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What determines innovation in the manufacturing sector at the private firm level? Evidence from China

Esam Elsheikh
har14eel@student.lu.se

Abstract: The objective of this study is to explore the determinant of innovation in the manufacturing sector at the private firm level in china. The data comes from the World Bank survey, China - Enterprise Survey Manufacturing Module (2012). In this paper, I used the broad definition of innovation that includes product and process innovation. Based on the survey answers, I sought to test four hypotheses by employing possible variables linked with key theoretical and empirical models including competition, access to finance, R&D activities and industry as independent variables and controlling for a set of private firm characteristics including age, size and location, among others. I found good evidence supporting two of my hypotheses indicating that access to finance and R&D expenditure are crucial determinists for private firm's innovativeness.

Key words: Innovation, China, private firms, manufacturing sector.

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1. Introduction

By any standard, what China has achieved since the economic reform in 1978 is phenomenal. After the opening up to foreign trade and the implementation of free market reforms, China has consistently been the world's fastest-growing economy, sustaining an average annual growth rate of 10% of (GDP) from 1978 through 2013. In recent years, China has emerged as a major global economical power; the "workshop of the world", the largest manufacturer and currently the world's largest economy after overtaking the US in 2014.

Lin (2013) argues that China basically relied on the advantage of backwardness Gerschenkron (1962) and its comparative advantage of cheap and intensive labour force to achieve the miracle. In the early stages, a shift from agriculture to manufacturing supplied the industrial sector with unlimited surplus of labour force, which in most cases joined state owned enterprises (SOEs). As a latecomer, China was successful to copy and imitate technology, industry and institutions from advanced countries at low risk and costs. The landmark trip of Deng Xiaoping, the "architect" of China's economic reform, to the southern cities of China was a key turning point in the process of capitalist restoration in China. This trip reflected the determination of the political power to proceed quickly towards market liberalism. As a result China has received enormous inflow of FDI, whereas industrial sector was the largest recipient. The West often sees China as "assembly hub" and the "copycat of the east" due to low technology- based products that do not required skillful labour force. Recently, there has been ongoing debate that China has reached a Lwisian "turning point" in economic development, signaled by the rising wages in urban areas

and the exhaustion of rural surplus labour. This view holds profound implications to the Chinese model of growth as it implies that China's comparative advantage has begun to be eroded since wages and other costs have risen. Furthermore, the emergence of some countries such as Bangladsh, which enjoys even lower unit labour than China, has delivered a clear message to China, It is time to change! There has been a wide speared recognition that China should make the shift and move up the value-added chain from lower end more basic products toward more sophisticated products to achieve a sustainable economic growth (see for example Cheong and Wu 2013). The relation between innovation and economic growth is widely acknowledged. On a macro scale, it has argued by many historians (Landes 1969; Rosenberg 1982; Mokyr 1990) "innovation and technological progress are the principal causes of material progress over extended periods of time" Meghana et al, (2007). Lin (2013) argues that the dramatic economic growth in modern times is a result of " paradigm shift in technological innovation". Thus, innovation would be at the heart of the shift due to its critical role in determining a country's overall competitiveness, productivity and hence economic growth. A structural change, substantially driven by innovation would be crucial to achieve sustainable growth. In recent years, it seems that China's leaders have got the message by starting to make innovation, China's main priority. This strategy has begun to pay off as China ranked second in innovation efficiency and 29th in innovation in Global Innovation Index of 2014.

The objective of this paper is to investigate the determinants of private firm innovation in China. The main stream of literature classified theses determinants into two categories: First, internal determinants such as size (Greve, 2003), age (Jung et al

2003), trade status Landry et al (2002) and the quality of management; education and experience of the managers and entrepreneurs Kollinger (2008), second external determinants such as firm's location, government policies and the general institutional structure that existed in the place where the firm operates (Smolny, 2003; Sternberg and Arndt, 2001; Coombs and Teomlinson, 1998, Baptista and Swann, 1998). (Mahareen and Hamna, 2011). Moreover, since it is not an easy task to quantify innovation as we have many types of it, it would be a wise approach to use the broad definition of innovation that includes these types, which discussed most in the large pool of literature on innovation. A study presented by Becheikh et al (2006)a revealed that 81% of the empirical studies done between 1993 and 2003 investigated product innovation or process innovation or both types. For this reason, in this paper, I will use the broad definition of innovation that includes both types in order to investigate the determinants of private firm innovation in China.

2. Market Transition Economy

To understand the impact of the transition from a central planned economy into a market economy on innovation, we need to go back to communist era command economies, such as in the former Soviet Union in the most of the 20th century, when the state owned all of the important means of production, set the prices and controlled the allocation of resources, labour and capital. State bureaucrats had the advantages of making the basic decisions about economy and intervening to assure that the system works, as they want. Thus, under this system, economic actors, outside the centrally planned economy, faced great obstacles that left them with little incentives to engage

in any sort of innovative activities. By contrast, a shift to a market economy minimizes the scope of state power over resources allocation and offers many opportunities to entrepreneurs to achieve profits. Moreover, in market capitalism, there is a more efficient way of allocating resources, which promotes all sorts of innovations: Innovation that increases the productivity and contributes to economic growth and also product innovation that improves the quality of life. In market capitalism, private firms and entrepreneurs are the major players as the market gives them incentives to seek out opportunities, rewards them economically for making the right decision and punishes them for making the wrong ones. Furthermore, the market put considerable pressure on firms to innovate in order to survive against competition. This means that innovation is an important key to determine the destiny of firms in market economy. Thereby, those firms, which engaged successfully in innovation activities, tend to expand and continue while those firms, which were not successful in innovation activities tend to contract and discontinue. Thus, the shift from central planned economy into market capitalism makes innovation a routine activity of firms.

3. The transition to dynamic capitalism in China

Prior to the initiation of economic reforms and trade liberalization in 1978, China was a central planned economy as the state owned and managed all productive assets from farmland to factories. The allocation of resources was controlled by the state through setting the prices by administrative fiat. Firms has no chance to get income from competitive advantage because simply there was no market to give any firm an opportunity to get benefits from their advantage as all firms were fully dependent on financial appropriations form the state. As a result to the poor policies, the economy was stagnant, inefficient and relatively isolated from the global economy. Moreover, the central planned economy gave bureaucrats and CCP (China communist party) members a control over economic actors.

The reform started in 1978 by introducing a "market track" economy to complement the "plan-track". The latter gradually phased until the 1990s. Under the new system, new free markets were established and producers granted the right to sell their surplus production after fulfilling their obligation towards state. In the mid of 1980s, after achieving success in agriculture under the household responsibility system, state started "a contract responsibility system" which enabled (SOEs) to sell their surplus in the free market as well. The gradual phasing out of the quota system allowed for more surpluses and more marketization. Market allocation became the dominant mechanism in China by 1990. The dual track system provided opportunities for new non-state competitors especially in the light industries, which were neglected by SOEs, the latter have the monopoly of strategic sectors such as electricity, energy

and finance. With increasing the legal protection and acknowledgment, the private firms have rapidly developed to become the driving force of China's economy. In 1990s, due to the intensified competition, state started the privatization of small and medium-size SOEs, while allowed for corporatization for the key firms in strategic industries. Many SOEs were listed on the domestic stock markets. The main reason behind this was to decrease state intervention and promote for more market liberalization. Kornai (1980) highlights the importance of reducing the state control over resources allocation on the emergence and growth of markets. The reduction of state intervention helped markets to develop and expand and that created opportunities and incentives for firms to generate revenue from innovation activities. Subsequently, the rapid development of market transition led to intensive competition between the private firms and SOEs as stated by Nee (1992), "the emergence and growth of privately organized markets created new opportunities for entrepreneurs of start-up private firms that innovate to compete with the established state-owned enterprises and local government-owned enterprises" Nee and Opper (2009). The fierce competition between SOEs and private firms led to a significant fall off of the share of SOEs in GDP from 78% to only 35% between 1979 and 2005. Furthermore, it led to a declining in state's capacity to subsidize loss-making industries (rent-seeking declined as well) as the ratio of the state budget to GDP declined from 31.1% in 1978 to 17.3% in 2005. These numbers reflected on the market share of new technology-based industries, as private firms dominated China's new technology-based industries in electronic and computer appliances.

It worth noting that, state adopted many policies to promote and encourage innovation; As it followed a strategy of rapid increase of governmental expenditure as

a share of GDP on R&D (from 0.8% to 1.3% of GDP between 1999 and 2003) which accompanied by the structural reorientation to firm-based research (more than 60% of R&D funds provided by firms, Nee, Kang and Opper (2007). Moreover, they encourage innovation by giving incentives to stimulate R&D for example; tax credits to new product sales. Furthermore, state was keen on developing inter-firm technological collaboration and regional innovation clusters to be the driving force of China's emerging national innovation system. A good example is Silicon Valley, which was a model to follow. Another example is Torch Program, which funded 35 Chinese cities to establish technology parks.

In recent years, as a result of policy changes in order to promote innovation and hence the development of a knowledge-based economy, China's expenditure on R&D has increased dramatically. According to the OECD report (2014), China ranked third after the US and the EU and is forecast to overtake both of them to be the world's top R&D spender by 2019.

To sum up, a radical transformation has occurred in China's economy during the last 36 years: from being a poor agrarian economy without competitive export production into the world's largest economy. China managed to avoid the crises that happened to other transitional economies such as Eastern European countries and Russia. Moreover, China transformed the centrally planned economy successfully into a mainly market oriented economy achieving unprecedented levels of economic growth.

4. Hypotheses

Schumpeter argues that in market capitalist economies, competition is a process of novelty generation and sorting of this novelty because competition among market participants gives incentives to entrepreneur to seek out new ways to improve technology and introduce innovation, which would increase profit margins and improve the entrepreneur's standard of living. However, sooner or later, this advantage will erode and the profit margin will be low due to the inevitable imitation or even surpassed by the innovations of other competitors. In the language of Schumpeter, profit is "at the same time the child as well as the victim of [economic evolution]." (Schumpeter, 1934, p. 154). As a result to this process a new incentive will be there for the initial entrepreneurs to seek out new innovations to replace old innovations in order to achieve high profits again. This process of replacing new innovations with old innovations describes by Schumpeter as "creative destruction" which is " the essence of capitalism". "Creative destruction" involves the recognition of opportunities for profitable change through "new uses and new combinations" and the pursuit of those opportunities all the way through until they are put into business practice. Nee, Kang and Opper (2007)

To analysis Schumpeterian competition we should conceptualize the firm as made up of a multitude of routines. *Nelson and Winter (1982)* argue that firms have many routines for their activities such as price setting, marketing and investment behavior and so on. In that sense, we can see competition as a process that includes introducing new routines by imitating the routines of other firms and that will lead to new

combinations of routines as firms with the better combinations will flourish and get competitive advantages while those firms with the inferior routines will shrink. However, those competitive advantages will not last forever, as it is a matter of time before those advantages will be lost which will put ongoing pressure on the firm to innovate in order to retain competitive advantage and achieve profits. Thus, fierce competition makes innovation a matter of destiny for the rival firms in market capitalist economies as it transforms innovation from being such lucky incidences into a routine i.e. competitive market pressure leads to "routinization of innovation that transforms it from a sequence of fortuitous occurrences into a businesslike activity that can be relied upon and is reasonably predictable" *(Baumol 2002:55)*. In sum,

Hypothesis 1: *with all other things being equal, the greater the competition, the more firm are compelled to innovate in order to survive.*

- There is a large pool of theoretical and empirical studies that link R&D expenditure with innovation (see for example Schmidt and Rammer, 2006). In China context, it argues that R&D expenditure has boosted China's innovation capacity. The remarkable increase in the number of patents from 45,100 in 1995 to 960, 513 in 2011 is evident (NBCS, 2012). It is noticeably that private sector has played the major role in R&D expansion as it counts for 74% of China's R&D investment in 2011 (NBCS, 2012). Accordingly, the share of patents granted to enterprises increased from 12% in 1995 to 40% in 2011 (NBCS, 2012). Another important aspect in this context is R&D cooperation among firms. Saxenian (2006) emphasized the importance of firm

cooperation arguing that the spillover effect of new technology and the exchange of information would take place as a result to cooperation and backward and forward linkages. In that respect, the spill over effect will save time and money because firms could start where the others end and thereby will have a shorter path for innovation. Membership in business associations would give a firm more capability to innovate due to spillover effect through networks. In sum,

Hypothesis 2: *with all other things being equal, engaging in R&D activities would have positive effect on private firms innovativeness*.

- Extensive literature has emphasized the significance of financial development in promoting economic growth. For example, Rajan and Zingales (1998) argued that, at the firm and industry level, access to external finance is positively correlated with growth. An interesting question is that whether financial development promotes growth by fostering innovation. This could happen only if the financial system has a significant role in supplying capital to firms in order to facilitate innovation activities (Levine, 2005). In China context, access to finance is a big obstacle, basically for small and medium enterprises (SMEs), which suffer from the lack of financial resources. Despite the big contribution of (SMEs) to economic growth, which counted roughly for 60% of GDP, they can only obtain less than 25% of bank credit (Zhu &

Sanderson, 2009). According to (EC, 2008), less than 10% of private firms can obtain bank loans and less than 1% can obtain other external financing from other sources. Commercial banks and other financial institutions are often reluctant to grant loans to (SMEs) due to the relatively high-risk profile. Obviously, the preferential treatment by the government and business environment favoured large firms at the expense of (SMEs), thereby large firms tend to corner or monopolize the market. Most of large firms are abundant with cash, thus less likely to apply for loans. As a result of the limited access to financial support, innovation by (SMEs) are very challenging. The alternative for those firms is to depend on self- financing. Given the nature of innovation which often needs long term investment in R&D, those firms have little chance to tackle the financial obstacle in order to innovate, rather they would prefer short term profit oriented investment to survive. According to (CTIBJ, 2008), 68% of SMEs would close down in their first five years (Zhu et al, 2011). In sum,

Hypothesis 3: *with all other things being equal, the better access to finance, the better probability for innovation.*

According to Lin (2013), before the reform took place in 1978, China adopted a wrong development strategy by relying mainly on heavy industries, which worked against its comparative advantage of intensive labour force. This strategy did not pay off, however the Chinese government had a big desire to protect those industries through subsidizing and monopoly. As a result the Chinese economy was almost a closed economy. Since the opening up in 1978, China has adopted a pragmatic,

gradual, dual-track approach in The process of transition from state-guided to privately organized production. Certain sectors have been liberalized while other sectors have remained under the state's control. By exploiting its comparative advantage through focusing on light industries such as textiles and food industries China was very successful to achieve outstanding economic growth. Such light industries do not require skillful labour force; they do require raw materials, which could be easily maintained from the agricultural sector. Simultaneously, a gradualist approach implemented in the manufacturing sector in order to move from very-labour intensive industries, at the beginning of the reform into more capital- intensive heavy and high-tech industries. Statistics from China statistical abstract (2010) reflect this structure change, reporting that primary and processed primary goods accounted for more than 75% in 1979 of China's exports while by 2009 manufactured goods represented more than 95%. Back to the point of industrial liberalization among sectors, Nee and Opper (2007) argued that the shift to market economy varied greatly among different industrial sectors. Strategic sectors such as electricity, automobile, chemicals, and most service sectors, state still has the dominance i.e. those sectors less liberalized and thereby have less potential of innovation, while other industrial sectors such as light industries and consumer goods have been quickly liberalized and have better possibility of innovation. The fact that the subsidizing has stopped for many of the firms working in strategic sectors has left those firms with no option but to innovate in order to survive and compete with other firms.

This is in line with the view that firms are often have no desire to change, rather they would resist any change and stick to their old ways in doing things in order to avoid the uncertainty involved in making such changes. Thus, in most cases, firms act to

make changes because they are compelled to do such changes. (Van de Ven, 1986).

In sum,

Hypothesis 4: *with all other things being equal, the more liberalization in industrial sectors, the higher level of firm's innovativeness.*

5. Data

In order to test my hypotheses I use data set from the World Bank questionnaire, *China - Enterprise Survey Manufacturing Module (2012).* The data collected in China between December 2011 and February 2013. The data is based on face-to-face interviews with 2700 privately owned firms representatives. The survey provides a comprehensive set of questions about the business environment in China. Firms have already categorized in the survey into three different sizes small, medium and large according to the number of employees. The survey provides many core questions on innovation activities. It also compiles data on the general characteristics of private firms such as their industry of affiliation, sales, employment, etc. These questions refer to the last complete fiscal year (2011). The objective of the survey as described by the world bank is to obtain feedback from enterprises on the state of the private sector in client countries as well as to help in building a panel of enterprise data that will make it possible to track changes in the business environment over time, thus allowing, for example, impact assessments of reforms.

Given the main objectives of this paper to look at the determinants of the probability

and success of innovation, I focus on the parts of the survey that questioned firms on whether they have engaged process or product innovations, factors that encourage them, and the impact of innovation on their business. It is noticeable that the dependence on self-reported measures would give accurate assessment of a firm's market position in China's transitory economy (Nee, Kang and Opper, 2007). Due to missing observations and inconsistent answers to questions (do not know or even not applicable categories) in the survey, our sample has reduced. Moreover, I have decided to drop 5 observations, which are obviously outliers from the data: 4 observations that have R&D expenditure<20000, and one observation that has total annual sales= 100 Yuan.

Table 1 shows descriptive statistic for our variables of interest.

Table 1: Descriptive statistic for variables in analysis

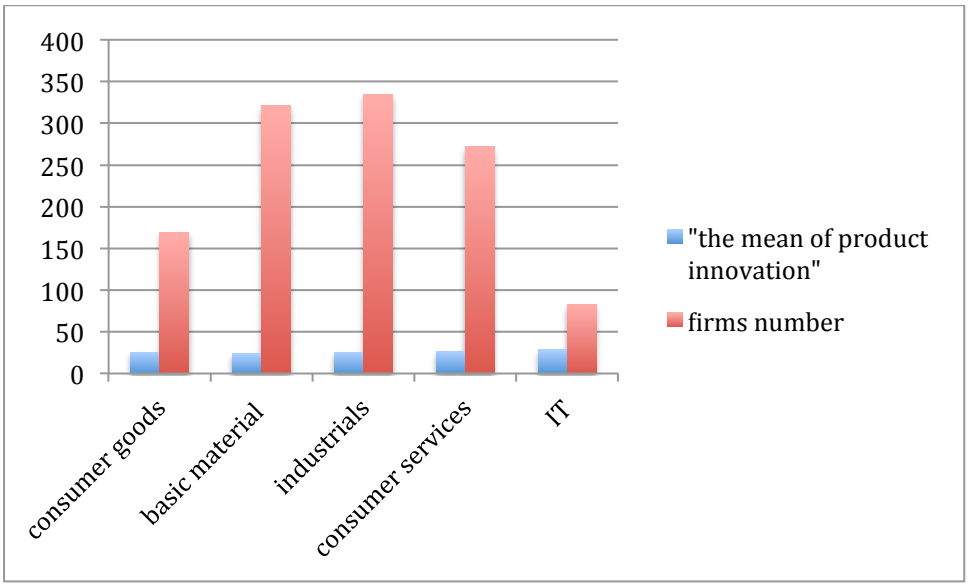
Variable	Obs.	Mean	Std. Dev.	Min	Max	%
I. Dependent variables						
1-Product innovation	**1180**	25.37	19.83	0	100	
2-Process innovation	**1173**	20.63	17.95	**0**	**100**	
II. Independent variables						
1- Competition (number of competitors)	**1323**			**0**	**>500**	**100**
1-Monopoly & Oligopoly (0-10)	167			0	10	12.62
2- Monopolistic (11-500)	50			11	500	3.78
3- Perfect competition (> 500)	1106			>500	>500	83.6
						100
2- Industrial sectors	**2695**					
1- Consumer goods	432					16.03
2- Basic Material	761					28.24
3- Industrials	788					29.24
4- Consumer Services	572					21.22
5- IT	142					5.27
						100

3- R&D activities						
A- R&D / sales ratio	**598**	0.05	0.09	0.00	0.79	
B- Dummy R&D						
(Yes) firm spends on R&D	690				1	41.17
(No)	986			0		58.83
	1676					100
C- Research network contracted with other firms (dummy):	1675					
Contracted with other firms	196				1	11.7
Not contracted	1479			0		88.3
						100
4- Access to finance	2628	11.22	20.68	0	100	
III. Control variables						
1-Location	**2695**					
1- North	338					12.54
2- Northeast	223					8.27
3- East	1254					**46.53**
4-Central	324					12.02
5- South	441					16.36
6- Southwest	115					4.27
						100
2- Firm's size	2695			1	3	
1- Small	988					36.66
2- Medium	950					35.25
3- Large	757					28.09
						100
3- Firms 's age	2622	12.72	7.914	0	125	
Manger experience	2635	16.34	7.52	1	55	
4- Education	1654	10.17	1.88	1	18	
6- State share in ownership (dummy):	2695					
State has share (Yes)	111				1	4.12
State does not (No)	2584			0		95.88
						100
7- Exports (dummy)	2695					
Firm exports (Yes)	647				1	24.01
Firm does not exp. (No)	2048			0		75.99

For product innovation, I have 1180 (43.7%) firms successfully sold their

innovations. OF these 1180 firms, 169 (14.3%) attributes to consumer products sector, 321 (27.2%) attribute to basic material sector, 335 (28.4%) attribute to industrials sector, 272 (23.1%) attribute to consumer service sector and 83 (7%) attributes to IT sector. Of these 1180 firms, 411(34.9%) small, 400 (33.9%) medium, 369 (31.2%) large. On average, the sale of innovations as a portion of total sales over the last three years is 25.3% for more. It is noticeable that, only a few firms (10) report that 100% of their sales associated with product innovation. 9 out of 10 of theses firms are less than 13 years old. After investigating the product innovation different measures, particularly, the new products and services to average annual sales ratio (CNo2 from the survey) and the question whether a firm has introduced a new product or new service over the last three years (CNo14e from the survey). I found that, roughly 69% of the firms that introduced new product or service were successful at bringing out their products to the market and sold them. Only 2 firms reported 0% product innovation. For process innovation, I have 1173 (43.4%) reporting process innovation. Of these 1173 firms, 297 (25.3%) attribute to consumer products, 534 (45.5%) attribute to basic material category, 334 (28.5) attribute to industrials category, 7 (0.6%) attribute to consumer service and 1 (0.1%) attribute to IT category. Of these 1173 firms, 263 (22.5%) small, 487 (41.5%) medium and 423 (36%) large. 46 (3.9%) firms engaged in product innovation are new start-up firms (up to 3 years old) while 19 (1.8%) firms engaged in process innovation are new start-up. On average the process innovation, as a portion of total production over the last three years is 25.3%. Also only a few firms (5) report that 100% of their production associated with process innovation. All these firms established after the reform in 1978. It is noticeable that 97 firms reported 0% process innovation.

Figure 1



In figure 1, we observe that there are no big disparities among industrial sectors engaging in product innovation. The blue chart refers to the mean of process innovation within the sector. In general, all industrial sectors have a mean more than 20% of product innovation measured by the percent of total annual sales accounted for by products or services that were introduced in the last 3 years.

Figure 2

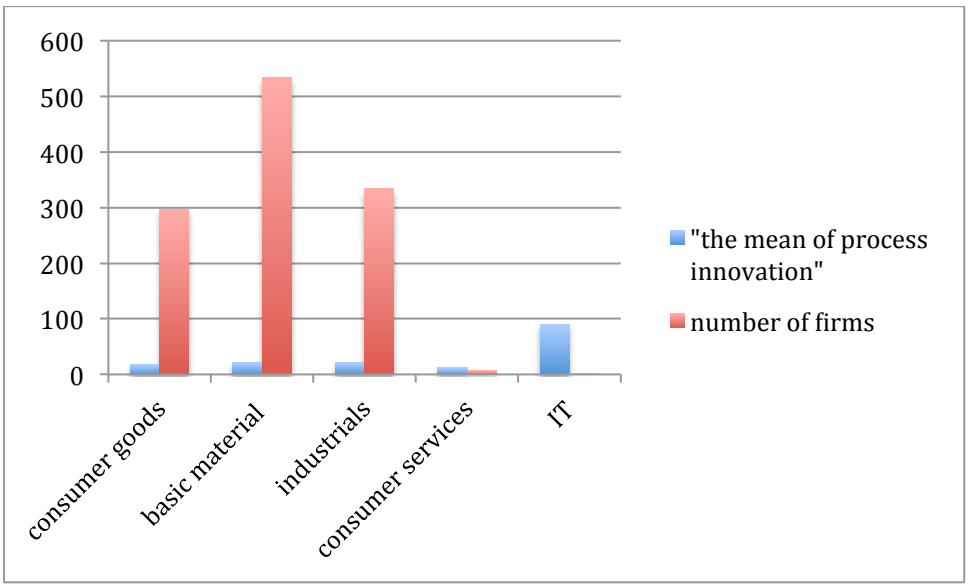
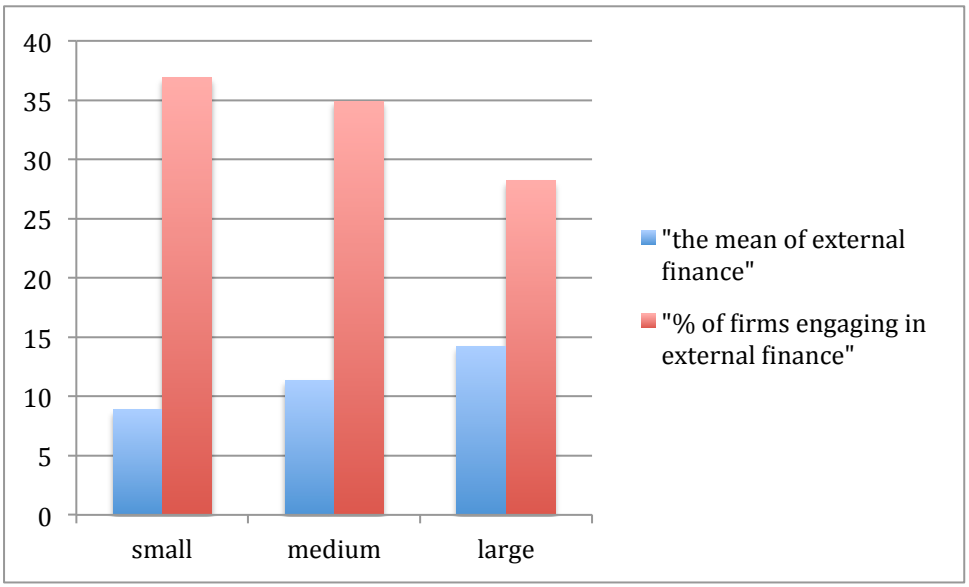


Figure 2 shows the distribution of industrial sectors that engaged in process innovation in the last 3 years. The blue chart refers to the mean of process innovation within the sector. Of note, only 1 firm represents IT sector engaged in process innovation, stating that 90% of its production over the last 3 years was associated with new or improved process.

Figure 3



The charts in figure 3 shows some interesting statistics in our sample relating to the size of firms and access to finance: While small size firms represent about 37% of our sample, the average of the proportion of working capital that was financed from external finance is 8.8 %. Medium size firms, are about 35%, has a mean of 11.3% and large size firms represent about 28% has a mean of 14.2%. The statistics shows the bias and preferential treatment that large firms get in access to external finance.

6. Data Checking:

It is not traditional to begin with data checks before model specification. However, I have a reason for that; in order to reach a good model, which can capture the effect of independent variables on innovation types, I need to make sure that our data does not suffer from problems such as non-normality distribution of residuals, heteroskedasticty and multicollinearity. For example, when using OLS, we assume that our residuals should be normally distributed, however, as noted by George Box, this assumption will never be exactly true when one is working with real data. For checking the data, I subscribe in the view of (Williams 2014), which suggests that we can use OLS regression for checking the data and recognize its problems with no issue.

➢ Checking for Multicollinearity

In order to measure the possibility of multicollinearity between our variables of interest, I use the variance inflation factor test (VIF). VIF reflects the degree of which other coefficients' variance and standard deviation are increased because of the inclusion of that predictor. The rule of thumb to interpret the test is that a VIF of 5 or more indicates multicollinearity. Our variables of interest passed the test successfully scoring low values, below the value of 5 (see appendix 1). Thus multicollinearity is not something that we need to concern ourselves with.

➢ Checking for normality

For both types of innovation, residuals seem to have non-normally distribution with right skeweness. This is more obvious in the case of process innovation with thicker right tail and more right skewness. However, I will not rely on the visualization of residuals, rather I will run a test for normality. The results from the normality test confirms the visualization from the graph, both types have non-normal distribution of the residuals. (See appendix 2)

➢ Checking for Heteroskedasticty

The patterns of the scatter plot regarding using OLS for both types of innovation (see appendix 3), give us impression that Heteroskedasticty might be a problem, thereby we need to do tests to investigate this concern.

First, using the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity, for process innovation we find that, P value> chi2=0 which means that P value <0.05 level of significance. Also for product innovation P value> chi2=0 and P value <0.05. Thus, we indicate that our models of innovation using OLS might suffer from Heteroskedasticty. To make sure I will run another test.

Second by using the White's test for Heteroskedasticty, in this test the null hypothesis is Ho: homoskedasticit, and against Ha: unrestricted heteroskedasticity. For process innovation, the test shows that P value> chi2=0 i.e. P value <0.05. For product innovation P value> chi2= 0.0003 i.e. P value <0.05 our level of significance. Theses tests further confirm that OLS models for

both types of innovation suffer from Heteroskedasticty. (see appendix 3 for Heteroskedasticty tests)

7. Models Specification

In order to assess the determinants of firm innovation, I use the Tobit models to test my hypotheses. I will not use the Ordinary Least Squares (OLS) regression, which is problematic as we illustrated in the previous section. Particularly, non-normal distribution of residuals violates the assumptions of OLS. Thereby, using OLS will yield a downwards-biased estimate of the slope coefficient and an upward-biased estimate of the intercept if not the limits were not included. (Dougherty 2011: 369) Moreover, the OLS model will be heteroskedastic not homoscedastic; the violation of the later assumption could be pernicious. This problem could be addressed well by censored regression models such as Tobit, which is basically employed when the values of the observed dependent variable are exclusively non-negative. The use of Tobit model is appropriate with this kind of continuous, yet constrained (censored) outcome variables. (Verbeek, 2012)

Formally our models are:

$$(1) \qquad y_i = \alpha + X_i\beta + \varepsilon_i \qquad \textbf{For product innovation}$$

$$(2) \qquad Y_i = \alpha + X_i\beta + \varepsilon_i \qquad \textbf{For process innovation}$$

y_i *in model* (1)*:* A dependent variable measures product innovation as sales ratio, i.e. the percent of total annual sales associated with new product or service over the last 3 years.

Y_i *in model* (2)*:* A dependent variable measure process innovation as production ratio, i.e. the percent of annual production associated with new or improved process

over the last 3 years.

a: Is the constant term

X_i: A set of variables covering: competition categories, industrial sectors, R&D expenditure dummy, whether a firm contracted with another firm to conduct R&D dummy, access to finance, whether a firm exports dummy, whether the state has share in ownership dummy, education of labour force, experience of the manger and distinct firm characteristics (size, age and location).

$\mathcal{B}$: Is a vector of corresponding coefficients

$\mathcal{E}_i$: Is the residuals

Here, I apply two Tobit models, with the same set of independent variables but a different dependent variables as shown in equation (1) and (2). The dependent variable might be 0 or a positive number that does not exceed 1, which is the case in our study as both dependent variables are ratio that has the range from 0 to 1. Thus, the Tobit model is estimated with maximum likelihood, censored form an upper limit (100%) and a lower limit (0%). For dealing with the problem of heteroskedasticty, White developed an estimator for standard errors that is robust to the presence of heteroskedasticity, this command works perfectly with large dataset (Stata.com). Thus, I will use the robust command in stata for robust standard errors. In my study, I will mainly focus on competition, R&D activities, industry and access to finance in my analysis by controlling for many firm characteristics such as size, age, location, education, manger experience, research network (contracting), whether a firm exports and state share in ownership.

Table 2 blew shows the measures and definition of our variables in analysis.

Table 2

Variables	Questions using as measures from the survey
I. Dependent variables	
1- Product innovation	(CNo.2)
	In fiscal year **2011**, what percent of this establishment"s total annual sales was accounted for by products or services that were introduced in the last three years?
2- Process innovation	(CNo.16)
	In fiscal year **2011**, what percent of this establishment"s annual production volume was associated with new or improved processes introduced over the last three years?
II. Independent variables	
1- Competition	(E.2)
	In fiscal year **2011**, for the main market in which this establishment sold its main product, how many competitors did this establishment"s main product face?
2- Industrial sectors	(A4.a)
3- R&D ratio to sales	(CNo.4)/ (D.2)
R&D	(CNo.4)
	Over the last three years, how much did this establishment spend on research and development activities performed within this establishment on average annually?
Total sales	(D.2)
	In fiscal year **2011**, what were this establishment"s total annual sales for ALL products and services?
4- R&D dummy	(CNo.3)
	In the last three years, did this establishment spend on research and development activities within the establishment?
5- Research network	(CNo.5)
	In the last three years, did this establishment spend on research and development activities **contracted** with other companies?

6- Access to finance	(K3bc+K3e+K3f+K3hd)
	Over fiscal year **2011**, please estimate the proportion of this establishment"s working capital that was financed from each of the following sources? Working capital is used to pay for day to day operations. Borrowed from banks (private and state-owned), non-bank financial institutions which include microfinance institutions, credit cooperatives, credit unions, or finance companies, Purchases on credit from suppliers and advances from customers, Other, moneylenders, friends, relatives, etc.
III. Control variables	
1- Firm age	(B5)
	In what year did this establishment begin operations?
2- Firm size	(A6.a) Number of employees
	Small >=5 and <=19 Medium >=20 and <=99 Large >=100
3- Manager experience	(B7)
	How many years of experience working in this sector does the Top Manager have?
4- Education	(L9.a)
	What is the average number of years of education of a typical permanent full-time production worker employed in this establishment?
5- Location	(A3.a)
6- State share in ownership	(B2.c)
	What percentage of this firm is owned by each of the following: Government or State
7- Exports	(D3.b) + (D3.c)
	In fiscal year **2011**, what percentage of this establishment"s sales were: -Indirect exports (sold domestically to third party that exports products)

	-Direct exports

In the next section I will discuss the variables of choice then I will discuss our models.

8. Dependent variables

Social science researches on innovation frequently classified it into either innovative inputs or outputs. Typical measures of innovative input include R&D expenditure and personnel involved in R&D, while the main proxy for innovative output is the number of patents. According to Griliches (1979) and Pakes and Griliches (1980), "patents are a flawed measure of innovative output, particularly since not all new innovations are patented and since patents differ greatly in their economic impact." I subscribe in this assumption claiming that patents, as a proxy for innovation would not be good enough to use in transition economies and in particular, in China case. My reasons for that are: First, weak enforcement of law lead to little fear of prosecution so if any firm uses another firm patent, the patent bureau will almost do nothing so you have to take it to the court, which means high costs and long time, second, low respect for intellectual property rights, third, many firms has had a tendency to misreport patents in order to be rewarded by the government and finally, firms may develop new technologies through patenting activity, but they often fail to capitalize on their inventiveness to bring new products to the market (Sorensen and Stuart 2000:109).Given the nature of the data obtained from the survey this study adopts the innovative output approach, focusing on the finished product or new

process. Specifically, I would apply a measure that used by Schumpeter to analyze the rise of routine innovation that drives China's transition to dynamic capitalism. Thus, my measure for product innovation in model one is CNo.2 from the World Bank questionnaire, which refers to product innovation of the firm as in the following question: *In fiscal year 2011, what percent of this establishment"s total annual sales was accounted for by products or services that were introduced in the last three years?* This measure has a big advantage because it shows to what extent a firm was capable of developing its new product and sell it successfully in the market i.e. as (Schumpeter 1942) claimed to consider a patent as an innovation, it must be brought to the market. Furthermore, It has been argued that there is a broader concept of firm's innovativeness includes the introduction of a new production process and the introduction of new quality-control measures. It is noticeably that product innovation refers to the efforts to move a firm to a new cost-quality position, while process innovation and new quality management aim basically to cost reduction Nee, Kang and Opper (2007). Furthermore, product innovation, in most cases is a much radical change while process innovation and new quality management tend to be an up gradation of existing procedures. In that sense, we can say that the product innovation and R&D expenditure measures require a sort of entrepreneurs that are capable of taking more risk and exerting more efforts responding to market opportunities than those entrepreneurs practicing innovation process and new quality management measures Thus, it seems that product innovation usually required more time and capital than process and quality control innovations.

In this paper, I will use the broad definition of innovation that includes product innovation and process innovation as proxies for a firm's innovativeness. My measure

for the process innovation, in model two, is the percent of annual production associated with new or improved process over the last three years. Of note, despite the close link of the both types of innovation, there are some economists who have argued that product innovation and process innovation have a different set of determinants (see Freer, 2003 and Sternberg and Arndt, 2001). Against this backdrop, I follow the approach of (Nee and Opper, 2009) by using the same set of variables in both models (using different dependent variables).

9. Independent Variables

9. 1. Competition

To measure competition I will use (E.2) the question from the World Bank survey, referring to the number of competitors in the main market, in which this firm sold its main product. According to Hayes (2008), there are four degrees of competition in a market economy: perfect competition as a firm has infinite number of competitors, monopolistic as a firm has many competitors, oligopoly as a firm has a few competitors, and monopoly where the firm has no competitors. Since there is no clear limitation for the number of firms/competitors in each degree of competition in existing theories, I will categorize the number of competitors into 3 points scale (1: monopoly & oligopoly = 0-10 competitors, 2: monopolistic =11-500, 3: perfect competition = more than 500). The reason to combine the first two categories of monopoly and oligopoly is the small number of observations of monopoly that would not be sufficient to run separately. It worthwhile noting that the data from the World Bank is wrongly coded, given the value of negative 4 to “too many competitors”

category, which does not allow me to investigate the potential non-linear relation that could be tested by squaring the number of competitors and see the effect in our model. The non-linear relation could be existed as assumed by (Scherer 1967; Aghion et al. 2005), a certain threshold of competitive market pressures may be required to stimulate innovation. Additionally, in this study I presumed that "too many competitors" refers to a number more than 500 or "perfect competition". I have done this because this category contains 1106 (83.6%) observations out of 1323 in competition.

9. 2. R&D activities

There is a rich body of literature, which views R&D expenditure as the most important explanatory factor of innovation because it is believed that R&D is the input in producing innovation, this idea is expressed through the knowledge production function by Griliches (1979) and has been followed by many studies (See for example, Pakes and Griliches, 1984; Hall and Ziedonis, 2001).

Furthermore, the fact that private firms work under hard budget constraints will make them basically rely on regional technical and research cooperation. In order to test the impact of R&D activities on innovation types, I will employ 2 variables; (CNO.3 from the survey), a dummy variable that has value of 1 when firm spend on R&D and 0 otherwise, another dummy variable (CNO.5) that has value of 1 when firm spends on R&D contracted with other firms and 0 otherwise.

9. 3. Industry:

As the main focus of this investigation is looking into the industry variation in firm's innovativeness activities, an adequate measure is essential to capture the effect of industrial sectors on innovation. Rather than simply presenting the 26 different industry sectors in a regression, I classified the industries (A4.a) into 5 different categories based on the FTSE Industry Classification Benchmark (FTSE 2010) as following: 1 "consumer goods" 2 "basic material" 3 "industrials" 4 "consumer services" 5 "IT". These dummies serve as general proxies of competitive pressure, technological opportunity conditions, and average innovativeness (Mairesse and Mohnen 2002). As well as, theses dummies control for industrial policy priorities, which may influence a firm's access to finance, information public science and technology programs.

It worth noting that certain traditionally industry categories here are not represented by any firms in from the survey and so are not included in the model. Also, in the different models done here, IT sectors ended up with no observations and dropped.

I would expect that the sectors, which have been favoured by the state in liberalization process, sectors such as consumer goods and consumer services sectors, would be more innovative; simply because the state has stopped subsidizing these sectors since long time so firms have been working on these sectors have no option but to innovate in order to survive and compete with other firms.

9. 4. Access to finance

For Schumpeter (1912; 1934), bank credit is fundamentally necessary for innovation "new combinations". I took the sum of these categories (K3bc, K3e, K3f and K3hd) from the survey to generate a new variable in order to capture the effect of access to finance on innovation types. The variable refers to the proportion of firm's working capital that was financed from external sources such as banks, financial institutions etc.…

10. Control Variables

Distinctive firm's characteristics such as size, age and location could have an impact on a firm's innovation. According to (Hannan and Freeman 1989) a firm's age is generally believed to affect its adaptability. The older private firms are likely to have a structural disadvantage in innovation especially those pre-reform firms. My measure for firm's age is (B5) that give us information of which year firm begin its operation. In order to get firm age I calculate it by subtracting 2012- the year of operation. Firm size acknowledged as an important factor in firm's innovation. (Schumpeter, 1942) refers to firm size as an indicator, which reflects scale economies, access to finance and organizational features. My measure for firm size is (A6a) which basically using the number of employee as a measure. The size categorized in the survey into 3 groups (small, medium and large). I use (A2) for the firm's location: I designed 6 dummy variables, which represents the provinces in the survey as a proxy for location. The inclusion of location is important in our model because many firms could benefit from being located in industrial parks and economic zones

through the potential diffusion of innovation activities from the spillover effect. Arrow (2007) argues that propinquity gives a firm a big advantage as a result to the reduction in information costs through spillover effect. So, many companies do not rely on formal contractual agreements to conduct R&D but rely basically on its location to get the knowledge and save costs. Porter (1993) emphasized the importance of the fierce competition steaming from location in promoting innovation activities. Furthermore, human capital has considered by many economists as the most important firm characteristic, it could make the difference at private firm level because it is unique and hard to imitate and that can give a firm a vital competitive advantage over their rivals. This is in line with the Schumpeterian view of innovation which focuses basically on the importance of the independent entrepreneur in capitalist economies, for him, the independent entrepreneur – distinct from the capitalist and businessman– is the purveyor of innovations. Furthermore, upper echelon theory shows the influential role of top mangers on organization performance i.e. "organization are just reflections of their top managers". Moreover, Lin et al. (2011), by using World Bank Survey data in 2002, they had evidence that ECO education and incentive scheme are positively associated with firm's innovation. Thus, I include 2 variables to control for human capital on innovation; education of labour force measured by the average number of years of education for a typical permanent full-time worker (L9.a), and manger experience, measured by the years of experience that the top manager has (B7). I control also for ownership, It is true that the theme of this study is to measure the innovativeness activity at the private firm levels using the data belongs to private firms on the survey, however after checking the data carefully, I noted that the state has a share in ownership in some firms. Thus, I decided to include a dummy variable in my model

to control for state ownership. The conventional wisdom says, if the state has a share in a firm, probably this firm is not totally liberalize and still somehow under the state control which could affect its innovativeness activity.

11. Empirical Results:

Table 3, shows the results of the Tobit regressions

Innovation types	**Product**	**Process**
Tobit models	**Model 1**	**Model 2**
	Basic	**Basic**
N	*540*	873
Pseudo R-squared	*0.018*	0.036
Prob > F	*0.000*	0.000
Log pseudo likelihood	*-2312.13*	-3412.38
	Coefficient	**Coefficient**
Independent variables	**(SE)**	**(SE)**
1- Competition		
Monopoly & Oligopoly	Ref.	
Monopolistic	*-6.264*	1.828
	(4.870)	(4.466)
Perfect competition	*-6.91***	-6.14***
	(2.645)	(1.788)
2- Industrial sectors		
Consumer goods	*Ref.*	
Basic Materials	*-2.253*	2.100
	(1.758)	(1.418)
Industrials	*-1.552*	1.384
	(2.137)	(1.721)
Consumer Services	*-2.772*	-0.577
	(4.504)	(10.032)
IT	*Empty*	
3- Access to finance	*0.199****	0.158***
	(0.052)	(0.038)
4- R&D activities		
Yes_ RD	*3.787**	6.389***
	(1.580)	(1.272)
Research network (cooperation)	*3.397*	1.200
	(2.506)	(2.103)
Control variables		
1- Location		

North	*Ref.*	
North East	*7.606*+	−5.352+
	(4.349)	(2.893)
East	*2.649*	-2.809
	(2.506)	(2.326)
Central	*5.416**	4.087+
	(2.402)	(2.469)
South	*8.840***	2.009
	(2.43)	(2.763)
South West	*-5.911**	-6.157
	(3.001)	(5.526)
2- Firm Age	*-0.055*	0.007
	(0.114)	(0.101)
3- Firm Size	*0.492*	1.228
	(0.965)	(0.864)
4- Manger experience	*-0.267**	0.010
	(0.116)	(0.082)
5- Yes state has share in ownership	*3.305*	-28.5***
	(6.549)	(3.678)
6- Education	*0.675*	1.17***
	(0.459)	(0.361)
7- Yes _exports	*-2.200*	0.053
	(1.816)	(1.645)
Constant	*19.74***	4.984
	(6.772)	(5.146)
Note: In parentheses are standard errors; + p<.10, * p<.05, ** p<.01, *** p<.001	**F(19, 521)= 5.35**	**F(19, 854)= 13.55**

Before discussing the results of the Tobit in Table 3 above. It is very important to recall that the interpretation of pseudo R in the Tobit model is different from the interpretation of OLS. While we use R-squared in OLS as a goodness-of-fit measure we cannot interpret pseudo R the same. Moreover, Tobit regression coefficients are interpreted in similar manner to OLS regression coefficients, for example, based on model 1, table 3, when holding all other independents at their mean value, for 1% increase in the working capital that financed from external finance, there is almost 0.2 % increase in the likelihood of private firms product innovation (new product to sales

ratio); It is noticeable that the linear effect is on the uncensored latent variable, not the observed outcome, see McDonald and Moffitt (1980). Another method to interpret the coefficients required calculating the marginal effect, however given the nature of our dependent variables of innovations; there is no need to calculate the marginal effects because the effect of our independent variables on innovation would be percentage i.e. I tried calculating the marginal effects and got precisely the same values of the coefficients.

For hypothesis I

I predicted that competition will have a positive linear relation with innovation i.e. as the competition increase in the market, any firm are compelled to innovate in order to survive and continue in the market. Table 3 reports the results from equation (1). The results are against the first hypothesis, as it seems that competition has no linear relationship with both types of innovation, the relation seems to take a form of U inverse. In comparison with the reference category– number of competitors from 0 to 10 – we observe that in Model I (product innovation), the signs of both coefficients in the other two categories – from 11 to 500 competitors and over 500 competitors (too many in the survey) – turned to negative which indicates that these two categories are likely to have less product innovation than when the number of competitors are from 0 to 10 competitors. This result is significant for perfect competition and insignificant for monopolistic. While in Model II (process innovation), the second category – competitors from 11 to 500 – is likely the most innovative category, when the number of competitors exceeds 500, process innovation (new process to production ratio) decreases. Thus, from both models, we can interpret that, at low levels of competition, an increase in competitive pressure would have a positive effect on private firm

innovation up to certain level. The tipping point is different in both types of innovation; process innovation requires more pressure from competitors to reach the tipping point. Beyond this level, the relation turns negative and any further increase in competition would have a negative impact on a firm's innovativeness, this is obviously seen in the consistent negative sign of perfect competition (over 500 competitors) coefficients in both models. The high statistic significance of perfect competition category at 0.1%, and 1% levels of significance confirm this view. This result is in line with the earlier literatures discussed by (Podolny et al. 1996; Aghion et al. 2005).

For hypothesis II

I predicted that engaging in R&D activities would have a positive impact on firm innovativeness. From the table above, in model I and II, we observe that the coefficients of the dummy variable which refers firm conducts R&D are positive and significant in both models at 5% and 0.1% respectively. We can say that firms, which conduct R&D are more likely to have higher innovation, this result are consistent with our hypothesis. We interpret the coefficient as a firm that conduct R&D has more probability of product innovation and process innovation by (%3.8) (%6.4) respectively than a firm that does not conduct R&D. However, the usage of the dummy variable here limited the scope of our interpretation. The reason behind not using another measure for R&D, in particular, the ratio of R&D expenditure to the average of total annual sales over the last three years, is the dramatic reduction of the sample using the latter measure. Nevertheless, this problem will be addressed in the robustness section, in which I will apply the same model using R&D ratio to sales to confirm our results. The positive sign of the dummy research network, which refers to

firm spending on R&D activities contracted with other companies, could give us indication that firms that are part of cooperative innovation are more likely to have a higher innovation rate, however, this result is not statistically significant in both models. Overall, the results support our hypothesis that engaging in R&D activities positively affects private firm innovativeness.

For hypothesis III

Our prediction by assuming that access to finance will facilitate innovation activities at private firm level does hold. The signs of coefficients in both models are positive. The results are very statistically significant using 0.1%, which confirms that access to finance is necessary for the likelihood of firm innovativeness. We interpret the coefficient as with 1% increase in accessing to external finance from banks and other financial institutions, there is (%0.2) and (%0.16) increase in the probability of product innovation and process innovation respectively.

For hypothesis IV

I assumed that the more the liberalization in industrial sectors the better likelihood of innovation. The benchmark here is consumer goods category. For product innovation, all the sectors (basic materials, industrials and consumer services) have negative signs. So, in comparison with consumer goods, it seems that these sectors are less likely to innovate. For example, basic materials sector has less probability of product innovation by (%2.25) in comparison with consumer goods sector. This is consistent with our hypothesis because consumer goods sector was quickly liberalized by the state while other sectors still not liberalized enough and thus might have less innovation. When it comes to process innovation, the less likely to innovate sector is

consumer service as the only category holding negative sign, while the most innovative sector seems to be basic materials. I should mention that it was not possible to get statistically significant results to industrial sectors using different methods (categories, dummies etc…), so we cannot rely so much on the results, these results could only serve as a basic indicator showing the direction of the effect of different industrial sectors in our dependent variables. Overall, it seems that both types of innovation have different results, which make it hard to draw a significant conclusion especially with the non-significant coefficients. It is noticeable to mention that IT sectors has no observations in both models due to the overlap of variable that have missing observations which automatically drop by Stata while running the Tobit regression.

For control variables

Results from the Tobit estimation show in model 1 that the coefficient of firm age is negative and insignificant, indicating that a firm younger by one year has more probability of product innovation by (%.055). In model 2, the coefficient is positive and insignificant, a firm older by one year has a better chance of process innovation by (%.007). The statistically insignificance and the mixed signs in both models does not deliver a clear message. This is in line with Arrow's (1962) view on the assumption that more experienced firms benefit from "learning by doing" is weak. Firm size in both models are positive and insignificant, for interpreting the size coefficient we should note that one unite of size means moving from a lower category to the higher one (from small to medium and medium to large), so for example one category higher in firm size engaging in process innovation will generate better probability of process innovation by (%1.22). This is in support of Schumpeter's view

that larger firms stimulate innovations. Manager experience is significant and negative for product innovation indicating that one year increase in the experience of the top manger, decrease the probability of product innovation by (%0.26).For process innovation, the coefficient is positive and insignificant. The dummy representing state share in ownership is highly significant for process innovation with negative sign indicating that 1% increase in the share of state in private firm will decrease process innovation by (%28.5). For product innovation the coefficient is positive and insignificant. The coefficient of education is highly significant in process innovation with positive sign indicating that one year more for a permanent full time worker will increase the likelihood of process innovation by (1.17%). For product innovation, the coefficient is positive but insignificant. The consistency of positive coefficients for education in both models may confirm that a well-educated labour force is crucial for innovation. A dummy of an exported firm has negative and insignificant coefficient in product innovation. This means that an exported firm has less probability of product innovation by (%2.2). This result is not expected because a priori was expected that an exporting firm is more likely to innovate introducing new products and successfully sell them in order to be competitive on the international level. It supposes that those exporting firms have a better chance to get the latest technology, which would facilitate innovation. This assumption is in line with the results attribute to process innovation; the coefficient is positive and insignificant.

For location, as expected, the less liberalized parts of China such as south west has less possibility to innovate as the negative sign of the coefficients in both models refer. This result is significant for product innovation and not significant for process innovation. To interpret the coefficient here we compare with the benchmark which is

north category; so for example a firm locates in the north has a better possibility of product innovation and process innovation by (%5.9) and (6.1) respectively than a firm locates in the southwest. The northeast is significant in both models. The mixed signs for innovation types do not deliver a clear message. The south coefficients are positive, significant in product innovation while insignificant in process innovation indicating that a firm locates in the south is more likely to generate innovation than a firm locates in the north. Both coefficients for the central are positive and significant indicating that firms locating in the central part of China have a better likelihood of innovation. East category is insignificant in both models, with negative coefficient in process innovation and positive sign in product innovation. Overall, our estimations show that central and south regions are the most likely to generate both types of innovation. Based on the results from table 1 and 2, we can say that both types of innovation are more or less determined by the same set of explanatory variables. This is consistent with earlier studies that linked and connected both types (for example see Martines-Ros, 1999).

In general, the results from our models support 3 out of 4 of our hypotheses, engaging in R&D activities and access to finance are particularly strong predictors of firm innovativeness.

12. Robustness Checks:

➢ Removing a few observation through flagging

In order to make sure that our results are robust, we need to see how our model will response if we remove some observations via flagging.

By marking the private firms established before the reform took place in 1978 with a flag in order to run the Topit regressions with/without these observations to investigate the impact on the results. In model 3 and 4, I used only the private firms, which founded since the reform in 1978 i.e. firms that have more than 34 years old were neglected in these models. To compare our results with ease, I gathered all the models in Table 3.

Table 4 shows comparison between the models

Innovation types	**Product**	**Process**	**Product**	**Process**
Tobit models	**Model 1**	**Model 2**	**Model 3**	**Model 4**
			Age=<34	**Age=<34**
N	*540*	873	*535*	860
Pseudo R-squared	*0.018*	0.036	*0.018*	0.035
Prob > F	*0.000*	0.000	*0.000*	0.000
Log pseudolikelihood	*-2312.13*	-3412.38	*-2292.18*	-3363.06
	Coefficient	**Coefficient**	***Coefficient***	**Coefficient**
Independent variables	***(SE)***	**(SE)**	***(SE)***	**(SE)**
1- Competition				
Monopoly & Oligopoly	*Ref.*			
Monopolistic	*-6.264*	1.828	*-6.153*	2.114
	(4.870)	(4.466)	*(4.874)*	(4.500)
Perfect competition	*-6.91***	-6.14***	*-6.80***	-6.25***
	(2.645)	(1.788)	*(2.657)*	(1.799)
2- Industrial sectors				
Consumer goods	*Ref.*			
Basic Materials	*-2.253*	2.100	*-2.221*	2.005
	(1.758)	(1.418)	*(1.765)*	(1.418)

Industrials	*-1.552*	1.384	*-1.470*	0.988
	(2.137)	(1.721)	*(2.150)*	(1.716)
Consumer Services	*-2.772*	-0.577	*-2.621*	-1.124
	(4.504)	(10.032)	*(4.589)*	(9.516)
IT	*Empty*			
3- Access to finance	*0.199****	0.158***	*0.207****	0.154***
	(0.052)	(0.038)	*(0.052)*	(0.037)
4- R&D activities				
Yes_ RD	*3.787**	6.389***	*3.523**	6.274***
	(1.580)	(1.272)	*(1.598)*	(1.277)
Research network (cooperation)	*3.397*	1.200	*3.437*	1.532
	(2.506)	(2.103)	*(2.499)*	(2.103)
Control variables				
1- Location				
North	*Ref.*			
North East	7.606^{+}	−5.352^{+}	7.814^{+}	-4.418
	(4.349)	(2.893)	*(4.478)*	(2.870)
East	*2.649*	-2.809	*2.703*	-2.127
	(2.506)	(2.326)	*(2.520)*	(2.283)
Central	*5.416**	4.087^{+}	*5.318**	5.062*
	(2.402)	(2.469)	*(2.435)*	(2.453)
South	*8.840***	2.009	*8.853***	3.050
	(2.43)	(2.763)	*(2.850)*	(2.720)
South West	*-5.911**	-6.157	−5.909^{+}	-5.497
	(3.001)	(5.526)	*(3.036)*	(5.576)
2- Firm Age	*-0.055*	0.007	*-0.017*	-0.098
	(0.114)	(0.101)	*(0.164)*	(0.132)
3- Firm Size	*0.492*	1.228	*0.439*	1.093
	(0.965)	(0.864)	*(0.968)*	(0.866)
4- Manger experience	*-0.267**	0.010	*-0.281**	0.034
	(0.116)	(0.082)	*(0.121)*	(3.082)
5- Yes state has share in ownership	*3.305*	-28.5***	*3.270*	-27.3***
	(6.549)	(3.678)	*(6.558)*	(3.596)
6- Education	*0.675*	1.17***	0.707^{+}	1.25***
	(0.459)	(0.361)	*(0.466)*	(0.367)
7- Yes _exports	*-2.200*	0.053	*-2.393*	-0.325
	(1.816)	(1.645)	*(1.833)*	(1.640)
Constant	*19.74***	4.984	*19.34***	4.922
	(6.772)	(5.146)	*(6.821)*	(5.204)
Note: In parentheses are standard errors; + p<.10, * p<.05, ** p<.01, *** p<.001	**F(19, 521)= 5.35**	**F(19, 854)= 13.55**	**F(19, 516)= 5.29**	**F(19, 841)= 13.18**

From tables 1, 3 above, belongs to product innovation, we find that all our variables

remain significant with almost the same level of significance. Coefficients have slightly changed. From tables 2, 4 belongs to process innovation, we have very minor changes in terms of statistic significance. While it is worth noting that, the signs of coefficient has turned negative for exports and firm age. In comparison with the model 1 and 2 firm age turned from 0.007 to -0.098 and the dummy of exports from 0.053 to -0.325. It is obvious that the exclusion of the private firms, which established before 1978 did not bring any essential change in our results, just some minor changes that have no effect on our estimation. All our independent variables remain high significant with almost the same effect on innovation.

- **The problem of over-control**

Second, in our model, I controlled for a large set of variables, which could be problematic. In order to address this problem, I will re-estimate my model without using these control variables. Clearer, I will run the Topit regression only with my independent variables of interest. The comparison between the models after reduction (table 5) and the full models 1 and 2 shows no considerable changes, just some minor changes in the value of the coefficients, though the signs remain consistent. All the independent variables remain statistically significant, only a few of them have slightly different level of significance. For example the dummy of R&D in model 5 became significant using the generous level of (10%) instead of (5%) in model 1. Also in the perfect competition category, the level of significant has decreased from 0.1% to 1%. It is obvious that there are no dramatic changes in our models, though the full models are statistically more significant. Thus, the comparison confirms the fact that the significance of our variables of innovation is not driven by a possible omitted variable bias.

Table 5 shows models after reduction

Tobit Models	Model 5	Model 6
Innovation types	**Product**	**Process**
N	557	909
Pseudo R-squared	0.011	0.017
Prob > F	0.000	0.000
Log pseudo likelihood	-2400.95	-3619.56
	Coefficients	**Coefficients**
	(SD)	**(SD)**
Competition		
Monopoly & Oligopoly	Ref.	Ref.
Monopolistic	−7.529	1.766
	(4.693)	(4.271)
Perfect competition	-7.263**	-5.539**
	(2.553)	(1.757)
Industrial sectors		
Consumer goods	Ref.	Ref.
Basic Materials	-2.503	2.949*
	(1.831)	(1.446)
Industrials	-0.708	1.235
	(2.189)	(1.675)
Consumer Services	-1.711	-6.000
	(4.012)	(4.031)
IT	Empty	
Access to finance	0.213***	0.177***
	(0.050)	(0.031)
Yes _RD	3.111+	9.148***
	(1.589)	(1.242)
Research network (cooperation)	2.611	1.636
	(2.340)	(1.991)
Constant	26.940***	14.859***
	(3.131)	(2.132)
Note: In parentheses are standard errors; + p<.10, * p<.05, ** p<.01, *** p<.001	**F(8, 549) = 5.56**	**F(8, 901) = 15.26**

➢ Replacing dummy R&D with R&D ratio to sales

I went one step further; I executed another test to make sure that my estimation will remain robust. One way to do that is to replace the dummy

variable of R&D, which has a value of 1 if firm conduct R&D and 0 otherwise, with the counterpart of the ratio of R&D expenditure to annual total sales. This measure could give us more information since it not only tell us whether or not firm spend on R&D but also reflects the intensity of R&D. I do not use this ratio as my main measure because the inclusion of this variable resulted in making the number of observations considerably lower and this could reduce the explanatory power of our model. The reduction of our sample from 540 observations in model 1 to 327 in model 7 of product innovation weakened the explanatory power of our model as it turned perfect competition category from being statistically significant at 1% in to insignificant. Manager experience turned form significant at 5% into insignificant, (south) region category turned from significant at 1% into insignificant, even the level of significance of access to finance reduced from 0.1% to 1%. However, the ratio of R&D is more statistically significant than the dummy; in table 6 we can see that R&D ratio is high statistically significant at 0.1% while its counterpart measure, dummy R&D in model 1 is significant at 5% level. It is tempting to interpret the coefficient of R&D ratio in model 7; with 1% increase in R&D expenditure to sales there is roughly 48% increase the probability of product innovation. Overall, my main concern for not using this model was the reduction in our sample, which affected some of our key variables negatively, especially competition. Thus, model 7 is not the best model regarding to my hypothesis. In model 8 our sample has reduced form 873 into 393. As expected, the reduction in the sample weakened the explanatory power of our variables, which led to less level of statistic significance of the model. For example, perfect competition category turns from significant at 0.1% in model

2 into 1% in model 8. More negatively effect seen in access to finance from 0.1% to 5%. Education and the dummy of state share of ownership turned as well from significant at 0.1% in model 2 into insignificant in model 8. The ratio of R&D spending is significant only at 5% while its counterpart in model 1 more significant at 0.1% level of significance. Thus, from the comparison it is clear that using the dummy of R&D is statistically more appropriate to use in our models. Of note, in my comparison, I did not rely on pseudo R Square because it does not fully explain how our model fit. Since it is the same pseudo R Square, according to (Veall and Zimmermann, 1996), we can use it to compare models. Even by taking pseudo R Square in consideration we do not see any profound effects. Pseudo R Square is slightly higher in model 7 than model 1 by (0.001), while there is a relatively big difference between model 8 and model 2 by (0.019).

Table 6 Using R&D ratio

Innovation types	**Product**	**Process**
Tobit models	**Model 7**	**Model 8**
N	327	393
Pseudo R-squared	0.019	0.017
Prob > F	0.000	0.000
Log likelihood	-1407.752	-1653.711
Competition		
Monopoly &Oligopoly	Ref.	
Monopolistic	2.472	7.109
	(6.541)	(6.814)
Perfect competition	-3.731	-5.952**
	(3.137)	(2.242)
Industrial sectors		
Consumer goods		
Basic Materials	-2.025	1.243

	(2.272)	(1.987)
Industrials	-0.259	3.084
	(2.974)	(2.300)
Consumer Services	14.346+	-2.162
	(8.652)	(10.672)
IT	empty	
Access to finance	0.177**	0.125*
	(0.064)	(0.052)
R&D to sales ratio	47.853***	24.663*
	(14.225)	(10.083)
Research network (cooperation)	2.825	1.262
	(2.960)	(2.403)
Location		
North	ref.	
North East	1.017	-2.504
	(6.845)	(5.197)
East	1.822	3.523
	(3.706)	(3.136)
Central	4.132	9.958**
	(3.514)	(3.408)
South	4.868	2.174
	(4.319)	(3.516)
South West	-9.048*	-5.101
	(4.177)	(6.314)
Firm Age	-0.075	0.169
	(0.14)	(0.154)
Firm Size	0.974	2.656*
	(1.312)	(1.204)
Manger experience	-0.067	-0.250*
	(0.147)	(0.109)
Yes state has share in ownership	-0.339	-4.566
	(8.342)	(5.515)
Education	0.909	0.691
	(0.572)	(0.479)
Yes _exports	-3.501	-2.647
	(2.674)	(2.050)
Constant	13.319+	10.758+
	(7.949)	(6.486)
Note: In parentheses are standard errors; + p<.10, * p<.05, ** p<.01, *** p<.001	**F(19, 308) = 33.00**	**F(19, 374) = 3.23**

➢ Reverse causality problem

The problem of reverse causality is common when we deal with the determinists of innovation. Probably this problem could present in the most of our variables of interest. To address this problem we will divide our dataset into two sub-samples, firms established before 2001 and firms established after 2001. The reason of choosing 2001 as a benchmark year is that in this year China has joined WTO. No doubt that, its admission to WTO in December 2001, has been a turning point in the Chinese economic history. Marketization has accelerated and many regulations have relaxed by the government to encourage private firms. The CCP endorses role of the private sector, inviting entrepreneurs to join (OECD). Also by using this year as a benchmark, we would have sufficient number of observation that would enable us to re-estimate and compare our results. We presume that older firms may have different characteristics since some of them started up in different time period when private firms were not encouraged. Old firms tend to resist any attempt to change as they would prefer to stick to their old ways and that would weakened their ability of innovation. So we need to confirm the significance of our results for older firms i.e. our results are not driven by selection bias. Based on the comparison in table 7, we see evident that all results for our independent variables are statistically significant i.e. by comparison the results of sub-samples with our model we can confirm that our model does not suffer from reverse causality. Of note, regarding to the comparison between the sub-samples, we can say that

Table 7 shows comparison between coefficients of the total sample and subsamples

Variables		Product innovation	Process innovation
Competition			
Monopoly & Oligopoly		ref.	ref.
Monopolistic	**Total**	2.472	7.109
	Firm age<=11	-8.425	4.448
Khe567 5esssrresto jlpd6r43	Firm age>11	**-4.798**	**0.413**
Perfect competition	**Total**	-3.731**	-5.952***
	Firm age<=11	-6.778*	-6.666**
	Firm age>11	-7.823^{+}	**-5.115***
Industrial sectors			
Consumer goods		ref.	
Basic Materials	**Total**	**-2.025**	**1.243**
	Firm age<=11	-1.899	3.932^{+}
	Firm age>11	-2.100	0.161
Industrials	**Total**	**-0.259**	**3.084**
	Firm age<=11	-0.873	4.048^{+}
	Firm age>11	-0.571	-1.318
Consumer Services	**Total**	**14.346**	**-2.162**
	Firm age<=11	-0.930	7.596
	Firm age>11	empty	-22.453***
Access to finance	**Total**	**0.177*** **	**0.125*** **
	Firm age<=11	0.127*	0.150**
	Firm age>11	**0.287*** **	**0.155** **
Yes engage in RD activities	**Total**	**47.853***	**24.663*** **
	Firm age<=11	1.257	6.248***
	Firm age>11	**6.014** **	**7.163*** **
Research network (cooperation)	**Total**	**2.825**	**1.262**
	Firm age<=11	7.167^{+}	7.618*
	Firm age>11	0.219	-2.25
N		540	873
		262	439
		278	434

➢ Correlation Matrix

"Correlations measure the strength and direction of the linear relationship between the two variables. The correlation coefficient can range from -1 to +1, with -1 indicating a perfect negative correlation, +1 indicating a perfect positive correlation, and 0 indicating no correlation at all. A variable correlated with it self will always have a correlation coefficient of 1" stata.com. The matrix shows no high correlation should concern our self about. All values are almost under 0.5 except for both type of innovation, which is naturally. For example 0.5958 value of correlation of innovation types means positive correlation, indicating that as product innovation increases, we expect that the process innovation increase as well. The matrix shows also positive correlation with both types of innovation for the following variables: access to finance, conducting R&D, contracting with other firms in R&D, firm size and education.

	innova~n	proces~n	compet~n	location	ind_se~s	New_ac~e	yes_RD	yes_co~n	firmAge
innovation	1.0000								
process_in~n	0.5958	1.0000							
competition	-0.1939	-0.1999	1.0000						
location	0.0951	0.0479	0.1022	1.0000					
ind_sectors	-0.0012	-0.0052	-0.0976	0.0186	1.0000				
New_access~e	0.2524	0.2217	-0.2066	0.0163	0.0434	1.0000			
yes_RD	0.1014	0.1525	-0.1474	-0.0476	0.0785	0.0997	1.0000		
yes_cooper~n	0.0900	0.0308	0.0019	0.0394	0.0462	0.0996	0.1984	1.0000	
firmAge	-0.0429	-0.0040	0.0490	-0.0566	-0.0813	-0.0356	0.1250	0.1011	1.0000
firmSize	0.0541	0.1019	-0.0668	-0.0507	-0.0659	0.1042	0.1191	0.0562	0.1658
Mangexp	-0.1365	-0.1122	0.0141	-0.1937	-0.0150	0.0064	0.0969	0.1653	0.3087
educa	0.0246	0.0705	-0.0598	-0.2077	0.1009	0.0829	0.0774	-0.1276	0.1320
yes_exports	0.0226	-0.0046	-0.0246	0.1709	0.0503	0.1210	0.1103	0.2086	0.1452
yes_states~e	0.0415	-0.0238	-0.0796	-0.1143	0.0411	0.0921	0.0891	0.0580	0.0383

	firmSize	Mangexp	educa	yes_ex~s	yes_st~e
firmSize	1.0000				
Mangexp	0.1539	1.0000			
educa	0.0948	-0.0114	1.0000		
yes_exports	0.1601	-0.0000	-0.0366	1.0000	
yes_states~e	0.0821	0.1112	0.0546	0.0091	1.0000

Finally, I tried different techniques trying to get some statistical significance for

industrial sectors. For example, one way is by generating 26 dummy variables representing our industrial sectors. However, this method did not lead to any significant results.

13. Concluding remarks and criticism

The objective of this study was to explore the determinant of innovation in the manufacturing sector at the private firm level in china. The data come from the World Bank survey, China - Enterprise Survey Manufacturing Module (2012). In this paper, I used the broad definition of innovation that includes product and process innovation. Based on the survey answers, I sought to test 4 hypotheses by employing possible variables linked with key theoretical and empirical models including competition, access to finance, R&D activities and industry as independent variables and controlled for a set of private firm characteristics including age, size and location, among others. I found good evidence supporting 2 of my hypothesis. Engaging in R&D activities found to be an important factor in determining the probability of private firm innovativeness. Particularly, R&D expenditure found to be crucial for innovation. Likewise, access to finance is very significant for private firm innovativeness. Obviously, private firms that have higher proportion of their working capital financed from external finance have higher probability of innovation. This is consistent with the large body of literatures that emphasized the crucial impact of R&D expenditure and access to finance on innovation. Against our hypothesis, competition is significant up to certain level, beyond this level; competition is more likely to have a negative effect on private firm innovativeness. An important limitation of the dataset, regarding to the number of competitors, is the ambiguous

category of "too many competitors" which represents more than 80% of observations. Given the importance of competition in our study, I did not drop those observations; rather I grouped them in one category (over 500 competitors). Unfortunately, I could not confirm the relation between the type of industry and innovation, not even on a rather generous level of 10%. A possible explanation for that is related to the quality of the dataset. For example, the dataset in hand belongs to the manufacturing sector. However, we have a significant number of observations that have been taken from service related industries. A coherent, representative dataset are vital to draw any conclusion. Another limitation in the dataset is observable from the question (A.16) at the end of the survey "It is my perception that the responses to the questions regarding opinions and perceptions: Truthful, Somewhat truthful, Not truthful". Of 2695 observations 42 (%1.5) belongs to "Not truthful" category, which was a concern that I should deal with. In order to investigate the impact of those "Not truthful" observations on the model, I marked them with a flag in one group. After running the regression without these observations, I found that the exclusion of these observations did not have any essential impact on model 1 and 2 (for the comparison see appendix). It worth noting, after the exclusion, the number of observation in model 1 remains the same (540) i.e. theses observations was dropped due to the overlapping, while the number of observations in model 2 reduced by 10. Overall, based on our empirical results, we have good evidence that access to finance and R&D expenditure are crucial determinists for private firm's innovativeness.

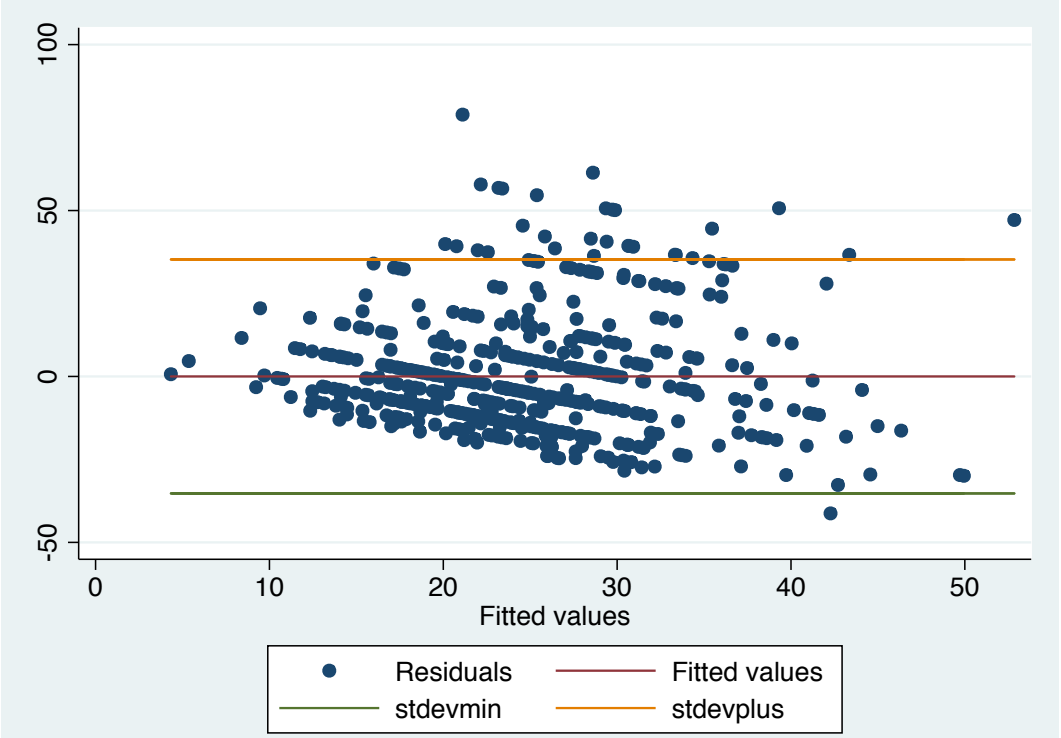
Appendix 1: VIF test for multicollinearity shows no issue we should concern our self about.

	Product		Process	
Variable	VIF	1/VIF	VIF	1/VIF
Competition				
Monopolistic	1.25	0.80	1.26	0.79
Perfect competition	1.38	0.73	1.37	0.73
Location				
North East	1.87	0.53	1.77	0.56
East	4.35	0.23	3.25	0.31
Central	3.26	0.31	2.26	0.44
South	4.27	0.23	2.83	0.35
South West	1.48	0.67	1.25	0.80
Industrial sectors				
Basic Materials	1.53	0.65	1.49	0.67
Industrials	1.59	0.63	1.57	0.64
Consumer Services	1.09	0.92	1.04	0.96
Access to finance	1.12	0.90	1.13	0.89
Firm conduct R&D	1.15	0.87	1.25	0.80
Firm age	1.19	0.84	1.18	0.85
Firm size	1.12	0.89	1.11	0.90
Manger experience	1.23	0.81	1.24	0.81
Network research coop.	1.14	0.87	1.15	0.87
State share in ownership	1.08	0.93	1.19	0.84
Education	1.26	0.80	1.18	0.85
yes_exports	1.21	0.82	1.23	0.81
Mean VIF	1.71		1.51	

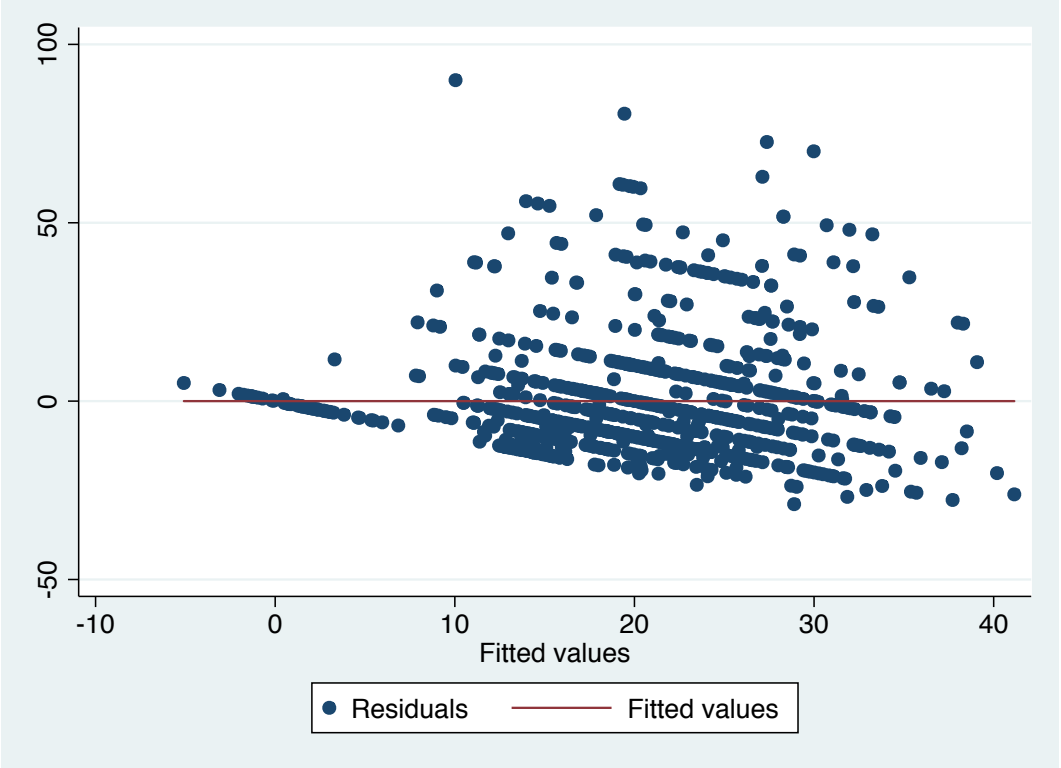
Appendix 2

Checking for Heteroskedasticity

Product innovation



Process innovation



Cameron & Trivedi's decomposition of IM-test

	Source	chi2	Df	P
Process	Heteroskedasticity	222.42	154	0.0003
	Skewness	62.41	19	0
	Kurtosis	5.48	1	0.0193
	Total	290.31	174	0
Product	Source	chi2	Df	P
	Heteroskedasticity	277.49	166	0
	Skewness	73.99	19	0
	Kurtosis	12.56	1	0.0004
	Total	364.04	186	0

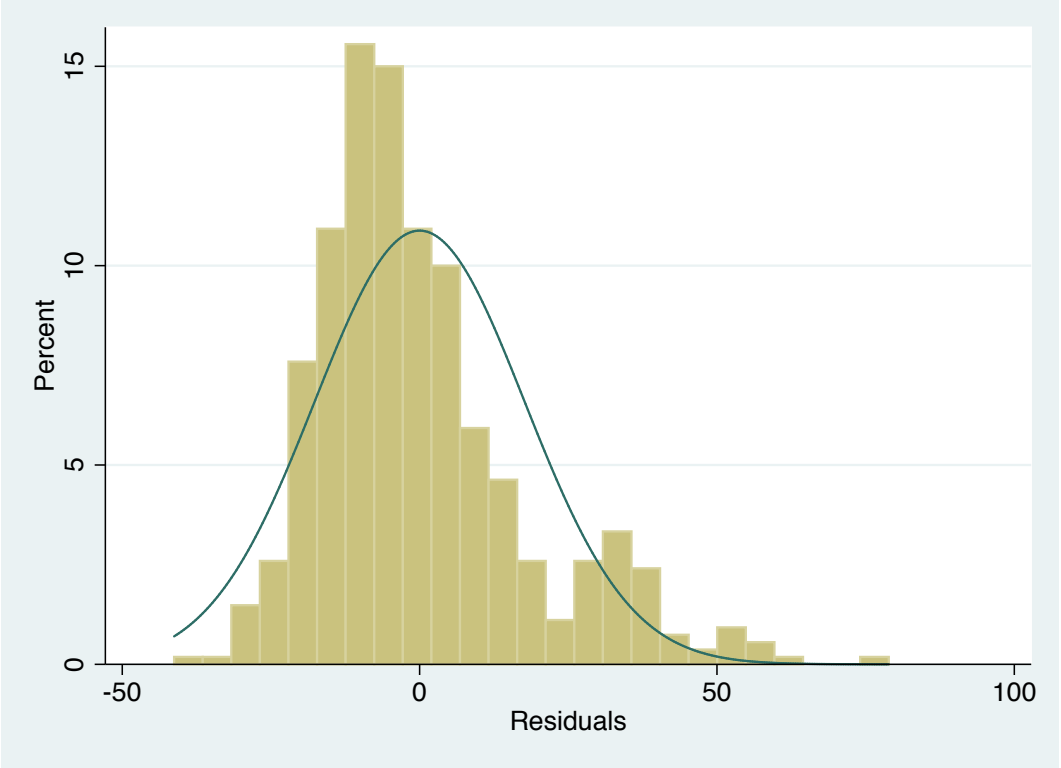
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of innovation

product	chi2(1)	56.6
	Prob > chi2	0
Process	chi2(1)	31.26
	Prob > chi2	0

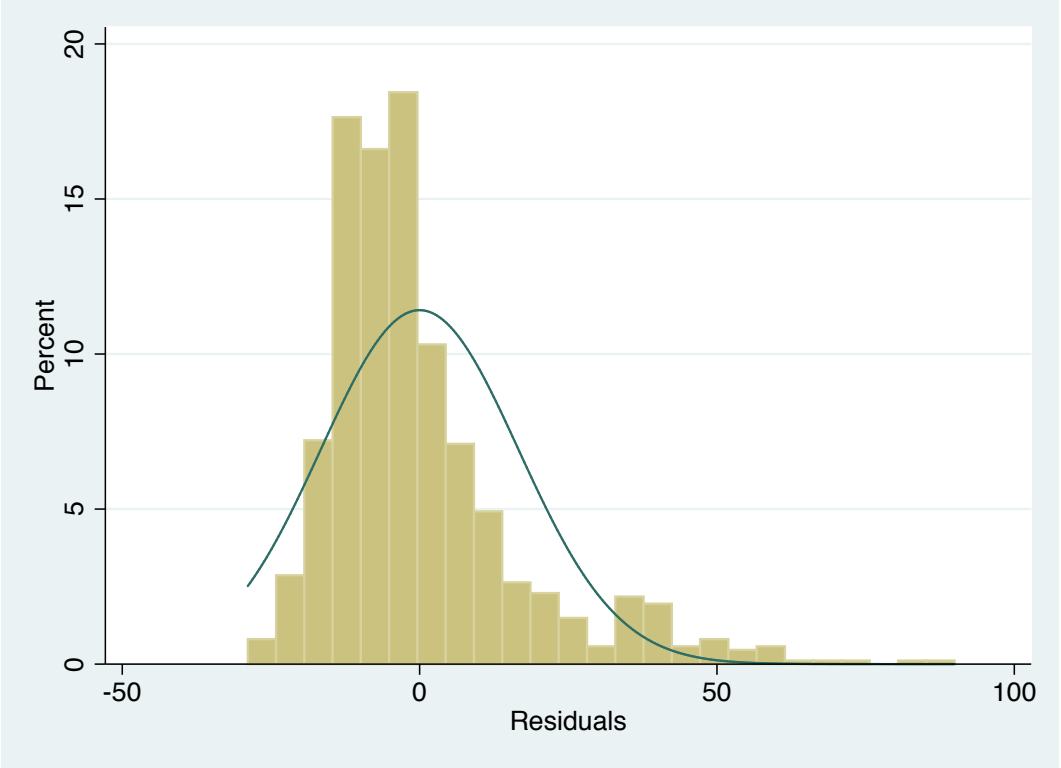
Appendix 3

Checking for normality:

Product innovation



Process innovation



Normality test

	Variables	Obs	Pr(Skewness)	Pr(Kurtosis)	chi2(2)	Prob>chi2
Product	E	540	0	0	97	0
Process	e2	873	0	0	304.66	0

.

Appendix 4

Comparison between model 1 and 2 and the models after excluding (Not truthful category)

Innovation types	**Product**	**Process**	**Product**	**Process**
Tobit models	**Model 1**	**Model 2**	**Model 9**	**Model 10**
	Basic	**Basic**		
N	*540*	873	*540*	863
Pseudo R-squared	*0.018*	0.036	0.018	0.036
Prob > F	*0*	0	0	0
Log pseudo likelihood	*-2312.13*	-3412.38	-2312.13	-3364.11
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
Independent variables	**(SE)**	**(SE)**	**(SE)**	**(SE)**
1- Competition				
Monopoly & Oligopoly	Ref.			
Monopolistic	*-6.264*	1.828	*-6.264*	1.862
	(4.870)	(4.466)	*(4.870)*	(4.473)
Perfect competition	*-6.91***	-6.14***	*-6.91***	-6.267***
	(2.645)	(1.788)	*(2.645)*	(1.789)
2- Industrial sectors				
Consumer goods	*Ref.*		*Ref.*	
Basic Materials	*-2.253*	2.100	*-2.253*	1.725
	(1.758)	(1.418)	*(1.758)*	(1.417)
Industrials	*-1.552*	1.384	*-1.552*	1.235
	(2.137)	(1.721)	*(2.137)*	(1.729)
Consumer Services	*-2.772*	-0.577	*-2.772*	-0.812
	(4.504)	(10.032)	*(4.504)*	(10.067)
IT	*Empty*		*Empty*	
3- Access to finance	*0.199****	0.158***	*0.199****	0.156***
	(0.052)	(0.038)	*(0.052)*	(0.038)
4- R&D activities				
Yes_ RD	*3.787**	6.389***	*3.787**	6.636***
	(1.580)	(1.272)	*(1.580)*	(1.272)
Research network (cooperation)	*3.397*	1.200	*3.397*	1.230
	(2.506)	(2.103)	*(2.506)*	(2.109)
Control variables				
1- Location				
North	*Ref.*		*Ref.*	
North East	7.606^{+}	-5.352^{+}	7.606^{+}	-5.306^{+}

	(4.349)	(2.893)	*(4.349)*	2.895
East	*2.649*	-2.809	*2.649*	-3.219
	(2.506)	(2.326)	*(2.506)*	2.324
Central	*5.416**	4.087+	*5.416**	4.135
	(2.402)	(2.469)	*(2.402)*	2.469
South	*8.840***	2.009	*8.840***	1.774+
	(2.43)	(2.763)	*(2.43)*	2.764
South West	*-5.911**	-6.157	*-5.911**	-6.131
	(3.001)	(5.526)	*(3.001)*	5.505
2- Firm Age	*-0.055*	0.007	*-0.055*	0.020
	(0.114)	(0.101)	*(0.114)*	0.101
3- Firm Size	*0.492*	1.228	*0.492*	1.003
	(0.965)	(0.864)	*(0.965)*	0.859
4- Manger experience	*-0.267**	0.010	*-0.267**	0.003
	(0.116)	(0.082)	*(0.116)*	0.082
5- Yes state has share in ownership	*3.305*	-28.5***	*3.305*	-28.23***
	(6.549)	(3.678)	*(6.549)*	3.678
6- Education	*0.675*	1.17***	*0.675*	1.085***
	(0.459)	(0.361)	*(0.459)*	0.359
7- Yes _exports	*-2.200*	0.053	*-2.200*	0.341
	(1.816)	(1.645)	*(1.816)*	1.656
Constant	*19.74***	4.984	*19.74***	6.478
	(6.772)	(5.146)	*(6.772)*	5.112

Note: In parentheses are standard errors; + p<.10, * p<.05, ** p<.01, *** p<.001

We note that model 1 and 9 are identical. Minor changes are found in location in model 10 in comparison with model 2. Thus, the exclusion of these observations does not lead to any significant change. Even if we consider pseudo R2, it remains with the same value.

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