological trend appears to be always toward increased fundamental understandings leading quickly or eventually to important capability advances accessible to household sector innovators.

With respect to production of physical products based on free designs, technical trends are increasingly empowering householders to complete the full development process by putting what they have designed into physical, usable form. As was mentioned earlier, personal and commercial production machines increasingly have the ability to produce a single unique item at a cost no higher than the cost per unit of a stream of identical items made with the same machines (Pine 1993; Tseng and Piller 2003).

In net, as a consequence of these exogenous technical trends, producer innovators—and innovation researchers and policymakers—increasingly must understand and contend with free single innovators and collaborative innovation projects as developers of innovative products, processes, and services (Benkler 2006, Baldwin and von Hippel 2011). To visualize the effect, imagine that figure 3.3 was populated with numerous points, each representing an innovation opportunity. As design and communication costs fall, each point moves down and to the left. Because of this general movement, some innovation opportunities would leave the region where only producer innovation is viable and cross into a region where single free and open collaborative innovation are also viable.

Although not all designs are equally affected, Baldwin and I believe that declining computation costs, communication costs, and single-unit production costs are having enough of an effect across the economy to change the relative importance of the three different models of innovation discussed in this chapter.

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