International Economics with a focus on China

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Master Thesis

Innovation in China: Finding the Balance between Short-Term Viability and Long-Term Success

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Abstract

This paper traces the role of innovation in China, a developing economy striving for developed status. China has enjoyed blockbuster economic growth over the past three decades thanks to economic reforms which have allowed it to utilize its comparative advantages as a low cost center of manufacturing and become the so called 'workshop of the world'. But much of China's growth to date has stemmed from its ability to reduce and maintain low costs—a position which is increasingly challenged as its continued economic growth places increasing pressure on prices. In order for China to sustain its economic growth on a long term basis it must begin to put a focus on innovation in order to be capable of generating new sources of economic growth. But investing in innovation places firms in a contradictory situation where they must try to continue to reduce costs to ensure short term growth while at the same time invest increasing resources in innovation in order to ensure long term viability. Through analysis of what innovation means both to a nation and its firms, this paper takes a critical look at the path China must follow in its pursuit of innovation. Using empirical evidence this paper will show how firms that are pursuing innovation in China's still nascent economic development actually face economic hardships in the short term as the costs of innovation are immediate while its benefits take time to develop. Through an outline of the role of innovation in an economy and tracing China's economic growth to date this paper argues that China is currently caught in a paradoxical situation where it must continue to focus on cost-efficiencies while at the same time investing in innovation for future sustained economic growth. In order to help firms, the government will need to strengthen institutions, primarily ensuring the free flow of capital and a stronger legal system to both allow firms to have the resources to invest into innovation and then to protect those investments. However, the government will need to do this in a manner which will still continue to allow market forces to operate. This paper will show however that while firms in China are incurring profit loss in their pursuit of innovation, if China is to truly become the economic superpower of the 21st century its firms must learn to maintain a balance focusing on short-term viability with long-term growth.

Keywords: Innovation, China, Institutions, Capital Markets, Government Role, Economic Balance

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I. Introduction

As China's economy continues its rapid ascent and becomes a global economic engine a paramount question becomes how sustainable is China's economic expansion? A large component of China's growth thus far has been due to comparative cost advantages China has enjoyed that have enabled it to become the so called 'workshop of the world'. But no nation can rely on cutting costs in perpetuity. Traditional economic theory dictates that as China continues to develop and become richer it will lose these cost advantages which have been fueling its growth. This would indicate that China's current economic rise is not sustainable. Thus it would appear that in order for China to continue to grow it must be able to move up the economic value added chain and move away from low skilled manufacturing. A key factor for China to be able to compete in the future will be in its ability to innovate.[1] Indeed, this has become a focus of the central government itself as in 2006 it outlined its intent to make China an innovation based economy by 2020.[2]

While according to traditional theoretical analysis, China must at some point become an innovative society in order to continue growth, the costs of such a transition are high. The question then becomes how firms will handle the pursuit of innovation. Innovation has been shown to stimulate growth but only once countries move into the middle-income stage of development.[3] Below that threshold the adoptive capacity of a country and its firm to adopt advanced technology and methods is limited. If the benefits of innovation are limited to a low-income country but necessary to the growth of a high income country then how is China to pursue innovation as it seeks to become a developed country. While many consider innovation as the basis of all economic growth resulting from efficiency gains, the path to innovation is not easy and it involves substantial investments that must be made long before benefits can be realized.[4] China then must face the dilemma of providing for the costs of innovation

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[1] Y. Shahid and S.J. Evernett, *Can East Asia Compete? Innovation for Global Market*s, Oxford University Press, 2002, vii.
[2] P. Ford, "China Ready to leap from industrial to information-age economy", *Christian Science Monitor*, September 5, 2007.
[3] Sanjaya Lall, "Indicators of the relative importance of IPRs in developing countries", *Research Policy*, Vol. 32, No. 9, 2003, 1658.
[4] Greg Clark, A *Farewell to Alms: A Brief Economic History of the World,* Draft, 27 November 2006. Princeton University Press, June 2007, 226.

while still a poor country in order to be better able to reap the rewards once it has become more developed. This then places China in the awkward position of trying to maintain its competitive cost position while at the same time making the investments necessary in order to maintain long-term economic growth at a future point of time. But the dilemma facing this theory is that while in the long term firms that are unable to innovate should be forced out of the more advanced market, what happens in the short term. If firms that do not innovate in the long-term lose their cost advantage through being unable to come up with new ways to reduce costs or drive revenue, could it not also be true that those firms that begin to invest in innovation lose their cost advantage in the short-term through the additional costs of investment in innovation? The question then faced is if this loss of cost advantage in the short term is small enough so that firms can survive for long term benefits. This paper will take a theoretical look at the institutional need for innovation, the basis of China's economic growth to date, the future need for it in China and current obstacles to innovation in China. If China is not to see significant benefits from innovation until it reaches middle-income status than the firms currently pursuing innovation should theoretically be hurting their short-term profit growth rate while laying the foundation for long term economic growth from innovation. Using data from "Investment Climate Survey" conducted by the World Bank in China in 2003, this paper will then attempt to analyze whether firms in China that are currently investing into innovation now are suffering a corresponding drop in profit growth.[5] Based on this, analysis will be done on what this portends for China's economic future. Does a current lack of relative economic success by innovative firms indicate that China has not yet entered its innovative epoch? If firms that are undertaking the pursuit of innovation are meeting with economic success at present then does this signify that China has begun to move beyond its base of low cost manufacturing and has entered its next stage in economic development and has begun to see the benefits of innovation even though it is still considered a low-income country?

[5] "Investment Climate Survey". *World Bank*. 2003.

II. The Institution of Innovation

The importance of innovation comes on the basis that there are two central avenues firms can take in order to become and remain competitive: cost reductions and innovation.[6] With cost-cutting the firm relies on existing business structures in order to reduce costs and thus improve profits. However, cost reductions without innovation results in a finite limit of potential savings without the introduction of new methods, technologies or even inputs and must because of this be viewed primarily as a short term solution. As will be shown in Section III, this is the primary method of growth that China has used to date. This then leaves innovation as the principle conduit for firms to achieve long term competitiveness. But then what exactly is innovation?

Schumpeter, in 1911, was amongst the first economists to introduce the idea of innovation in an economic sense as a concept of five approaches that entrepreneurs could take in the pursuit of new opportunities:

1. New products
2. New technologies and/or processes
3. New markets
4. New organizations
5. New inputs[7]

The basic premise of Schumpeter was that economic growth was dependent upon the introduction of foreign elements being introduced into the current economic system whether these foreign elements be ideas, technologies or inputs. Without these foreign elements or innovation as they can be referred to, economies and firms were to be bound in a static growth cycle with no real long term potential for economic expansion. This contrasted sharply with the leading neoclassical static equilibrium theory which was prevalent at the time. This theory stated that economic systems were largely passive and adapt to influences that act upon them without causing a

[6] Jan Lambooy, "Innovation and Knowledge: Theory and Regional Policy", *European Planning Studies,* Vol. 13, No. 8, December 2005, 1139.
[7] Lambooy, 1137.

shift in the system and that in the end exogenous factors had little long-term effect.[8] By contrast, Schumpeter argued that it was new factors, principally innovation, that were necessary to provide shocks to the economic system. Without innovation countries will become stuck in a 'circular flow' which is essentially a static economy and that there is no possibility for long term profit. Only those firms that innovate and thus break the circular flow are able to profit.[9] Because of this one of Schumpeter's central tenets was that forces of competition become one of the major drivers of innovation.[10] Innovation essentially then becomes the application of knowledge in a new way in order to bring about profit.[11] Thus, Schumpeter argued innovation is necessary for sustained economic growth.[12]

This theory was later built upon by Solow (1956) who showed the sustained gains in per capita GDP are impossible without innovation because of diminishing marginal productivity using existing technology.[13] Solow promoted the exogenous growth models that innovation came from outside current economic systems. Because innovation was an exogenous factor it was felt that it could be shared equally by all countries which would lead to a gradual convergence in incomes as long as nations practiced sound policy choices.[14] Some, such as Gerschenkron (1952), also provided support for the idea of an economic convergence through such advantages as 'relative backwardness' which would allow less developed countries to catch up by adopting already successful technologies and innovations in a low-cost manner[15]. Further research done by Aghion and Howitt (1992) shows more specifically that economic growth comes almost exclusively from technological progress which is a direct result of competition between firms to generate innovation in order to fuel this progress and

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[8] Jan Fagerberg, "Schumpeter and the revival of evolutionary economics: an appraisal of the literature", *Journal of Evolutionary Economics*, 13, 2003, 128-129.
[9] D.F. Dixon, "Schumpeter—Fifty Years Later", *Journal of Macromarketing*, June 2000, 84.
[10] Fulvio Castellacci, "Evolutionary and New Growth Theories, Are They Converging?", *Journal of Economic Surveys,*Vol. 21, No. 3, , 2007, 586.
[11] N. Valery and L. Kekic, "Innovation: Transforming the way business creates", *The Economic Intelligence Unit* (2007), 3.
[12] D.F. Dixon, "Schumpeter—Fifty Years Later", *Journal of Macromarketing*, June 2000, 84.
[13] P. Aghion and P Howitt, "Capital, innovation, and growth accounting", *Oxford Review of Economic Policy*, Vol 23: 1, 2007, 79.
[14] Valery and Kekic, 3.
[15] Stephen Knack and Philip Keefer, "Why Don't Poor Countries Catch Up? A Cross-National Test of an Institutional Explanation", *Economic Inquiry*, Vol. XXXV, July 1997, 590.

generate profit and reinforced the hypotheses of Shumpeter.[16] This effect is felt even in labor productivity because in the long run all productivity increases are as a result of technological improvements stemming from innovation.[17] However, the lack of economic convergence that has occurred since Solow made his predictions have led some to conclude that innovation is not necessarily an exogenous factor that could be equally shared by all but rather an endogenous factor that is a result of a nation's stock of human capital and existing knowledge.[18] For developing countries to be able to take advantage through adopting advanced methods in order to jump ahead in their development depends in turn on the strength of their institutional framework.[19] This has profound effects on a country such as China that is looking to leap ahead in its economic development and shows the necessity of fostering strong institutions in order to both foster internal innovation as well as being able to take advantage of advancements other countries have achieved. For example, if a country does not invest into education, a key input of innovation, then there is little likelihood of innovation occurring internally or having the internal capability to adopt and implement advanced external technologies.

While Schumpeter expounded that innovation would be a foreign force it does seem that he could have accepted it as both an endogenous and exogenous force. It could be endogenous in that it was the creation of internal forces that would lead to the birth of innovation and thus the creation of a shock that would disrupt the economic system and lead to its expansion. Much as in the natural sciences the mixing of two existing elements can lead to the creation of new substances, so this can be true in economics. This view would help in explaining the relatively slow economic growth throughout world history until the industrial revolution of the 18th and 19th centuries. Until 1750, on average over long periods technological advancement never occurred faster than .05% on an annual basis.[20] This translates into an increase in production possibilities of no more than 5% every 100 years. In fact, from the year 1 CE to 1750

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[16] P. Aghion and P Howitt, "A Model of Growth Through Creative Destruction", *Econometrica*, Vol. 60, No.2, March 1992, 349.
[17] Aghion and Howitt, "Capital, innovation, and growth accounting", 80.
[18] Valery and Kekic, 3.
[19] Stephen Knack and Philip Keefer, "Why Don't Poor Countries Catch Up? A Cross-National Test of an Institutional Explanation", *Economic Inquiry*, Vol. XXXV, July 1997, 601.
[20] Greg Clark, A *Farewell to Alms: A Brief Economic History of the World,* Draft, 27 November 2006. Princeton University Press, June 2007, 6.

CE technology improved by on average only 24%. However, since the industrial revolution successful countries have had on average technological growth rates of greater than 1% per year.[21] From this perspective it took this long for the internal forces to build and create the requisite body of knowledge and technologies that would allow for innovation to occur. Once innovation was able to occur it was able to build upon itself and allow for the comparatively rapid economic growth that the world has witnessed since the dawn of the industrial revolution.

That this growth has been concentrated and not spread uniformly throughout the world could perhaps be explained in that those countries which most benefited from rapid economic growth were those that were best able to foster the institutions that support it. Principally, the state must provide a stable macro-economy and clearly defined rules of the game which allow for a transparent business operating environment.[22] Those countries that were able to do so were able to benefit from innovative growth. Consequently, as innovation began to occur more rapidly, it began to build upon itself. For example, those countries that already had a certain degree of technological ability were the one that were best able to utilize further advances. This then helps to explain the exogenous nature of innovation. As innovation began to occur more rapidly its ability to transfer between economic systems grew. However, while Solow predicted that this would lead to a greater convergence between economies, instead those countries that had the institutions best able to absorb the new innovations were those that were able to grow the fastest. But what both sides, those who claim that innovation is an exogenous factor and those who claim it is endogenous, can agree is that the proper institutions need to be in place in order for innovation to flourish.[23] Institutions, as defined by North (1991), are the constraints that society imposes in order to impose an incentive structure which in turn helps to facilitate business.[24] Thus, for developing countries such as China who seek long term economic growth the necessity of furthering institutions

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[21] Clark, 162.

[22] Sanjaya Lall, "Reinventing Industrial Strategy: The Role of Government Policies in Building Industrial Competitiveness", *The Intergovernmental Group on Monetary Affairs and Development (G-24)*, 2003, 1.

[23] Valery and Kekic, 3.

[24] Douglass C, North, "Institutions," *Journal of Economic Perspectives*, 5(2), 1991, 97.

that properly reflect desired incentive structures and overcoming obstacles to innovation becomes paramount.

Today the need for innovation in both the macro and micro level is clear. The Organization for Economic Cooperation and Development (OECD) has long been a proponent that innovation is the single most important factor of long-term economic and productivity growth and that those nations that foster innovation tend to grow the fastest.[25] Likewise, on the micro level innovation is found to be a key ingredient to sales growth. In an economic survey done by the Economist Intelligence Unit in 2007 it was found that of firms that viewed innovation as critical to their success, 46% did better than their competitors. Meanwhile, of firms that did not view innovation as critical to their success, only 32% performed better than their competitors. Of particular note from this survey as concerns this paper is that of Chinese firms only 28.6% viewed innovation as critically important as opposed to the sample average of 46.9% taken from the 64 countries.[26] This helps to illustrate the relatively low level of emphasis that China has placed on innovation to date and which must change if China is continue its economic expansion on a long term basis.

III. China's Economic Growth History

While innovation is the way to move a country economically forward in perpetuity, China's economic expansion experience to date has been largely without the aid of innovation. China's rapid economic growth was sparked in the late 1970's by the stimulus of gradual economic reforms instituted by the government moving the country's economy from a centrally command driven to one approaching market based status. However, it is important to note the possibility that these reforms were not by themselves the reason for China's explosive growth over the past quarter century but rather only the method through which China's comparative advantages were allowed to be unleashed and the inefficiencies that had been a corrosive aspect under central planning were diminished. Broadly speaking, China's growth was largely due to an enormous cheap labor pool which China was able to take advantage of through structural change much in the way that other East Asian countries have

[25] Valery and Kekic,8.
[26] Valery and Kekic, 6.

done. Table 1 illustrates the shift of labor away from agriculture in other South Korea and Taiwan as well as China:

Table 1: Percentage of Labor in Agriculture Sector

Country	Year	Percentage in Agriculture	Year	Percentage in Agriculture
South Korea	1963	63%	2003	9%
Taiwan	1965	46%	2003	7%
China	1978	71%	2003	49%

Source: Carsten Holz, "Why China's Rise is Sustainable".[27]

This transition of labor away from agriculture is important because it is estimated that labor productivity in industry is on average seven times higher than agriculture and three to four times higher in the service sector compared to agriculture. What this means is that every time a worker moves away from agriculture to industry or the services sector his value added to the economy dramatically increases creating strong economic growth.[28] China's government has helped to fuel this growth through dedicated infrastructure investment in order to ensure continued productivity and increase efficiencies. While not every country with cheap labor has been able to enjoy rapid economic growth this is due to the fact that not all nations have committed to investing in the infrastructure and the erection of institutions necessary for economic growth in the way that China's government has been proven to be adept. In particular, it is China's relative open economy compared to other developing countries that has enabled it to best benefit from its comparative advantages.[29] Because China has been able to create an environment where it is able to benefit economically from its cheap labor, it is expected that in China, over the next several decades, 1% of the workforce will continue to transition away from agriculture

[27] Carsten Holz, "Why China's Rise is Sustainable", *Far Eastern Economic Review*, April 2006, 41.
[28] Holz, 42.
[29] "OECD Reviews of Innovation Policy: China Synthesis Report", *Organisation for Economic Co-Operation and Development*, 2007, 11.

annually. By itself that could translate into annual economic growth of 4-5%.[30] It is this constant infusion into the industrial and service sector labor forces that has thus far allowed China to keep labor costs relatively low even during the prolonged period of growth. While wages in China are not now the lowest in the world, government investment in infrastructure and the focused direction of inward investment has allowed productivity gains to outstrip increases in labor wages so that the unit labor costs have actually decreased since 2000.[31] Thus, assuming that labor will continue to shift away from agriculture, and by all appearances it should considering that the average amount of agricultural laborers is 100 times higher per acre in China than the United States[32], it would appear that the value added coming from structural change can play a role in helping to abet the costs of innovation as China moves forward into the future.

IV. Sustainability of China's Economic Growth

The question remains how sustainable China's economic growth is based as it is on structural change built in order to continue to take advantage of China's low cost labor pool. Looking at history one sees that the United States used a similar method of utilizing structural change in shifting employment away from agriculture into sectors it enjoyed productivity and cost advantages in order to overtake Great Britain as the world's economic superpower in the late 19th century and early 20th century.[33] During this period the United States was criticized for many of the same misdeeds that China is now blamed for such as theft of intellectual property and inferior quality of manufactured goods.[34] Is China then destined to overtake the United States as the world's economic superpower purely on the basis of taking advantage of benefits derived from structural change as the United States was able to overtake Great Britain? While the answer to this question may have historically been yes, in today's globalized world it is unlikely that this still remains true. The United States was able to overtake Great Britain in a world in which multi-national corporations did not exist.

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[30] Holz, 42.
[31] "How Fit is the Panda?", *The Economist*, September 27, 2007.
[32] Holz, 42.
[33] S.N. Broadberry (1998), 'How Did the United States and Germany Overtake Britain? A Sectoral Analysis of Comparative Productivity Levels, 180-1990', *Journal of Economic History*, 58, 375
[34] S. Mihm, "A nation of outlaws - A century ago, that wasn't China -- it was us", *Boston Globe*, August 26, 2007.

However, in the current era of globalization, any comparative advantages that China currently enjoys due to low costs will prove to be much more transitory than ever before in history.[35] At the slightest rise in price companies will go elsewhere to produce their goods. While China will continue to enjoy the benefits from structural change it does face demographic pressures. China's working age population will peak in 2010 at 72.2% of the population and will then decrease to 60.7% by 2050 which can not help but place pressure on prices.[36] Furthermore, the shift of labor away from agriculture is predicated on historically low prices. But in recent months meteoric rises in food staples has threatened this assumption and China may actually see a shift in labor back towards agriculture which would place enormous pressure on wages in manufacturing sectors in the short term resulting both from this shift of labor back to agriculture as well as demands by workers for wage increases in line with the rising price of food. Even ignoring the recent impact of higher food prices and its as yet unquantified impact on the labor market in China, some argue that China has already reached its 'Turning Point' which is the state in a developing country's development where cheap labor from rural areas begins to become scarce and real wages dramatically increase.[37] Even in the areas in which China today enjoys a cost advantage, globalization has created an ultra competitive world that has made it difficult for firms in China to realize significant profits.

Further threatening the sustainability of China's economic growth are the environmental costs that must eventually be accounted for. China's breakneck growth, based as it is on low cost manufacturing, has often come with little regard for efficient or environmentally friendly production. This has translated into all sectors of the economy as China's firms and political leaders have sought the cheapest and quickest solution to developing problems.[38] For example, while other developing countries have generally seen a decrease in energy intensity as their GDP increases, China has actually seen an increase in energy intensity per unit of GDP since 2002. This increase that began in 2002 marked a dramatic shift from the reduction that had been occurring in China since the start of reforms in 1978 until 2002 where the rate of

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[35] T. Friedman, *The World Is Flat*, Penguin, second edition, 2006.

[36] I. Bremmer, "China's Underpopulation Problem", *Slate*, March 7, 2006.

[37] R. Garnaut and L. Song, "China's Resources Demand: At the turning point", prepared for Rio Tinto-ANU China Partnership, August 2007, 4.

[38] "OECD Reviews of Innovation Policy", 15.

energy consumption grew only half as fast as the economy's growth rate as a whole. Since 2002, however, energy consumption growth has been 1.5 times greater than that of the economy. This was largely a result of a shift back to heavy industries and inefficient but low costs practices.[39] As energy consumption increased faster than the economy as whole, China's government was caught unprepared and the result was rolling power blackouts in 2003. To prevent this, numerous cheap but environmentally damaging coal power plants were constructed such that 80% of China's energy needs now come from coal.[40] This system of choosing the cheap and quick method over long term sustainable approaches is taking its economic cost in China which the government will increasingly need to take into account as firms striving for short term cost advantages will presumably continue to follow cost friendly but economically damaging business practices. The deputy minister at China's chief environmental regulator has estimated that the damage from this environmental recklessness runs at between 8-13% of GDP.[41] While these costs can continue to be ignored at the firm level in the short term it will have to be addressed at the national level immediately. Even at the firm level these costs will soon need to be addressed as factors such as the deteriorating health of workers or falling water tables will force a change in business practices which can only increase the cost of doing business.

V. The Need for Innovation in China

While China's exports continue to boom, (in the first 11 months of 2007, China's exports totaled $1.1 trillion which is up 26% from the same period in 2006) the profits they are able to realize from many of these exports are still small.[42] For example, 90% of China's high-tech exports are still produced by subsidiaries or joint ventures of foreign joint ventures and furthermore 60% of profits from high-tech exports go to foreign firms.[43] What this means, according to estimates from China's commerce ministry, is that for a $700 laptop exported from China only $15 of value may be

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[39] China's Quest for Resources: The Perils of Abundance", *The Economist*, 13 March 2008.
[40] China's Resources Demand: At the turning point", *The Economist*, 13 March 2008.
[41] China's Resources Demand
[42] W. Foreman, "The pitfalls of China's rough capitalism", *Associated Press*, 11/1/2008, http://news.yahoo.com/s/ap/20080111/ap_on_bi_ge/china_raw_capitalism_2;_ylt=Aus1pbZ4QLPpUyCVgcECJUYE1vAI, 12/2,2008.
[43] "Something New", *The Economist*, August 6, 2006.

accounted to value added from China. Furthermore, while China makes 90% of the world's DVD players, China must pay license fees for every player produced to foreign firms.[44] For the DVD players that China exports only $1 from a $32 machine will remain in China while $20 goes to the foreign patent holders, 60% of the total value.[45] Furthermore, this also leaves China dependent on being granted production licenses in the first place in order to enter legitimate production. This is illustrated by the fact that to date no firm in China has been granted a license to produce the next generation DVD player with Blu-ray technology for fear of undercutting prices and theft of intellectual property.[46] These examples show to some extent the narrowness of the base on which China has supported its economic expansion. This shows China's reliance on the import of foreign technology and indeed much of its export growth has been because of a mix of China's cheap labor with imported foreign technology.[47] While China's potential based on this pattern of growth is clearly not exhausted thanks to the size of China and the benefits yet to be unlocked from structural change and economic reforms, it is clear that in the long term this is not sustainable and indeed even in the short term it is not desirable.

China, in order to move its entire country up the wealth ladder and not narrow segments, a policy its political leaders must abide by in order to avoid political instability, needs to move beyond its current strength and economic base of low cost manufacturing helped by foreign investment. To do this China's leaders realize that the country must learn to innovate. Thus, for firms in China facing increasing cost pressures in a competitive market with low profit margins the need for innovation becomes clear in order to generate substantial profits and move ahead of competitors. As stated previously, of the two main avenues to economic growth, cost-cutting and innovation, China has to-date largely focused on reduction of costs. But as further reductions become impossible, to continuation of growth will become increasingly dependent on innovation. But this places Chinese firms in the position of increasing investment in innovation while concurrently trying to further reduce total costs. As

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[44] C. Chandler, "Chasing the Dragon", *CNN Money*, 19/3/2007, http://chasingthedragon.blogs.fortune.cnn.com/2007/03/19/beyond-the-sweatshop-can-china-innovate/, 12/2/2008.
[45] "China's innovation campaign: dos and don'ts", *China Daily*, 19/3/2006.
[46] S. Hansell, "A $299 Sony Blu-ray Player, but No Cheap Chinese Models", *New York Times*, 5 March 2008.
[47] "OCED Review of Innovation Policy", 15.

Schumpeter stated, countries locked in a static growth cycle have little need for innovation. But in order for China to maintain sustainable growth in a manner corresponding to its previous 30 year history, innovation will become of paramount importance as it seeks to break out of its current economic cycle and create a larger one.

VI. Impediments to Innovation in China

For China to be able to obtain its goal of becoming an innovation-oriented society by 2020, it first needs to overcome significant obstacles. While these barriers are myriad they can perhaps be summed up succinctly through five general obstacles:

1. Chinese companies and political institutions must learn to place innovation at the center of their business strategies.[48]
2. The products of innovation must be protected through a stronger legal system.
3. The population itself must learn how to innovate.
4. Continued government interference in the economy stifles innovation.
5. China's allocation of capital must be reinvented in order to encourage innovation.

The first of these obstacles is perhaps the most intangible and thus difficult to change reflecting a conflict resulting from the clash of informal norms and formalized norms. Companies or bureaucracies can be told to place emphasis on innovation but it is not something that can be forced but only encouraged. Until companies see the benefits they can achieve through innovation they will only pay lip service to the idea of pursuing innovation and begin to look beyond short term gains towards the benefits that innovation can bring in the medium and long term. Chinese companies have long pursued the advantage of general backwardness and been able to imitate their way to success through reverse-engineering which has been what many companies cite as their research and development efforts. The data collected from the ICS shows that in 2002 firms on average reported spending 2.5% of total sales on Research and Development costs. Furthermore, fully 910 companies of the 1565 reporting data on

[48] "Further reforms would boost innovation in China, says OECD", *OECD*, 27/8/2007. http://www.oecd.org/document/60/0,3343,en_2649_201185_39160380_1_1_1_1,00.html, 12/2/2008.

R&D spending spent no money.[49] This compares with an average from companies in other East Asian countries of approximately 3.0%, a rate 20% higher.[50] However, while it is impossible to force companies to innovate, the method that will overcome this obstacle is through the simple heartlessness of the economy. As Schumpeter predicted, 'Creative Destruction' will occur to the firms that prove unable to innovate.[51] This then becomes part of the circular flow as firms that prove unable to innovate and reach a limit in how far they can reduce costs are gradually forced out and free up resources for those firms that can innovate. In the ultra competitive market that exists in China, as firms begin to lose their cost advantage, those Chinese firms that prove unable to innovate will simply disappear and it is through their disappearance that resources will be made available for those firms that can innovate.[52] The Chinese firms of the future will not be able to afford to pay 60% of their profits to foreign patent holders when their local competitors have been able to innovate new solutions and new processes allowing them to keep a larger portion of the profits.

This efficient weeding out of the companies that refuse or are unable to innovate will only occur if China produces a legal system that enables companies to protect the results of their innovation. Companies and individuals will prove unwilling to invest their time and resources into innovation if their idea or product can then be simply copied by their competitors. China has been notorious for poor protection of intellectual property rights. But this obstacle is also easily overcome if the Chinese government merely proves responsive to the market. Until now the relative lack of innovation has resulted in Chinese companies benefiting from counterfeiting foreign intellectual property. But as China pursues innovation, internal pressures will demand that the government move beyond passing laws protecting property rights and move to actually enforce them. Thus, intellectual property rights in China were weak only so long as that is what provided the greater benefit to the economy. As the economy matures and becomes more sophisticated then the greater benefit to China will accrue from stricter intellectual property rights enforcement. According to the ICS there

[49] Investment Climate Survey
[50] "Investment Climate Surveys Draft Country Profile: China 2003 Survey". *The World Bank Group*. Washington, DC. 2005, 9. 1 February 2008. http://rru.worldbank.org/InvestmentClimate.
[51] J. A. Schumpeter, *Capitalism, Socialism, and Democracy*. New York: Harper and Brothers, third edition, 1950, 84. 13 March 2008 <http://www.sp.uconn.edu/~langlois/Creative%20destruction.htm>.
[52] Shahid and Evernett, 7.

exists a 64% confidence level by firms that the legal system will uphold contract and property rights in business disputes.[53] China has already come a long way from the days when the Communist party abolished all patents. From 2000 to 2003 the number of patents filed for in China by domestic firms doubled and those filed by foreign firms quadrupled.[54] The ICS itself notes a 54% increase in the number of patent applications merely in the two year period from 2000-2002.[55] This dramatic increase would only occur if companies and individuals had increasing faith on the strength of the patent and thus on protection of intellectual property rights gained through innovation.

In addition to the protection of intellectual property rights the clear demarcation of private property rights is an institutional need for the development of innovation. In a similar vein to the protection of intellectual property rights, firms need to hold a strong belief that their investments are secure and that their firm will still have the legal right to exists in the future when the benefits of innovation begin to accrue. Without this, firm have no incentive to invest in themselves and thus invest in innovation. Firms that have secure private property rights have more incentive to operate in terms of long-term strategies—the type of strategies that are crucial to the development of innovation.

But the protection of intellectual and private property rights will mean little if the people are unable to innovate. Emerging from the Communist period where during such times as the Cultural Revolution innovation was not simply discouraged but also persecuted it can be difficult now to foster innovation among the population as a whole. Furthermore, the relative low education of much of the population remains an obstacle. In 2000, only 16.7% had a senior high school education, 1.7% of the general population had a bachelor's degree and only .1% had an advanced degree. In comparison, in the United States 80.4% of the population held a senior high school education, 24.4% a bachelor's degree and 8.9% held an advanced degree.[56] While perhaps not a fair comparison to draw between the educational levels of developing China and the developed United States, it does illustrate one important difference

[53] Investment Climate Survey
[54] "Thinking for themselves", *The Economist,* October 20, 2005.
[55] Investment Climate Survey
[56] Holz, 43-44.

between a country struggling to become innovative and the United States which is generally considered one of the world's most innovative economies.[57] In addition to the educational discrepancies is the fact that the Chinese education system is not built to develop innovation and instead stresses memorization and conformity—the very antithesis to innovation and the creativity it needs.[58] However, as with the other obstacles attitudes are changing. While the overall education rates of the country remain relatively low the number of new enrollments in universities is skyrocketing. In 2001, new enrollments passed those in the United States for the first time and by 2005 new enrollments were already double that in the United States.[59] Of personnel occupying the most critical positions for innovation fully 82% of engineers and technical workers hold a college degree or higher while the level for managerial personnel is somewhat lower at 71% according to the ICS.[60] Meanwhile, the skyrocketing number of patents again testifies to the fact that people are learning how to innovate. In addition, China will benefit from its overseas diasporas that are better trained in the aspects of innovation and indeed that fled abroad in order to pursue better returns from the products of their innovation. These diasporas will return to China as it continues its economic ascent and they find increasingly greater rewards.

The fourth obstacle, the government intervention in the economy, results from the large presence the government stills holds both directly and indirectly in the economy and the large percentage of research and development spending that is accounted for by the government. According to the ICS, the average government ownership share of a firm in the data set was approximately 22%.[61] This large government presence often results in a focus on innovation coming from a top-down perspective where innovation is focused on a national strategy. This strategy then results in a reduction of efficiency, creativity, initiative and independence—all factors critical to the fostering of innovation.[62] This is because the influence of government on innovation causes a divorce between innovation and the market which reduces the economic

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[57] N. Valery and L. Kekic, "Innovation: Transforming the way business creates", *The Economic Intelligence Unit* (2007), 13.
[58] "Something New"
[59] Holz, 44.
[60] Investment Climate Survey
[61] Investment Climate Survey
[62] W. Yuan, "China's Government R&D Institutes: Changes and Associated Issues". *Science Technology Society*. 2005; 10: 11. 17.

incentives to be found in innovation as it is no longer focused on achieving economic growth but rather on government policy. Even if the government policy is to foster economic growth its interference in the market causes a reduction in efficiency as it plays the role of an unnecessary middle man that is often slow to adapt to changes in the market. However, the government's role in the economy is shrinking and in particular its role in fostering research and development is diminishing. During the planned economic period all research and development spending was centralized but now while government expenditure on R&D continues to grow its share of total R&D spending has shrunk from 80% in 1997 to 63% in 2002.[63] This reflects the rise of the importance of private sector R&D spending but as long as the government still has a large ownership share in firms it will continue to retard innovation.

The final obstacle, the allocation of capital, represents the most important obstacle to be overcome in order for China to realize its ambition of being an innovation based society. Currently capital is poorly allocated in China and still is tightly controlled by the government who feeds cheap capital into state owned enterprises and other favored firms. The capital that is available to private companies tends to go to those that already have a record of success. However, in the developed world it is venture capital which has had extreme success in spurring innovation, the same type of capital that is currently being stifled in China. It has been estimated that a dollar of venture capital is up to ten times more effective in stimulating patenting than that spent on corporate research and development.[64] In the developed world entrepreneurship has had a disproportionate affect at stimulating innovation and the current situation in China stifles the source of funds needed for such activity. Even the stock market remains heavily regulated. Looking abroad for foreign investment leaves Chinese companies in the trap where the benefits of innovation accrue to foreign multi-national corporations.

China will not be able to succeed at innovation until it has capital markets that function in a market-friendly way.[65] Luckily for China this obstacle is also the easiest to overcome as it would in large part simply be a matter of relaxing controls on the

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[63] "China's Government R&D Institutes: Changes and Associated Issues", 12.
[64] "The fading luster of clusters", *The Economist*, October 11, 2007.
[65] Friedman, 245.

capital market. However, China's political leaders have proven reluctant to perform these actions as control of capital has proven to be an effective means of control in both the political sense and the economic sense. Through only providing capital to favored companies, China's government ensures continued subservience to the state. But there is also a potentially more benevolent view to China insistence to maintaining tight capital controls and that is because it is seen as a method to dampen reckless speculation and reduce the risks of a credit bubble that is largely seen as one of the foremost causes of the East Asian financial crisis of 1997[66] as well as the credit crisis that enveloped the developed world 10 years later in 2007 and currently threatens financial stability today. After this credit bubble burst, the economies of these countries face strangulation as the supply of capital constricts. These countries rode the boom of cheap credit as a means of economic growth but then faced a downward spiral when speculation placed too great a demand on a weak banking system to evaluate risk.[67] But while these countries saw both the benefit and pain of easy capital, China has tried to limit firms from either experience. What China's leaders have failed to glean from the experience is that the financial capital crises were a result of too much of a good thing and not that firms ability to receive capital will necessarily lead to over-speculation. Meanwhile, China, has denied the opportunity for a potential boon in investment in innovation resulting from firms access to capital. According to the ICS only 25% of firms responded that they had access to credit.[68] But if China is to pursue a path of innovation than there is no way around this obstacle and China's leaders will have to face reality that there cannot be large scale innovation while maintaining tight capital controls. Indeed, the very existence of a vibrant capital market is one of the best signs of the strength of a nation's institutions in that it is an assurance by the state against future expropriations. Capital markets do not function well in a society where favoritism and corruption are rampant and if China's government were to emphasize the existence of a functioning capital market it would simultaneously be a declaration to fair and open governance with transparent institutions.[69]

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[66] Jong H. Park, 'The East Asian Model of Economic Development', *Journal of Developing Societies* 2002; 18; 332.
[67] Park, 333.
[68] Investment Climate Survey

[69]Douglass C. North and Barry R. Weigast, "Introduction: Institutional Analysis and Economic History", *The Journal of Economic History*, Vol. 60, No. 2 (Jun., 2000), 415.

With tight capital controls the Schumpeterian economic cycle is not allowed to occur and capital is not allowed to flow from underperforming segments of an economic system into more dynamic and innovative areas. The efficient economic system talked about previously breaks down as those firms who are not innovating fail but this does not create the freeing up of capital needed for those firms who are pursuing innovation. As a result, instead of economic growth the risk then becomes of economic contraction as the inefficient firms fail but the firms with innovative potential stagnate for want of capital. Innovation works best when the government removes the obstacles that it has emplaced. While that will prove difficult for China's political leaders who are so keen to remain in control it will nonetheless prove necessary. But even if the tight capital controls were to be lifted, the damage of their existence over the past 30 years has been to create an immature financial system in comparison with the rest of the economy. By not allowing the financial system to develop in tandem with the evolution of the rest of the market economy it lacks the sophistication necessary to identify and properly evaluate a capital venture system at its current stage of economic development. This translates into the fact that tight economic controls have stunted the development of China's financial system to develop the ability to efficiently allocate capital, particularly for smaller firms where the risks may be higher but the rewards correspondingly greater.[70] What capital there is in China currently does not go towards those firms where investments may take a long time to come to maturity—those very investments that innovation is so dependent on. Hence, while the government needs to lift its tight capital controls in order to stimulate investment in innovation, in the short term the damage will have already been done as the allocation in capital will still not be efficient. Current funding plans for the development of 'policy banks' and commercial banking to stimulate investment into these smaller firms have the possibility of being no more efficient than the state owned banks they are supposed to supplant.[71]

VII. Empirical Model and Hypothesis

Hypothesis

[70] "OECD Reviews of Innovation Policy", 19.
[71] "OECD Reviews of Innovation Policy", 19.

The Economic Struggles of Firms that are Innovating in China

As this paper has theoretically demonstrated innovation is critical to the long-term economic success of both firms and economies. However, in the short and even medium terms economic growth can be sustained without innovation. Indeed, attempts at innovation can even impede economic growth as costs for such items as research and development or structural reorganization are not always, and indeed are rarely met with immediate costs benefits or revenue growth. Thus attempts at innovation are often met with higher costs and negative consequence to a firm's performance in the short-term. Furthermore, if an economic system is not set up to protect and further the results of innovation such as a strong legal system then the costs of innovation can often exceed the benefits. For example, a firm in the pharmaceutical industry that produces a breakthrough drug will never become profitable and recoup its research and development costs if it competitors have the ready ability to copy and sell the drug.

Hence, it becomes possible to deduce how advanced China's economic development is in the realm of innovation by measuring the success of the firms that exhibit these characteristics in China. If the characteristics that indicate innovation are present in a firm and have a positive relationship to profit growth it would seem to indicate a more advanced economic system where the benefits of innovation are able to repay the costs a firm incurs to innovate. However, if these characteristics result in a neutral or negative relationship to profit growth this would indicate that China has not advanced to a point where firms in China are yet seeing benefits from innovation and indeed a strong negative relationship would indicate either the weakness of China's economic system to foster and protect the benefits of innovation and or the nascent development of innovation is only at the stage where firms are seeing the costs of innovation but not the benefits. Indeed, the costs could be so prohibitively high that firms prove unable to pursue a coherent policy towards innovation as they are unable to survive the short-term costs in order to realize the long-term benefits. As outlined in this paper above China currently faces numerous obstacles on its path to innovation and does not appear to be a society where the rewards of innovation are yet manifest. Thus:

Hypothesis: Firms that exhibit characteristics of innovation face a negative return on profit growth.

Data

In order to determine the economic performance of innovating firms in China, this paper uses data from the "Investment Climate Survey" conducted by the World Bank in China in 2003. The ICS was conducted amongst 2400 firms in 14 industrial sectors from 18 cities.

Difficulty in Quantifying Innovation

The idea of innovation as a concept is easier to define than to measure. The benefits that innovation can bring are difficult to quantify because the effects are often so gradual. In an attempt to create a common definition and method of measuring innovation the United States Department of Commerce created The Advisory Committee on Measuring Innovation (ACMI) in the 21st Century Economy. According to a report done on behalf of the United States Department of Commerce in 2008 for The Advisory Committee on Measuring Innovation in the 21st Century Economy the concept of innovation is: "The design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers and financial returns for the firm"[72] This concept remains much the same to how Schumpeter first attempted to define the concept back in 1911. The ACMI's definition helps to illustrate the centrality of innovation for new paths to economic growth while at the same time illustrating its vagueness. This makes empirically proving the existence of innovation or the benefits that innovation can bring extremely difficult. Some use the idea of Total Factor Productivity, which is the measure of productivity growth after taking into account growth in labor and capital, as a proxy for measuring innovation because many of the benefits of innovation are

[72] "Innovation Measurement: Tracking the State of Innovation in the American Economy", *The Advisory Committee on Measuring Innovation in the 21st Century Economy*, The United States Department of Commerce, January 2008, i.

thought to accrue in productivity growth.[73] However, this would negate some of the other important benefits such as the increase of revenue streams from invention. Because of this others believe that measuring the growth of patents is the most effective means to measure innovation.[74] While patents can measure the growth of inventions and provide an indicator of the success of research and development expenditure as it connects to patent outputs it again fails to measure other benefits of innovation such as new ideas that result in efficiency savings. Furthermore, even the measure of patents to measure inventiveness, just one benefit of innovation, has its drawbacks in that the frequency of firms to patent inventions varies from company to company and each invention patented varies in value.[75] In addition, in countries with weak legal protection such as China the propensity to patent is less because of fear that the invention will be immediately copied. Rather, firms have an incentive to try to keep their invention confidential as long as possible in order to maximize their benefit.

What these approaches have in common is that they serve as surrogates to a measure that would totally encompass the concept of innovation both to determine if it is occurring and if so what benefits are accruing from this. Because of the difficulty, even current impossibility, of accurately measuring if a firm is innovating or the benefits that a firm achieves from innovation this paper will instead build upon the proxy approach to determining innovation. Using the variables described below will serve both to identify outputs of innovation as well as identifying factors previously discussed in this paper that help to facilitate innovation.

Dependent Variable

Profit

[73] "Innovation Measurement: Tracking the State of Innovation in the American Economy", xi.
[74] "Compendium of Patent Statistics 2007", *Organization for Economic Co-Operation and Development,* 2007, 8.
[75] F.M. Scherer, "Firm Size , Market Structure ,Opportunity , and the Output of Patented Inventions", *American Economic Review* , 55(5) , 1965. 1098.

This variable measures the logged growth in profit for the firm from 2002 to 2001. As a firm is in business to generate profit, a strong growth in profit will serve to indicate business success.

Table 2: Profit Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Profit	2370	0.056	0.707	(7.444)	7.128

Independent Variables

Variables that Serve as Output Indicators of Innovation that Generate Short Term Costs

These variables are proxies for innovation output. However, their existence in a firm would imply that costs have been paid in order to generate the innovative output and should result in profit reduction.

Patents

As previously discussed the use of patents helps to identify inventive output, an important benefit derived from innovation. Because measuring the number of patents granted to a firm is not without its drawbacks because of the difficulty of directly comparing the value of patents, for the purposes of this paper the only factor to take into account is if a firm has been granted a patent in China in the past three years. Some might argue that using patents to identify innovation in China might falsify results because companies may be reluctant to apply for patents in an economy where property rights protection may be weak. However, the burgeoning growth of patent applications shows that they are becoming more important and thus the comparison between Chinese and foreign firms regarding invention patents becomes relevant.[76]

[76] China Statistical Yearbook, 2007.

This will serve to illustrate that firms are at least having inventive output and having some success at their attempts at innovation. The result is a dummy variable where the value of zero indicates no patents granted to the firm within the past three years while a value of one would indicate the grant of at least one patent. The table below shows that only approximately 10% of firms in China acquired a patent in the period 2000-2002.

Table 3: Patents Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Patents	2354	0.102	0.303	-	1.000

Innovate

Five questions are asked in the survey that indicate the role of innovation for the firm:

1. Introduced new products or services in existing business
2. Entered new business line
3. New process improvements
4. New management techniques
5. New quality controls in production[77]

Each of these questions results in either a yes or no answer which is categorized as a dummy variable with an answer of yes given a value of 1 and an answer of no given a value of 0. Combining these dummy variables into one variable, 'Innovate', results in the value ranging from zero to five with the value of five resulting from those firms who answered yes to every question and thus are theoretically the most innovative. The table below shows that on average firms responded yes to at least two of the five questions posed.

Table 4: Innovate Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Innovate	2357	2.030	1.787	-	5.000

Variables that Serve to Facilitate Innovation that Generate Short Term Costs

[77] Investment Climate Survey.

These variables correspond to factors, that when met, would serve to facilitate innovation but also result in costs increases to a firm. Thus, in the short-term, before benefits from innovation can be achieved they would result in a profit reduction.

RDShare

This variable represents the share of a firm's total sales spent on research and development. Heavy investment in research and development shows both a firms willingness to place innovation in a central position for their growth strategy as well as providing the resources to enable it.

Table 5: RDShare Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
RDshare	1565	0.025	0.253	-	9.274

EduEng

This variable indicates the education of a firm's engineers. At the macro level investment in education is seen as one of the key institutional investments for the development of innovation. This variable is then used in the micro level to differentiate between firms education levels amongst their labor pool. The data is recorded as a dummy variable where the value of one indicates that the average level of education for engineers is less than a primary school education while a value of seven indicates that on average the firm's engineers hold a master degree or higher. It is presumed that the higher the education an engineer has would result on average in higher salaries which translate into an investment by the firm into education as a component for innovation.

Table 6: EduEng Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
EduEgr	1727	5.111	0.829	1.000	7.000

EduMgr

This variable is recorded in the same manner as EduEgr.

Table 7: EduMgr Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
EduMgr	2267	4.867	0.804	1.000	7.000

Control Variables

The control variables selected were chosen because they have the potential to both facilitate and affect innovation and thus must be accounted for to avoid confounding effects. However, unlike the independent variables, the control variables have no discernable method in which to calculate the higher costs that a firm might suffer in their application and chiefly reflect the institutions the firms operate under in China and the characteristics of the firms themselves.

Law

Law variable represents the firm's view of the likelihood of the legal system to uphold contract and property rights. If a firm has a greater belief in the strength of the legal system it is more likely to pursue innovation.

Table 8: Law Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Law	2068	63.977	38.938	-	100.000

Cap

Cap variable indicates if a firm has access to capital which is a key input needed for innovation.

Table 9: Cap Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Cap	2333	0.254	0.435	-	1.000

PvtShare

PvtShare variable represents the percentage of the firm that is privately held. As previously discussed, public ownership of a firm can befuddle incentives for

innovation which must be clearly aligned towards profit maximization in order to be successful.

Table 10: PvtShare

Variable	Obs	Mean	Std. Dev.	Min	Max
Pvtshare	2399	78.100	40.215	-	100.000

Age

This variable represents the logged age of the firm. LogAge was chosen because the newer firms are generally thought to be more innovative.[78]

Table 11: Age Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	2400	2.430	0.799	1.099	3.970

Size and Size²

These variable represent the logged total sales of the firm. Size and Size² were chosen because firms usually need to be a certain size in order to have the resources to innovate but that a U shaped relationship exists in that firms can become too large and lose the ability and initiative to innovate as their size makes them unable to take advantage of the benefits of innovation as they become inflexible in changing current business practices.[79]

Table 12: Size and Size2 Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Size	2373	9.083	2.260	(0.105)	18.862
Size2	2373	87.607	42.451	0.011	355.772

Sector

This variable represents the 14 industrial sectors included in the survey. Innovation can vary across industries and thus therefore must be controlled.[80]

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[78] J. A. Hansen, "Innovation, Firm Size, and Firm Age," *Small Business Economics* 4, 1992, 37.
[79] Hansen, 37.
[80] For a list of sectors please see appendix table 1a.

City

This variable represents the 17 cities in which the firms surveyed are located. As innovation can vary across geographic areas and according to some data can occur more easily in innovation clusters this must be controlled.[81]

Expected Beta Coefficient Values

The table below outlines whether the predicted beta coefficient values for the independent variables will be positive (helps to promote profit growth) or negative (results in a reduction in profit):

Table 13: Expected Beta Coefficient Values

Variable	Expected Sign	Rationale
Patents	Negative	In a developing country with weak legal protection such as China, the costs and risks of obtaining patents (research and development, theft of property rights) outweigh the potential benefits.
Innovate	Negative	While these questions (and an affirmative response to them) indicate the possible existence of developed system of innovation, they too also signify additional costs that the firm must have incurred. However, these questions also signify benefits currently being received by the firm (i.e. enter into new business line, new products) so a positive value would not be totally unexpected.
RDshare	Negative	The costs of research and development, while necessary, reflect an immediate cost but can not begin to generate profit until a later date. Because of the proposed infancy of innovation in China this costs will still be viewed as a negative to firms.
EduEgr	Negative	Hiring better educated engineers represents an investment in the firm to the generation of future profit. Once again a case of current cost verses future return.
EduMgr	Positive	Hiring better educated managers also represents increased costs in the short term. However, better educated managers can be successful for increasing profit in the short-term because of innovative approaches to reducing costs as well as the long-term through new the pursuit of new business practices and products.
Law	Positive	Increased legal protection has almost no cost to a firm

[81] For a list of cities please see appendix table 2a.

		pursuing innovation and instead has numerous benefits.
Cap	Positive	Access to capital provides opportunity for a firm to expand activities.
PvtShare	Positive	Increased private ownership gives firms more incentive to concentrate solely on increasing profits.
Size	Negative	The larger a firm is, the more likely it is to have resources to expend on generating innovation. But these resources spent in the short-term would reduce profit.
Size2	Negative	As the firm gets larger, the benefits it can receive from innovation decrease as it loses its ability to transform itself. However, it is expected that this is not always recognized by the firm and continues to expend money on innovation.
Age	Negative	Because it is theorized that as a firm gets older it loses its ability to innovate, the maturity of a firm would seem to indicate that as it gets older it loses potential benefits from innovation.

Analysis Approach

This paper utilizes Ordinary Least Squared (OLS) analysis with robust standard errors in order to control for multicolinearity. This paper will test three functions with the control variables included in all three functions to determine which function has the most explanatory power for firm profit growth. Function 1 will consist only of the independent variables that serve as proxies for output of innovation and should theoretically have a short-term costs to a firm resulting in a reduction in profit: *Patents* and *Innovate.*

Function 1: Profit=f(Patents, Innovate, Law, Pvtshare, Cap, LogAge, Log Size, LogSize^2,City, Sector)

Function 2 will consists only of those independent variables that serve as inputs necessary for innovation which also have immediate costs: RDshare, EduEgr, EduMgr.

Function 2: Profit=f(RDshare, EduEng, EduMgr, Law, Pvtshare, Cap, LogAge, Log Size, LogSize^2,City, Sector)

Function 3 will consist of all independent variables.

Function 3: Profit=f(Patents, Innovate, RDshare, EduEng, EduMgr, Law, Pvtshare, Cap, LogAge, Log Size, LogSize^2,City, Sector)

Results

Table 14: Innovation Effects on Profit Growth

	Dependent Variable: Firm Profit Growth from 2001 to 2002					
Function	Function 1		Function 2		Function 3	
Observations		1,945		1,103		1,081
Profit	Coefficient Value	t-value	Coefficient Value	t-value	Coefficient Value	t-value
Patents	(0.087)	(1.450)	-	-	**(0.084)**	(1.690)
Innovate	**0.056**	5.640	-	-	**0.047**	4.430
RDshare	-	-	(0.022)	(0.650)	(0.029)	(0.810)
EduEgr	-	-	0.033	1.300	0.033	1.310
EduMgr	-	-	0.008	0.330	0.005	0.190
Law	0.000	0.760	0.001	1.170	0.000	0.920
Cap	**0.071**	1.930	0.021	0.540	0.001	0.030
Pvtshare	(0.000)	(0.290)	0.000	0.250	0.000	0.300
Age	**(0.040)**	(1.820)	**(0.058)**	(2.410)	**(0.045)**	(1.880)
Size	**(0.125)**	(2.050)	**(0.198)**	(2.510)	**(0.236)**	(2.920)
Size2	0.003	0.900	**0.008**	2.180	**0.010**	2.540
City	See Appendix		See Appendix		See Appendix	
Sector	See Appendix		See Appendix		See Appendix	
_cons	**1.021**	3.040	**0.857**	1.790	**1.255**	2.420
R-squared		7.30%		7.50%		9.10%

Note: Coefficient values in **BOLD** represent significance at the 10% level. Due to the low rate of significance prevelance for the City and Sector variables and the number of variables that were dropped due to multicollinearity they have been omitted from this table. For a complete table please see the appendix. For correlation matrix and analysis please see the appendix.

Between the three functions, Function 3 has the largest r-squared value of 9.1%. Because no independent variables beta coefficient values change signs or have a significant change in value between the three functions, indeed including all independent variables appears to have a normative affect causing the values to move closer to zero, only Function 3 will hitherto be discussed.

Function 3 shows mixed results as to what was predicted by the hypothesis. Of the five variables that were identified as resulting in increased costs to a firm and thus had the potential to negatively affect profit growth, only two variables (Patents and RDshare) were in fact shown to do so. Of these, only Patents was found to be statistically significant at the 10% level. However, of the five variables, these are the two that would generally involve the most significant upfront costs and delayed return on investment.

The variable Innovate was shown to actually provide a benefit to profit growth. Looking more closely at the questions though this is perhaps not surprising as the questions represent a somewhat more advanced stage of innovation where benefits from innovation have started to accrue such as the actual introduction of new products into the market rather than the costs of developing such products which would be covered under RDshare. Affirmative answers would provide benefits to the firm but do not necessarily preclude the possibility that the firm went through a period of profit decline when it began its investments into innovation. Furthermore, the overall idea that China is still at an early stage of innovation development is not harmed when one looks at a breakdown of the number of firms that answered affirmatively at each level:

Table 15: Innovate Breakdown

Innovate	Freq.	Percent	Cum.
0	723	30.670	30.670
1	310	13.150	43.830
2	428	18.160	61.990
3	283	12.010	73.990
4	295	12.520	86.510
5	318		

		13.490	100.000
Total	2,357	100.000	

Table 15 shows that over 30% of firms were not able to answer yes to even one question and that more than 60% answered yes to two or fewer questions. Thus, this variable may be skewed by the benefits to profit growth the more advanced innovative firms were accumulating while the firms that who answered yes to fewer questions or to none at all may have not been even attempting to innovate and thus would not be suffering from negative cost effects sometimes associated with early stage attempts at innovation.

The remaining two independent variables, EduEgr and EduMgr showed a positive affect on profit growth. It was predicted that EduMgr could have a positive influence on profit through immediate business changes and it is also extremely possible for EduEgr to have as well although it would be thought that the benefits that a highly educated engineer would bring would come in the long term through product development. However, the data suggests that the benefits that come from a having a higher educated workforce are immediate. Of the variables that serve to identify cost inputs into innovation, these two are perhaps the weakest. Attributing the additional cost of hiring educated workers towards innovation is at best an indirect method but the importance of education as an input to innovation is too important to not be discussed and an attempt at being quantified. Thus the proxies of EduEgr and EduMgr were used as the best variable possible from the survey. However, both variables were found to be insignificant at the 10% level.

The control variables Law, Cap and PvtShare showed no significance at the 10% level and indeed their beta coefficient values showed no affect on profit growth. These variables largely show the strength of China's institutions and as such would seem to indicate that institutions in China are neither harming nor helping firms in their quest for innovation.

Age, Size and Size2 shown to be significant. Age and Size had negative beta coefficient values which conforms to predictions. Size2 did have a positive affect on

profit growth though and this illustrates that extremely large firms do not suffer negative consequences from innovation either because they do not pursue or because they are so large they can absorb the additional costs and achieve the benefits faster.

For the cities in Function 3, only Shenzhen was shown to be significant with the largest positive beta coefficient value, .411, in the analysis. This is perhaps unsurprising as Shenzhen has since the late 1970's been the center of foreign investment into China and was the first city selected to be a Special Economic Zone (SEZ), where one of the primary purposes was to foster innovation and business.[82] If any area of China was to be at a more developed stage of innovative development where benefits from innovation would start to present themselves it would be in Shenzhen.

Of the sectors, only the Electronic Equipment industry was found to be significant. With a beta coefficient value of -.366 it was also the largest negative beta coefficient value in the analysis. This conforms well with the hypothesis as the Electronics Industry, as described above with the example of DVD players, would be one of the main beneficiaries of innovation and because of the large scale manufacturing already set up to support electronic exports would have one of the greatest incentives to innovate. That the beta coefficient value is so strongly negative could indicate that the industry is in the first costly phases of innovation as the hypothesis would support. This finding represents an opportunity for more focused research into the Electronics Industry on the topic presented in this paper.

Limitations

The overall low pseudo R^2 value of 9.1% and the lack of significance of many of the variables measured would seem to indicate the relative weakness of the overall model as a whole to illustrate that China is still at a nascent stage of innovation. Conversely, no evidence was found that is able to disprove the hypothesis that China is at a stage of innovation development where its firms will suffer more drawbacks than benefits in the short term. Indeed, much of the evidence, however weakly, points to the fact

[82] Naughton, 28.

that currently firms in China are receiving little benefit from efforts to innovate from a firm profit perspective. The only other possible explanation being that firms in China are simply not pursuing innovation and this does not coincide with the negative beta coefficient values found for Patents and RDshare. If firms were not innovating then these values would be closer to zero due to the fact they if they are not innovating they would not be spending funds on the effort and consequently would not suffer from reductions in profit. This then answers the question if the costs of innovation are too great and as a consequence firms are not innovating. While firms are enduring loss of profit due to investment in innovation, it appears not to be deterring them away from such a strategy. Indeed, according to the variable Innovate, some firms, at a more advanced innovative level, have already begun to realize a benefit from innovation and as a consequence the variable had a positive beta coefficient value.

The principle difficulty in analyzing this issue again turns to the difficulty in measuring innovation. The very variable being measured, innovation, is exceeding difficult to quantify and the attempt to do so in this paper is at best an approximation that indicates the existence of innovation rather than providing a true measure.[83] This however has more to do with the failing of the variables to be able to accurately capture the concept of innovation as theoretically described in this paper. For example, while the data in the ICS shows a marked increase in the number of patents applied it is unable to describe the number of these that are for actual inventions. According to the China Statistical Yearbook, of the number of patents granted to domestic firms in China in 2006 only 11.2% were for inventions. The corresponding figure for Chinese patents granted to foreign firms shows that 74.1% were for inventions and the absolute number of invention patents granted to foreign firms was 30.4% higher than the corresponding figure for Chinese figures.[84] Thus, using the variable Patents can count costs that should not be applied to innovation. In another example, RDshare can not capture efforts spent by a firm towards innovation that do not come directly from R&D spending and likewise it counts R&D spending towards innovation when that spending may not be on innovating new products but on reverse engineering competitors' products. For Innovate, what the questions do not cover

[83] Hansen, 43.

[84] China Statistical Yearbook, 2007.

because of the limits of the Investment Climate Survey is what percentage of the new products or techniques are actually a result of innovation and not simply copied from other businesses both domestic and foreign. Moving on from the data presented in the Investment Climate Survey it is important to note perhaps its greatest weakness in describing firms in China and that is its age. The latest data from the ICS comes in 2002 and in an economy as dynamic and expansionary as China that proves a liability. China's economy at the end of 2006 (21,087.1 billion RMB) was approximately 75% larger than the one measured by the ICS in 2002 (12.033.7 billion RMB).[85] But then if the data used is in the ICS can be construed as dated then it is important to analyze what direction China's economy has taken towards innovation in recent years in order to observe if firms are still investing in innovation despite the loss of profit this entails.

Implications

What then do the results of this data mean moving forward? Of the variables that most concretely represent monetary investment into innovation, Patents and RDshare, negative beta-coefficient values were observed. While only Patents had a significant value this still does lend credence to the hypothesis that firms in China, in the early stage of innovation, do suffer negative profit returns on their investments. Conversely, the variable Innovate, with its positive beta-coefficient, shows the benefits firms can hope to achieve once they have achieved a more developed state of innovation. What the results do not indicate is the sustainability of firms to be able to absorb these costs in the short-term during the limited return phase of innovation. Are the costs so high that firms are not able to survive until the benefits of innovation start to accrue? Based on the ultra-competitive market in China that exists, where the lowest cost means everything, this would seem to be a real possibility. The investment costs that a firm incurs in order to pursue innovation could then literally be the difference between survival and bankruptcy in the short-run. This then leaves the catch-22 trap that firms cannot survive the short-run costs of innovation but then can not sustain long-term viability without the benefits of innovation. Clearly this would appear to be a developmental issue of a country unable to move out of its low-income level. However, China is not the first country to face the twin pressures of trying to invest in

[85] China's Statistical Yearbook, 2007.

the future while at the same time trying to maintain competitiveness in the short-term. Many of the so called Newly Industrialized Countries such as South Korea and Taiwan were once known primarily for their low-cost manufacturing but have since been able to redefine themselves as centers of innovation. Once again the efficiency of the market comes into play. In order to balance both long term viability and short-term survival the firms that will do best are those that prove to be able to become innovative as quickly as efficiently as possible.

VIII. Government Role in Fostering Innovation in China

The role the Chinese government should take for the promotion of innovation is a passive approach to minimize the costs that firms must incur in their pursuit of innovation. The Chinese government must ensure that the institutions promoting a transparent governance and business structure exists while at the same time helping to reduce the obstacles faced for the growth of innovation. Some nations, such as Singapore, have thrived under a government led drive towards innovation.[86] However, this approach is unlikely to work in China because of the size, complexity and diversity of its economy. The government, in trying to promote innovation in one segment of society would run the risk of stifling it in another. While benefits of promoting innovation in certain potential high growth sectors such as biotechnology do exist the risks of such an approach such as misallocation of capital are also manifest. This type of industrial policy, favoring some industries over others, results in market distortions as the government proves to be unwieldy in attempts at economic reform because of bureaucratic inefficiencies. Long term economic growth in a large economy, such as China, is dependent on an alignment of incentives based on an efficient market. In an efficient economy capital will flow towards those areas where it will yield the highest returns. Thus the Chinese government, if it truly desires to see China become an innovation driven economy by 2020, should try to minimize direct attempts at both fostering and inhibiting innovation.

Instead the government should serve to promote innovation in an indirect manner. The government's primary role should be is to help to minimize the costs of

[86] Lall, "Reinventing Industrial Strategy", 22.

innovation, foster the institutions necessary to both promote and then protect the benefits of innovation, and finally to reduce the barriers to innovation it has emplaced itself. Through this approach the government can indirectly help to promote innovation while still allowing, critically, the market to operate in an efficient manner and for the incentives to remain unbiased. To do this the government needs to make sure that the supply of inputs needed for innovation, as described in this paper, will be available for firms to call upon. Most critically, as described above in obstacles to innovation, the relaxation of capital controls will prove to be important in order to help the financing of companies seeking to survive in the short-term. As the capital market matures in order to be able to be able to properly access risks, firms with the best business plans and most viable paths to innovation will be the ones to receive financing.

In addition to the relaxation of capital controls, the government will need to ensure that supporting institutions are strong enough to ensure the flow of capital to innovation. Crucial of these will be the strengthening of the legal institution to protect both private and intellectual property which will be needed to secure investments, protect innovation and to give assurances of long term stability. The relaxation of capital controls and a strong legal environment to support the flow of capital will provide the needed support for firms to be able to survive the short-term costs of innovation and avoid the low-income developmental trap described in this paper. Of course all firms will not prove successful in this transition and many will fail. But not all firms in China need survive in order to make to it an innovative based economy as the Schumpeterian cycles will enable those firms that fail the needed capital for stronger and more successful innovative firms to survive.

IX. Conclusion

The path forward for China will not be easy. China has long relied on cost advantages to fuel its economic growth. But this approach is unsustainable in the long run being as it is predicated on China being able to maintain its low cost position in the global marketplace amidst increasing price pressures. Economic theory shows that sustainable economic expansion is not possible without innovation. Because of this China must remain focused on long term goals as it seeks to move up the

economic value added ladder through innovation. The immediate returns from innovation are not always apparent and the cost of investment into such activities as higher education is not always readily realized. While it is theoretically clear that all current obstacles to innovation can be overcome in China, this will only be done if China's political leaders continue to have the political will to pursue innovation and support the institutions needed to ensure the inputs and environment are suited for firms to pursue innovation.

In comparison with its more developed East Asian neighbors who have successfully developed into innovative economies, it appears that China has made the right moves towards an innovation based economy. But while China has positioned itself on the route to innovation it is not yet apparent how far China has gone down this path. Taiwan went from almost no patent applications in the United States in the 1980's to being the recipient of the fourth largest amounts of patents granted in the United States. Japan is second after only the United States itself in granted patents while Korea's Samsung Corporation is one of the top ten largest recipient of patents given to corporations.[87] Clearly innovation is alive and well in these countries, at least based on the perspective of inventive patent output, and these countries have all successfully managed the transition from low-cost manufacturing base to high-tech innovation driven economies. China must follow in these countries footsteps if it is truly to emerge as the economic giant of the 21st century because the 21st century will be based on superiority of knowledge much as the 20th century was based on superiority in manufacturing.

This paper has given evidence that firms in China undertaking innovation are doing so at the expense of profits. But it has also shown from a theoretical standpoint that innovation is critical to long-term growth in China if it is to move beyond its current level of economic development. This has brought up the possibility of a developmental trap whereupon firms are unable to afford the investment into innovation necessary to be able to move into the next phase of their business development and lead China up the economic ladder. However, this paper was not able to conclusively prove if the costs of innovation are proving too great to firms and

[87] "Thinking for themselves"

that because of them they are either failing or opting to forego the investments all together in order to maximize short-term profits. But helping to overcome this developmental trap is where the government will play a key role in helping to ensure that these costs of investing in innovation are minimized to as great of an extent as possible. This should not be done through direct intervention or aid to firms. Instead assistance should be rendered in an indirect manner through helping to maintain a stable and open business environment and helping to reduce and minimize the obstacles presented in this paper. Chief amongst these includes the relaxation of capital controls and the strengthening of the legal institution so that firms with viable innovative strategies have the capital needed to persevere and confidence of the protection of their investments. While firms in China that are pursuing innovation are incurring costs that hurt their profits, it is more important that they continue to pursue innovation in a balanced manner. This is crucial for China's future economic prospects as it continues to grow and become more advanced these investments in innovation will become all the more important. This paper has shown that firms who will prove the most successful will be those that are best able to balance short-term interests with long-term goals in the development of their innovation strategy. Firms that focus solely on either the short-term or long-term are doomed to fail as either they prove unable to either provide the needed investment into innovation thus sacrificing future growth or concentrate too many resources into innovation as to become insolvent in the short-term. In the end, the ultimate test for firms in China and the economy as a whole will be in their ability to survive a short-term loss of profit in order for long run success.

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APPENDIX

Full list of tables

	Table 1a Sector List	Freq.	Percent
1	Garment & leather products	353	14.71
2	Electronic equipment	185	7.71
3	Electronic parts making	276	11.5
4	Household electronics	63	2.63
5	Auto & auto parts	358	14.92
6	Information technology	203	8.46
7	Accounting&non-banking financial serv.	157	6.54
8	Advertisement & marketing	154	6.42
9	Business services	270	11.25
10	Food processing	71	2.96
11	Chemical products & medicine	66	2.75
12	Biotech products & Chinese medicine	36	1.5
13	Metallurgical products (manuf.&tools)	158	6.58
14	Transportation equip. (incl. telecom.&s	50	2.08
	Total	2,400	100

	Table 2a City List	Freq.	Percent
1	Benxi	100	4.17
2	Changchun	150	6.25
3	Changsha	150	6.25
4	Chongqing	150	6.25
5	Dalian	100	4.17
6	Guiyang	150	6.25
7	Haerbin	150	6.25
8	Hangzhou	100	4.17
9	Jiangmen	100	4.17
10	Kunming	150	6.25
11	Lanzhou	150	6.25
12	Nanchang	150	6.25
13	Nanning	150	6.25
14	Shenzhen	100	4.17
15	Wenzhou	100	4.17
16	Wuhan	150	6.25
17	Xian	150	6.25
18	Zhengzhou	150	6.25

Table 3a: Innovation Effects on Profit Growth

Regression Results for Functions 1-3 with Robust Standard Errors						
	Dependent Variable: Firm Profit Growth from 2001 to 2002					
	Function 1		Function 2		Function 3	
Observations		1,945		1,103		1,081
Profit						
Patents	(0.087)	(1.450)			**(0.084)**	(1.690)
Innovate	**0.056**	5.640			**0.047**	4.430
RDshare			(0.022)	(0.650)	(0.029)	(0.810)
EduEgr			0.033	1.300	0.033	1.310
EduMgr			0.008	0.330	0.005	0.190
Law	0.000	0.760	0.001	1.170	0.000	0.920
Cap	**0.071**	1.930	0.021	0.540	0.001	0.030
Pvtshare	(0.000)	(0.290)	0.000	0.250	0.000	0.300
Age	**(0.040)**	(1.820)	**(0.058)**	(2.410)	**(0.045)**	(1.880)
Size	**(0.125)**	(2.050)	**(0.198)**	(2.510)	**(0.236)**	(2.920)
Size2	0.003	0.900	**0.008**	2.180	**0.010**	2.540
city1	(dropped)		(dropped)		(dropped)	
city2	(0.007)	(0.070)	(0.017)	(0.100)	(0.008)	(0.050)
city3	0.008	0.080	(0.002)	(0.010)	0.002	0.010
city4	0.049	0.500	0.109	0.660	0.120	0.730
city5	0.016	0.110	0.073	0.430	0.112	0.670
city6	(0.063)	(0.530)	(0.066)	(0.390)	(0.028)	(0.160)
city7	(0.179)	(1.620)	(0.104)	(0.580)	(0.083)	(0.470)
city8	0.090	0.780	0.235	1.360	0.208	1.240
city9	0.087	0.740	0.290	1.540	0.344	1.840
city10	(0.069)	(0.620)	(0.045)	(0.230)	(0.011)	(0.060)
city11	(0.101)	(0.900)	(0.065)	(0.350)	(0.031)	(0.170)
city12	0.097	0.980	0.110	0.670	0.122	0.750
city13	**(0.259)**	(1.950)	(0.082)	(0.440)	(0.061)	(0.330)
city14	**0.263**	2.310	**0.359**	1.970	**0.411**	2.260
city15	**0.188**	1.690	0.188	1.120	0.244	1.470

city16	(0.166)	(1.500)	(0.083)	(0.470)	(0.066)	(0.380)
city17	0.014	0.130	0.068	0.390	0.079	0.450
city18	(0.017)	(0.170)	(0.019)	(0.110)	0.021	0.130
sectors1	(0.177)	(1.380)	0.115	0.720	(0.187)	(1.120)
sectors2	**(0.250)**	(1.770)	(0.010)	(0.060)	**(0.336)**	(1.940)
sectors3	(0.133)	(1.030)	0.173	1.100	(0.144)	(0.880)
sectors4	(0.202)	(1.460)	0.090	0.520	(0.268)	(1.520)
sectors5	(0.014)	(0.110)	**0.284**	1.830	(0.039)	(0.240)
sectors6	(0.219)	(1.560)	(dropped)		(dropped)	
sectors7	**(0.284)**	(1.930)	(dropped)		(dropped)	
sectors8	**(0.279)**	(1.920)	(dropped)		(dropped)	
sectors9	(0.091)	(0.680)	(dropped)		(dropped)	
sectors10	(0.034)	(0.250)	**0.296**	1.890	0.002	0.010
sectors11	(0.135)	(0.880)	0.181	0.970	(0.122)	(0.650)
sectors12	(dropped)		0.296	1.520	(dropped)	
sectors13	(0.153)	(1.080)	0.238	1.390	(0.062)	(0.350)
sectors14	(0.166)	(1.300)	(dropped)		(0.305)	(1.520)
_cons	**1.021**	3.040	**0.857**	1.790	**1.255**	2.420
R-squared		0.073	0.075		0.091	

City 1 was dropped due to multicolinearity in all functions. In addition, Sectors 6-9 were dropped due to multicolinearity in Functions 2-3 and Sector 12 was dropped in Functions 1 and 3. There was a low incidence of significance in the variables controlling for cities and regions.

Table 4a: Correlation Matrix to show potential multicolinearity

	Profit	Patents	Innovate	RDshare	Law	EduEgr	EduMgr	Cap	Pvtshare	Age	Size	Size2
Profit	1.000											
Patents	(0.026)	1.000										
Innovate	0.091	0.256	1.000									
RDshare	(0.028)	0.001	0.025	1.000								
Law	0.026	0.038	0.118	0.012	1.000							
EduEgr	0.025	0.145	0.232	0.026	0.113	1.000						
EduMgr	(0.004)	0.182	0.213	0.035	0.097	0.589	1.000					
Cap	0.008	0.124	0.225	0.037	0.083	0.063	0.052	1.000				
Pvtshare	0.050	0.002	0.005	(0.045)	(0.025)	(0.000)	(0.003)	(0.017)	1.000			
Age	(0.083)	(0.040)	(0.097)	0.028	(0.041)	(0.144)	(0.170)	(0.006)	(0.421)	1.000		
Size	(0.056)	0.244	0.375	(0.030)	0.157	0.223	0.263	0.365	(0.032)	(0.038)	1.000	
Size2	(0.042)	0.255	0.358	(0.031)	0.146	0.224	0.265	0.369	(0.035)	(0.037)	0.988	1.000

Beyond the previous incidents of multicolinearity discussed above, table 4a shows little other potential for multicolinearity with the exception of the strong relationship between Size and Size^2 which is to be expected due to the fact that Size^2 is simply the square of Size. The next strongest relationship is between EduEgr and EduMgr indicating that people tend to work together of a similar educational background. There are no other values above .5.