The major shift towards user-centered innovation: Implications for China's innovation policymaking

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ABSTRACT

An important form of user innovation – Internet-supported collaborative design of new products and services by user communities – is likely to progressively supplant producer product and service design in many fields. This shift will require changes in governments' innovation policies, for example, with respect to intellectual property rights. We discuss some general categories of innovation policy that it will be important to re-examine. We also suggest some innovation policy opportunities specifically relevant to China, as an emerging major player in global innovation.

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1. Overview

At least since Schumpeter (1934), economists and policymakers have assumed that the dominant mode of innovation is a *"producers model."* That is, it has been assumed that economically important innovations are developed by producers, and that these producers need to be able to protect their innovations by intellectual property rights in order to secure monopolies over them for some period of time (Arrow 1962). Differences found in the social vs. private rates of return for innovations also suggested that drawing forth more innovations would increase public welfare (e.g., Mansfield et al 1977).

Accordingly, around the world, policies have been developed and progressively elaborated to support *producers* in their innovation-related efforts. Prominent among these are various kinds of government subsidy for the "properly documented" research and development expenditures of private firms, and intellectual property law protections to increase the profits of those who introduce innovations into the marketplace.

If, as we now are discovering, users are an important – and perhaps the *most* important developers of innovations, two things must be done: (1) Present, producer-centric innovation policies must be re-examined to identify any negative impacts on user innovation and (2) New policies should be considered that might provide valuable additional support to user innovation. Countries like China, which do not have such a long tradition of innovation policies biased towards the needs of private producers, may have a better ability to quickly adapt their policies to the new realities of user-centered innovation.

In what follows, we first very briefly summarize what we know about the importance of innovation by individual lead users (section 2). Next we describe an important form of user innovation - collaborative innovation by user communities - that shows promise of largely supplanting producer innovation in many fields (section 3). Then we describe some general categories of innovation policy that it will be important to

re-examine in the light of the progressive supplanting of producer innovation by collaborative user innovation (section 4). Finally we suggest some innovation policy opportunities specifically relevant to China, as an emerging major player in global innovation (sections 5).

2. The importance of user innovation

Users, as we use the term in this paper, are firms or individual consumers that expect to benefit from *using* a product or a service. In contrast, manufacturers expect to benefit from *selling* a product or a service. A firm or an individual can have different relationships to different products or innovations. For example, Boeing is a manufacturer of airplanes, but it is also a user of machine tools. If we were examining innovations developed by Boeing for the airplanes it sells, we would consider Boeing a manufacturer-innovator in those cases. But if we were considering innovations in material-forming machinery developed by Boeing for in-house use in building airplanes, we would categorize those as user-developed innovations and would categorize Boeing as a user-innovator in those cases.

2.1 Many important products have been developed by lead users

Research in a range of fields has shown that many of the innovations judged to be most important with respect to both improved functionality over previous best practice and commercial value are in fact developed by users rather than manufacturers. Thus Enos (1962) reported that nearly all the most important innovations in oil refining were developed by user firms. Freeman (1968) found that the most widely licensed chemical production processes were developed by user firms. Von Hippel (1988) found that users were the developers of about 80 percent of the most important scientific instrument innovations, and also the developers of 67% of the major innovations in semiconductor processing. Pavitt (1984) found that a considerable fraction of invention by British firms was for in-house use. Shah (2000) found that the most commercially important equipment innovations in four sporting fields were developed by innovating users.

It has also been found that innovations developed by users are often of high *technical* quality. A study by Lettl et al (2007) examined 2795 patent families in "surgical instruments, devices or methods." They found that citations of user inventor patents were lower than that manufacturer patents in terms of immediate impact on subsequent technological developments in a focal technological domain. Later in the patent's life, however, this gap was closed. Their study also shows that user patents cited more classes than did manufacturer patents – were broader. The subset of user patents that were as narrowly focused on a particular technical field were as technically important (cited as frequently) as patents filed by manufacturer inventors who were on the leading edge of that discipline.

Users that innovate have been found to typically be "lead users" – defined as having two characteristics: (1) expecting major benefits from solutions to the novel needs they encounter, and (2) being at the leading edge of important marketplace trends. It has been shown that, because 'necessity is the mother of invention' (characteristic 1), many lead users will innovate to solve the problems they have encountered. It has also been shown that innovations that lead users develop to solve problems they encounter at the leading edge of the market (characteristic 2) will later also be wanted by others – and therefore will be potentially profitable products for manufacturers. Studies of innovations commercialized by manufacturers in a range of fields show this (e.g., Franke et al 2006, Luethje 2003, von Hippel 2005).

Innovations developed by lead users often are commercialized by users that initially develop their product in order to use it – and then also begin to manufacture their innovation in order to supply it to others. Shah (2000) documents the founding of such early companies in the field of sports equipment. Shah and Tripsas (2007) show that, in at least one field (the multibillion dollar juvenile products industry), 60% of all firms now extant in the industry were founded by user-innovators.

A study by Baldwin et al (2006) describes and models the pathway that user innovations commonly traverse on their way to commercialization. The path begins when a lead user develops an important new innovation and demonstrates its value in use. Other users are attracted by this demonstration and join together to both replicate and use the innovation, and also to help develop and improve it further. Some of these users then

become the first to form small new companies to commercialize the new product and its improvements. Only after designs stabilize and market potentials become clear will existing manufacturers find it profitable to join in and compete with user-founded companies.

2.2 Many users modify or develop new products

It is important to understand that user innovation is not a rare event. It is now well-documented that *many* product users innovate to modify or develop *de novo* products that they use in many fields. Consider the following sampling of studies (table 1).

Table 1: Studies of user innovation frequency

Innovation Area	Number and type of users sampled	% developing and building product for own use
Industrial products		
1. Printed Circuit CAD Software (a)	136 user firm attendees at a PC-CAD conference	24.3%
2. Pipe Hanger Hardware (b)	Employees in 74 pipe hanger installation firms	36%
3. Library Information Systems (c)	Employees in 102 Australian libraries using computerized OPAC library information systems	26%
4. Medical Surgery Equipment (d)	261 surgeons working in university clinics in Germany	22%
5. Apache OS server software security features (e)	131 technically sophisticated Apache users (webmasters)	19.1%
6. Twenty six 'Advanced Manufacturing Technologies' introduced into Canadian plants (f)	4200 Canadian manufacturing plants Nine Manufacturing Sectors (less food processing) in Canada, 1998.	28%
Consumer products		
7. Outdoor consumer products (g)	153 recipients of mail order catalogs for outdoor activity products for consumers	9.8%
8. "Extreme" sporting equipment (h)	197 members of 4 specialized sporting clubs in 4 "extreme" sports	37.8%
9. Mountain biking equipment (i)	291 mountain bikers in a geographic region known to be an "innovation hot spot."	19.2%

Sources of Data: (a) Urban and von Hippel (1988); (b) Herstatt and von Hippel (1992); (c) Morrison et al. (2000); (d) Lüthje (2003); (e) Franke and von Hippel (2003); (f) Arundel and Sonntag (1999); (g) Lüthje (2004); (h) Franke and Shah (2003); (i) Lüthje et al. (2005).

3. Collaborative user innovation likely to displace manufacturer innovation in many fields

The fact that many users innovate creates the conditions for collaborative innovation among users having similar interests. When many users are interested in developing new or improved innovations in a specific area, it has been shown that they can gain in effectiveness and efficiency by joining together into innovation communities and carrying out innovation projects collaboratively. Users participating in these communities each freely contribute what they have developed at their own private expense to the community commons. Why do they do this? In essence, since innovation-related information is a non-rival good, when user-innovators that are not competitors freely share what they have developed, the ability of each innovator to gain private benefit from using its own innovation is unaffected by this action. The innovators then may gain additional private benefit from free revealing their innovations as a public good via network effects, reputational advantages and so on. (Allen, 1983, Harhoff et al 2003, Lerner and Tirole 2002, von Hippel 2005).

The recent radical reduction in communication costs achieved via the Internet, and the steady improvement of computerized tools for design, are making it much more cost-effective for users to innovate collaboratively within communities. Open source software projects like Linux and Apache are examples of this new pattern. Users (and some manufacturers too) each develop the particular bits of the software that they individually need – and then "contribute" those innovative bits to the project by openly revealing the details of what they have done. Of course, the same economic change has affected the development of physical products. These too are now designed on computers, and the designs can be cheaply shared among collaborators in the form of digital files.

Benkler (2006) elaborates upon the recent changes that have made collaborative innovation via the Internet increasingly cost-effective. "The great success of the Internet generally, and peer-production processes in particular, has been the adoption of technical and organizational architectures that have allowed them [individual contributors] to pool such diverse efforts effectively. The core characteristics underlying the success of these

enterprises are their modularity and their capacity to integrate many fine-grained contributions. … "Granularity" refers to the size of the modules, in terms of the time and effort that an individual must invest in producing them. … The granularity of the modules therefore sets the smallest possible individual investment necessary to participate in a project. If this investment is sufficiently low, then "incentives" for producing that component of a modular project can be of trivial magnitude. …. If the finest-grained contributions are relatively large and would require a large investment of time and effort, the universe of potential contributors decreases." (ibid, p. 100-101).

Analysis suggests that user communities that develop innovative designs collaboratively are likely to drive producers *out* of product design in many fields. There are two basic reasons for this. First, user communities can benefit from the work of many more innovators – with much more varied backgrounds - than any individual producer can marshal. Second, participants can adopt and benefit from a solution developed by *any* contributor. This means that the *best solution any contributor develops is available for all to use.* In contrast, in the traditional situation where competing producers each develop rival products, and each protects its innovations via intellectual property law, no producer is likely to have access to the best solution that anyone has developed for each of the many elements making up that product type. (von Hippel 2005, Baldwin and Clark 2006).

4. General implications for government policymaking

In earlier sections, we have argued that user innovation has always been important - and that collaborative user innovation will become a process of central importance to the economic welfare of nations. In addition, innovation by users appears to increase social welfare. Henkel and von Hippel (2005) found that, relative to a world in which only producers of products and services innovate, social welfare is very probably increased by the presence of innovations freely revealed by users. For all these reasons, it seems to us that policy making should support user innovation, or at least should ensure that legislation and regulations do not favor producers at the expense of user-innovators.

The transition from the traditional, producer-centered model of innovation will be painful for many producers – how can government policymaking assist? We see three major areas where governments can be very useful: (1) improve measurement; (2) lower the cost of collaborative user innovation via infrastructure improvements; (3) improve intellectual property law to create an even playing field for user and producer-innovators. We discuss each in turn.

4.1: Improve the measurement of user innovation

Until the actual levels of user innovation and expenditures are made clear, it will be difficult to get academics and policymakers to take the policymaking needs of user innovators seriously. Current government innovation surveys seriously undercount user innovation. This situation must be corrected. Researchers are now beginning to develop and test new methods for collecting data on user innovation more accurately. The Chinese government and Chinese academics should join in this important work.

The present situation with respect to measuring user innovation in consumer products fields is dismal: current government surveys do not collect *any* data on innovation development work by "consumers." Yet, as we saw in table 1, end users of consumer goods are extremely active in both developing and modifying the products they use. Proper measurement may well show that the collective innovation development efforts and expenditures by end users outweigh those of consumer product producers.

The present situation with respect to measuring user innovation in the case of industrial products is only slightly better. Innovations developed by firms for their own use are termed process innovations. Currently, the definitions of process innovation are so broad as to be essentially meaningless. For example, according to the third edition of the Oslo Manual (2005), a process innovation need not be *developed* by a given firm in order to be counted as an innovation for that firm: the firm need only to *adopt* it – for example, by buying a new machine from a manufacturer - and it will be counted as an innovation if it is new to that firm. (The Oslo Manual is a work assembled and updated by developers of technical and scientific indicators, and published by the OECD

Statistical Office as a way to bring consistency to innovation-related data collection efforts across many countries.)

It *is* possible for government statistical agencies to address the current bias against reporting of innovations by users by changing the questions asked, and changing who is asked. We are aware of one survey in which *users,* rather than manufacturers, were asked by a government statistical agency to report on an innovation "adoption" process from their point of view. In 1998 Fred Gault of Statistics Canada directed a survey to Canadian plants using Advanced Manufacturing Technologies (AMTs) rather than to, as was customary practice, AMT equipment suppliers. This survey covered 9 manufacturing sectors in Canada (food processing was excluded) and inquired about methods plants had used to introduce any of 26 AMTs they were using.

In the Statistics Canada survey, two questions were asked about possible user innovation: (1) had the plants introduced an AMT "by customizing or significantly modifying existing technology?;" and (2) had the plants introduced an AMT "by developing brand new advanced technologies?." Data were obtained from 4,200 manufacturing plants, and the data were analyzed by Arundel and Sonntag (1999) and by Sabourin and Beckstead (1999).

Table 2: Results of a Statistics Canada survey of *users* of Advanced Manufacturing Technologies

Method of introducing advanced technologies into a plant (Establishment Weighted)

METHOD	YES	NO
	(percentage of establishments)	
a) by purchasing off-the-shelf equipment	84	16
b) by licensing new technology	18	82
c) by customizing or significantly modifying existing technology	50	50
d) by developing brand new advanced technologies	29	72

Source: Table 5.1, Sabourin and Beckstead (1999)

As can be seen in table 2, this survey showed extensive innovation by users. Fully 29% of plants – AMT users – reported introducing advanced technologies into the plant "by developing brand new advanced technologies." Fully 50% reported that they

did this "by customizing or significantly modifying existing technology." This finding fits the case data in table 1 which shows a similar proportion of users innovating in a range of product categories. It also suggests that better measures of process innovation by user firms will show users to be the dominant developers of process innovations. Work in this direction is now being initiated by a few researchers – Chinese researchers should join in.

4.2: Reduce the transaction costs for collaborative user innovation

Earlier, we described collaborative, user-centered innovation as joint development of new innovation via users acting collaboratively over the Internet. Often, in such processes, many users contribute to what can ultimately become a major innovation - but each individual may make only a small contribution. Since each user-contributor to a collaborative innovation has to make his or its contribution yield justifiable private benefit without aggregation of demand across multiple users – *it is key to the success of user distributed user innovation that the fixed and variable cost of making contributions to an innovation commons be as low as possible.* (An example of a fixed or "setup" transaction cost would be acquiring a computer or learning a new computer language. An example of a variable or "frictional" transaction cost would be the costs associated with submitting code in that language to solve a specific problem.)

Government actions to assist in lowering transaction costs for user-innovators include ensuring that widely-distributed potential innovation contributors have low-cost access to each other and to problems of interest to them being worked upon by others. To achieve this, government may wish to support low-cost or free Internet access for those who currently lack it – for the same reasons that governments decided it was good public policy to support the development and support of roads as a public good in previous generations. Governments should also consider supporting the development and diffusion user-friendly computer-aided design tools that are central to collaborative innovation work conducted over the Internet. As a third example, government should support open standards and open interfaces, so that participants in collaborative projects can innovate with the fullest information and the fewest interface constraints possible.

Here government policymakers will be working in tandem with marketplace trends: there is now significant marketplace pressure towards open standards and interfaces in many fields.

4.3: Review intellectual property laws

Today, policymakers in many Western countries are working hard to strengthen the enforcement of patent and copyright laws so as to reduce unauthorized copying. However, many academics now think that this trend can result in collateral damage to efficient open and distributed innovation processes. It should therefore be reviewed and reconsidered by policymakers.

Granting monopoly rights to inventors and authors via intellectual property law is commonly justified as public policy because it is assumed that it will increase the amount of innovation investment, to the benefit of the public. Instead, it now appears that there are economies of scope in both patenting and copyright that allow firms to use intellectual property law in ways that are directly opposed to the intent of policy makers and to the public welfare. For example, major firms can invest to develop large portfolios of patents. They can then use these to create "patent thickets"—dense networks of patent claims that give them plausible grounds for threatening to sue across a wide range of intellectual property. They may do this to prevent others from introducing a superior innovation and/or to demand licenses from weaker competitors on favorable terms (Shapiro 2001). Movie, publishing, and software firms can use large collections of copyrighted work to a similar purpose (Benkler 2002). In view of the distributed nature of innovation by users, with each tending to create a relatively small amount of intellectual property, users are likely to be disadvantaged by such strategies.

It is also important to note that users (and manufacturers) tend to economize when building prototypes of their innovations by modifying products already available on the market to serve a new purpose. Laws such as the (US) Digital Millennium Copyright Act, intended to prevent consumers from illegally copying protected works, also can have the unintended side effect of preventing users from modifying products that they purchase (Varian 2002). Both fairness and social welfare considerations suggest that innovation-

related policies should be made neutral with respect to the sources of innovation, and that rights traditionally granted for the "fair use" of protected property should not be restricted.

In sum, in order to build the efficiency of collaborative user innovation over time, contributors to collaborative innovation processes need to be able to freely reveal, deposit and withdraw solution information to and from information commons at low cost. Policymakers should review intellectual property rights that have the effect of enabling owners of intellectual property to put all sorts of barriers and toll booths in the path of those who would freely access and use information. In net, they must seek to level the playing field among user and producer innovators.

5. Implications for government policymaking in China

Innovation strategy in China can be seen as passing through three stages. The first stage (year 1949 to 1978) focused on closed and independent innovation within China. Innovations during this stage were produced only at high cost and low efficiency. During the years 1978 to 2006, most technical innovations introduced in China were based on adoption and adaptation of external foreign technologies. Since 2006, the Chinese government has adopted a new innovation strategy that emphasizes internal development of new innovations based upon Chinese R&D.

With the fast growth of information and communication technologies (ICTs), the impact of globalization, and the rapid emergence of more open and collaborative innovation patterns around the world, the innovation strategy in China should place more emphasis upon *open* R&D and innovation. Especially, if user-involved innovation is to be the new paradigm for most Chinese manufacturers, these firms must first learn the importance of more fully understanding user needs in order to develop successful products. Manufacturers also must learn to invite users to participate in their NPD processes directly by contributing their needs, ideas and – increasingly – the user innovations they have themselves developed. Doing this will enable manufacturers to accelerate their innovation processes, and also reduce the costs and the risks associated with market introduction of new products (von Hippel, 1988, 2005). Through close

contact with innovative users, manufactures in China can also better absorb radically new product concepts and select the most promising prototype versions that users have developed. Furthermore, increased user interaction will enable manufacturers to acquire new technological competencies, learn about relevant technological trends, and extend their innovation and technology-related networks (Lettl, Herstatt & Gemuenden, 2006).

In order to promote user-centered innovation in China, the government should, first, adopt a "Respect All innovators" policy, and raise general awareness of user innovation and collaborative user innovation. That means innovation in China should be the responsibility of all people (Tucker, 2002; Shapiro, 2002; Christiansen and Bower, 1996; Dundon, 2002). In Baosteel Corporation, the largest Chinese steel manufacturer, the notion of "all members are innovators", and especially innovations developed by lead users allow the company to achieve extraordinary innovative performance.

Second, the Chinese government should strive to reduce the cost of ICTS to promote the exchange of problem-solving content among all people. ICTs could be one of the innovation expenditures provided at low cost or freely by the Chinese government. For example, a new policy in Hangzhou City is to set up a "Wireless City" program. This will mean all the people in Hangzhou can access the internet totally free in the city from the end of 2008. "Computer plus brain" allows more users innovate, and to collaborate at any time and from any geographical location. As a result, there will be many more user centered start-ups at Hangzhou such as Kadang Com et al. Hangzhou City is also the birthplace of many excellent e-commence companies like Alibaba. The case of Hangzhou shows that both the Chinese central government and local governments should support some ICTs as free public goods, because they are vital tools for collaborative innovation work. These tools will aid the emergence and evolution of the user-centered innovation paradigm in China, and will assist China in its program of fast technological catch-up, enabling it to more quickly join the leading innovator countries in the world.

Third, the Chinese government should strive to provide an "innovation-friendly" intellectual property law environment. Appropriate enforcement of intellectual property rights (IPRs) is a still a serious problem in China. But, as academic research mentioned earlier in this paper is showing, strict enforcement of intellectual property rights, without proper regard to legal and traditional rights to "fair use," can hinder knowledge diffusion,

unfairly impede follow-on innovations, and adversely affect social welfare. Therefore, the Chinese government should carefully study how to develop an IPR policy that leads the world in its understanding of how to balance the needs of all parties an increasingly fast-moving and collaborative innovation environment. Officials at the IPR Bureau have already announced the importance of balancing IPR policy and public policy. Accordingly, the Chinese government will take some measures to protect IPR to increase firms' incentive to innovate. At the same time, it will take some measures to appropriately loosen IPR to encourage the exchange and diffusion of knowledge, and to create better conditions for additional innovations by user-innovators and others. Certainly, as an early step, the Chinese government should move to lower the level of IPR in public sectors like Chinese Universities and State Research Institutes, so more innovators can more freely access the knowledge these institutions develop.

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