

# Technological Advance, Economic Growth and Anti-trust of Intellectual Property

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## 1 Market categories and economic efficiency

In market economy, there are four types of markets: perfect competition, monopolistic competition, oligopoly, monopoly. The main differences among them are the ability to set price, barrier to enter and exit the market, numbers of companies. To study innovation's efficiency in these markets, it is necessary to understand their special characteristics. To simplify the problem, when patent is employed, only the innovation company has the access to this new technology. When it does not exist, every company in the market can use the new technology. In perfect competition market, there are no barrier to enter or exit and lots of companies producing identical products, so no company can set the price. Because there is no barrier, companies that can earn profit will enter the market, which decreases the price. Eventually, all companies' marginal cost, average cost and marginal benefit is equal to the price, average benefit. In other words, companies in perfect competition market earn zero economic profit. Social welfare is always maximum in this type of markets. In this case, when one company discovers new production technology, other companies will follow immediately. Lower cost causes higher supply, which makes the price decrease and equal to the average cost eventually, leaving every company having zero economic profit, including the first company discovered the new technology, so there is no incentive for any company to spend resource on innovation. However, consumers' welfare would increase because of lower price. When patent is employed, one company can produce

products in a lower price and earn certain economic profit, but can hardly make an influence on the market because there are too many suppliers. Thus, in perfect competition market, patent is a good way to provide incentives for innovations. In monopolistic competition market, there are lots of companies selling slightly different products. The difference among products enables one company to increase the price over in a limited range, so monopolistic competition market is inefficient. In this type of markets, there are two types of innovations: technology and product. The former one reduces the cost and has the same consequence as that in perfect competition market. The latter one, product innovation, makes the product more special, giving the company more market power. However, without patent, product innovation will be copied easily, making the original product less special and canceling out the market power gained by the original company. Since there is no economic benefit, there is no incentive for any company in the market to innovate. When patent is employed, products' difference is kept and gives the company more market power since there is consumer preference in monopolistic competition market. This increase of market power is not as negligible as that in perfect competition market, so the market becomes less efficient when the company with patent increases the price. In oligopoly market, there are only a few companies with great market power, so all of them can set the price. In this market, companies make decision based on both output and price effects. Output effect means when price is higher than marginal cost, companies can increase profit by increase its output. Price effect means when a company increases its output, the market price goes down, causing less profit for the company. When output effect is more impactful than price effect, companies will increase sales. When price

effect is more impactful than output effect, companies will decrease sales. Oligopoly market can be inefficient without restrictions. Regarding innovations, there is still no incentives without the presence of patents. With patent, innovation company will gain market power that is huge enough to cause inefficiency and even to force other companies to exit the market. Thus, patent in oligopoly market will cause negative impact on society, which should be limited. The last type of markets is monopoly. In monopoly market, there is only one company, so patent is necessary. When this company innovates and decreases its production cost, it will tend to increase its output to maximize profit, which enlarges consumers' welfare. However, this increase is not as much as that in perfect competition market, so innovation in monopoly market is still inefficient.

## **2 Innovation, technology diffusion and economic growth**

The relationship among innovation, technology diffusion, and economy is complicated. To find it out, definition for each of them is needed. Schumpeter's definition of innovation is a new combination of current resources. There were five types of innovations according to him: to provide new products; to employ new ways of production, to create a new market, to take over new supply of any raw material, and to form a new organization of industry. There are several characteristics of such innovations. First, innovation is an endogenous reason for economic growth. In other words, innovation both affects economy and is affected by economy. Innovation in this case is also destructive: the real competition under capitalism is about production, which means companies have to employ new machines or technology to reduce costs. Companies that fail to do this will be weeded out from the market. In this case, old machines, technology, industry structured will inevitably be destroyed. Innovation is also related to economics cycle according to Schumpeter. Before innovation, the market is in an equilibrium. After one company innovates, other companies will follow it, which causes a wave of production requiring more production material and causing economic growth. However, after production increases, the price goes down, causing supply to decrease and thereby causing economic recession.

During the course of economics' development, the relationship between technology improvements and economic growth has changed. At first, economists

thought only productivity affected economy. Neoclassical economics regarded technology improvements as an exogenous reason for economic growth, which means though technology improvements promote economic growth, economic growth cannot promote technology improvements. Then, the endogenous growth theory argued that economy will keep growing without any exogenous promotions, because economics growth would promote technology improvements, and technology improves would promote economic growth. Economists built different model to describe this theory. According to Paul M. Romer, innovation is a function of capital. Technology improvement will be influenced by the quantity and quality of production. According to Robert E. Lucas, technology improvement is the result of human capital.

According to Marx, innovation is a type of labor: complex and abstract labor. He argues that economic competition comes from people's subjective initiatives, and goods' value comes from labor spent to produce them. Innovation the result of people's subjective initiative. Different levels of innovation cause different level of economy.

Besides innovation itself, the spread of new technology is also important for economy. However, spread of technology will reduce the profit brought, thus reduce the initiatives for innovations. In other words, to promote innovation, spread of technology should be regulated. Investors, or companies, require a minimum profit, which is influenced by other companies and society. If the profit brought by regulation is lower than the minimum required, no company would choose to innovate. After the innovation is done, companies not only have initiatives to protect the new technology from spreading but also initiatives to spread and charge certain fee. Spread of technology also contributes to efficiency. If one country has already done the research, it will be inefficient for other countries to repeat the same research, so spreading new technology is more efficient.

Market allocates technology most efficiently. The market allocates technology to companies that can use them in most efficient ways. Companies with new technology have two options: to share the technology and charge or to produce by the technology and earn certain profit. If the charge is more than the profit, companies will choose to share the technology. Since only companies that can employ the new technology with higher efficiency than that of the original

companies will pay more profit, the new technology will be allocated to companies with higher efficiency.

### 3 Competition and monopoly

Competition in a market means every company tries to maximize its own profit and market portion while minimizing others'. Monopoly means to prevent other companies from entering the market through varied means such as Patent Law. Both competition and monopoly have the same cause: self-interest: competition and monopoly are two ways for a company to maximize its own profit. However, they have a different outcome: competition helps the market reach equilibrium that maximizes both company and customers surplus, and thereby maximize the efficiency for society; monopoly helps the company maximize its own profit but undermines total surplus. Since Government's goal is to maximize the social well-being, government should fully forbid monopoly and support competition. However, there're still reasons for monopoly to exist. First, there're natural occasions in which monopoly does better than competition. For example, if government wants to build a national park, it's better to contract with only one company than with ten companies. When one company handles the job, it only needs to buy all the necessary equipments once. When ten companies undertake the job, they all need to buy the same equipments. The total work is split into ten parts assigned to each company, but the fixed cost stays the same. The outcome of having ten companies finishing the national park is that the average cost for one company becomes as ten times large as that of having only one company. Second, monopoly gives companies incentives to innovate. Take biochemistry industry as an example. The cost and time of developing a new kind of medicine can be huge, but the huge profit of monopoly can cover such a cost, which makes companies willing to develop new medicine. It's similar in every other industries, so monopoly is necessary to stimulate future innovations. However, there is a balance the government needs to control: it needs not only to keep the degree of monopoly not so severe that wealth is mostly distributed to monopolies and that the social welfare is minimal, but also keep the profit from monopoly enough to stimulate companies to create new products and technologies.

### 4 Game theory

Game Theory studies the decision-making of

individuals whose interests are related either negatively or positively. The primary assumption is that all these individuals are reasonable themselves, know others are reasonable and all seek the best interest for themselves. There're four components of each game: participants, strategies/actions, rules, and outcomes. Participants are individuals who need to decide their actions. Actions are what the participants can do. Strategies can be employed to decide how to maximum participants' interest by choosing different actions. Outcomes are what participants will get after all decisions are made. There're three categories of games: (non)-cooperative game; (non)zero-sum game, and dynamic/static game. Cooperative game involves participants that are willing to cooperate with each other to create a better outcome. Zero-sum game means one participant's benefit brings about another's loss. Dynamic game means participants can make decisions for several times. In non-cooperative games, there is an anticipated solution called Nash Equilibrium. In Nash Equilibrium, each player cannot increase their benefits by only changing their own actions.

In oligarchy market, which is non-cooperative, there is Nash Equilibrium. However, such an equilibrium can base on either output or price. Cournot duopoly model is used to find the equilibrium based on output, while Bertrend Competition deals with oligarchies that only consider price. Cournot duopoly model's assumption is that there're only two companies with homogeneous products and zero marginal cost. In this case, the first company would choose to produce half of the maximum quantity demanded to maximize its profit, because at this point there's unit elasticity. When the second company enters the market, it has only half of the total market left, so it chooses its output at a quarter of the total quantity demanded. After this, the first company has only  $3/4 Q_d$ , which makes its output  $3/8 Q_d$ , which makes the output of the second company  $5/16$ ..... Thus the output of the first company can be expressed as  $Q_1 = Q_d * (1/2 - 1/8 - 1/32 - 1/128 - \dots)$  The output of the second company can be expressed as  $Q_2 = Q_d (1/4 + 1/16 + 1/64 + \dots)$  Using infinite series, both  $Q_1$  and  $Q_2$  should be  $1/3 Q_d$  at last. The Nash Equilibrium in oligarchy market with two companies is thus both companies produce  $1/3$  of the maximum quantity demanded by the market.

### 5 Intellectual property and Antitrust Law

Intellectual property right is an intangible ownership

of creation of human intellect, whose most common example is patent. With intellectual property, companies are able to operate accorded production of goods or services themselves and to exclude other companies in employing the intellectual property, which is exactly monopoly. Antitrust law protects a fair competition in the market as well as consumers' welfare. The major anticipated outcome of Antitrust law is to fairly allocate social welfare to both companies and consumers, rather than an excessive accumulation of wealth. Intellectual property and antitrust have not only potential conflicts but also common attributes. Regarding conflicts, intellectual property enables companies to exclude or limit competitors in the market, which is opposed by antitrust law. However, antitrust law doesn't oppose to the action of monopoly but its deleterious effect on the market. In other words, antitrust law doesn't oppose to intellectual property right, but misuse of intellectual property that greatly hurts the market and its components, namely consumers and other companies. In fact, intellectual property and antitrust law have common goals and similar outcomes. Both of them can stimulate innovation, control monopoly by intellectual property, and set standards for how to use intellectual property. While Intellectual property ensures companies to earn enough profits from innovations, antitrust law enables new companies to enter the market through innovations. For example, if huge companies don't share their core technology, it's hard for other companies to create new technology since the necessary core technology is not available. While intellectual property focuses on companies' abuse of intellectual property, antitrust law focuses on the outcome of such an abuse that restricts competitions. When applied, the former's standard is whether the use of intellectual property is beyond its proper ownership, and the latter's standard is whether it hurts competitions.

Intellectual property right is designed to provide incentives for innovations. Among all forms of intellectual property, patent is the most classical and easiest to access to, so most researches mainly focus on patent. Patent provides inventors a legal right to monopolize the market of products relating to the patent. However, such a right has a time limit. The implicit reason for providing such a right is the assumption that monopoly brings higher economic profits and thereby recover the cost of researching and innovations. In this case, companies are usually regarded as the major force to innovate, because

innovations can be used as input for production.

Such innovations can be divided into two types: technological innovation and product innovation. Technological innovation can reduce the production cost, while product innovation allows company to produce new types of goods and service. Government usually endeavors to promote both types of innovations, because both of them would increase the social welfare. There are different incentive mechanisms: laissez faire, government funding, and patent. Perfect competition market can be used to study how these mechanisms work. In the circumstance of laissez faire, every company will use the most efficient innovation, so every company has a reduction in their cost and earns economic profits, leading more companies to enter the market. At last, every company, including the company that created the new technology, will earn zero economics profit. However, consumers' surplus would be increased because the price would decrease. Overall, the social welfare increases. However, because there is no profit in innovation but cost in innovation, no companies would innovate. Thus, even if the overall social welfare would increase by innovations, innovations will not happen, which means market failure. Apparently, laissez faire is not the best mechanism. If the government provides funds for innovations, the maximum social welfare will be achieved. However, government's capital is limited, so it is impossible for the government to fund every innovation. Another option is patent, which allows only patent holder to produce in such a low cost. While there could be certain dead weight lost, the total social welfare still increases after meeting the time limit for the patent of this technological innovation. For another type of innovation, product innovation, these mechanisms work in a similar way. In the circumstance of laissez faire, a new perfect competition market is created, in which the producer surplus is still zero, which fails to provide incentives for innovations. If the government funds the innovation, the total surplus will be maximized. Again because of limited government capital, patent is needed. In this case, patent allows the patent holder to monopolize the market. In monopoly market, there is a certain deadweight lost, but the total social welfare is still increased by the new market. To conclude, patent is usually an effective way to provide incentives to companies when government cannot fund innovations.

However, it's been argued whether big companies

or small companies have a larger incentive to innovate with patent rights. Schumpeter thinks that big companies, who are more capable of bearing risks, have better ability to innovate. He also argues that incumbent companies have higher incentive to innovate than potential companies, because incumbent companies are more afraid of losing their current monopoly or oligarchy position. Nevertheless, there is opposed opinion: while technological innovation is the only way for small companies to increase profits, big companies that have already monopolized the market have sustainable profits even without innovations. This leads small companies to have more incentives to innovate.

There are two major categories of patent: one is among patent holders and licensee, patent license; another is among different patent holders, such as patent pool. Patent license usually involve so many contracts that it is hard to distinguish whether it promotes competition or works in the opposite way, so it is important to analyze some typical examples. Two main paying methods are non-linear charge and commission. Non-linear charge includes fixed franchise fee and wholesale price. Commission charges according to the profit of licensee or the quantity sold by licensee. In real life these two methods are usually combined together to charge the licensee. There are several special contracts that can be signed to increase profits: resale price maintenance, tie-in sale, exclusive contract, and long-term contract. Resale price maintenance is the contract that limits the price resellers can set. Tie-in sale forces licensees to buy a pack of patents to increase the patent holder's profit. Exclusive license contract gives licensee exclusive right to use this patent. Long-term contact simply involves a deal in long-term.

Another type of patents is among different patent holders. Typical examples are Standard Essential Patent, cross-licensing, and patent pool. The first example is the patents one company must have to meet the standard in a certain industry. There are two types of organizations setting the standard: International Standardization Organization and Standard Setting Organization. The former one is formed by different governments. The latter one comes from enterprises and companies, which provides quick reaction. It is easy for these organizations to cause monopoly, since they force other companies to use certain patents which only they have. One example is patent hold-up: after the standard is widely accepted, the SSO will charge a unreasonably high price. Another type of patent is cross-licensing,

which means patent holders can exchange their own patents. This can benefit competition by preventing excludability and cost of torts, providing a combination of patents, and decreasing the cost of trade. However, cross-licensing may also limit competition when the powerful companies exclude other companies in the market.

## **6 Compulsory patent licensing**

While patent gives one company an exclusive market power to earn profit, compulsory license enables another company to use the patent, breaking the exclusive market power, without the original company's consent. However, government who employs compulsory license needs to pay the original company as compensation for losing its exclusive market power. Compulsory license is usually employed by underdeveloped or developing countries because it's more likely for them to need advanced technology, such as new medicine, software, or food, from developed countries. One example can be compulsory license of HIV medicine. According to Third World Network, "The government of Zimbabwe on 27 May declared a national emergency for six months over the HIV/AIDS pandemic and has decided to override patent protection to enable the procurement and sale of HIV/AIDS drugs in their generic names." The cause of this event were HIV's great threat to Zimbabweans and the HIV medicine's price unaffordable for Zimbabweans. In other occasions, the exclusive market power of patent hurts social welfare and impedes efficient market competition and innovation. Compulsory license can protect public welfare, prevent the original patent holder from using the patent inefficiently. It's also a remedial measure for antitrust law when the original patent holder refuses reasonable patent request or interferes competition. Compulsory license has several characteristics: mandatory, exclusiveness, temporary, compensated, dynamic, and socially beneficial. Mandatory reveals that compulsory license does not need patent holder's consent. In other words, it's forced by governments. Exclusiveness means the original patent holder still keeps its patent right. Temporary means compulsory license has a time limit. Compensated means governments need to pay compensation to cover the loss of patent holders. Dynamic means there are several rounds of games between the government and patent holders. Socially beneficial means the original goal of compulsory license is to increase social welfare.

However, compulsory license, while diminishing the exclusive right of patent holders, reduces the incentive for innovation. Even governments pay compensation, it is usually less than the profit earned with exclusive market power. The reason is simple: if the government can pay up patent holders' profit, it would just pay the desired goods for public, because goods' price is equal to the sum of production cost and profit. In developing countries, production cost is usually higher than that in developed countries with advanced production technology and machines. While patent provide incentive, exclusive market power with a huge potential profit, to innovations, compulsory license reduces this profit and thus this incentive. While innovation increases total social welfare, compulsory license focuses exclusively on consumers' welfare. Since both of them bring positive influence to society, yet neither of them can function properly with another's presence, there is a incompatible contradiction between patent and compulsory license.

Different countries employ compulsory license in different ways. In Paris Convention 1925, the fifth article replaced revocation of patent with compulsory patent. Most countries, especially developing countries, employ compulsory license. In United States, patent law

does not include compulsory patent system aiming to increase social welfare. However, there is still specific compulsory system in U.S. In China, development of compulsory system is relatively late. Specific conditions which allow compulsory license are: after three year since the patent has been given and after four years since the patent has been applied, the patent holder does not use it patent efficiently with no reasonable excuses; the way by which patent holders use the patent is regarded as monopoly which hurts efficiency and competition.

In China, one example of compulsory license happens between Hussein and InterDigital Group. Huawei accused that InterDigital Group did not proceed actual production, but only earned profits by patent license, and that InterDigital Group charged much more license fee than the license fees charged on other companies such as Apple Inc. and Samsung. The court of Shenzhen decided that the fundamental issue is not license fee, but that InterDigital Group had to accept Chinese law about compulsory license. The result was that the maximum rate InterDigital Group could charge was 0.019%. This result was based on the average profitability of radio communication industry, the research cost, and the charge rate for the previous licenses.