Abstract

This paper considers the process competition approach to explain why firms engage in technology innovation, as an alternative to the traditional structure approach which inadequately explains the incentive of the technology innovation. We propose a game theoretical model which demonstrates high intensity of process competition is the key driving force for technology innovation. Subsequent analysis indicates the strength of administrative monopoly is the most important constraint for process competition. Our conclusions are supported by a Microsoft case study and an econometric study based on the province regional data from China. In order to stimulate technology innovation in the country such as China, an effective way is to reduce the degree of administrative monopoly and hence enhance the intensity of the process competition.

*JEL Classification*: L16; L51; O31; O38

*Key Words*: Technology innovation; Process Competition; Administrative Monopoly; Market structure
Process competition and incentive of innovation

1. Introduction

The importance of technology innovation to the sustainable competitive advantage, economic growth and social welfare improvement of a country cannot be underestimated. Many economists have recognized that one of the most important jobs for the policy maker is to design and implement the efficient policy to foster technology innovation. But what kind of policy and market condition can encourage technology innovation is still a controversial issue and has been an important topic for economists to investigate in the past decade.

“What market condition is appropriate for technology innovation?”, Schumpeter initiated to use market structure approach to answer this question (Scherer 1992). According to the structure approach, market concentration, i.e. the number of incumbents in the existing market, determines the incentives created by the market. In short, structure approach persists that innovation incentive lies on market structure. Following Schumpeter’s work, Arrow (1962) argues that, based on a mathematical model, in a competitive market the incentive for firms to engage in technology innovation is higher than in a monopoly market. Arrow’s model was challenged by Demsetz (1969). Demsetz claims that a monopoly market is more favorable to technology innovation. Debates between Arrow and Demsetz stimulate a large number of theoretic and empirical studies since then. Besides Arrow and Demsetz’s researches, some economists bring about a compromising argument in which the intermediate state between competitive market and monopoly market provides the best incentive to the technology innovation (Scherer 1967; Kamien and Schwartz 1975; Lee 2005).
Although structure approach has been a long-accepted paradigm to explore the suitable market condition for technology innovation, structure approach has many vital defects. None of the above arguments in the structural approach can explain the real world adequately. Arrow’s argument neglects the competition between the incumbents and potential entrants (hereinafter referred to as challengers). Demsetz emphasizes that the power of a monopolist is beneficial for technology innovation. The power of monopolist includes monopolist’s capital strength which insures necessary investment for technology innovation; the experience of previous success and the ability to attract the “brains” which reduce the risks in the process of technology innovation; huge sales network and diversified business areas and specialized professionals which create suitable conditions for rapid application of new technologies. However, as the resource allocation for technology innovation becomes more market-oriented, the type of technology innovation becomes more diversified and the transaction of new technology becomes more realistic and feasible, the influences of monopolist’s power on innovation are in fact declined. The compromising argument obviously lacks in supports from economic theory. Because of these aforementioned defects, the results from empirical studies are confusing (Kamien and Schwartz 1975). Cohen and Levin commented, the effects of concentration on innovation, if they exist at all, do not appear to be important for the technological innovation (Scherer 1992).

Different from the structure approach, this paper argues that the most important condition which determines the incentive of technology innovation lies on dynamic competitive process. We use the entry cost to measure the intensity of process competition. We present a model which is developed from Arrow’s model and shows how entry cost determine the incentive of
technology innovation. We further investigate the constraints for process competition and find that administrative power or administrative monopoly is most important for the incentive. This conclusion is supported by a Microsoft case study and an empirical model based on a province regional data from China.

The economic implication of this paper is significantly important to such economy as China. In order to ensure the control to economic development and protection of local governments’ interests, China government grants monopoly power to a large number of enterprises (mainly state-owned enterprises). China government uses administrative power to set entry barriers to protect these state-owned enterprises and also strengthen these enterprises’ monopoly position by exclusively supplying them economic resources. This low intensity of process competition weakens the incentive of technology innovation and lead to the lack of innovation. As to encourage technology innovation in China, policy maker should not focus on market structure, but rather to enhance the intensity of process competition by removing administrative monopoly from the market. This implication is also of great value for the other countries which has the similar economic and political environment like China.

The rest of this paper is organized as follows. Section 2 discusses the relation between process competition and the incentive of innovation. Section 3 presents a game-theoretical model for the process competition. Section 4 provides discussion on the endogenous and exogenous constraints of the process competition. Section 5 demonstrates our theoretical observations the through a case and an econometric study. Finally, Section 6 concludes.
2. Process competition and the incentive of innovation

Process competition is defined as a type of competition which the incumbents always face the threats coming from potential entrants. The ease of the potential entrants substitute for incumbents, the higher the intensity of the process competition might be. In this sense, process competition can be understood as dynamic competition. In the pioneering work concerning technology innovation, Schumpeter (1943) points out innovation rent induces new firms to enter into market. Once the new firms acquire alternative technology, there will be a serious attack to the incumbents. “Which commands a decisive cost and quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very life.” (Schumpeter 1943). To be consistent with Schumpeter’s idea, modern Austrian economics, which is represented by Hayek, Mises and Kirzner et al. (Kirzner 1997) persists in the process competition.

According to modern Austrian economics, the real competition comes from the challenger outside market. If a market is isolated from potential entrants’ challenge, the concept of competition based on neoclassical economics loses their meaning. Hayek points out that competition is a process of discovery (Hayek 1978, p.179). Under this process, entrepreneurs continue to discover and market continues to make correction. Entrepreneurs’ discoveries naturally include inventions and the selection of appropriate technology, while market correction includes using better technology to replace old one. Market structure depends on the competitive process. A market structure generated at a time is only coincident. Using coincidence as criteria to evaluate economic efficiency and social welfare is extremely misleading. An optimal market structure with best technology innovation does not exist and
specific result of competition is neither predictable nor sustainable. The randomness and temporality of the process competition result in the instability of the technology rent. Process competition makes the process of technology transformation more efficient.

Following the above arguments, the smoothness of substitution process between old and new technologies has a critical influence on the technology innovation. In other words, the high intensity of process competition is the critical issue to flourish innovation.

Perfect process competition depends on a critical condition - freedom to enter market. As Kirzner (1997) points out: in order for process competition to function well, we require the enterprise to have enough freedom to enter every market which might be profitable. In order to ensure challengers to enter a targeted market, we must ban any privileges that the incumbent has over the challenger or eliminate artificial barriers of entry. Free market entry means a perfect process competition. Once the process competition is perfect, the challenger will be able to discover or acquire new technology, and the challenger can enter the market to compete with the incumbent successfully. Because it is impossible to find who is the challenger, where and when a challenger will arise, in order to avoid being elbowed out from market, the incumbent should overcome the inertia to implement innovation and be persistently committed to technology innovation.

The existence of an entry deterrent results in imperfect process competition. Once process competition is not sufficient or perfect, even when a new technology is discovered by challenger, the incumbent monopolist can not fully recognize the market value of the new technology and only offer a cheaper price to buy the new technology. As a result, a challenger has a lower incentive to innovate. For the incumbent, entry deterrence reduces the
risk of being replaced by. The fact that the incumbent will underestimate the market value of new technologies also means the reduction of his own incentive to innovate. As long as there is entry deterrence, many technology innovations opportunities will be wasted. The more the perfect process competition, the more alert the incumbent will be to guard against the challenger. Technology innovation is both a means for incumbent to protect the rents and a means for challenger to challenge the incumbent and replace his market position. Innovation contests always exist between the incumbent and the challenger in a market with perfect process competition.

Only in the market with perfect process competition, opportunity of technology innovation can be thoroughly discovered and speedily utilized. Technology innovation process can be efficiently organized, maximal revenue can be achieved by the technology innovation and prosperity of technology innovation can be maintained.

3. The model

Our proposed model follows Arrow model with the difference in the measure of incentive of technology innovation. Arrow’s model assumes the incentive of technology innovation for the incumbent depends on how large the incremental profits are brought from innovation. Since a loss of self-substitution exists for the incumbent monopolist who engages in technology innovation\(^1\), the monopolist has less incentive for innovation. In our model, we claim that the game player is not only the incumbent monopolist but also the potential entrants who always anticipate resorting to new technology to acquire chances to enter.

\(^1\) Self-substitution indicates that when the incumbent introduces new product to replace the old one, the profits obtained from the old product for the same incumbent will lose.
market. As the advent of new technologies, there is no reason that the old technology can create profit suitable. Therefore, the value of innovation should be determined by an auction process which is opened to all possible new technology adopters to obtain the highest auction price.

Our model consists two parts. Part I does not consider the cost of technology innovation while Part II does. We use the cost of entry to measure intensity of process competition.

3.1. Process competition and the revenue of technology innovation

Suppose the existing technology is $k_1$ which makes $FC = 0, MC = c_1$ to produce a product. An innovator invents a new technology $k_2$ which makes $FC = 0, MC = c_2 < c_1$ to produce the same product. The demand function for this product is $Q(p)$, where $dQ(p)/dp < 0$. A new entrant needs to pay the entry cost $f \geq 0$ in order to enter market. $f, Q(p)$ and the cost function based on different technology are public information. The product market can be classified into monopoly market and perfectly competitive market. In monopoly market only one producer exists and price of product is set based on $MR = MC$. In perfect competitive market the price of product is set based on $p = MC$. Anyone has chance to be successful in technology innovation and become intellectual property owner of $k_2$.

To facilitate our analysis, we assume that innovators and technology adopters are separated. Moreover, intellectual property protection in market is perfect, that is, if the technology is not licensed by the technology owners, any firm can not use the technology. The license fee which the innovators charge the technology adopters is determined through an auction process. For simplicity, we assume that the original market structure can not be changed after the technology is licensed. Therefore, in a competitive market, innovators should license his
new technology to more than one technology adopters and the licensing fee can be calculated per unit (denote $r$ as the license fee per unit). On the other hand, the new technology can only be authorized to a sole technology adopter in a monopoly market, and the way of license is complete authorization, i.e. after paying the license fee $R$, the technology adopters can produce without any quantity limitation.

Based on $MR = MC$, the technology adopter prices its product at $p_{2}^{M}$. Following Arrow model, if $p_{2}^{M} < c_{1}$, we called the innovation as drastic innovation; if $p_{2}^{M} \geq c_{1}$, we called it as moderate innovation.

3.1.1. Drastic innovation

First, we consider a perfect competitive market. An innovator obtains the license fee $r$ through an auction process. If $0 < r \leq c_{1} - c_{2}$, all the incumbent producers will accept $r$. The incumbent producers cannot boycott new technology or lower the license fee, so the innovator can maximize his profit without introducing entrants, the entry cost has no influence on innovation revenue. The objective function of innovator is $\max_{r} rQ(r + c_{2})$. Therefore, the optimal license fee is $r_{D}^{*} = p_{2}^{M} - c_{2}$. $k_{2}$ is accepted by the market and $k_{1}$ is elbowed out from market. The revenue of the innovator is:

$$\Gamma_{D}^{*} = r_{D}^{*}Q(r_{D}^{*} + c_{2}) = (p_{2}^{M} - c_{2})Q(p_{2}^{M})$$

(1)

where $\Gamma_{D}^{*}$ is the market value under drastic innovation for the innovator.

Second, in a monopoly market the monopolist’s profit is $\pi_{1}^{M}$. If $k_{2}$ is obtained, then the monopoly position will be maintained and profit will increase to $\pi_{2}^{M} = (p_{2}^{M} - c_{2})Q(p_{2}^{M})$. If the innovator sells $k_{2}$ to an entrant through auction, the entrant will obtain $\pi_{2}^{M} - R - f$, and the existing monopolist will be pushed out. Suppose the entry process is perfectly competitive,
the optimal auction price from the entrant will be \( R_0 = \max \{ (\pi_2^M - f), 0 \} \). \( R_0 \) is the security profit of technology innovation under drastic innovation. When \( f \leq \pi_2^M \), it is possible that the challenger enters the market, \( k_1 \) becomes worthless and the incumbent is retreated from market. In order to keep this position, the highest price that the incumbent is willing to pay for \( k_2 \) is \( \pi_2^M \). Negotiation interval between the innovator and the incumbent is \( R_0 \in [R_0^-, \pi_2^M] \). Total transaction surplus is \( v_1 = \pi_2^M - R_0 \). When \( f > \pi_2^M \), it is impossible for the challenge to enter into the market (i.e. \( R_0^- = 0 \)) and the original revenue of the monopolist becomes secure. The highest price that the incumbent monopolist is willing to pay for \( k_2 \) reduces to \( \pi_2^M - \pi_1^M \). Negotiation interval is \( R_0 \in [0, \pi_2^M - \pi_1^M] \). Total transaction surplus changes to \( v_2 = \pi_2^M - \pi_1^M \). We assume the innovator and adopter start an indefinite bargaining process to split the total transaction surplus, where \( \delta_i, \delta_a \) represent the discount rate of the innovator and adopter respectively. \( \delta_i < 1, \delta_a < 1 \). Let \( A = \frac{1-\delta_a}{1-\delta_i} \), \( A < 1 \). The solution of this game will be a sub-game perfect Nash equilibrium (Rubinstein 1982) and the equilibrium license fee is:

\[
R_0^* = \begin{cases} 
\pi_2^M - (1-A)f, & \text{if } f \leq \pi_2^M \\
A(\pi_2^M - \pi_1^M), & \text{if } f > \pi_2^M
\end{cases}
\]

(2)

From equation (2), three cases exist as following:

1) Under a perfect process competition, i.e. \( f = 0 \), the incumbent monopolist will lose his monopoly rent. There is no difference in innovation revenue obtained from a monopoly market and from a competitive market, i.e. \( R_0^* = \Gamma_0^* \).

2) Under an imperfect process competition i.e. \( f \in (0, \pi_2^M] \), the incumbent needs to pay less amount than case 1) to maintain monopoly position. As entry cost increases, innovation revenue obtained from a monopoly market will decrease which is less than the revenue...
obtained from a competitive market.

3) Under a case that process competition is completely destroyed, i.e. \( f \in (\pi^M, \infty) \), possibility of entry is eliminated. It is unnecessary for the incumbent to pay for maintaining monopoly position. Innovation revenue obtained from a monopoly market becomes constant that is less than what he can obtain from a competitive market.

The conclusions from Arrow model only hold in case 2) and 3).

3.1.2. Moderate innovation

First, we still consider a competitive market which \( c_i \leq p_2^M \), so \( r < p_2^M - c_2 \). Innovation revenue is denoted as \( \Gamma_M(r) \). \( r < p_2^M - c_2 \) implies \( \frac{d\Gamma_M}{dr} > 0 \). The best license fee which the incumbent can accept is the highest license fee. That is \( r_M^* = c_1 - c_2 \). As the result, \( k_2 \) is accepted and \( k_1 \) is phase out. Entry cost cannot affect the innovation revenue. Innovation revenue is expressed as follows.

\[
\Gamma_M^* = r_M^* Q(r_M^* + c_2) = (c_1 - c_2)Q(c_1)
\]  \( (3) \)

Let \( X = (c_1 - c_2)Q(c_1) \), \( X \) measures the total market value of the new technology under moderate innovation.

Second, we consider a monopoly market which the innovator might license the technology to an entrant. Since \( k_1 \) is held by the incumbent monopolist, the highest price that the entrant can charge for the product is \( c_1 \). Herein the highest sales revenue and the highest net income is \( X \) and \( X - R - f \) respectively. If the perfect competition for entry is taken into account, the highest auction price from the entrant is \( R_m = \max \{ (X - f), 0 \} \), where \( R_m \) is the security profit for the technology innovation.

If \( f \leq X \), entry is possible. The owner of old technology has the right to restrain the price
of the adopter’s product, which means \( k_1 \) has market value. In order to calculate this value, we suppose an entrant obtains \( k_2 \) from auction, then he obtains the license of \( k_1 \) by paying \( x \) to the incumbent monopoly. Based on dual license, the maximal sales revenue obtained by the entrant increases to \( \pi_2^M \). It means that the market value of \( k_1 \) equals to \( \pi_2^M - X = x^* \). As a result, the highest price that the incumbent monopolist is willing to pay for the new technology must be the total market values that can be gained from \( k_1 \) and \( k_2 \) minus the market value of \( k_1 \) (i.e., \( x^* \)). So the highest price that will be paid by the incumbent monopolist for the new technology is \( X \). Negotiation interval between the innovator and the incumbent monopolist is \( R_M \in [R_M^L, X] \). If \( f > X \), entry is impossible. The highest price which the incumbent monopolist is willing to pay reduces to \( \pi_2^M - \pi_1^M \) and the negotiation interval changes to \( R_M \in [0, \pi_2^M - \pi_1^M] \). We also assume the innovator and adopter start an indefinite bargaining process. The solution for this game will be a sub-game perfect Nash equilibrium, and the equilibrium license fee is:

\[
R_M^* = \begin{cases} 
X - (1 - A)f, & \text{if } f \leq X \\
A(\pi_2^M - \pi_1^M), & \text{if } f > X 
\end{cases}
\]  \( (4) \)

In the same way, based on equation (4), three possible cases exist:

4) Under a perfect process competition, i.e. \( f = 0 \), there is no difference in the revenue of innovation obtained from a monopoly market or a perfectly competitive market.

5) Under an imperfect competitive market, i.e. \( f \in (0, X] \), as the entry cost increase, the innovation revenue obtained from a monopoly market which is less than the revenue obtained from a competitive market decreases.

6) Under the case that process competition is completely destroyed, i.e. \( f \in (X, \infty) \), possibility of entry is zero. In this case, the innovation revenue obtained from a
monopoly market which is less than from a competitive market and becomes a constant.

The conclusions from Arrow model only hold in case 5) and 6).

Based on equation (2), figure 1 depicts the relationship between entry cost and innovation revenue in the case of drastic innovation. Entry cost does no affect innovation revenue in a competitive market. Once entry cost exists, innovation revenue obtained from a monopoly market is determinately less than from a competitive market. Only in this case Arrow’s argument is correct. In a monopoly market, as entry cost increases, innovation incentives obtained from a monopoly market becomes weaker and weaker than the competitive market counterpart. Once entry cost is over a threshold value $\pi_2^M$, threat of entry will be completely eliminated and rent of new technology becomes constant.

![Diagram](image)

**Fig.1** the relationship between entry cost and innovation revenue in the case of drastic innovation

Now we discuss the policy for technology innovation. Suppose the market condition is at
$f = a$, as shown at point B in Figure 1. Clearly, two kinds of policies which increase the incentives of innovation profit exist. Policy I: create a competitive market by splitting monopoly market, as Arrow suggested, so market condition C can be reached. Policy II: create a process competition, as this article suggests. The value $f$ is lowered through the elimination of entry barriers so that market conditions D can be reached. Clearly, policy I comes into conflicts with intellectual property system. In the case the incumbent holds its monopoly position based on the ownership of intellectual property, splitting this kind of monopoly is undoubtedly a departure from original purpose of intellectual property system. In other words, removing the existing monopoly position of an innovator will weaken the present innovation; granting the innovator’s monopoly position will weaken future or subsequent innovation. In a word, policy I and intellectual property system are incompatible. Fortunately, policy II and intellectual property system are compatible. In addition, some factors such as Minimum Efficient Scale (MES), the cost subadditivity and network externalities result in that point C can never be reached. In conclusion, the better policy to motivate technology innovation is to create a competitive process rather than to achieve a competitive market structure.

3.2. Process competition and selection of the technology innovation projects

Based on previous conclusions we further investigate the impact of entry cost on the selection of technology innovation project in monopoly markets. Suppose in a simple economy, assumes $n$ products exist. Each product has same demand function denoted by $Q(p) = (a - p)/b$, $a > 0, b > 0$ and same production function $FC = 0, MC = c_1, \frac{a}{2} < c_1 < a$. 
We further suppose one opportunity for technology innovation exists in each market.

Through the implementation of technology innovation in market \( i \), marginal cost of the production can be reduced to \( c_i, c_i \sim U[0, c_i] \). Entry cost for all markets is \( f \). We assume that the negotiation process between innovator and technology adopter is the same as the previous discussion. To simplify our description, we assume that the cost of every technology innovation project equals \( \gamma = A c_i^2 / 4b \). The interval of cost saving is \([0, 2c_i - a]\) for the drastic innovation while the interval of cost saving is \([2c_i - a, c_i]\) for the moderate innovation\(^3\).

Based on these assumptions, if \( f > a^2 / 4b \), the innovator cannot make any profit from innovation and all the technology innovation projects are abandoned. When \( f \leq a^2 / 4b \), partial technology innovation projects will be implemented whose interval of cost saving is \([0, c^\wedge(f)]\). It can be shown that \( c^\wedge(f) \) can be described as the following function. (See the mathematical proofs in the Appendix).

\[
c^\wedge(f) = \begin{cases} 
  c^{\wedge_1}(f) = c_i - \frac{b}{a - c_i} \left(1 - A f + \frac{Ac_i^2}{4b}\right), & \text{if } 0 \leq f \leq \frac{c_i^2}{4b} \\
  c^{\wedge_2}(f) = c_i - \frac{bf}{a - c_i}, & \text{if } \frac{c_i^2}{4b} < f \leq \frac{(a - c_i)^2}{b} \\
  c^{\wedge_3}(f) = a - \sqrt{4bf}, & \text{if } \frac{(a - c_i)^2}{b} < f \leq \frac{a^2}{4b} 
\end{cases}
\] (5)

In equation (5) \( \frac{dc^\wedge(f)}{df} < 0 \) and \( c^{\wedge_1}(f) < c^{\wedge_2}(f) < c^{\wedge_3}(f) \), which means as \( f \) increases, the value of right endpoints of cost saving interval \([0, c^\wedge(f)]\), determined by actual implemented innovation projects, decreases correspondingly. Hence, the quantity of actual

\(^2\) We can still derive the same conclusions in this paper even if we do not impose this assumption.

\(^3\) New marginal cost \( c = 2c_i - a \) satisfies \( P^M = c_i \), \( c = 2c_i - a \) is watershed among drastic and moderate innovation.
implemented innovation projects decreases. Thus, in the presence of entry cost in a monopoly markets, those technology innovation projects which have less market values will be given up. The higher the value of $f$, the more quantity of the innovation projects will be abandoned. When $f$ is over the threshold value, all technology innovation projects are abandoned.

4. Constraints for process competition

In the previous section, entry cost is used to measure the intensity of process competition. Obviously the determinants of entry cost are also constraints for the process competition. As for which are the determinants of entry cost is still a controversial issue. (Mcafee et al. 2004). We argue that entry cost is the cost of challenger to overcome the barriers of entry and this is not the cost which is indispensable for producing the products. Entry costs can be divided into two types: 1. costs paid by anyone who intends to enter market; 2. costs paid by the challenger not by the incumbent. The former is endogenous to market environment and the level of science and technology while the latter is not. Endogenous and exogenous entry costs constitute endogenous and exogenous constraints respectively in process competition. In this paper, we focus on the exogenous constraints. This section gives a detailed discussion about the constitution of the endogenous and exogenous constraints

4.1. Endogenous constraints

The cost to obtain market information by consumer is the most important endogenous constraint in the process competition. This cost makes consumer disgust the risk from purchasing new brand and foster brand loyalty. The one time consumption, the difficulty in
inspecting product quality and the firms’ spending for advertisement can strengthen the brand loyalty. In a market with high degree of brand loyalty, the entrant has to pay persuading cost. The switching cost for consumer is another type of endogenous constraint. In order to enter into the market, the entrant must compensate for the switching cost incurred by the consumer. (Teece and Coleman 1998). Other endogenous constraints include professional investment. Professional investment constitutes the sunk cost incurred by the entrant once the entrant exits the market. The higher of the sunk cost, the stronger will be the entry deterrence (Mcafee et al. 2004).

All endogenous constraints are induced by the asymmetry of information and the restriction in the current level of technology. Endogenous constraints are unavoidable to everyone. New technology will not be adopted by the market if its gain cannot compensate for the cost of endogenous constraints. In real world, entry process is full of frictions. The new technology cannot always replace the old technology rapidly and completely as Schumpeter supposed even if there is gain in new technology. Different levels of technologies exist in a market at the same time.

### 4.2 Exogenous constraints

All exogenous constraints are used to protect the incumbent and make the challenger face asymmetric and unfair entry conditions. One type of exogenous constraints derives from entry deterrence by the incumbent. The entry deterrence generally consists of three forms:

1) **Predatory pricing**. Whether predatory pricing induces entry cost is still controversial, Teece and Coleman (1998) argue that the answer depends on whether the winner is able to
elbow the competitors out from market and obtain compensatory profits when predatory pricing is implemented. For those industries in which technology changes greatly, compensatory profits are difficult to obtain. The contestable market theory argues that if there are not significant sunk costs in the market, predatory pricing is difficult to work (Baumol, 1982). This paper argues that, due to presence of endogenous constraints, those competitors who are squeezed out will bear cost to entry again. In the other word, with the help of endogenous constraints, predatory pricing obtains the effect to deter entry. Predatory pricing should be considered as an exogenous constraint.

2) **Peer-monopoly agreement.** Agreements are made among the incumbent’s counterparts, for such purpose as joint restriction of price or quantity, resistance to new technology, entry deterrence and so on.

3) **Vertical control.** Vertical control includes vertical integration and vertical contracts which have the effect of vertical restraints, aimed at achieving the upstream industries’ exclusive supply and downstream industries’ exclusive demand. Vertical control restrains horizontal competition from which the challenger’s entry is blocked unless the challenger can reconstruct another independent industrial chain.

Another type of exogenous constraints comes from administrative monopoly, i.e. government uses its administrative power to prevent undesirable potential entrant from entry. Administrative monopoly can be classified into two forms:

1) **Entry administrative permission.** In the entry administrative permission, authority strictly controls the number of licenses to exclude undesirable applicants to achieve the purposes of ownership discrimination, regional protection and departmental protection. Due
to the history of implementation of planned economy and ensuring the government’s absolute control on the process of economic development, China still maintains ownership discrimination. In a number of industries, monopolistic positions are given to state-owned enterprises, while non-state-owned enterprises with more advanced technology cannot challenge their positions. Regional protection and department protection is frequently used by regional governments or administrative departments to protect their own interests.

2) **Administrative monopoly of venture resources.** Administrative monopoly of venture resources means a challenger’s core venture resource is controlled by government. Administrative departments have the right to determine who can and who cannot secure these resources. Financial resource, the most important form of venture resources, is monopolized by the China government. Combining administrative monopoly of venture resources with entry administrative permission, administrators acquire stronger power to restrict entry. Solely relying on administrative monopoly of venture resources, government can covertly interfere with process competition.

Entry deterrence means the abuse of market power by the incumbent while administrative monopoly means the abuse of administrative power by government. If there is no government interests involved in entry deterrence, it is not difficult to forbid the incumbent’s entry deterrence. Administrative monopoly requires government to self-regulate, self-restrain and self-correct its own behavior. Compared to elimination of entry deterrence, elimination of administrative monopoly is a more difficult task.

Entry costs created by endogenous constraints are always finite. Through discovery of better technology which created higher technology rents, a challenger can overcome
endogenous constraints. In other words, Endogenous constraints only restrain small portion of technology innovation. Otherwise, entry costs created by administrative monopoly may be infinite. In many cases it is impossible for a challenger to overcome administrative monopoly. Administrative monopoly is bound to restrain most technology innovation which leads innovation projects to be greatly deserted. When a market is completely protected by administrative power, incentive for technology innovation provided by market is extremely weak. In this case administrative arrangements can be used to promote technology innovations. However, technology innovation based on administrative arrangements is full of moral hazard and fraud which is confirmed by the investigation of state-owned enterprises’ innovation in the former Soviet Union and China (Dearden et al. 1990; Wang et al. 2000). Generally speaking, the most important constraint for process competition is administrative monopoly. We illustrate this point based on a case study and an econometric model in next section.

5. A Microsoft case and an empirical model

Up to now two observations have been obtained. First, in a market with perfect process competition, static market structure does not affect innovation rent. In order to maintain technology rent, the incumbent monopolist has the same incentive to innovate as the incumbents in the competitive market. Second, in a market with an imperfect or failure process competition, the incumbent monopolist doesn’t have strong incentive to innovate. Among the constraints for process competition, administrative monopoly destroys process competition seriously. In this section, we use Microsoft case to illustrate the first observation. In addition, we present an econometric study based on province regional data from China to
verify the second observation. Since there is no direct measurement on the profit from technology innovation, we follow the frequently used method in technology economics and use technology innovation input or output as an indirect measurement for profit of technology innovation. This method connotes an important hypothesis in which as a rational player a firm invests more resource to R&D only in case that he anticipates more profit can be earned, investing more resource to R&D generally means more outputs from R&D.

5.1. Microsoft Case

Bill Gates founded Microsoft in 1975. Because of advanced technology and reliable product quality, Microsoft quickly won over IBM, APPLE and other competitors and established leadership in the field of personal computer operating systems. Microsoft Windows operating system has maintained 90% market share since the 1980’s, an incontrovertible dominance in its market. In accordance to Arrow’s model, due to the loss of self-substitution, Microsoft should show less interest in innovation. However, Microsoft’s technology innovation has never stopped. The argument is supported by two facts.4

1) Input in technology innovation. According to Arrow's model, a competitive market provides stronger incentive to innovate than a monopolistic market. Microsoft’s peer-listed companies (referred to as Microsoft’s counterparts) should show higher incentive to innovate than Microsoft because they do not possess the monopoly power. However, Figure 2 shows Microsoft RDI ( R & D Intensity: R & D investment divided by sales income) was not lower than its PMV (Peer’s Median Values) from 1986 to 1992 and from 2004 to 2008.

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4 The investments of R&D, sales income and net income of Microsoft and its counterparts come from Compstat database. We collect totally 2746 listed firms as Microsoft’s counterparts based on their shared industrial code SIC737. The other information about Microsoft comes from related literatures.
From 1993 to 2003, Microsoft’s R & D intensity was lower than PMV, but it does not mean that Microsoft has lessened its technology innovation. Microsoft’s long-term sales growth was ahead of his counterparts which make Microsoft have much higher sales income compared to his counterparts. The result is that the total investment of Microsoft in R&D was ahead of his counterparts. From 1993 onwards, the average annual R & D investment of Microsoft was 86 times more than his counterparts.

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<td>16</td>
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<td>17</td>
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<td>27</td>
<td>37</td>
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<tr>
<td>R&amp;D Investment of CMV</td>
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<td>3</td>
<td>3</td>
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<td>R&amp;D Investment of CAV</td>
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<td>44</td>
<td>47</td>
<td>57</td>
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<td>113</td>
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<tr>
<td>R&amp;D Investment of CMV</td>
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<td>6</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>11</td>
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CAV: Microsoft counterpart’s average value; CMV: Microsoft counterpart’s median value.

2) **Output in technology innovation.** Technology economics often use the number of patents granted to measure output of technology innovation. Microsoft maintained remarkable achievements in this aspect. According to the National Patent Office in USA,
from 2005 to 2009, the number of patents granted to Microsoft were 750, 1473, 1637, 2030 and 2906, ranked 19, 13, 6, 4 and 3 respectively among the companies with maximum patents in USA. Financial performance (e.g. ROA: return on net assets) is also used to measure output of technology innovation. Figure 3 shows Microsoft have much higher ROA than his counterparts’ median ROA over the years. Obviously Microsoft maintains not only high intensity input but also high efficiency in technology innovation which resulted in profits to support further innovation.

Undoubtedly Microsoft’s continuous devotion to innovate cannot be explained by market structure approach. Base on process competition approach, we give the following explanations.

1) Microsoft has never obtained administrative protection from the government. Microsoft is no doubt the largest U.S. high-tech exporting corporation. Unlike the state-owned enterprises in China, Microsoft has never obtained any “favorable benefit policy” from government. USA government does not hold Microsoft’s shares, no need to take into the consideration on the financial performance of Microsoft and to worries about the consequence of social problems if Microsoft declares bankruptcy. On the contrary, USA
government has been committed to monitor Microsoft’s competition behavior and warned Microsoft to obey fair competition rules under the US laws. Since 1990, USA government spent 10 years to investigate Microsoft’s “antitrust” violation and attempted to split Microsoft into two companies. USA government’s antitrust investigation effectively constrained the “bundling sale” behavior and other means of vertical agreements to deter entry.

2) Microsoft always faces the threat from potential entrants. As an IT producer, Microsoft’s products have advantages in high network externalities and high consumer switching costs which in theory can constitute endogenous constraints. In fact, these constraints are not sufficient to deter entry. While Microsoft has established a monopoly position for a long time, a lot of substituting products for Microsoft’s products still exist. The Explorer browser was attacked by the Scape browser which exceeded the market share of Microsoft at one time. The Windows operating system was attacked by Linux and Unix competitors. With the support of other countries’ governments and giants such as IBM, HP, SUN, ORACLE, Linux operating system became a very popular substitution for Microsoft’s products. Linux’s market share in server operating system is approaching Microsoft’s market share. Linux also extended their products to serve desktop users which constitute a major threat to Microsoft. The venture resource of the United States is allocated completely by market-oriented mechanism, not by administrative arrangement. Therefore, the entry of substituting products will not encounter bottleneck in venture resource. If a substituting product is confirmed to have significant advantages, the product will easily and quickly enter into market and replace Microsoft’s market position. Thus, Bill. Gates always warns Microsoft employees that “Microsoft has only 18 months from bankruptcy”.

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On one hand, Microsoft cannot use endogenous constraints to deter potential entrants. On the other hand, it is always under the pressure of supervision from USA government and the threat of substituting product from the potential entrants. Microsoft is always facing a nearly perfect process competition which cannot be explained by structure approach. The only way for Microsoft to prevent from new competitor’s entry is a continuous technology innovation and always keeping ahead in product’s performance and quality. Microsoft’s monopoly position does not reduce technology innovation\(^5\). Thus, Microsoft case is the good evidence to support our first observation.

5.2. An econometric study

Our empirical study is based on a regional study by Yu et al. (2009) in China. We define a provincial region in China as a market. RAMI (Regional Administrative Monopoly Index) is used to measure degree of administrative monopoly in a region. RAMI is constituted by 49 weighted sub-indexes. These sub-indexes include entry administrative permission and administrative monopoly of venture resources. The higher of the RAMI, the higher the degree of administrative monopoly will be and thus the weaker will be process competition. Our hypothesis is as follows.

H1: in a provincial region, higher RAMI is, the lower will be the intensity of technology innovation of large and medium size industrial enterprises.

28 provinces in China are used as the sample of region over the period 2000-2006. The sampling size is dictated by data availability\(^6\). 7 annual observations for each explanatory

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\(^5\) That is the reason why USA government eventually gave up the pursuit of competitive market structure and withdrew antitrust investigation against Microsoft.
\(^6\) It is unfortunate that we cannot acquire the RAMIs after 2006 because Yu et.al’s research does not publish these years’s data.
variable are available for each selected region. RAMI is obtained from Yu et al’s research (2009). The rest of data comes from “China Statistical Yearbooks”, “China Statistical Yearbooks of Science and Technology”, “China’s high-tech industry yearbook”, and “The Annual of China High Technological Industrial Development”.

To examine the hypothesis H1, the system generalized method of moments (system GMM) estimator is employed. The system GMM is preferred to the first-differenced GMM estimator, because it retains the time invariant variable—direction—and is found to perform better in a relatively short sampling period (Blundell and Bond 1998). These desirable properties are essential for our empirical study.

The empirical relationship takes the form of following dynamic panel model:

\[
RDI_{i,t} = \beta_0 + \beta_1 RDI_{i,t-1} + \beta_2 RAMI_{i,t} + \beta_3 HT_{i,t} + \beta_4 SECOND_{i,t} + \beta_5 \ln(GDP_{PER})_{i,t} + \beta_6 EAST_{i,t} + \beta_7 WEST_{i,t} + \beta_8 (YEAR_{DUMMIES})_t + \gamma_i + \epsilon_{i,t}
\]

In equation (6) \( \gamma_i \) is the unobserved region specific effects, \( \epsilon_{i,t} \) is the disturbance term and \( t \) denotes the years. \( RDI_{i,t} \) represents R&D intensity of the large and medium size industrial enterprises in region \( i \) and year \( t \) which is measured by the proportion of the large and medium size industrial enterprises R&D inputs to corresponding enterprises’ sales income. \( RAMI_{i,t} \) measures the regional administrative monopoly index in region \( i \) and year \( t \). \( HT_{i,t} \) is the proportion of the high technological industry in region \( i \) and year \( t \) which equals to the total production value of high technological industry divided by the total production value of large and medium size industrial enterprises. \( SECOND_{i,t} \) measures the proportion of second industry in region \( i \) and year \( t \) which equals to the total added value of second

\[
\text{We use the total production value of large and medium size industrial enterprise as the proxy of total production value of all industrial enterprises because we cannot acquire t total production value of all industrial enterprises.}
\]
industry divided by region $i$’s GDP. $RDI_{i,t-1}$ is the lag of R&D intensities of the large and medium size industrial enterprises in region $i$. $Ln(GDP\_PER)_{i,t}$ denotes logarithm of the GDP per capita in region $i$. Considering the regional development in China is not balanced which means the level of technology application is not balanced, we further include the zone dummy variables ($EAST_{i}$ and $WEST_{i}$) to indicate the location of a region in China. Finally, the zone variables ($EAST$ and $WEST$) and the year dummies are assumed to be exogenous and uncorrelated with unobserved individual region’s effects $\gamma_i$. The lagged dependent variable is treated to be predetermined. We experiment with remaining explanatory variables, as if exogenous or predetermined with respect to the disturbance term.

We adopt Arellano and Bover (1995) system GMM estimator to estimate the coefficients in the above dynamic panel data model. Following the standard procedure in panel data estimation, we conduct the Hansen’s $J$ tests for the over-identification test and the Arellano-Bond $ar1$ and $ar2$ test statistics for the presents of first-order and second-order serial correlations in the first differenced residuals respectively. The result is shown in table 2.

Our model specification passes all necessary $ar1$, $ar2$ and Hansen’s $J$ tests. The result of the $J$ test does not reject the over-identification test (p>0.05), confirming the validity of instruments chosen for the level equations and the first-differenced equations. The $ar1$

| Table 2. System GMM estimation for the dynamic panel model |
|-----------------|-----------------|
|                | RDI$_{i,t}$     |
| RAMI$_{i,t}$   | -0.2143***      |
| RDI$_{i,t-1}$  | 0.4214***       |
| HT$_{i,t}$     | 0.7243***       |
| SECOND$_{i,t}$ | 0.5621          |
| $Ln(GDP\_PER)_{i,t}$ | 0.2194 |
| $WEST_i$       | -1.256***       |
| $EAST_i$       | 0.2134          |
| Constant       | 0.4313***       |
| Hansen J statistic | 0.2081   |
| $ar1$          | -4.1041         |
| $ar2$          | -1.2325         |
| Wald           | 307***          |
| Observations   | 168             |
| Number of Regions | 28            |

*denotes significance at 10% level.
**denotes significance at 5% level.
***denotes significance at 1% level.

time dummies are not displayed to save space.
and \(ar2\) tests also indicates the absence of the second order autocorrelation in the residuals of the first-difference estimators (\(p<0.01\) and \(p>0.05\) respectively); In addition, the Wald test demonstrates the overall significance of our model (\(p<0.01\)).

Our estimated results demonstrate that presents of the dynamic effect as the estimated lag effect of \(RDI\) is positively significant. The estimated coefficient of \(RAMI\) is negatively significant which demonstrates that \(RAMI\) has significant negative impacts on variables \(RDI\). In addition, the estimated coefficient of \(HT\) also shows significantly positive impact on the \(RDI\). On the other hand, the variable \(SECOND\) and \(\ln(GDP\_PER)\), although show positive effects on \(RDI\), are not statistically significant. Finally, the negative significance of the zone variable, \(WEST\), indicates that compared to eastern and central zone of China, due to the low level of economy development Western China lacks innovation resource and cannot but lower intensity of R&D.

In the other word, the econometric model supports the H1. That is, higher the regional administrative monopoly, lower the incentive for the large and medium industrial enterprises to engage in technology innovation.

6. Conclusion

The traditional argument based on market structure approach fails to give satisfactory explanation for incentive of technology innovation. In this paper, we adopt the process competition approach to present an alternative explanation. We propose a game-theoretical model, which the intensity of process competition is measured by entry cost, to explain why process competition has a great impact on incentive of technology innovation. Our analysis shows that in a market with perfect process competition, everyone can discover new
technology and earns the maximum technology rent. Technology rent is the reward supplied by market to innovator for the improvement of production and promoting technology progress. Market structure does not affect the level of technology rent in a market with perfect process competition. Under this situation, the argument based on the structure approach (Arrow model for example) is invalid. This result is further confirmed by a Microsoft case. Arrow’s model only valid under the market with imperfect process competition, i.e., incentive to innovate in a monopoly market is less than in a competitive market. As entry cost increases, the incentive for innovation provided by a monopoly market will be less than from a competitive market. We further classified the constraints for process competition as either exogenous or endogenous. Administrative monopoly is one of the important exogenous constraints which should get more attentions from economists. We hypothesize a negative relation between the strength of administrative monopoly and the incentive for technology innovation. Through an empirical model based on regional data from China, our econometric analysis demonstrates that administrative monopoly leads to insufficiency in the process competition and hence less incentive for technology innovation. Based on this, we argue that this is the most important reason why the China’s enterprises lack incentive to engage in technology innovation. So, to enhance the intensity of process competition by reducing the degree the administrative monopoly from market is the key point for the government like China to foster technology innovation and strengthen its competitive advantages.

Acknowledgements

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Appendix

Any new marginal cost created by technology innovation \( c \) has a corresponding innovative profit line from the monopoly market (denotes as profit line). \( 0 \leq c \leq c_1. c = 0 \) corresponds to the profit line \( X \). (See Figure 4.). The \( R^* \)-intercept of line \( X \) equals to \( \frac{a^2}{4b} \).

\[ f_s = \frac{a^2}{4b} \] is threshold value of entry cost for line \( X \) which means when \( f > f_s \) the innovation project is given up because \( R_D^* = \frac{Ac_i^2}{4b} \) and cost of innovation \( y = \frac{Ac_i^2}{4b} \). When \( c = 2c_1 - a \), the corresponding profit line is \( Y \) which is the watershed between the profit area of moderate innovation and drastic innovation (See Figure 4.), the corresponding threshold value of entry cost equals to \( f_s = \frac{(a - c_i)^2}{b} \). For line \( Z \) \( \lim_{f \to X} R_M^* = \lim_{f \to X} AX = y \), which means turning point of line \( Z \) is just break-even point of the innovation project, the threshold value of entry cost for line \( Z \) equals to \( f_s = \frac{c_i^2}{4b} \). The turning points of all profit lines fall on line \( OM \).

When \( f_a \in [0, f_s] \), a dividing profit line can be derived from \( f_a \) which touches the intersection point of \( f = f_a \) and \( R_M^* = y \), the corresponding \( R^* \)-intercept is \((1 - A)f_a + y\). From this, We know \( \frac{1}{b}(a - c_i)(c_i - c^{1/4}) = (1 - A)f_a + y \), so

\[ c^{1/4}(f) = c_i - \frac{b}{a - c_i}\left[(1 - A)f + \frac{Ac_i^2}{4b}\right]. \]

Obviously, a non-negative profit can be obtained from
the innovation project \( j \) if \( 0 \leq c_j \leq c^{\lambda}(f) \). When \( f_b \in (f_1, f_2) \), the profit line whose threshold value of entry cost equals to \( f_b \) is the dividing profit line. The corresponding \( R^* \)-intercept of the dividing profit line equals to \( f_b \), the expression for \( c^{2\lambda}(f) \) is obtained by the following equation, \( \frac{1}{b}(a-c_1)(c_1-c^{2\lambda}) = f_b \). When \( f_c \in (f_2, f_3) \), the profit line whose threshold value of entry cost equals to \( f_c \) is the dividing profit line. The corresponding \( R^* \)-intercept of the dividing profit line equals to \( f_c \). The expression for \( c^{3\lambda}(f) \) is be obtained by the equation \( \frac{1}{4b}(a-c^{3\lambda})^2 = f_c \). (Q.E.D)

![Diagram](image)

**Fig.4** The relation between the entry cost \( f \) and right end point of the interval of cost saving \( c^{\lambda}(f) \) in the technology innovation projects

**References**


