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KNOWLEDGE CREATION BY CONSUMERS AND OPTIMAL STRATEGIES OF FIRMS

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Abstract

In this paper, we analyzed the patterns of knowledge creation from the collaboration of producers and consumers. The essential differences from traditional knowledge creation mechanisms arise from consumers' contribution to knowledge creation in three areas. The value of a product to the consumer depends on the amount of knowledge creation by consumers, which is affected by the amount of public infrastructure, which in turn affects the price of the product. It should be noted that the pattern of knowledge creation varies drastically depending on the shape of the response function of effort time for knowledge creation between consumers.

(JEL categories: L15, M15)

I. INTRODUCTION

Increasing awareness of the major influence of creativity and innovation on the competitiveness of business organizations has prompted research into the mechanisms of knowledge creation by researchers from various disciplines. Previous studies have focused on knowledge creation within the firm, with analysis pioneered by Nonaka (1994) and Nonaka and Takeuchi (1995) of the organizational characteristics of knowledge creation mechanisms. Their model of the knowledge creation mechanism in organizations is a spiral of socialization, externalization, combination, and internalization, which they called the “SECI” process. At the core of the spiral process is a continual dialogue between explicit and tacit knowledge which drives the creation of new ideas and concepts. They clarify the conditions which enable knowledge creation, and explain the process of creating tacit knowledge.

Nonaka's model gained much attention and was well regarded as a practical theory of organizational knowledge creation, but some recent critics of the theory, for example, Bereiter (2002, 175–9) and Gourlay (2006), argue that the model does not fit the reality of the contemporary business world, in which research and development and innovation occur due to interactions of actors both inside and outside the firm. A typical example is the open innovation model, in which research and development outputs of venture companies are purchased and become new research and development inputs of major companies.

Complementing the organizational mechanism of knowledge creation is the economic analysis of knowledge creation, as pioneered by Berliant and Fujita (2008; 2009; 2011; 2012), who studied the knowledge creation process by identifying diversity as a key factor. Melnikas (2010) observes that the creation and development processes in a knowledge-based society and the knowledge economy are determined by the economic system, which transforms the global movements of the economy into sustainable development processes. Gunn and Johri (2011) model the endogenous production of knowledge capital through a learning-by-doing process, and describe the situation where the value of knowledge capital rises when firms are induced to invest more staff time in the development of knowledge capital.

The questions we pose here are twofold. First, how is new knowledge created through the collaboration of producers and consumers? Second, how is the market value of new knowledge determined? The importance of knowledge creation through collaboration with consumers in designing products has been recognized in the modern economy as discussed by Esper et al. (2010). A typical example is the Genius Bar located in Apple stores. Formally, the Genius Bar is designed to provide support to customers. Apple, however, utilizes this support system as a knowledge creation system by collaborating with "innovative" or "cyber" consumers who are sophisticated and informed consumers, influencers and potential advocates for the brand.

Rogers (1995) classified consumer attitudes toward purchasing products into five categories in his book *Diffusion of Innovations*. These categories include innovators (2.5% of consumers), opinion leaders or early adopters (13.5%), early majority adopters (34%), late majority adopters (34%), and laggards or very late adopters (16%). For more information on the concept of the "cyber" consumer, see the RealBusiness website (accessed September 2012): http://realbusiness.co.uk/advice_and_guides/3-ways-to-satisfy-the-cyber-customer.

By employing these types of consumers as support staff in the Genius Bar, Apple creates knowledge on the real-time needs of consumers and provides proactive opinions on the products from interacting with "mass customers."

Consumer-focused knowledge creation systems are gaining in importance as social networking services have gained a larger role in society and the economy. Cross et al. (2001)

examine the effectiveness of social networking in problem solving. By analyzing how consumers use social media, it becomes possible to track the competitive landscape and monitor consumer feedback. Questions and complaints can be analyzed to identify trends and build brand affinity.

Kotler et al. (2010) argues that the concept of knowledge creation in the consumer market has moved from mere customer satisfaction to attaining higher affirmation of the human spirit. In their book, they argue that today's customers choose products and companies which satisfy deeper needs for creativity, community, and idealism. That is, the knowledge creation system incorporates the essence of humanity in creating value in the market. Meeting these needs of consumers is one reason why collaboration between producers and consumers is deemed to be important.

The purpose of the paper is to describe the behaviors of consumers and producers in the knowledge creation process, and derive the optimal strategy for increasing the value of creativity in the market.

II. CONSUMER BEHAVIOR AND KNOWLEDGE CREATION

We consider an economy consisting of two consumers, A and B, and one producer. Each consumer devotes time (e^i) for contributing to knowledge creation, which is used to improve the utility from consumption activities. For example, consider a consumer who devotes time to develop new ways of utilizing the Apple iPad and contributes to feedback through the Genius Bar and social networking services.

Knowledge created by a consumer *(i)* is given by the knowledge creation function, which is formulated as follows:

$$n^i = n^i(e^i; e^{-i}),\ \frac{\partial n^i}{\partial e^i} > 0, \frac{\partial^2 n^i}{\partial e^{i2}} < 0,\ i = A, B\,. \tag{1}$$

The knowledge creation of consumer A depends on the time spent on related activities such as using social networking services, given the time spent by consumer B.

The utility function (U) is assumed to be a concave function given by the following equation:

$$U^i = \phi(n^A(e^A, e^B) + n^B(e^A, e^B); sg^s)U(c^i, s^i, l^i), \ i = A, B . \qquad (2)$$

Here, g^s is the public infrastructure investment by an information technology (IT) producer for knowledge creation. Examples of public infrastructure investment (g^s) include services provided by companies such as Apple, Google, and Microsoft. ϕ is the knowledge function by which the utility of each consumer is improved and serves as a public good in the economy, and is assumed to be concave function. c is a general consumption good whose price is set to 1 as numéraire, s is the IT product and l is leisure time.

The budget constraint on consumers is given by

$$w(T - l^i - e^i) = c^i + ps^i , \qquad (3)$$

where w is a wage rate, T is the total time endowment, and p is the price of the IT product. The utility maximization problem of individual A is formulated as follows:

$$Max_{c,l,e,s} \ \phi(n^A(e^A, e^B) + n^B(e^A, e^B); sg^s)U(c^i, s^i, l^i),$$
$$s.t. \ w(T - l^i - e^i) = c^i + ps^i .$$

The Lagrangian function of individual A is defined as follows:

$$L(c, l, e^A, \lambda) = \phi(n^A(e^A, e^B) + n^B(e^A, e^B); sg)U(c, s, l) - \lambda(w(T - l - e^A) - c - ps) . \qquad (4)$$

The optimality conditions are given by the following five equations:

$$\psi_1 = \frac{\partial L}{\partial c} = \phi \frac{\partial U}{\partial c} - \lambda = 0 , \qquad (5)$$

$$\psi_2 = \frac{\partial L}{\partial s} = \frac{\partial \phi}{\partial (sg)} gU + \phi \frac{\partial U}{\partial s} - p\lambda = 0 , \qquad (6)$$

$$\psi_3 = \frac{\partial L}{\partial l} = \phi \frac{\partial U}{\partial l} - w\lambda = 0\,, \tag{7}$$

$$\psi_4 = \frac{\partial L}{\partial e} = \frac{\partial \phi}{\partial e} U - w\lambda = 0\,, \text{ and} \tag{8}$$

$$\psi_5 = \frac{\partial L}{\partial \lambda} = w(T - l - e) - c - ps = 0\,. \tag{9}$$

By combining optimality conditions (5) and (6), we derive

$$\left(\frac{\partial \phi}{\partial (sg)} gU + \phi \frac{\partial U}{\partial s}\right) / \, p = \phi \frac{\partial U}{\partial c}\,. \tag{10}$$

This new equation states that the optimal combination of the general consumption good (*c*) and IT product (*s*) is given at the point where the marginal utility from the IT product (*s*) per $1 equals the marginal utility from the general consumption good (*c*). The marginal utility from IT product (*s*) is generated through the marginal contribution to the knowledge creation of the IT product and the direct utility increase from consumption of the IT product.

Combining optimality conditions (7) and (8), we derive

$$\frac{\partial \phi}{\partial e} U = \phi \frac{\partial U}{\partial l}\,. \tag{11}$$

This states that the optimal allocation of time to knowledge creation is determined at the point where the marginal increase in utility from knowledge increase equals the marginal utility of leisure.

The demand function of the IT product (*s*) is given by

$$s^D = s^D(p, w, g)\,. \tag{12}$$

By assuming that the wage rate (*w*) is given exogenously in a general labor market, we rewrite the equation as

$$s^D = s^D(p, g)\,. \tag{13}$$

III. RESPONSE FUNCTION

To examine the slope of the response function, we conduct a comparative static analysis using the following equation:

$$\frac{de^A}{de^B}=\frac{1}{|H|}\begin{vmatrix}\psi_{11} & \psi_{12} & \psi_{13} & -\psi_{1e^B} & -1\\ \psi_{21} & \psi_{22} & \psi_{23} & -\psi_{2e^B} & -p\\ \psi_{31} & \psi_{32} & \psi_{33} & -\psi_{3e^B} & -w\\ \psi_{41} & \psi_{42} & \psi_{43} & -\psi_{4e^B} & -w\\ -1 & -p & -w & 0 & 0\end{vmatrix}, \qquad (14)$$

where

$$\psi_{11}=\phi\frac{\partial^2 U}{\partial c^2}<0,$$

$$\psi_{12}=\frac{\partial\phi}{\partial s}\frac{\partial U}{\partial c}+\phi\frac{\partial^2 U}{\partial c\partial s}>0,$$

$$\psi_{13}=\phi\frac{\partial^2 U}{\partial c\partial l}>0,$$

$$\psi_{14}=\frac{\partial\phi}{\partial e}\frac{\partial U}{\partial c}>0,$$

$$\psi_{15}=-1,$$

$$\psi_{2}=\frac{\partial L}{\partial s}=\frac{\partial\phi}{\partial(sg)}gU+\phi\frac{\partial U}{\partial s}-p\lambda=0,$$

$$\psi_{21}=\frac{\partial\phi}{\partial(sg)}g\frac{\partial U}{\partial c}+\phi\frac{\partial^2 U}{\partial s\partial c}>0,$$

$$\psi_{22}=\frac{\partial^2\phi}{\partial(sg)^2}g^2U+\frac{\partial\phi}{\partial(sg)}g\frac{\partial U}{\partial s}+\frac{\partial\phi}{\partial(sg)}g\frac{\partial U}{\partial s}+\phi\frac{\partial^2 U}{\partial s^2},$$

$$\psi_{23}=\frac{\partial\phi}{\partial(sg)}g\frac{\partial U}{\partial l}+\phi\frac{\partial^2 U}{\partial s\partial l}>0,$$

$$\psi_{24} = \frac{\partial^2 \phi}{\partial(sg)\partial e} gU + \frac{\partial \phi}{\partial(sg)} \frac{\partial U}{\partial s} > 0,$$

$$\psi_{25} = -p < 0,$$

$$\psi_{31} = \phi \frac{\partial^2 U}{\partial l \partial c} > 0,$$

$$\psi_{32} = \frac{\partial \phi}{\partial(sg)} g \frac{\partial U}{\partial l} + \phi \frac{\partial^2 U}{\partial l \partial s} > 0,$$

$$\psi_{33} = \phi \frac{\partial^2 U}{\partial l^2} < 0,$$

$$\psi_{34} = \frac{\partial \phi}{\partial e} \frac{\partial U}{\partial l} > 0,$$

$$\psi_{35} = -w < 0,$$

$$\psi_{41} = \frac{\partial \phi}{\partial e} \frac{\partial U}{\partial c} > 0,$$

$$\psi_{42} = \frac{\partial^2 \phi}{\partial e \partial(sg)} gU + \frac{\partial \phi}{\partial e} \frac{\partial U}{\partial s} > 0,$$

$$\psi_{43} = \frac{\partial \phi}{\partial e} \frac{\partial U}{\partial l} > 0,$$

$$\psi_{44} = \frac{\partial^2 \phi}{\partial e^2} U < 0,$$

$$\psi_{45} = -w < 0,$$

$$\psi_{51} = -1 < 0,$$

$$\psi_{52} = -p < 0,$$

$$\psi_{53} = -w < 0,$$

$$\psi_{54} = -w < 0,$$

$\psi_{55} = 0$,

$$\psi_{1e^B} = \frac{\partial \phi}{\partial e^B}\frac{\partial U}{\partial c} > 0,$$

$$\psi_{2e^B} = \frac{\partial^2 \phi}{\partial (sg)\partial e^B} gU + \frac{\partial \phi}{\partial e^B}\frac{\partial U}{\partial s} > 0,$$

$$\psi_{3e^B} = \frac{\partial \phi}{\partial e^B}\frac{\partial U}{\partial l} > 0,$$

$$\psi_{4e^B} = \frac{\partial^2 \phi}{\partial e \partial e^B} U > 0, \text{ and}$$

$$\psi_{5e^B} = 0.$$

The second-order condition for the maximization requires that the determinant of the bordered Hessian must be positive (i.e., $|H| > 0$). Thus, if the determinant of the numerator is positive, we can derive that $de^A / de^B > 0$. In general, it is nontrivial to examine the sign of the determinant because of the complex combination of mixed effects. Thus, in this paper, we highlight the interesting case where the response function has a positive slope, which possibly occurs in certain situations. For example, in the specific case where the second-order effects of the consumer good (*c*) and leisure time (*l*) are negligibly small, and the market wage (*w*) rate is given exogenously at 1, we can derive

$$\frac{de^A}{de^B} = \frac{1}{|H|}\left(\frac{\partial \phi}{\partial (sg)} g \frac{\partial U}{\partial l} + \phi \frac{\partial^2 U}{\partial s \partial l}\right)\left(\left(\phi \frac{\partial^2 U}{\partial l \partial s} + 2\frac{\partial \phi}{\partial s}\frac{\partial U}{\partial c} + \phi \frac{\partial^2 U}{\partial c \partial s}\right)\frac{\partial \phi}{\partial e^B}\frac{\partial U}{\partial l}\right) > 0 \qquad (15)$$

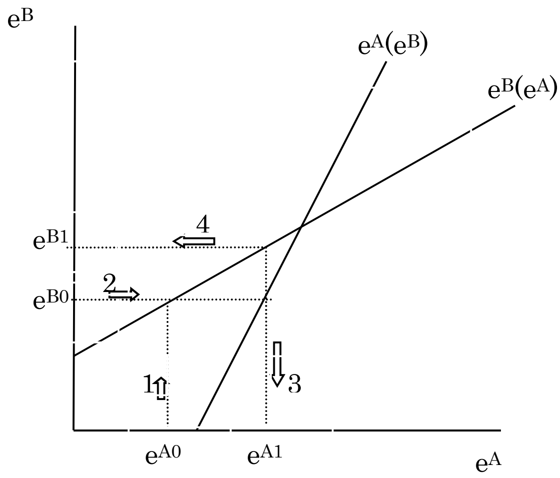
by using the first-order condition

$$\phi \frac{\partial U}{\partial c} = \phi \frac{\partial U}{\partial l}.$$

This implies that the slope of response function may be positive at some local point. Depending on whether de^A / de^B exceeds 1, the stability of the equilibrium is determined. As shown in Figure 1, the equilibrium is stable when $de^A / de^B \leq 1$. That is, when neither consumer changes his or her time for knowledge creation more than the other consumer does, the equilibrium becomes stable. On the other hand, the equilibrium is unstable when $1 < de^A / de^B$ (Figure 2). In this case it is possible that one consumer increases his or her time for knowledge creation more than the other does, and the investment time for knowledge creation increases sharply in a local range. This situation seems to be realistic if the consumers are sensitive to interactions with others on social networking services and debate increases as consumers voice their opinion though social networking services. In addition, we should pay attention to any increase in the value of IT products over the course of debate on social networking services. That is, as the knowledge creation among consumers increases, the value of IT products increases and demand for IT products increases.

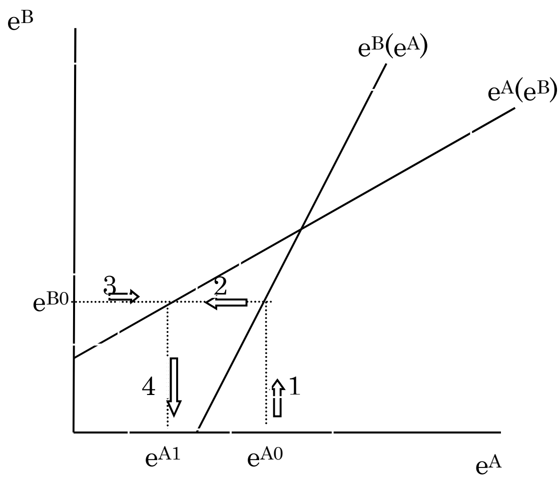
In the case where two consumers want to decrease the time spent for knowledge creation, it is reasonable to consider the case where the response function has a negative slope. When one consumer increases time for knowledge creation and the other decreases his or her time, and the amount of the increase is less than the amount of the decrease, the equilibrium is stable as is shown in Figure 3. On the other hand, when the consumer is strongly sensitive to the behavior of the other consumer and the amount of increase is less than the amount of decrease, the equilibrium is unstable as is shown in Figure 4. In contrast to the case with a positive slope, there is no possibility of a case where both consumers increase their time for knowledge creation. In this case, the equilibrium becomes unstable, and no equilibrium point is attained.

FIGURE 1



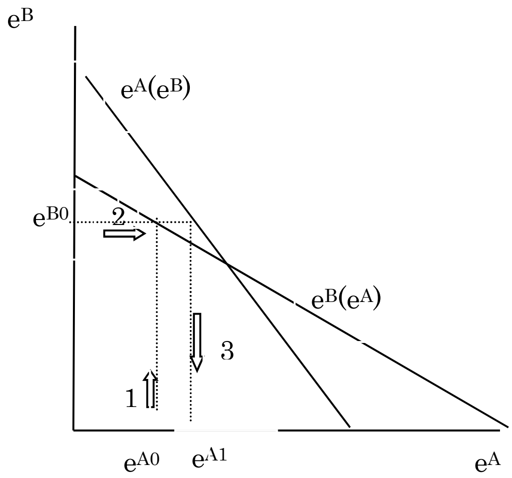
Stable Equilibrium Case ($0 < \frac{de^A}{de^B} \leq 1$)

FIGURE 2



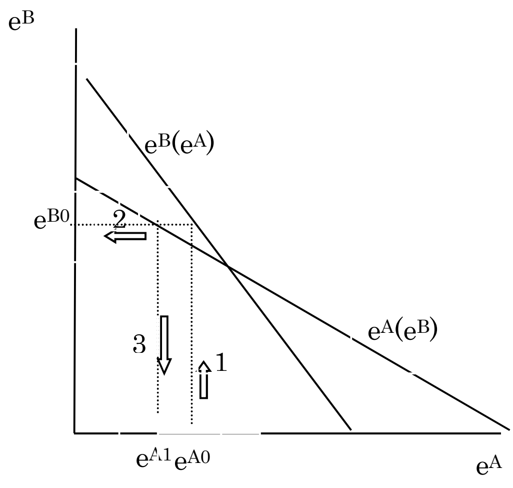
Unstable Equilibrium Case ($1 < \frac{de^A}{de^B}$)

FIGURE 3



Stable Equilibrium Case ($-1 \leq \frac{de^A}{de^B} < 0$)

FIGURE 4



1

Unstable Equilibrium Case ($\frac{de^A}{de^B} < -1$)

IV. PRODUCER BEHAVIOR AND MARKET EQUILIBRIUM

The profit function of the producer is given by

$$\pi(s,g;p) = p(s,g)s - C(s) - g \ , \qquad (16)$$

where $C(s)$ is the cost function.

The optimality conditions for profit maximization are given by the following two equations:

$$\varphi_1 = \frac{\partial \pi}{\partial s} = \frac{\partial p}{\partial s}s + p(s,g) - \frac{dC(s)}{ds} = p(1-\frac{1}{\varepsilon}) - \frac{dC(s)}{ds} = 0,\ where\, \varepsilon = -\frac{ds/s}{dp/p}, \qquad (17)$$

and

$$\varphi_2 = \frac{\partial \pi}{\partial g} = \frac{\partial p}{\partial g}s - 1 = 0\,. \qquad (18)$$

From equation (12), the optimal production level of the IT product (s) is given by

$$s^S = s^S(p,g)\,. \qquad (19)$$

The optimal public infrastructure investment (g) is determined such that equation (18) holds.

That is,

$$g = g(s)\,. \qquad (20)$$

From the market equilibrium condition and optimality condition (20), we derive

$$s^D = s^S = s = s^{-1}(g) = \mu(g)\,. \qquad (21)$$

The market equilibrium levels of the IT product price (p) and the public infrastructure investment (g) are found by solving this system of equations.

Totally differentiating (18), we derive

$$(\frac{\partial^2 p}{\partial g \partial s} s + \frac{\partial p}{\partial g}) ds + \frac{\partial^2 p}{\partial g^2} s dg = 0. \quad (22)$$

In other words, we derive

$$\frac{dg}{ds} = -(\frac{\partial^2 p}{\partial g \partial s} s + \frac{\partial p}{\partial g}) / \frac{\partial^2 p}{\partial g^2} s > 0. \quad (23)$$

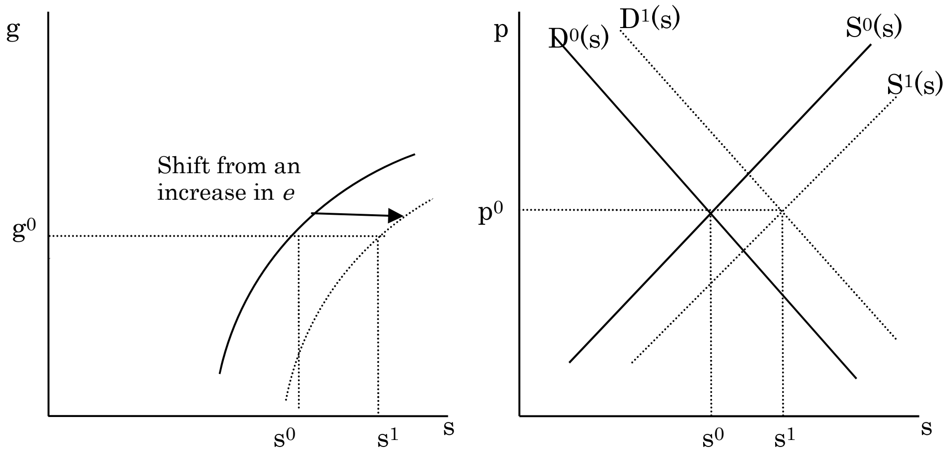


Figure 5 g-s curve and market equilibrium

The equilibrium is attained at the intersection of the demand and supply curve, where the combination of public infrastructure investment (*g*) and the IT product (*s*) is on the optimality condition (20). When consumers increase the amount of time for knowledge creation (*e*), the value of *s* increases through a shift of the utility function, as shown in Figure 5. It should be noted that profit-maximizing firms will adjust their optimal production by responding to the shift in the marginal revenue function caused by the change in the amount of time for knowledge creation (*e*). This implies that both the demand and supply curves possibly shift rightward, and their intersection shifts rightward, as is shown in Figure 5. The equilibrium supply of the IT product increases with increased knowledge creation by consumers.

The pattern of the shift of equilibrium therefore depends on the relative slope of the response functions. The analysis in Section 2 shows that there are three patterns of equilibrium effort levels. In the case of stable equilibrium, the equilibrium effort level is determined at a certain level, given the level of public infrastructure investment (g). In this case, the producer observes the equilibrium effort levels of consumers, and the equilibrium price and quantity of an IT product are determined in the market. If the optimality condition for public infrastructure investment (g), which is given by (18), is not satisfied, the level of this investment is adjusted. This affects the optimal effort level of consumers, and a new market equilibrium is attained. The adjustment process continues until all the control variables satisfy the optimality conditions.

Contrary to the stable equilibrium case, the unstable cases lead to the sharp increase of effort levels or zero effort levels. When the effort levels increases to the upper bound, the equilibrium quantity and public infrastructure investment (g) increase until the effort level reaches the upper bound. Whether the equilibrium price increases or not depends on the shape of function (20). If an increase in the quantity of IT production decreases the marginal cost of the product through the decrease in per unit cost of providing public infrastructure g, the market equilibrium level of product price might not increase.

On the other hand, as the equilibrium effort level converges to zero, the demand for the IT product decreases and the equilibrium quantity decreases. In this case, the IT product could possibly disappear from the market.

V. CONCLUDING REMARKS

In this paper, we analyzed the patterns of knowledge creation from the collaboration of producers and consumers. The essential differences from traditional knowledge creation mechanisms arise from consumers' contribution to knowledge creation in three areas. The first is the possibility of free ride in knowledge creation. The knowledge created by consumers is a public good, and they do not charge for its creation and this knowledge is available for free. The second is the complicated strategy that producers use to price and provide public infrastructure. The value of a product to the consumer depends on the amount of knowledge creation by consumers, which is affected by the amount of public infrastructure, which in turn affects the price of the product. Finally, the pattern of knowledge creation varies drastically depending on the shape of the response function between consumers. A sharp increase in knowledge creation may occur when the value of knowledge generated by consumers is large.

These characteristics of knowledge creation should be analyzed in various settings. Such analysis is expected to bring about important results for understanding the mechanism of knowledge creation.

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