Innovative behavior and the Chinese enterprise survival risk: An empirical study

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The Chinese firms face enormous survival risk duing economic transition, with an average life expectancy of less than 4 years. From the perspective of enterprises' innovative activities, this paper conducts dynamic tracks on the survival situation of those enterprises entering the market after 2000. By employing propensity score matching and Cox model to overcome the difficulties such as sample bias and censoring of data with long duration, the inhibitory effect of innovative activities on enterprises' survival risk has been captured and investigated in both static and dynamic dimensions. The findings are as follows. First, compared with the non-innovative enterprises, the innovative enterprises own higher competence of risk resistance, as innovative activities can release about 12% survival risk for enterprises and extend their survival time by 0.84 year. Second, the influence of innovative intensity on the enterprises' survival probability presents the characteristics of being non-stationary rather than proportional, which means the stronger innovative intensity will not necessarily bring more obvious inhibition effect. Third, the characteristics of being different within enterprises will change the effect of innovation activity on inhibiting survival risk. The survival incremental effect of large-scale enterprises with high productivity through innovative activities is more apparent, as innovative activities help to relieve the agglomeration of survival risk from those long-established enterprises. But those enterprises with financing limit are not suitable for innovative activities. Then, it must be one of the main priorities for China's government in formulating current and future policies about industrial organization to encourage enterprise independent innovation through a series of measures.

Keywords: innovative behavior, survival risk, Cox risk model, treatment effect

1. Introduction

As China's market-oriented reform steps gradually into the "abyssal region", its macro environment has also become increasingly dynamic and complex, putting forward higher demands for the business to conduct continuous operation. At this stage, a large number of enterprises with low efficiency choose to or are forced to leave the market, even including many reputable household names of century-old shops such as Wang Mazi and Zhang Xiaoquan, both of which have undergone profit

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decline, suspension or even bankruptcy. A large number of literatures have shown that high dropout rates from the market are a striking feature of China's transitional process, which can be testified by most of the industry with the characteristics of high dropout rates (Caves, 1998). According to the statistics made by Mao and Sheng (2013) on the Chinese manufacturing enterprises exiting from the market from 1999 to 2006, there had been an average about 17% of the incumbent firms exiting the market each year. Setting aside whether this high flow characteristic can improve China's macro economic efficiency, a more direct and realistic problem is that facing enormous survival risk, Chinese enterprises usually can only successfully operate business in a quite short period. According to the statistics from White Paper of Human Resources Management on China's Small and Medium-sized Enterprises, the average survival time of Chinese companies is about 3.6 years, among which the average survival time of the small and medium-sized enterprises is much shorter, at around only 2.5 years, far less than those Euro-American counterparts with an average life expectancy of more than 40 years. It is safe to say that most Chinese enterprises have been repeating the path on which they make a fortune for the first year, get richer in the second, but fail in the third. Only a scantly few companies sustain and expand their scale. There fore, how to reduce the enterprises' survival risk and increase the enterprises' survival time is an extremely important research topic for Chinese scholars.

In recent years, there are already literatures focusing on the decisive factors related to the Chinese enterprises' survival risk, such as system evolution, market selection, international trade have been proposed (Yu *et al*., 2015; Xiao *et al*., 2014; Yu *et al*., 2014). However, there is a fact which is easily ignored by policy makers and theory circle - the ratio between research and development spending and sales revenue of all the enterprises exiting the market in 2006 was around 0.036%, far less than that of incumbents at 0.045%. This incurs a question naturally: does zero innovation increase the risk of enterprises' survival and shorten their survival time in the market? Recently, it has been clearly put forward in the report at 18th Party Congress that China will implement the national strategy of innovation-driven development which stipulates that the innovation drive is the requirement of the transformation of economic development pattern at the macro level and the source of innovation drive is to improve enterprise efficiency at the micro level. Therefore, to answer these questions will help inspect the microscopic approach by which the efficiency of the enterprise survival is improved by innovation-driven strategy.

In the early 1930s, Schumpeter put forward the viewpoint of "creative destruction" on industrial evolution. "Creative destruction" is the typical characteristics of market economy whose structure is created and destroyed by the competition on innovation among different main bodies. Each destruction can eliminate some backward production technology and production methods, leading enterprises to merger or perish (Hopenhayn, 1992). The evolution model made by Ericson and Pakes (1998)

provided an important theoretical perspective for the relationship between innovation and survival. Assume there is self-selection effect of production efficiency distribution in the market, enterprises can change the productivity efficiency distribution by researching and developing investment activities as well as technology. If the enterprises' productivity is lower than the lowest productivity required remaining in the market, the enterprise will exit the market through the selection effect. Such exit can be understood as a process in which the enterprises with higher productivity caused by innovation squeeze those with lower productivity out of the market as a result of innovation. It is undeniable that innovative activities will not necessarily enhance the distribution of the enterprises' productivity distribution, as innovation implies a high degree of uncertainty which may worsen the productivity distribution of the enterprise.

In empirical studies, the relationship between innovative behavior and enterprise survival has always been a hot issue in the field of micro research. But so far, there are many contradictions in existing literature, and no uniform conclusion. There is one viewpoint that regards innovation as the essence of the enterprise survival from the perspective of industrial organization. Only innovative companies can establish and maintain a competitive advantage in the market, making enterprises' profitability significantly higher than that of the non-innovative enterprises. Thus the enterprises' duration in the market will expend (Mahmood and Audretsch, 1995; Geroski, 1995; Fontana and Nesta, 2010). Esteve *et al*. (2010) has measured and calculated the exit risk for enterprises conducting financial innovative activities, concluding that their risk rate is 57% lower than those not. This gap is more prominent in export enterprise. Cefis and Marsili (2005) have further measured the survival premium of successful innovation on the basis of transition probability matrix and found that successful innovation can increase enterprises' survival time by about 11%.

The alternative view is developed in recent years, according to that the relationship between innovation and enterprise survival is complex and regulated by many factors. For instance, the difference on characteristics inside the enterprises and the difference in the industry cause a great amount of uncertainty between innovation and survival time. Esteve and Manez (2008) found that only in the highly innovative industry can innovative behavior extends the survival time in the market. Bayus and Agarwal (2007) also think that the industrial difference is one of the important conditions to establish such relationship which is relatively longer in technology-intensive industries. There are also some other similar study (Chen and Wang, 2014; Huang, 2010). In the study on the adjustment of the difference on enterprises' internal characteristic, Argils and Moreno (2007) argue that only in small enterprises can this positive correlation be set up. Cefis and Marsili (2005) found the highest survival premium resulted from innovation exist in newly-established and small scale enterprises by nonparametric method and a 23% increase of survival probability was found in young small

businesses. Esteve (2010) considered the characteristics of enterprises to export. Buddelmeyer (2010) focused on the enterprises' capital scale, while Xiao *et al.* (2014) analyzed the expansion of enterprise behavior.

In general, there are already a few studies into the survival effect of innovative behavior in existing literature, although there is no uniform conclusion yet. By contrast, systematic study of Chinese enterprises' survival from the angle of innovation is very scarce. In fact, for China's economy in the rapid transformation, the innovation incentive of the enterprise survival is particularly worthy of our attention and research. At present stage, Chinese companies especially for small and medium-sized enterprises whose innovation impetus are grossly inadequate are generally reluctant to invest in innovation. On the one hand, market uncertainty and high transaction cost lead to great cost for innovational failure which is likely to cause the enterprise bankrupt or even to be expelled from the market. On the other hand, the imperfections in such laws as protection of intellectual property rights and property rights system lead to a rather low enterprise innovation premium rate. The former causes enterprise too timid to undertake innovation, while the latter can lead enterprises "unwilling" to innovate. This paper aims to reveal that innovative behavior can bring enterprise with survival premium and can effectively reduce the enterprises' survival risk in order to extend their survival time. Therefore, the empirical research in this paper can be the basis for Chinese enterprises to make investment into innovation, especially for small and medium-sized enterprises, which will further support innovation-driven national strategy.

Compared with the existing literature, there has been obvious improvement on research methods within this paper. That is, the solution for problems such as sample selection bias and censoring of data with long duration through the method of matching scores for tendency and Cox survival model. On the one hand, it is undeniable that there exists obvious selection bias problem in this article's sample data. Enterprises' innovative behavior is not randomly distributed, but is the result of their own choice. Enterprises' survival time has a positive impact on the development of new products and innovation output (Sivadas and Dwyer, 2000; Tripsas and Gavotte, 2000). In order to solve this problem, this paper tends to use the method of propensity score matching to construct a controlling group which has similar main characteristics of the enterprise before conducting innovative activities and then to capture the average differences in survival time of the experimental group and control group to avoid selectivity bias problem of samples. On the other hand, there are usually data censoring problem for data with long duration. This means that when the study being, some companies already existed in the market, or when the study end, some companies have not been withdrawn from the market. We then adopt the following measures. Firstly, eliminate the samples already existed before 2000, and track the dynamic like the life cycle of those enterprises entering the market after the year 2000 in order to overcome left

merge problem. Secondly, whether using a virtual variable to record observations of individual enterprise cycle is complete and whether Cox survival model can solve the problem in the duration data's right merge.

2. The innovative behavior and the statistical fact of Chinese enterprises' survival time

2.1. Sample data

The data in this paper are from "China's Industrial Enterprise Database" spanning from 2000 to 2007. This database includes all the basic information and financial data of the state-owned and non-state-owned enterprises above designated size. In order to improve the accuracy of the estimated results, we take a preliminary screening by referring to literature written by Yu Jiao (2015). Obviously, the survival time of the enterprise in the market should be classified as data with a long duration. For this kind of data, there is usually problems with data merging problems (censoring), which means when the study began, some companies already exist in the market, or when the end of the study, some companies have not been withdrawn from the market. In general, this merge problem produces the estimation errors. To improve the accuracy of survival estimate, we take the year 2000 as the base, delete enterprises existing before 2000, so we can overcome the problems of left merge for data with a long duration.

We identify the enterprises' survival time in market mainly through the enterprise code in database. Similar to Yu *et al.* (2015) and Namini (2013), we define enterprises' survival time in the market as the period in which the enterprise entered the market for the first time until it exited. If the enterprise code does not exist in time t, but appears in time t+1, then we can basically make the judgement that the enterprise enters the market in time t+1. So is the definition of its exit. In addition, in order to further improve the accuracy of identifying individual enterprises, we also match information such as name, telephone number and postal code and ensure observation samples of the same enterprise attached with the same code. There is one point that is worth special attention, the subjects covered by the database are all state-owned enterprises and non-state-owned enterprises above designated size. Then, in enterprise code, there may be cases of erroneous judgement on enterprises in which the enterprises are mistaken as entry firms but are actually sustaining with changes on scale or the enterprise disappears but appear again years later. We find that of all the companies entering the market after 2000, there are fault samples in a total of 1436 enterprises. To simplify the process, we will eliminate these samples.

As there is no accurate method to measure the intangible assets from the perspective of accounting standards, and the measurement on innovation by existing research is almost dependent on proxy variables, the most common measures are R&D

(Esteve and Manez, 2008) and the number of applied patent (Cockburn and Wagner, 2007). These two indicators represent the different stages of enterprise innovation. Patent number measures the output of innovative activities, but this only represents a small portion of the original innovation activity (Kleinknecht *et al*., 2002), and the distribution of patent information is highly left-skewed (Harhoff *et al.*, 1999). R&D can accurately reflect the current innovative behavior, and also can measure the enterprises' innovative process, so R&D spending is a reasonable variable of enterprises' innovative activities. The practice of Lin (2013) can be referred to use the new product production in database as the proxy variable of R&D. Finally, the number of sample enterprises after screening is 39762, among which 28351 companies belong to the category of non-innovative enterprises and 11411 innovative enterprises accounting for 28.70% of total samples.

2.2. The preliminary statistical analysis of Chinese enterprise survival time

Because of the complexity of the data structure, non-parametric estimation methods such as risk function and survival function are generally used in the analysis of data with a long duration to track the distribution features of the individual enterprises' survival time (Chen *et al*., 2012). These methods do not require prior assumptions on the probability distribution of the data, also do not need to estimate parameters, so it is more suitable for exploratory analysis. Survival function S (t) refers to the probability of individual enterprises' survival time exceeding time t. If there is no problem of right merge in the data structure, we can simply define the survival function as the proportion of the enterprises whose survival time exceeds time t among all enterprises. Otherwise, Kaplan Meier estimator is needed for analysis, for in the case of independent merge it is still a consistent estimator of S (t).

Based on survival analysis method, we estimate the survival status of those enterprises entering the market after 2000. Two typical facts can be found in table 1. First, generally speaking, the duration of the Chinese enterprises' market management is very short, with an average of survival time of just 4.89 years. The number of enterprises whose survival time is above 8 years accounted for only 10.89%, which is far lower than the average level of developed countries, showing that in the process of market transition, dynamic market environment put forward a bigger challenge for the enterprise to continue its operation, which is inevitably accompanied by characteristics of high market flow including entry and exit. The enterprise that has just entered the market faces huge risk of being expelled from the market, which can be illustrated by 23.53% of enterprises dying in the first year and 56.57% of enterprises whose survival time is less than 4 years. The distribution of survival time presents typical features of right avertence, which implies that only a small number of firms survive longer than average survival time. This means that with the background of economic transition,

there is a lower chance for enterprises just entering the market to survive. But after the initial phase, their life expectancy begins to increase (Audretsch, 1995; Audretsch and Mahmood, 1995).

In the second place, from the perspective of classification of innovative enterprises and non-innovative enterprise group, we can find that the performance of innovative enterprises or those with a survival time of more than 8 years is much more steady than non-innovative enterprises in both the average survival time and the exit status in the first year of coming into the market. The average survival time of innovative enterprise is 6.32 years, nearly 50% higher than the non-innovative enterprise whose average survival time is 4.31 years. The proportion of exit among innovative enterprises is only 15.57%, about 10% lower than non-innovative enterprises whose ratio of survival within one year is 25.83%, while innovative enterprise with 8 years of continuous operation account for 16.41%, far higher than the ratio of innovative enterprise at 9.19%.

Table 1
The distribution of survival time of Chinese enterprises (entering the market after the year 2000)

	Average survival time	Number of enterprises	The proportion of survival time			
			1 year	2~4 years	5~7 years	8 years and above
Innovative enterprises	6.32	11411	15.57%	29.68%	38.34%	16.41%
Non-innovative enterprises	4.31	28351	25.83%	35.82%	29.16%	9.19%
All enterprises	4.89	39762	23.53%	33.04%	32.54%	10.89%

Based on Kaplan Meier survival function in figure 1, the innovative enterprises and the enterprises' survival time of survival function estimation, we can clearly find that on the one hand, with the passage of time, both the innovation and the innovation of enterprises' survival probability is gradually reduced, especially for the non-innovative enterprises, their survival probability is significantly reduced, and on the other hand, the difference between the survival probability of innovative enterprises and non-innovative enterprises appeared to be enlarged year by year. This suggests that with the passage of the time, innovative enterprises' survival probability will be significantly greater than the innovative enterprises. Further, figure 1 also describes risk function of both the innovative and non-innovative enterprises. It can be found that although the tendency of the risk function of two kinds of enterprises is roughly same, there exists higher risk of failure in the non-innovative enterprises than the innovative enterprise, with the difference on risk of failure at about 30%, which means that the innovative enterprises have better ability to resist risk.

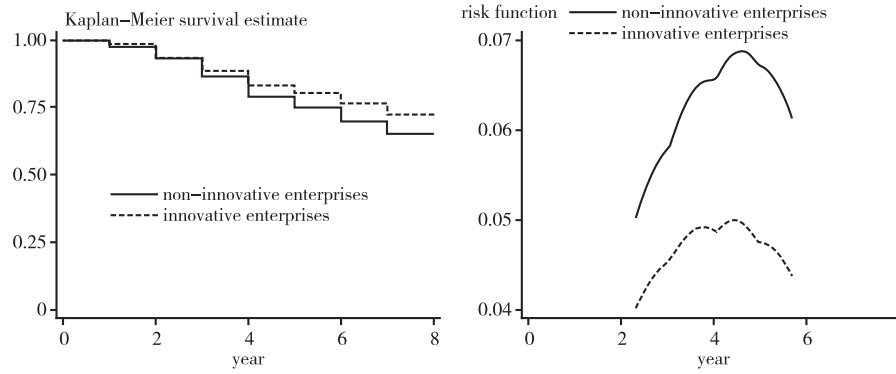

Figure 1. Kaplan Meier survival curve and risk function of innovative enterprises and non-innovative enterprises

3. Research design

This study aims to reveal the influence of enterprises' innovative behavior on enterprises' survival risk, namely whether there is a causal relationship between innovative behavior and enterprises' survival risk. Before designing study methods, we need to sort out the fact that there may be a logical relationship that enterprises' innovative activities may be affected by the enterprises' survival time. Although there is no consensus in theoretical circle on the impact of enterprises' age on innovative activities. It is undeniable that enterprises' age is an important factor influencing innovative activities (Chen and Bao, 2015; Coad *et al*., 2010). For Chinese companies, in particular, imitation innovation is one important driving force of China's economic growth in the past 30 years. The absorption of the imitation innovation can be gained through the long time survival in the market of the enterprise. That is to say, the enterprise innovative behavior is not randomly distributed, but is the result of the enterprises' own choice. Innovative behavior is not only a factor affecting the enterprises' survival time, but also likely to be a result of the enterprises' continuous survival. It is safe to say that there is severe selection bias in research samples in this paper. So, we need careful study design to overcome the problem of selection bias resulting from reverse causation.

By using the propensity score matching method, we artificially construct a group of enterprises with similar main characteristics with those innovative enterprises prior to innovation to simulate the treatment effect. Propensity score matching method is a widely recognized appropriate method to deal with the binary variable in theory circle. The main idea of propensity score matching is as follows. First, set the innovative enterprise as the experimental group and then build a control group with similar

characteristics to innovative enterprises before the innovation. Second, eliminate the differences on characteristics of those individual enterprises in different groups by matching the subject of control group with experimental group to ensure that there is only difference on innovative behaviors between them, which will simulate the survival characteristics of those non-innovative enterprises in the condition of "zero innovation". Third, compare the average difference on survival time between control group and experimental group to capture the causal relationship between the enterprise innovative behavior and survival time.

3.1. Propensity score matching

3.1.1. Identify experimental group and control group

According to whether there is innovational behavior, we classify samples into experimental group and control group. Experimental group is designed to be a group in which new product value is above zero, while control group includes non-innovative enterprises whose new product value is zero. We establish a binary virtual variable $Creation_{it} = \{0, 1\}$, that innovative enterprisess' value is 1 and the value of non-innovative enterprise is 0. Set enterprises' survival time as Time, then the average effect of the innovation on the enterprises' survival time is:

$$E\{Time_{it}^{1} - Time_{it}^{0} \mid Creation_{it} = 1\} = E\{Time_{it}^{1} \mid Creation_{it} = 1\} - E\{Time_{it}^{0} \mid Creation_{it} = 1\} \tag{1}$$

In this formula, $Time_{it}^{1}$ refers to innovative enterprises' survival time and $Time_{it}^{0}$ refers to non-innovative enterprises' survival time. In the above formula, $E\{Time_{it}^{0} \mid Creation_{it} = 1\}$ refers to the survival time of innovative enterprise before innovative behaviors, which is a counter fact.

3.1.2. Data matching

The process of matching data is the key step in propensity score matching, aiming to ensure the matching variables of successfully matched control group and experimental group as alike as possible. The matching variables need to be designated in propensity score matching, a factor that influences enterprises' innovative behavior and enterprises' survival simultaneously. According to the existing theoretical and empirical literature, the matching variables we select are as shown in table 2.

Next, we take the Logit method for the regression of binary variables, and regard estimated coefficient of each covariant as weights, fitting out the propensity score of each enterprise.

Table 2
The measurement method of matching variable

Symbol	Name of variables	Measurement methods
Size	Scale of enterprises	Logarithm of enterprise sales, sales deflate in accordance with the producer price index in 2000
TFP	Enterprises' production	Using the OP measure method (1996) to calculate
Finance	Financing constraints	The ratio of interest payments and fixed assets
Capital	Capital intensity	The ratio of fixed assets and employees, fixed assets deflates according to the price index of investment in fixed assets of 2000
Profit	Return on sales	The ratio of operating profit and sales revenue
Resource	Human capital	The ratio of workers with college bachelor degree or above among all staff
Export	Export intensity	The ratio of export delivery value and enterprise sales
Debt	Asset-liability ratio	The ratio of enterprises' liabilities and assets

$$PS(X_{it}) = Pro(Creation = 1 \mid X_{it}) = \frac{\exp(\alpha X_{it})}{1 + \exp(\alpha X_{it})} \tag{2}$$

In this formula, X refers to the matching variable. The score reflects the probability of a certain enterprises' being innovative. Then, we can match the experimental group and control group according to propensity score value. We use recently widely used nearest neighbor matching method inside caliper to search and match the non-innovative enterprises whose score is the most close to the innovative enterprises in a given range of caliper of $\varepsilon \leqslant 0.25\hat{\sigma}_p$. After complete matching, there will be no differences between the matching variables of the experimental group and control group. So, the survival duration $E\{Time_{it}^0 \mid Creation_{it} = 0\}$ of the enterprises without innovative behavior can be used as the replacement of $E\{Time_{it}^0 \mid Creation_{it} = 1\}$, the survival time of an innovative enterprise before innovation. At this point, the only difference left between the control group and experimental group is the innovative behavioral difference.

3.2. The Cox Risk Model

Cox model has obvious advantages in analyzing the data with a long duration, able to skillfully incorporate enterprises' survival time with whether to withdraw from the market. As to the question of the right merge, the Cox model builds a virtual variables to record and check whether the observations cycle of individual enterprise i is complete. At the end of the study period, it is designated that the value of enterprises still surviving in the market is 0, and enterprise samples with a complete observation cycle 1. Through the enterprises' hazard function, the distribution of the enterprises' survival time is estimated, and the probability for the enterprise to exit the market in the future is predicted. This way can we solve the problem of special right merger that the data with a long duration is unable to avoid.

Assume that enterprises face various risk of exiting the market in the process of

continued operation, and its risk function in period t is $\lambda(t; x)$, the risk function can be decomposed into:

$$\lambda(t; x) = \lambda_0(t) e^{x'\beta} \tag{3}$$

In this formula, $\lambda_0(t)$ is the baseline hazard function, which is exactly same for each sample enterprise, independent from the differences among enterprises but only being affected by the factor of time. $e^{x'\beta}$ is the relative risk of the enterprises, x' is the assembly of concomitant variables, while β is the assembly of parameter variables. $x'=(x_1, x_2, \cdots, x_n)$. This formula means that for each increase of a unit in x', new risk rate will be the original e^{β}.

Suppose there are two types of enterprises: i and j whose assembly of covariant are x'_i and x'_j, then the ratio of risk function of enterprise i and j is:

$$\frac{\lambda(t; x_i')}{\lambda(t; x_j')} = \frac{\lambda_0(t) e^{x_i'\beta}}{\lambda_0(t) e^{x_j'\beta}} = e^{(x_i' - x_j')'\beta} \tag{4}$$

Obviously, the ratio between the risk functions of enterprise *i* and *j* will not change as time passes but only relates to x_i - x_j. This enables us to estimate β even without designating the concrete function form for baseline hazard function $\lambda_0(t)$. Specifically, in this study, the risk function of innovative enterprises can be illustrated as $\lambda(t; x_{Creation=1}) / \lambda(t; x_{Creation=0}) = e^{(\Delta x)'\beta}$. We can estimate the assembly of each covariant -coefficient β, through partial likelihood estimate.

Referring to the driving factor of enterprises' survival probability estimated from Cefis and Marsili (2005) transition probability matrix and combining with the special institutional factors related to Chinese enterprises' entering and exit, we select the following indicators as a measure of China's enterprise survival risk covariant.

(1) Return on sales (Profit).Profit is the most fundamental power for enterprises to enter and exit the market. For free access to exit the market, low profit or failure to gain profit or even continuous loss will drain enterprises to gradual death, which can be measured by the ratio between operating profit and sales revenue.

(2) The scale of enterprises (Size). On one hand, large enterprises can achieve economies of scope and economies of scale, in order to reduce the production cost of the products. On the other hand, large enterprises will transfer the signal of high quality products to consumers, thus increasing the products' premium capability. These two aspects can improve the enterprises' survival ability which can be measured by logarithmic of enterprise sales deflating by the producer price index of 2000.

(3) The age limit of enterprises' setting up (Age). It is believed in literature proposing the view of first-mover advantage that enterprises entering the market in an earlier time period would own survival advantage than those later comers by gaining

first-mover advantage in an relatively earlier time period (Kim and Lee, 2011). This can be measured by the formula in which the year of sample observation minuses the year of the enterprises' setting up and then plus 1.

(4) Business productivity (TFP).The lessons from Tian and Yu (2012) can be drawn and OP (1996) method can also be used to measure the productivity of the enterprise.

(5) Export intensity (Export). There has been empirical study showing that the relationship between export strength and enterprises' survival probability appears to be inverted "U" shaped. When export strength is low, the increasing export strength lowers the risk of an enterprise. But when the export strength exceeds a "threshold", export intensity would reduce the enterprises' survival time (Yu *et al*., 2015), which can be measured by the ratio of export delivery value and sales (Chen and Guariglia,2013).

(6) Financing constraints (Finance). This can be measured by the ratio between the differentials gained by liquid assets' deducting liquid liability and total assets (Chen and Guariglia, 2013).

(7) Ownership types (Owner). With special institutional background in China, as the exit mechanism is not perfect, a large number of state-owned enterprises exist in the form of continuing losses rather than directly exiting from the market. We have introduced a virtual variable to measure the factors of corporate ownership, designating state-owned enterprises' value as 1 and non-state-owned enterprises' as 0.

In addition, we also took control of the fixed effects from the perspectives of industry, year and region (Du *et al*., 2012). (i) Industrial dummy variable: establishes dummy variables in two-dimension code industry to control heterogeneity among industries; (ii) Year variables (Year): used to control the change of time and other macroeconomic factors; (iii) Regional virtual variables (Area): to build a binary virtual variable to control the difference on survival risk between coastal area and inland area. Set the value of enterprises in coastal regions as 1 and those not as 0. Here the coastal areas include a total of eight regions, namely, Shanghai, Zhejiang, Jiangsu, Beijing, Shandong, Jiangsu, Fujian and Guangdong. The rest of the 23 areas belong to inland areas. The descriptive statistics of main variables is as shown in table 3.

Table 3
The descriptive statistics of main variables

Name of variables	Symbol	Average	Minimum	Maximum	Standard deviation
Return on sales	Profit	0.061	-1.000	1.000	0.191
Enterprises' size	Size	9.866	3.714	17.275	1.223
Age limit of the enterprises' establishment	Age	5.329	1.000	8.000	1.785
Enterprises' productivity	TFP	501.006	0.072	84607.480	1767.674
Export intensity	Export	0.0675	0.000	1.000	0.215
Financial restraints	Finance	0.067	0.000	1.000	0.215
Ownership type	Owner	0.053	0.000	1.000	0.224
Capital intensity	Capital	9.934	0.000	19.011	1.642
Human capital	Resource	0.346	0.000	1.000	0.247
Asset-liability ratio	Debt	0.853	0.000	1.000	0.158

4. The empirical result analysis

4.1. Results of propensity score matching

We find non-innovative enterprises whose score is the most close to the innovative enterprises within the scope of a quarter of the caliper of standard deviation of propensity score matching ($\varepsilon \leqslant 0.25\hat{\sigma}_p$). In order to ensure the reliability of the matching results, we test the matching results from two aspects - mutual support hypothesis and balance hypothesis. The fulfillment of mutual support means that the distribution form of propensity score between experimental group and control group is nearly the same. By comparing nuclear density distribution characteristics before and after the matching of the experimental group and control group, we find that after a match, the nuclear distribution features of control group and experimental group changes from original low correlation to almost the same. As a result, we can conclude that matching the effective mutual support assumptions are met and matching process significantly improves the distribution deviation of propensity score of the experimental group and control group.

Table 4
Test on the balance of matching variables

T Variables	Samples	Average		Standard Deviation	Decrease range of standard deviation	Value of t
		Experimental group	Control group			
Size	Before matching	8.866	8.204	44.28%	99.2%	14.73
	After matching	8.866	8.853	0.3%		0.57
TFP	Before matching	6.161	5.832	30.4%	97.6%	21.47
	After matching	6.161	6.138	2.5%		1.38
Finance	Before matching	1.133	1.285	-12.7%	50.3%	-8.31
	After matching	1.133	1.126	3.2%		2.44
Capital	Before matching	0.964	0.739	25.9%	85.7%	11.38
	After matching	0.964	0.955	1.8%		0.87
Profit	Before matching	3.624	2.172	60.2%	99.8%	30.16
	After matching	3.624	3.486	6.4%		2.81
Resource	Before matching	0.396	0.335	5.2%	46.7%	2.33
	After matching	0.396	0.391	0.6%		0.05
Export	Before matching	0.160	0.138	8.4%	97.4%	3.61
	After matching	0.160	0.168	-1.5%		-0.52
Debt	Before matching	0.572	0.541	10.3%	89.3%	4.28
	After matching	0.572	0.570	0.4%		0.08

Test hypothesis of matching balance requires to meet $Creation_i \perp X_i \mid P(X_i)$ after the match. This means that in the case of a given figure "$P(X_i)$" of probability of enterprises' innovation, enterprises' innovative behavior and the covariant are independent from each other. We can examine the effects of matching balance by standard deviation.

Standard deviation reflects the difference in the characteristics of variables' distribution among groups. The smaller the value is, the difference will be. If the absolute value of the standard deviation is less than 20, we can think that the matching results are ideal. Table 4 reports the test results of the balance among matching variables. It can be found in table 4 that the vast majority of the absolute value of the standard deviation after the match is less than 5%. That means matching results meet the symmetry hypothesis. As a result, we can consider the matching variable selection as reasonable and matching results reliable. It should be pointed out that propensity score matching only controls the problem of measurable variables selection but can hardly solve the invisible deviation brought by unobservable variables.

4.2. The innovative tendency and enterprise survival risk

After finishing matching effectively, we will estimate the survival risk of 39762 sample enterprises by Cox model. The first question to be answered is whether the enterprises' innovative tendency significantly reduces the their survival risk. Therefore, virtual variables of enterprises' innovation (INNOV) should be introduced. If a certain new product's output value of an enterprise is greater than zero, then the value will be set as 1; otherwise, the value would be 0. It is important to note that $\lambda\ (t; x) = \lambda_0\ (t)\ e^{x'\beta}$ is an important assumption in Cox model. If this assumption is inconsistent, the Cox model would not be used. Before empirical estimates are made, there is a need to set up and testify the model for data of long durations. This test is done with PH hypothesis which is on the basis of Residual-Based Test whose purpose is to calculate enfield residuals of various explanatory variables and then conduct regression of time parameter through residues in order to test whether the estimated time coefficient is zero or near zero. The test results of testing residual variables show that the time coefficients estimated by different residual errors is less than 0.003, indicating that setting of Cox model is reasonable.

Table 5 reports the inspection results of innovation tendency on enterprises' survival risk. It is important to note that our report focus on the risk ratios (Hazard Ratios) between the innovative enterprises against non-innovative enterprises, that is the index from of estimated coefficient. Risk ratio, less than 1, indicates that the variable will reduce the innovative enterprisess' survival risk; equal to 1, indicates that the explanatory variables exert equal influence on both innovative and non-innovative enterprises in terms of survival risk; greater than 1, shows the explanatory variables can increase innovative enterprises' survival risk. Column (1) controls the variables related to enterprises' characteristics, while column (2) further controls the regional effects, trade effects and the year effect. Comparison of the results of column (1) and (2) would enable us to find that after controlling factors outside the enterprise internal control characteristics, there comes an increase in logarithmic likelihood value in

Cox model, that is, the explanatory power of the model increases. This means that the Chinese enterprises' survival risk is not only affected by its own internal characteristics but also by the industry characteristics, the macroscopic characteristics or even regional environment. In terms of the variables of innovative tendency, their risk proportions in the first column (1) and (2) are significantly less than 1, showing that the enterprises' survival risk of experimental group is significantly lower than that of the control group. This implies that innovative activities can lower the enterprises' survival risk in the market, and improve enterprises' survival time in the market. Innovative enterprises' survival risk is about 11%-13% less than that of the innovative enterprises. This conclusion verifies the efficacy of the micro approach of present innovation-driven development strategy formulated by the Chinese government.

Among the internal characteristics influencing the enterprises' survival, the survival risk of state-owned enterprises is significantly lower than that of non-state-owned enterprises. Such conclusion is in line with expectations, for most of the state-owned enterprises that are not expelled out of the market on account of continuous losses or no earnings expectations but due to policy factors. Therefore, we can see a phenomenon that a large number of state-owned enterprises are surviving in the form of loss in the market (Li, 2011). Enterprises' size, age and productivity are negatively related to the innovation enterprises' survival risk, which means that the large-scale enterprises with high productivity of can take advantage in economies of scale, efficiency and ability to resist risks, all of which have reduced the enterprises' risk in the market (Tsvetkova *et al*., 2014; Manjon and Arauzo, 2008; Jensen, 2008). Old enterprises' survival risk, significantly lower than that of young enterprises, would show that there is inertia in old enterprises, increasing the difficulty of the "search matching" and incurring an unavoidable question of survival risk concentration. Extent of financing constraints is positively related to enterprises' survival risk, associated with the degree of, which means to alleviate Chinese enterprises' financing constraints, meaning that easing financial constraints of Chinese enterprises helps to extend the survival time of enterprises (Lu *et al*., 2014). What needs to be pointed out is that profitability and foreign trade do not significantly reduce enterprises' survival risk. Instead, the more enterprises rely on export, the bigger enterprises' survival risk is. This conclusion is vastly different from existing literature (Esteve *et al*., 2010; Tsvetkova *et al*., 2013).

For further inspection of the influence of innovative activities on the internal mechanism of enterprises' survival risk, we add the innovation tendency to interact with the enterprises' characteristic variables, which can be seen reported in column (3). It can be found in the seven interactive items that enterprises' size, age, financing constraints, productivity and innovative tendency all boast the level of level of 10% and pass the test. The risk ratio coefficient between innovative tendency and the enterprises' scale is significantly less than 1, which suggests that innovative behavior will help increase survival time of scale enterprises. Such is particularly apparent in

Table 5
The test result of the innovative tendency on enterprises' survival risk

Explanatory variables	Cox model (index regression)			Cloglog model		Samples of non-state-owned enterprises	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INNOV	0.890*** (0.013)	0.876*** (0.028)	0.851*** (0.029)	0.876*** (0.028)	0.875*** (0.030)	0.855*** (0.030)	0.853*** (0.029)
C	0.520*** (0.015)	0.404*** (0.013)	0.388*** (0.012)	0.402*** (0.013)	0.406*** (0.013)	0.496*** (0.015)	0.473*** (0.015)
Profit	0.964 (0.128)	0.966 (0.128)	0.964 (0.128)	0.966 (0.128)	0.956 (0.124)	0.958 (0.124)	0.963 (0.123)
Size	0.759*** (0.028)	0.656*** (0.003)	0.659*** (0.028)	0.682** (0.003)	0.731** (0.025)	0.754*** (0.025)	0.752*** (0.003)
Age	0.921*** (0.018)	0.833*** (0.017)	0.832*** (0.017)	0.875** (0.017)	0.844** (0.017)	0.882*** (0.020)	0.882*** (0.020)
TFP	0.888*** (0.004)	0.873*** (0.004)	0.888*** (0.004)	0.873*** (0.004)	0.897* (0.004)	0.846*** (0.004)	0.842*** (0.004)
Export	0.894 (0.006)	0.879 (0.006)	0.883 (0.006)	0.873 (0.006)	0.868 (0.006)	0.891 (0.006)	0.892 (0.006)
Finance	0.854 (0.017)	0.831* (0.017)	0.830* (0.017)	0.831* (0.017)	0.830 (0.017)	0.868* (0.016)	0.865 (0.016)
Owner	0.637*** (0.022)	0.614*** (0.023)	0.602*** (0.022)	0.614*** (0.023)	0.602*** (0.023)	0.627*** (0.023)	0.605*** (0.021)
Profit* INNOV			0.970 (0.113)		0.947 (0.108)		0.925 (0.110)
Size* INNOV			0.933*** (0.016)		0.916* (0.015)		0.927*** (0.016)
Age* INNOV			0.821** (0.007)		0.802* (0.007)		0.814** (0.007)
TFP* INNOV			0.870* (0.015)		0.866* (0.015)		0.861* (0.014)
Export* INNOV			0.837 (0.039)		0.835 (0.039)		0.830 (0.038)
Finance* INNOV			1.014** (0.047)		1.006* (0.047)		1.008* (0.042)
Owner* INNOV			1.075 (0.067)		1.244 (0.067)		1.072 (0.071)
Industry	No	Yes	Yes	Yes	Yes	Yes	Yes
Year	No	Yes	Yes	Yes	Yes	Yes	Yes
Area	No	Yes	Yes	Yes	Yes	Yes	Yes
LogLikelihood	-112184.31	-99372.26	-99464.77	-99388.21	-99361.93	-98471.88	-98463.69
Number of samples	184282	184282	184282	184282	184282	123061	123061
Rho Value				0.164	0.168		
Likelihood ratio test of RhoValue				150.31 (0.128)	148.76 (0.111)		

Note: ***, ** and * represent siguificant level of 1%, 5% and 10% respectively, and standard errors are in panentheses; "yes" refers to control in industry, region and year.

the survival incremental effect of the large enterprises. The interaction ratio coefficient of innovation tendency against enterprises' age is significantly less than 1, which suggests that innovative activities help ease agglomeration of the survival risk of those enterprises established long time ago. The conclusion of the two interactive items is consistent with the research conclusions drawn by Cefis and Marsili (2006). The ratio coefficient of the interactive items of innovative tendency against the business productivity, significantly less than 1, suggests that enterprises with high productivity can get more enduring survival time by adjustment on innovation.

It is worth noting that when the risk ratio coefficient of interactive items between financing constraints and innovative behavior is greater than 1, innovative behavior would accelerate the accumulation of risks of financing constraints, thus enterprises with financing constraints should not do any innovative activities. The possible reason is that innovative process requires considerable investment and undertake huge risk (Li and Song, 2010). Once the innovative activities can not be transferred into income in a short period, coupled with the huge restraints for enterprises in the financing channels and methods, enterprises' cash flow will appear a lot of problems that may increase their probability of withdrawing from market. Therefore, for enterprises whose financing is rather limited, we should carefully choose the inputs in innovative activities. This conclusion reflects the dilemma Chinese companies experience at this stage. Especially for small and medium-sized enterprises, they have faced financing difficulties of "uneasy and expensive financing", such as high threshold, unitary ways, narrow channels, high cost the huge funding gap. Under such background of the financing constraints, small and medium-sized enterprises generally do not choose to make investment in the risky innovative activities, for their innovative impetus is insufficient. In addition, return on sales, export intensity ownership type and interactive items of innovative behaviors failed to pass the test of significance, suggesting that the profit ability, export intensity, and differences on ownership can exert adjustment on survival time.

To test the estimation robustness, on the one hand, we refer to the method conducted by Mao and Xu (2015) and adopt Clog log discrete-time survival model to estimate successful matching data. Figures from (4) and (5) report the estimated results in the case of no interaction and with interactive items. Likelihood ratio test of ρ value with two results has accepted original hypothesis of the unobservable heterogeneity. Therefore, this is a further sign of Cox model design's reasonability. On the other hand, considering the particularity of state-owned enterprises' survival time, we extract the samples from the database of all the non-state enterprises, estimate once again with the above-mentioned method and Cox model, and gain the results of (6) and (7). Such test results show that the estimated results have very strong robustness. In addition, we further use Weibull regression to further broaden the value of assumed risk function in index regression, only to find that there is no obvious fluctuations in inspection results.

4.3. The release effect of innovation intensity on the enterprises' survival risk

It has been mentioned that samples are divided into experimental group and control group on the basis of innovation tendency. It has been demonstrated relatively logically that the innovative activities can inhibit the enterprise survival risk. What needs to be pointed out is that this merely reflects the average effect of innovation to the enterprise survival risk. In fact, as some entrepreneurs and scholars concern, while innovation produces "creative destruction" in the dynamics of the industry, the cost of innovation also is significant as an important item of enterprises' spending. In general, the enterprise will not make innovation investment without reservation. Otherwise, the enterprises' cash flow will be tightened with gathered risk.

Next, it is necessary for us to explore some questions. What is the appropriate level for innovation strength? What is the optimal innovation strength level for enterprise survival? To answer these questions, we first define the strength of innovation. Innovation strength (INTEN) is defined as the ratio of enterprises' new products production against sales, and deflates in accordance with the producer price index in 2000. Then, for a more detailed analysis on the heterogeneity effect of innovation strength on the enterprises' survival risk, we order the innovation intensity from low to high and classify the samples as per as quartile into four segments (INTENi, I = 1, 2, 3, 4) - weak innovation strength group INTEN1 [0, 25 %), medium innovation strength group INTEN2 [25, 50 %), strong innovation strength group INTEN3 [50,75 %) and the strongest innovation strength group INTEN4 [75100%). So, heterogeneity effect of the enterprise survival risks can be observed by comparing the size of the estimated coefficient.

Table 6 reports the estimated results of innovative intensity under different quantile intensity. Comparing the estimated results in the above, we have controlled the differences of enterprise s' internal and external characteristics. Column (1) is the regression result of the whole experimental group. The test results show that there is negative correlation between the strength of innovation and enterprises' survival risk. On average, every increase unit of R&D intensity can make enterprise survive in market risk by 28.3%.

Column (2) is an estimated result of segmented experimental group differentiated by the quartile. We can find that, on the one hand, the risk coefficient of INTEN1, INTEN2 and INTEN3 is significantly less than 1, and the absolute value of the three estimated coefficient presents the trend of decreasing after increasing first. Such results show that the influence of R&D intensity to the enterprises' survival risk has non-stationary characteristics rather than proportional one. The stronger research and development is, the obvious its inhibition effect on enterprise risk will be. The relationship between innovation strength and enterprises' survival risk is like "inverted U", meaning the marginal contribution of inhibition effect is gradually reduced. On the other hand, the risk ratio of INTEN4 is less than 1 and does not own statistical significance.

Table 6
Heterogeneity effect of innovation intensity on enterprises' survival risk

Explanatory variables	Cox model (index regression)			Cloglog model		Samples of non-state-owned enterprises	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INTEN	0.717*** (0.019)			0.719*** (0.019)		0.702*** (0.018)	
$INTEN^2$			1.091** (0.028)				
$INTEN_1$		0.825*** (0.012)			0.813*** (0.012)		0.846*** (0.012)
$INTEN_2$		0.664*** (0.018)			0.636*** (0.018)		0.652*** (0.018)
$INTEN_3$		0.798* (0.020)			0.763* (0.024)		0.781** (0.018)
$INTEN_4$		0.913 (0.103)			0.911 (0.102)		0.917 (0.109)
Profit	0.934 (0.125)	0.936 (0.125)	0.937 (0.125)	0.931 (0.122)	0.931 (0.122)	0.925 (0.128)	0.924 (0.128)
Size	0.768*** (0.003)	0.754*** (0.003)	0.768*** (0.003)	0.732*** (0.002)	0.726*** (0.002)	0.754*** (0.003)	0.748*** (0.003)
Age	0.817*** (0.018)	0.815*** (0.018)	0.817*** (0.018)	0.843*** (0.018)	0.840*** (0.018)	0.891*** (0.019)	0.888*** (0.019)
TFP	0.691*** (0.004)	0.680*** (0.004)	0.680*** (0.004)	0.703*** (0.003)	0.703*** (0.003)	0.682*** (0.004)	0.682*** (0.004)
Export	0.927 (0.009)	0.925 (0.009)	0.925 (0.009)	0.942 (0.010)	0.942 (0.010)	0.931 (0.010)	0.933 (0.010)
Finance	0.823* (0.016)	0.823* (0.016)	0.828* (0.015)	0.864 (0.014)	0.864 (0.014)	0.831* (0.015)	0.831* (0.015)
Owner	0.615*** (0.021)	0.618*** (0.022)	0.612*** (0.021)	0.620*** (0.023)	0.620*** (0.023)	0.601*** (0.020)	0.601*** (0.020)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Area	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LogLikelihood	-92184.31	-91463.26	-91632.53	-91768.66	-91226.90	-91242.98	-91488.21
Quantity of samples	184282	184282	184282	184282	184282	123061	123061
Rho Value				0.146	0.142		
Likelihood ratio test of RhoValue				130.77 (0.153)	151.26 (0.138)		

Note: ***, ** and * represent the significant level of 1%, 5% and 10%, respectively. Inside the bracket is standard error; "Yes" means to control on industry, year and region, while the negative means "No"; Quantity of samples signify the observed value instead of the number of individual enterprises.

Such result shows the enterprises fully focusing on innovative activities will not reduce their risk of survival in the market significantly. That is to say, there is an optimal critical level suitable for the innovative enterprises' survival strength. The possible reason is that characteristics of high-risk of innovative activities has made enterprises

with innovation strength face survival risks of inadequate market demand and nervous cash flow in a given year. This conclusion proves partially that the fact that Chinese enterprises lack innovation power, and would rather bear the risk of producing homogeneous products due to low price competition than undertake the risk of failure to innovate.

In order to ensure the reliability of innovation intensity to the enterprises' survival risk, this article has carried on the robustness test as follows. First, introduce quadratic term of innovative strength to further determine the non-equilibrium effect of innovation intensity on enterprises' survival risk. Second, in order to further determine the rationality of the existence model usage Cloglog discrete-time survival model is introduced to make a second estimate. Third, extract all the non-state enterprises' samples and estimate once again by using the above matching method and Cox model. Estimated results from column (3) to column (7) show that the setting-up and regression of the model have high robustness.

6. The conclusion and policy meaning

There is no denying on the fact that Chinese companies are not willing to make investment in innovation during the transition. This paper aims to reveal the inhibition effect of innovative activities on the enterprises' survival risk can prolong the survival time of enterprises. In particular, the targets include using micro-level data of China's industrial enterprises from 2000 to 2007 and investigate the innovative behavior's influence on enterprises' survival time by using quasi natural experiment design. Research results are as follows. (1) The innovative enterprises have better ability to resist risk than non-innovative enterprises, as innovative activities release about 12% survival risk and can increase their survival time of 0.84 years. Each additional unit of the innovation strength can lower the risk of the survival of 28.3% on average, which verifies the efficacy of the micro approach towards enterprises' survival of present innovation driven development strategy formulated by the Chinese government. (2) The inhibition effect of R&D intensity to the enterprises' survival present non-stationary characteristics. When the R&D intensity reaches a certain threshold, the inhibition effect of enterprise risk began to gradually decline. (3) The difference of the enterprises' internal characteristics will change the inhibition effect of innovation activity on survival risk. The incremental effect of innovative activities from large enterprises with high productivity is more apparent, as innovative activities help ease the survival risk agglomeration of enterprises established long time ago. Innovative behavior, however, will accelerate accumulation of risks from financing constraints, so enterprises with financing limit should not conduct innovative activities.

So, to reduce the enterprises' survival risk and increase the longevity of Chinese enterprises and given the conclusion of this article, the Chinese government endeavors

to take measures in identifying the future direction of the industrial organization policy from the following several aspects. On the one hand, improve the enterprises' financing mechanism to make enterprise "dare" to make innovation. This paper concludes that companies with financing limit will accelerate the agglomeration of survival risk in the case of innovation. At present, small and medium-sized enterprises are faced with the problems of financing difficulties of uneasy and expensive financing, narrow channels and universal cowards for innovation. Therefore, only through perfecting enterprises' financing mechanism, alleviating the above-mentioned enterprises' financing difficulties can enterprises be courageous to invest a lot of money on the innovative activities. On the other hand, improve the system of intellectual property protection to make enterprise "willing" for innovation. There is no denying on the fact that China's property rights protection system have a lot of defects including imitation and plagiarism, and Chinese enterprises' innovation premium rate is not high. Therefore, only enough homework is done in terms of the intellectual property system can enterprises' innovation have clear property rights, and increase innovation premium rate. As a result, enterprises will be willing to engage in innovative activities.

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