Ownership Structure and Intellectual Property Strategy: Patent Analysis in China (*)

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The purpose of this study is to analyze the impact of shareholder structure on the innovation activities of firms by using the patent database and industrial enterprises database of China. In particular, we focus on the role of state-owned shareholders. The main results are as follows.

First, there is a tendency that the central state-owned firms and local state-owned companies produce new products. However, we only observed the tendency of patent application and registration for central state-owned firms.

Second, regarding the effect of privatization on innovation, we find that firms that have been privatized to private firms (hereafter: PPF), reduce patent application or registration and tend to produce new product. However, we do not find any significant effect on firms that have been privatized to foreign companies (hereafter: PFF).

Third, our analysis shows that firms with high competitive pressures from foreign companies, export firms, debtless firms, firms with large market shares, firms with large asset size and elder firms have a tendency of application, registration and new products.

The results of this study suggest that in China, leading-edge innovation was driven by state-owned firms, particularly state-owned firms which have strong supports from government, while new products that respond to market needs are mostly developed by the private firms.

I Introduction

Until now, China has been able to achieve high growth of its economy. However, without falling into the middle-income country trap, there is a need for innovation in order to maintain sustainable economic growth. In recent years, as seen from the series of policies of the Chinese government, China is attempting to transform into an innovative country from a low-cost production base.

In this study, we analyze the activities of the innovation of Chinese firms in terms of shareholder composition by using firm-level financial data and patent data. In particular, we focus on the role of state-owned shareholders to reveal the reality of innovation activities in China. The definition of innovation is "implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business…." (OECD, 2009, pp. 11-12). In this study, patent applications, patent registration and the production of new products are used as indicators of innovation.

So far, there is little accumulation of research on the patent activity of Chinese firms, with most previous research being study on innovation in relation to economic environment changes or shareholder composition. Based on the previous studies, this study analyzes the innovation strategy of firms with different compositions of shareholders. Especially, we focus on the differences between central state-owned firms and local state-owned firms.

In addition to analyzing the differences between state-owned firms and private firms, we also analyze the different impacts of the local state-owned shareholders and the central state-owned shareholders, and the impacts of the privatization on innovation activities. Moreover, we classified firms into two types: PPF and PFF. Furthermore, we not only focus the registration and application of patent activity, but also focus on the production of new products.

First, there is a tendency that central state-owned firms and local state-owned firms produce new products. However, we only observed the tendency of patent application and registration for central state-owned firms. Second, regarding the effect of privatization on innovation, we find that firms that have been privatized to domestic private firms reduce patent application or registration and tend to new product production. However, we do not find any significant effect on firms that have been acquired by foreign firms. Third, our analysis shows that firms with high competitive pressures from foreign firms, export firms, debtless firms, firms with large market shares, firms with large asset size and elder firms have a tendency of application, registration and new products.

The results of this study suggest that state-owned firms, particularly state-owned firms that have strong supports from government, do innovation activities aggressively in present China.

II Data Set

In the present study, we analyze the impact of shareholders on firms' innovation activities by using the patent database and manufacturing firm database of China. Patent data were collected by the China Intellectual Property Office (SIPO) and were sold by intellectual property publishers that are under the umbrella of the SIPO. The data is from 1985 to 2011, and we only use the data on invention patents in this paper.

The manufacturing firm database for China is sold by GTA, Co., Ltd, and the period is 1998-2008. This database has the basic financial information of all of the manufacturing firms with more 50,000 RMB capital stock. The number of firms has increased over the years, recording the number of firms from 160,000 in 1998 to more than 300,000 in 2007. It indicates that, together with the economic growth, the amount of firms with more than 50,000 RMB capital stock increased. This database has been used widely in the research field of the Chinese economy.

In addition, the data of the central state-owned firms was collected by hand from the homepage of each central state-owned firm.

In order to carry out the empirical analysis of this study, we matched a name and year by using the patent database and manufacturing firm database. About 30% of firms who filed a patent application can be matched (Figure 8). So, we think that using the matching data, we should be able to capture some extent of the patent activity of Chinese companies.

III Empirical Model

In this paper, firstly, we analyze the characteristics of innovative firms in China in terms of patent applications, patent registration and the production of new products. Then, we analyze how privatization has effects on the innovative activities. In particular, we divide the sample into a central state-owned firm group and local state-owned firm group. In this section, the estimation model and variables to be used for each analysis will be described.

1 What Kind of Firms Like to Do Innovation?

We estimate the following three models to analyze the features of innovative firms.

$$
\begin{aligned}
\text{Appilication}_{it} = {} & \beta_0 + \beta_1 Comp_{i,t-1} + \beta_2 Comp2_{i,t-1} + \beta_3 Centralstate_{i,t-1} + \beta_4 Localstate_{i,t-1} \\
& + \beta_5 Exportdummy_{i,t-1} + \beta_6 Longdebt_{i,t-1} + \beta_7 saleshare_{i,t-1} + \beta_8 saleshare2_{i,t-1} \\
& + \beta_9 Lnast_{i,t-1} + \beta_{10} Age_{i,t} + \sum_{\tau=1}^{n} \gamma_\tau Industry_\tau + \sum_{\theta=1}^{n} \varphi_\theta Province_\theta + \sum_{t=1}^{n} \alpha_t Year_t + \varepsilon_{it}
\end{aligned}
$$

$$(1)$$

$$
\begin{aligned}
\text{Grant}_{it} = {} & \beta_0 + \beta_1 Comp_{i,t-1} + \beta_2 Comp2_{i,t-1} + \beta_3 Centralstate_{i,t-1} + \beta_4 Localstate_{i,t-1} \\
& + \beta_5 Exportdummy_{i,t-1} + \beta_6 Longdebt_{i,t-1} + \beta_7 saleshare_{i,t-1} + \beta_8 saleshare2_{i,t-1} \\
& + \beta_9 Lnast_{i,t-1} + \beta_{10} Age_{i,t} + \sum_{\tau=1}^{n} \gamma_\tau Industry_\tau + \sum_{\theta=1}^{n} \varphi_\theta Province_\theta + \sum_{t=1}^{n} \alpha_t Year_t + \varepsilon_{it}
\end{aligned}
$$

$$(2)$$

$$
\begin{aligned}
\text{New}_{it} = {} & \beta_0 + \beta_1 Comp_{i,t-1} + \beta_2 Comp2_{i,t-1} + \beta_3 Centralstate_{i,t-1} + \beta_4 Localstate_{i,t-1} \\
& + \beta_5 Exportdummy_{i,t-1} + \beta_6 Longdebt_{i,t-1} + \beta_7 saleshare_{i,t-1} + \beta_8 saleshare2_{i,t-1} \\
& + \beta_9 Lnast_{i,t-1} + \beta_{10} Age_{i,t} + \beta_{11} Application_{i,t-1} + \sum_{\tau=1}^{n} \gamma_\tau Industry_\tau + \sum_{\theta=1}^{n} \varphi_\theta Province_\theta \\
& + \sum_{t=1}^{n} \alpha_t Year_t + \varepsilon_{it}
\end{aligned}
$$

$$(3)$$

Here, i is the firm, t is the year, τ is the industry and θ represents the region (province). β, γ, φ and α are coefficients and ε is the error term.

In this study, three indicators are used as dependent variables. *Application* is a patent application dummy variable (1 if a firm filed patent applications, 0 otherwise). *Grant* is a patent registration dummy variable (1 if a firm registered patents, 0 otherwise). New is a new products dummy variable (1 if a firm produce new products, 0 otherwise).

Comp is in the market share of foreign firms vis-à-vis industry; *Comp2* is the square of the market share of foreign companies vis-à-vis industry; *Centralstate* is a dummy of the central state-owned firms (1 if a firm is central state-owned firms, 0 otherwise); *Localstate* is the local state-owned firms dummy (1 if a firm is a local state-owned firm, 0 otherwise); *Exportdummy* is a dummy of exports (1 if a firm export products, 0 otherwise); *Longdebt* is long-term debt ratio (long-term debt / total assets); *Saleshare* is the share of the sales of the industry companies (sales / total industry-wide sales); *Saleshare2* is the squared market share (sales / industry-wide sales); *Lnast* is the total assets of the companies that took the logarithm; *Age* is the firm age.

Besides the above variables, an industry dummy, year dummy and regional dummy are also added to the estimation equation. Since whether or not to produce new products is affected by the situation of innovation activities in the previous fiscal year, we also add previous *Application* in equation (3).

2 The Effects of Privatization on Innovation

Since privatization is not chosen in a random manner (for example, companies with originally low innovation capability are likely to be privatized), the selection bias will occur when we estimate the effect of privatization on the innovation activities. Therefore, it is necessary to use a propensity score matching method (propensity score matching).

In this study, first we estimate the probability of being privatized, and then analyze the average treatment effect of the privatization by Kernel matching and Caliper matching. Following Bai et al. (2009), Todo et al. (2014), we use the following logit model (4) and (5) to obtain the probability of being privatized.

$$
\begin{aligned}
\text{Pri\_dome}_{it} = {}& \beta_0 + \beta_1 Comp_{i,t-1} + \beta_2 Profit_{i,t-1} + \beta_3 Liquidity_{i,t-1} + \beta_4 Longdebt_{i,t-1} + \beta_5 Saleshare_{i,t-1} \\
& + \beta_6 Saleshare2_{i,t-1} + \beta_7 Sbjct_{i,t-1} + \beta_8 Lnemp_{i,t-1} + \beta_9 Age_{i,t} + \sum_{\tau=1}^{n} \gamma_\tau Industry_\tau \\
& + \sum_{\theta=1}^{n} \varphi_\theta Province_\theta + \sum_{t=1}^{n} \alpha_t Year_t + \varepsilon_{it}
\end{aligned}
$$

$$(4)$$

$$
\begin{aligned}
\text{Pri\_foreign}_{it} = {}& \beta_0 + \beta_1 Comp_{i,t-1} + \beta_2 Profit_{i,t-1} + \beta_3 Liquidity_{i,t-1} + \beta_4 Longdebt_{i,t-1} + \beta_5 saleshare_{i,t-1} \\
& + \beta_6 Saleshare2_{i,t-1} + \beta_7 Sbjct_{i,t-1} + \beta_8 Lnemp_{i,t-1} + \beta_9 Age_{i,t} + \sum_{\tau=1}^{n} \gamma_\tau Industry_\tau \\
& + \sum_{\theta=1}^{n} \varphi_\theta Province_\theta + \sum_{t=1}^{n} \alpha_t Year_t + \varepsilon_{it}
\end{aligned}
$$

$$(5)$$

Here, i is the firm, t is the year, τ is the industry and θ represents region (province). β, γ, φ and α are coefficients and ε is the error term.

Pri_dome is that a state-owned firm is privatized to a domestic private firm (1 if a stated-owned firm has changed to domestic private firm, 0 otherwise).

Pri_foreign is that a state-owned firm is acquired by a foreign firm (1 if a stated-owned firm is acquired by a foreign firm, 0 otherwise).

Comp is in the market share of foreign firms vis-à-vis industry; *Profit* is the revenue ratio (income /

total assets); *Liquidity* is the liquidity ratio ((current assets - current liabilities) / total assets) which shows the abundance of internal corporate funds. *Exportdummy* is a dummy of exports (1 if a firm exports products, 0 otherwise); *Longdebt* is long-term debt ratio (long-term debt / total assets); *Saleshare* is the share of the sales of the industry companies (sales / total industry-wide sales), and *Saleshare2* is the squared sales share. *Lnast* is the total assets of the companies that took the logarithm. *Sbjct* is the level of government that firms belonged to (central government, provincial government, municipal

government, six of the classification, such as the county government). *Age* is the firm age. In addition to the above variables, an industry dummy, year dummy and province dummy were also added to the estimation equation.

Since Heckman (1997) suggests that there is a need to match in the same labor market, in this study, we match the sample in the same year and the same industry. Furthermore, to eliminate time-invariant effects to obtain more clearly the effects of privatization, we use difference-in-difference (DID) PSM to estimate.

We compare the change of outcome variables from t-1 to t, from t-1 to t+1 and from t-1 to t+2. Here, outcome variables are the number of patent applications, the number of patent registrations and the new product dummy (*New*).

IV Empirical Results

1   What Kind of Firms Like to Do Innovation?

First, let's look at the coefficients of competitive pressure from foreign firms (*Comp*). The sign is significantly positive for *Application*, *Grant* and *New*, indicating that there is a positive effect of foreign competition on the firms' innovative activities. The reason is that if firms encounter the pressure of competition from foreign firms in the industry, the firms have a tendency of innovation activities. On the other hand, the square of the competition by foreign firms (*Comp2*) was found to have significantly negative impact on the three of the innovation index, indicating that if the competition from foreign firms exceeds a certain level, firms will not perform innovation activity. In a word, we find in China, the effect of foreign firms' competition is an inverted "U." This result is consistent with Aghion et al. (2005) that analyzes US firms.

Next, let us take a look at each of the innovation behaviors of the central state-owned firms and local state-owned firms, which is the main focus in this study. *Centralstate* has significantly positive impact on the three innovation indexes. On the other hand, *Localstate* has a negative impact on patent application or patent registration, and has a positive effect on new products. As mentioned above, as many of the central state-owned firms are important firms of key industries, they are responsible for the state of technological development. Therefore, they often participate in government-led innovation projects (for example the 863 plan or star fire plan). On the other hand, the major roles of the local state-owned firms are tax payment and maintenance of employment. Hence, local state-owned firms tend to produce new products rather than patent application and registration.

The export dummy (*Exportdummy*) have significant positive impacts on three innovation indexes. In general, export firms can access overseas markets easily and they tend to improve their products to meet the needs of foreign markets. So, it is considered that there is a tendency to carry out innovation activities in export firms. This result is consistent with Aw et al. (2010) showing that export has positive effects on innovation.

The long-term debt ratio (*Longdebt*) has negative effects on three innovation indexes. These estimated results indicate that it is difficult to secure funds to carry out innovation when firms have a higher long-term debt ratio.

In addition, *Saleshare* has positive impacts on the innovation activities, however *Saleshare2* has significantly negative impacts. This means that firms with a large sales share tend to innovate, but when the sale share exceeds a certain level, firms will not be likely to innovate.

Schumpeter argues that companies with a certain large scale and market power tend to innovate (Schumpeter hypothesis). Our estimated results show that *Lnast* has significantly positive impact on the three innovation indexes. This demonstrates the Schumpeter hypothesis in China. We also find that, the higher the age of the firm, the higher the tendency to perform innovation.

2   The Effects of Privatization on Innovation

Panel A of Chart 24 shows the innovation changes in the PFF. We do not find any significant changes on the innovative activities in terms of the amount of applications, the amount of registrations and the dummy of new products.

Panel B of Chart 24 shows the changes in the PPF. In the first and second years after privatization, it shows that the number of patent applications and the number of patent registrations have decreased. On the other hand, we find that firms tend to produce new products in the second and third year.

Based on these results, it can be considered as follows. First, most of the firms that have been acquired by foreigners often play a role as the production plants of foreign firms. So, these firms are originally manufacturing plants and they are not innovative firms. So, there is no change in their innovative activities, even after it has been acquired by foreign firms. However, it is considered that there may be some changes that cannot be observed in this study. For example, it is considered that there has been a change in the cost reduction and productivity.

Secondly, for PPF, after the privatization, they tend to improve their profit. Therefore, they may stop patents that will not lead immediately to profits, and they are likely to carry out new products that lead to immediate profits.

To confirm the robustness of the estimation results, we also estimate DID PSM by using the Caliper (0.05)

matching method. The results are shown in Figure 25, and the results are very similar to Figure 24.

V Conclusion

Intellectual property systems are a basic infrastructure in order to maintain economic growth. They not only affect China's sustainable growth, but also foreign firms' strategies on the Chinese market including Japanese firms.

This study analyzes the innovation strategies of firms in China in terms of central state-owned firms, local state-owned firms and privatization of state-owned firms. Features of this study can be concluded as follows. First, we merge two large-scale databases (patent database and Chinese industrial firm database) to analyze the effects of state-owned share and privatization on innovation. Second, this study analyzes state-owned firms by dividing them into central state-owned firms and local state-owned firms.

Our estimated results are as follows. First, there is a tendency that the central state-owned firms and local state-owned firms produce new products. However, we only observed the tendency of patent application and registration for central state-owned firms. Second, regarding the effect of privatization on innovation, we find that firms that have been privatized to domestic private firms reduce patent application or registration and tend to produce new product. However, we do not find any significant effect on firms that have been acquired by foreign companies. Third, our analysis shows that firms with high competitive pressures from foreign companies, export firms, debtless firms, firms with large market share, firms with large asset size and elder firms, have a tendency of application, registration and new product production.

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