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Public education expenditure, institution development, and regional innovations: an empirical evidence from China

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Abstract
This paper investigates the relationship between government education expenditure and regional innovation, a key engine of China's long-term economic growth as the nation undergoes massive economic restructuring and deep transformations. In an attempt to inform a whole-of-government approach in promoting indigenous knowledge generation, the authors examined the effect of two additional institutional factors, financial market development and Intellectual Property protection, as well as their interaction with education expenditure on regional innovation levels. By employing a sample of provincial panel data from 1998 to 2014, the authors find a significant positive correlation between education expenditure and regional innovation levels, an effect most pronounced in the Western provinces of China. Their analysis also revealed that financial market development augments the pro-innovation effect of education spending whereas a stronger IP protection regime could potentially mitigate such effect. The findings indicate that government investments in education as well as the creation of a more developed financial landscape will be effective ways to enhance regional innovation levels. However, attention should be paid to the nuances of the current IP protection system as well as the conduct of market players to pre-empt exploitations and enable greater incentives for sustained innovations.

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Keywords Education expenditure; innovation; financial market development; Intellectual Property protection

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1. Introduction

The relationship between innovation and long-term economic growth is almost an axiomatic one. Robert Solow (1957), via the staggering "Solow Residue", first established that technological progress accounted for the bulk of economic growth in the U.S. during the period of 1909 to 1949. It is in the neo-classical exogenous framework advocated by the Nobel Laureate that increase in Total Factor Productivity(TFP), the natural outcome of innovation and technological growth, was identified as a key contributing factor to economic progress after the initial period of catch-up growth and short-term convergence. While the empirical results of Solow were challenged by researchers such as Denison(1962) and Griliches(1967) who adjusted the residue to approximately one-third of economic growth, the positive correlation between technological advancements and long-term growth remains well-recognized and continues to shape the direction of growth-accounting research. Unsatisfied with the key assumption of exogenous technological growth, later scholars including Romer(1986,1990), Lucus(1988), Barro(1990), Aghion and Howitt(1992) have sought to fully endogenize the role of innovation in their theoretical works by considering different types of innovations, arguing that technological spillovers resulting from R&D generate vast positive externalities and form a critical component of the growth process. (Cameron, 1996)

Empirical studies centered on the positive growth effect of innovation have produced voluminous results. For example, Fagerburg (1987), based on pooled cross-sectional and time-series data from 25 industrial countries for the period 1960-1983, found that innovative activities appeared as a powerful explanatory factor of economic growth while recent studies by China scholars confirmed positive impacts of R&D on productivity performances in China on both firm and sector levels (Wei and Liu, 2006; Wu, 2006, 2009).

It is thus believed that technological development fueled by innovation and R&D activities could serve as a potent thrust for sustained, long-term economic growth, particularly for China which stands at the crossroad of economic transformations. For the past 35 years since the Reform and Opening Up championed by Deng Xiaopin, China's meteoric economic growth has been largely driven by massive fixed asset investments and exports. China surpassed U.S. as the largest foreign reserve holder in 2006, the largest global manufacturer in 2010 and the largest international trader in good in 2012 as it took dominant positions in various markets (Pencea and Balgar, 2016). However, the potential downside of the nation's export dependency was evinced in the wake of the 2008 Sub-Mortgage Crisis amidst weakening world demand as well as anti-globalization pressure. Problems of overcapacity, inflation and wage pressure have resulted from the government's stimulus package in the form of expansionary fiscal and monetary policies while environmental degradation and pollution arising from overexploitation of resources and lax regulations have clearly taken a toll on the nation's standards of living. On the other hand, China is expected to confront the gradual depletion of its vast supply of cheap labor as its own one-child policy backfires, leading to a projected fall of labor of 15 to 24 year old by 62 million and raising questions over the sustainability of the current development model (Fabre and Grundbach, 2012) .

To restore economic imbalance and ensure long-term, sustained competitiveness, it is imperative that China move away from its current factor and investment-driven model and advance towards a "new normal" of innovation-driven and wealth-driven development, in line with Michael Porter's (1990) theory of national growth. In his work on China's growth transition, Zilibotti (2015) highlights the significance of national policies and institutional reforms that trigger the switch from investment-led, to innovation-driven growth as the crux to escape the "middle-income trap". It is heartening to see that active steps have been taken by the Chinese government in a bid to encourage indigenous innovations and promote R&D activities, with the release of the *National Medium and Long–term Plan for Science and Technology Development* (2006-2020), painting an ambitious picture of the central government's vision of the nation's technological landscape. Between 2000 and 2010, China's R&D expenditure doubled as a share of GDP (0.8% to 1.75%) and R&D personnel increased from about 1 million to 2.8 million. At the end of the decade, its share of total global R&D spending equaled Japan's in purchasing power parity (12.3%) just behind the US (34.4%) and Europe (23.3%) (Fabre and Grundbach, 2012). Such top-down mobilization of national resources has clearly achieved commendable results, as evidenced by the spike in the number of applications for international patents by China as well as the staggering innovations of Chinese private firms in areas such as consumer electronics. Analysis by the McKinsey Global Institute (2015) suggests that by 2025, such new innovation opportunities could contribute $1.0 trillion to $2.2 trillion a year to the Chinese economy—or equivalent to up to 24 percent of total GDP growth. Yet, it must be acknowledged that in many other areas of innovation, China is still a follower, not a leader and the nation has been reaping technological growth by taking the "low-hanging fruits" of adaptation and international acquisition (Abrami et al., 2014). To devise institutional mechanisms to transform the nation towards an innovation-driven economy still represents a long-term challenge and a policy priority for the Chinese government.

As we look into the long-term driving forces of innovation, questions have surfaced over whether the Chinese education system is capable of producing the talented and innovative workers it needs, in terms of both quantity and quality. Numerous research works have pointed to the link between good education and augmented innovative capacity. Yet there is little doubt that the development and enhancement of the education system, particularly one as extensive and diverse as China's, is nothing short of a Herculean task that demands substantial commitment in both political will and finance. On 3rd May 2016, the Ministry of Education announced a 3.9 trillion Yuan expenditure on education in 2016, a 7.57 percent increase from 2015, following the reaching of its "4 percent of GDP" target in 2012 (Xinhua, 2013, 2017). However, education expenditure still lags far behind that of most developed economies, with the United States spending 7.3 percent of its domestic GDP on education, and the other OECD countries spending 6.3 percent of GDP on average, based on 2010 data (OECD, 2010). An understanding of the effect of education expenditure on innovative activities hence carries immense policy implications for the Chinese government in the heat of economic transformation and deepening of national reforms.

In addition to education spending per se, we do recognize that fostering innovation at a societal level is a multifaceted endeavor which requires not only fiscal input, but also effective governance and the establishment of favorable conditions---most notably sound institutions. Numerous studies in institutional economics have posited that the levels and modes of entrepreneurial and innovative activities are affected by surrounding institutions (Licht and Siegel 2006; Busenitz et al., 2000). According to Baumol (1990) and Nee (1996), institutions can help alter the constraints and structure of incentives in a society to direct self-interested behavior towards either more or less economically productive activities. In addition, new opportunities open up as emerging economics undertake the shift from redistributive bureaucracy to open markets (Nee 1996). It is hence believed that creating an institutional environment conducive to innovation could potentially augment the effect of fiscal investment in education and is thus of immense implication of policy-making as the government should seek to undertake a "whole-of-government" approach in promoting innovation and economic growth. In this paper, we examine two aspects of China's institutional environment, namely, financial market development and Intellectual Property protection, and their interplay with fiscal education spending.

In this paper, we examine whether the increase in the education spending in a region will result in the regional innovation, using a sample period from 1998 to 2014. As an identification strategy, a panel-based fixed effect model is employed. Our baseline results show that fiscal education spending has a significant positive effect on the regional innovation. In particular, the effect was larger for provinces in the western region. In addition, a higher financial market development level may enhance the positive effect of fiscal education spending on innovation, while a more severe IP protection will hinder this effect. We also conduct a number of robustness checks to examine whether our main results are robust.

Our paper offers new insights into the real effects of fiscal education spending on innovation and contributes to the literature on education spending and regional innovation. What's more, unlike earlier studies, we use a rich cross-province data set to examine the relation between education spending and innovation.

This paper endeavors to present an empirical survey of the correlations between education spending and innovation on a provincial level, employing panel data from 1998 to 2014. The rest of the paper proceeds as follows. Section 2 provides an overview of existing literature on education and innovation as well as the two institutional factors considered. Section 3 describes the data and provides summary statistics. Section 4 presents our empirical strategy and reports our main findings. Section 5 provides further discusses on our baseline results. Section 6 shows our conclusions as well as limitations of this paper and future areas of research.

2. Literature Review

Education is widely seen as one of the most important instrument to enhance human capabilities and achieve economic growth in the long-term, generating vast positive externalities that enable societies to achieve the desired objectives of social and economic development. On the fundamental level, education stimulates growth by facilitating the accumulation of Human Capital, which refers to the amalgamation of individuals' knowledge and abilities which determine their course of action (Coleman, 1998). Human capital is said to be embodied in the skills, knowledge, and expertise that people have and has been regarded as a key source of competitive advantage to individuals, organizations, and societies (Gimeno et al., 1997; Coleman, 1988). Black and Lynch (1996) proposed that investment in human capital through training and education are the driving force behind increases in productivity and competitiveness at the organizational level while Cannon (2000) argued that human capital raises overall productivity at the societal level by enabling increases in human input in the forms of physical and intellectual effort.

Endogenous growth theories, characterized by the works of Nelson and Phelps (1966), Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992), built on the idea of human capital and proffered the view that higher education attainment contributes to economic growth and perpetual rises in standards of living through technological innovations and knowledge diffusion---an idea dated back to as early as Schumpeter's (1942) concept of "creative destruction". Numerous empirical works have attested to the positive correlations between human capital and economic growth. For example, studies by Barro (1991, 2001) and Benhabib and Spiegel(1994) confirmed that the initial stock of human capital played a significant role in economic growth, while Gemmell (1996) showed that both the initial stock and accumulation of human capital were significant determinants of growth. Yet despite the argument of endogenous growth theories, significantly fewer studies have devoted to establishing the empirical link between human capital and innovative activities, although Dakhli and Clercq (2003) did find, using data across 59 different countries, a strong positive relationship between human capital and innovation on a societal level.

Growth accounting literature in China have similarly focused on the empirical correlations between human capital and economic growth. However, it is less conclusive with respect to China as to whether its economic growth in the last several decades should be attributed to growth in human capital or physical capital investments. (Chi and Qian, 2009) While it would be hard to dispute that China's double-digit growth miracle was predominantly driven by fixed capital accumulation, as concretely established by the studies of Arayama and Miyoshi (2004) and Wei et al. (2001), other studies that have found some measures of human capital, such as secondary and higher education enrollment, the number of science and technology workers in the labor force and per capita spending on education and science, are significantly related to the growth rate (Ding and Knight, 2008; Song et al. 2000; Yao and Zhang, 2001). Chi (2008) suggests that the higher education of workers contributes to economic growth, but the effect may be indirect. For example, Lai et al. (2006) and Kuo and Yang (2008) found that human capital as measured by the attainment of college education could enhance the absorptive capacity of workers to foreign knowledge and fruits of innovation. Yet still, studies on the specific relations between education and innovation are few and far between. The most convincing, so far, being Chi and Qian's (2009) work which found "strong and robust evidence for the prediction of endogenous growth theory regarding the effect of human capital on innovation", despite the results not being consistently significant.

As the government is directly responsible for the majority of investments in at least, basic education in most countries, it is believed that government expenditure on education could significantly impact the scale and quality of education and education attainment levels, which in turn, affects economic growth. Studies by Glomm and Ravikumar (1992, 1997, 1998), Eckstein and Zilcha (1994), Kaganovich and Zilcha (1999), Cassou and Lansing (2001), Blankeanu (2003) and Blankenau and Simpson (2004) constructed theoretical models supporting a direct positive effect between government spending on education and long-run growth. Other articles have pointed to the indirect relation between government education expenditure and the accumulation of human capital through private sector subsidies (Zhang, 1996; Hendricks, 1999; Brauninger and Vidal, 1999; Bouzahzah et. al., 2002). However, empirical results have not always been consensual, as Levine and Renelt (1992) concluded that government spending on public education is not robustly correlated with rates of growth. To reconcile the discrepancy, Teles and Andrade (2004) proposed that while theoretical models constructed for this relation may be correct regarding the direction of the relation, it is possible that some aspect of this relation has not been considered, as verified by the asymmetry of the empirical evidence.

Yet similarly, the bulk of literature in this area centered on the linkage between education expenditure and growth while few endeavored to look into the possible mechanism of education expenditure’s growth-inducing effect by discussing the correlations between educational spending and innovative activities. Amongst the limited studies that sought to shed light on this issue, Li and Liu (2013) employed Chinese provincial data in Year 2011 and derived a positive relationship between education expenditure and innovation for most of the provinces concerned. However, we feel that in contrast to cross-sectional data, research rooted in panel data analysis would better elucidate the relationship due to the inevitable time lag between fiscal spending and the actual increase in human capital which facilitates innovation and R&D.

With respect to institutional factors, both financial market development and Intellectual Property protection are found to exert positive impact on the level of innovation. Authors such as King and Levine (1993), Morales (2003), Acemoglu et al. (2006) found that banks promote technological innovation by allocating resources to entrepreneurs with the most promising new opportunities, such as new products and production methods. Meanwhile, Cabral and Mata (2003) argued that the unavailability of financing sources prevents firms from achieving their optimal size and hence reduces their involvement in innovation activities. Further studies suggested that different financial systems perform different functions and the co-presence of bank and capital market financing creates a well-functioning financial system that allows innovation to thrive and deliver benefits (Ghazali et al., 2014). Similarly, the positive relation between Intellectual Property protection and innovation is a well-established one. Nelson (1959) and Arrow (1962) pointed out that knowledge is a public good as knowledge produced can and will be used by other actors in an open market, which leads to underproduction of knowledge and innovations. Hence, based on Kalanje’s work, robust Intellectual Property protection systems mitigates market failure by helping a business to gain and retain its innovation-based advantage. At the same time, IP plays an important role in facilitating the process of taking innovative technology to the market place. Hence, we would expect both financial market development and Intellectual Property protection to enhance the positive impact of education spending on innovation.

Different from existing works, this paper investigates the relationship between education expenditure and innovative activities in the context of China using panel data on a provincial level from 1998-2014, while taking into account the potential time lag between education spending and the realization of its fruits. This is followed by examining the regional differences in the extent of impact of educational spending as well as the augmenting/mitigating effects of institutional factors on fiscal education investments, through our empirical models which would be expounded on in the next few sections. We find that the increase in fiscal education spending in the prior year caused an increase in the regional innovation output, espically for the western regions. We also show that a higher level of financial market development enhances the positive effect between fiscal education spending and innovation, while the IP protection weakens the effect.

3. Data and summary statistics

We compile our data set from several databases. We adopt the key data in our study from the China Statistics Yearbook and China Statistical Yearbook on Science and Technology---annual statistical publications released by the National Bureau of Statistics of China. Data for annual education budget and patent information by provinces are directly taken from the China Statistics Yearbooks from 1998 to 2014 for 31 provinces in China (excluding Hong Kong, Macau and Taiwan) whilst data selected for control variables include regional R&D spending, number of workers working in the R&D sector, GDP per capita, share of GDP of first / second industries, retail sales volume for consumer goods, external trade volume, number of students enrolling in tertiary institutions and number of enterprises above designated size[1], in line with factors affecting innovation recognized by existing literature. Meanwhile, as the paper also incorporates the levels of financial sector development and Intellectual Properties (IP) protection as another two variables, indexes for

[1] According to the National Bureau of Statistics of China, Industrial enterprises above designated sizes are all state-owned enterprises and non-state owned enterprises with annual revenue from principal business over 5 million yuan from 1998 to 2006, and are industrial enterprise with annual revenue from principal business over 5 million yuan from 2007 to 2010. In 2011, the State Council revised the definition of industrial enterprises above designated size to comprise industrial enterprises with annual revenue from principal business over 20 million yuan.

the above two factors are drawn from the NERI INDEX of Marketization of China's Provinces 2011 Report (Fan et al, 2011). However, statistics in the report are only released up to 2009 so data from 1998 to 2009 are used in this section.

Following the existing literature, a common proxy for innovative activities is the number of patent applications or patent grants---an approach adopted by this paper. Total number of patent applications instead of patent grants are used in this paper as the granting of patents may be subjected to differences in granting standards across provinces (Chi and Qian, 2009). Patents in China are classified into three main categories. An invention patent refers to any new technical solution relating to a product or process. Utility model patents refer to the shape, structure, or their combination of a product, which enhances the practical use of the product. A design patent means any new design of the shape, pattern, color, or their combinations that serves for the ornamental purpose. Here, the aggregate of applications for all three types of patents is used for analysis.

Table 1 provides summary statistics of the variables used in this study[2]. From the table, we can see that the maximum and minimum values of *edu* are 6.134 and 2735.655 respectively, and the standard deviation is 383.949, which indicates that the investment in education expenditure among provinces are very different. In addition, the maximum and minimum values of patent applications (*patent*) are 10 and 504500, respectively, and the standard deviation is 24478, indicating that the number of patent applications as well as the innovation capacity among provinces are significantly different. The average R&D investment intensity (*rd_gdp*) is 0.011 and the standard deviation is 0.010, which indicates that the intensity of R&D investment is not high among the provinces in China and the regional difference is still large.

4. Econometric Analysis

4.1. Empirical Model

To assess how fiscal educational spending affects regional innovation, we estimate the following fixed effect model:

$$lnpatent_{it} = \alpha_0 + \beta_1 lnedu_{i,t-1} + \gamma X_{i,t-1} + u_{year} + u_{prov} + \varepsilon_{it} \qquad (1)$$

where i denotes province and t denotes year. The independent variable, $lnedu$, is the natural logarithm of the total amount of education budget whereas the dependent variable, $lnpatent$,

[2] All monetary values in Table 1 are calculated in CNY.

Table 1: Summary Statistics of Key variables

Variable	Variable Description	Sample Size	Mean	S.D.	Min	Max
patent	Number of Patent Applications	527	24478	54303	10	504500
edu	Education Budget (in Billions)	496	37.412	383.949	0.613	273.565
rd_gdp	R&D spending as a share of GDP	527	0.011	0.010	0.001	0.060
rd_worker	Total number of workers in R&D Sectors (in Thousands)	527	59.46	7.645	0.20	506.86
Open	External Trade Volume as a Share of GDP	527	0.304	0.384	0.032	1.681
first_gdp	Output of First Industry as a share of GDP	527	0.137	0.072	0.0053	0.364
second_gdp	Output of Second Industry as a share of GDP	527	0.451	0.083	0.197	0.591
stu	Average Number of Students per Tertiary Institution (in Thousands)	527	7.29	0.275	0.85	13.83
Firm	Number of enterprises above designated size	527	9404.973	11939.348	56.000	65495.000
Sale	Retail Sales Volume for Consumer Goods (in Billions)	527	350.264	4250.776	3.500	2847.110
Lnpgdp	Ln (GDP per capita)	527	9.714	0.838	7.768	11.564

measures the intensity of innovative activities by taking the natural logarithm of the total number of patent applications. X represents control variables which are believed to affect the level of innovative activities based on past literature. The independent variable and all control variables are lagged by 1 year to account for the time lag between educational spending and changes in innovative activities. u_{year} and u_{prov} capture year and province fixed effects, respectively.

4.2. Baseline specification and results

The results of our analysis, as reported in Table 2, confirm the belief that education spending enhances the level of innovative activities. Column (1) shows the result of a simple regression analysis between $lnedu$ and $lnpatent$, suggesting an estimated positive coefficient of 0.194 at 10% significance level. Column (2) presents the result of the multivariate regression shown in model (1), giving an estimated positive coefficient of 0.327 at 5% level of significance, which validates the positive correlation between the amount of education budget and patent applications.

With respect to control variables, our analysis shows a strong positive correlation between R&D spending and innovation, a conclusion vindicated by various empirical research works in the context of China and beyond (OECD, 2007). Meanwhile, the level of trade openness, as measured by external trade volume, is found to exhibit a positive correlation with innovation intensity. This is consistent with the observation of Giammario and Licandro (2010), who argued that trade increases firm innovation through greater competition. Similar conclusions are made by Constantini and Melitz (2008), who used a dynamic model with rational expectations to show that the anticipation of trade liberalization may cause firms to bring forward the decision to innovate in order to make preparations for future export activities. In addition, both GDP per capita and the average number of students per tertiary institutions exert a positive impact on innovation. We posit that the former could be due to the incentivizing effect of higher level of commercial activities on innovation as well as internal migration of high-skilled labor to more developed regions which augments the capacity for innovation. Meanwhile, greater number of tertiary students may lead to an expansion of local talent pool and provide the necessary human capital for innovative activities.

Table 2: Baseline regression results

Models Variables	(1) Lnpatent	(2) Lnpatent
lnedu	0.194* (1.72)	0.327** (2.39)
rd_gdp		19.316** (2.35)
lnrd_worker		0.023*** (4.44)
Open		0.912*** (6.06)
lnpgdp		0.823*** (3.32)
first_gdp		-0.808 (-0.83)
second_gdp		-0.827 (-1.34)
stu		0.317** (1.98)
lnsale		0.009 (0.03)
lnfirm		-0.032 (-0.53)
Year fixed effects	Yes	Yes
Province fixed effects	Yes	Yes
Constant	9.015*** (12.06)	-1.108 (-0.55)
observations	465	465
R^2	0.973	0.980
Adjusted R^2	0.970	0.977

Note: Values in brackets are t-values. '***', '**' and '*' denote significant results at 1%, 5% and 10% significance level respectively. The independent variable and control variables in columns (1)-(2) are all lagged by one year to account for endogenous problem.

4.3. Robustness Checks

In this subsection, we checked for the robustness of the above results by varying the set of variables. For brevity, we report only the test results.

Firstly, we replace the control variable. By replacing Output of First Industry as a share of GDP (*first_gdp*) with Output of Third Industry as a share of GDP (*third_gdp*), the new regression, as shown in Column (1) of Table 3, continues to prove significant positive correlations between educational spending and innovation.

In addition, by substituting Fiscal Educational Expenditure(*Lnfinan*) and Education Budget with Education Spending as a share of GDP (*edu_gdp*), model (1) produces results as shown in Columns (2) and (3) of Table 3. Both analysis yield positive estimated coefficients at 1% and 5% levels of significance respectively, hence verified our conclusion that education spending exerts a positive impact on innovation levels.

Table 3: Regressions for Robustness Checks

Models Variables	(1) lnpatent	(2) lnpatent	(3) Lnpatent
lnedu	0.327**		
	(2.39)		
Lnfinan		0.421***	
		(2.97)	
edu_gdp			8.240***
			(3.76)
Control variables	yes	yes	Yes
Year fixed effect	yes	yes	Yes
Province fixed effect	yes	yes	Yes
Constant	-1.916	-1.140	-2.972
	(-1.01)	(-0.57)	(-1.43)
observations	465	465	465
R^2	0.980	0.980	0.980
Adjusted R^2	0.977	0.977	0.977

Note: Values in brackets are t-values. '***', '**' and '*' denote significant results at 1%, 5% and 10% significance level respectively. The independent variable and control variables are all lagged by one year to account for endogenous problem.

5. Further Analysis

5.1. Regional Differences

With China commanding around 9.6 square kilometers of land, the vastness of the nation has given rise to remarkable heterogeneity across regions as well as pronounced divergence in economic development. In the early stage of the Reform and Opening-up campaign, priority was given to the development of open cities and special economic zones in coastal regions. While this policy resulted in rapid growth in coastal areas, inland regions lagged behind, leading to expanding inequality between geographical regions (Oizumi, 2010). Given the regional disparity in development levels and economic conditions, we feel that education spending could engender varying effects on innovation levels, which in turn, calls for differentiated policy approaches in promoting innovative activities across regions.

Based on definitions prescribed by the National Bureau of Statistics of China, we grouped the 31 provinces in our study into 4 main categories, namely, the Eastern Region, the Central Region, the Western Region and the North-Eastern Region. Separate regressions are then conducted for each of these regions, whose results are reported in Table 4 below.

As shown in Table 4, divergences in effects of education spending are observed across the four regions. Regression of the Western Region provinces gives a high positive value of

β_1 (0.892), indicating a strong positive correlation between education spending and innovation intensity in the region, whereas the other coefficients are not statistically significant. The result might be hardly surprising as provinces in the Western Region are mostly plagued by poor education infrastructure and human capital stock, on part due to low regional income and the lack of central government support which leads to insufficient education funding and inefficiencies in resource allocation for human capital investment (Heckman, 2005). Assuming Diminishing Marginal Returns, one would expect provinces in the Western Region to benefit from a larger marginal return of education investments, which contributes to greater spill-over effects including a high rate of increase in innovative activities.

Table 4: Regression by region

Models Variables	Eastern Region Lnpatent	Central Region Lnpatent	Western Region Lnpatent	North-Eastern Region Lnpatent
Lnedu	-0.057 (-0.26)	-0.326 (-0.62)	0.892*** (3.23)	-1.242 (-1.20)
Control variables	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
Constant	-12.808*** (-4.34)	19.370 (1.35)	7.742** (2.07)	17.649 (0.71)
observations	165	90	165	45
R^2	0.989	0.959	0.985	0.987
Adjusted R^2	0.986	0.939	0.981	0.968

Note: Values in brackets are t-values. '***', '**' and '*' denote significant results at 1%, 5% and 10% significance level respectively. The independent variable and control variables are all lagged by one year to account for endogenous problem.

5.2. Institutional Factors

A separate regression was conducted to investigate the interactive effects of education spending and institutional factors, based on the model described below.

$$lnpatent_{it} = \alpha_0 + \beta_1 lnedu_{i,t-1} + \beta_2 FIN_{i,t-1}(protect_{i,t-1}) + \beta_3 lnedu_{i,t-1} \times FIN_{i,t-1}(protect_{i,t-1}) + \gamma X_{i,t-1} + u_{year} + u_{prov} + \varepsilon_{it} \quad (2)$$

Here, $FIN(protect)$ demotes the level of financial market development or Intellectual Property region of province *i* while the coefficient of the interaction term $lnedu_{i,t-1} \times FIN_{i,t-1}(protect_{i,t-1})$, β_3, measures the effect of each of the institutional factor on the effect of education spending. Similar to model (1), X represents other control variables and the variables are lagged by one year to account for the time lag. However, due to data constraints for the two institutional factors, regression was carried out using data from 1998 to 2009.

As seen from Column (1) of Table 5, interaction of financial market development and education spending gives a positive β_3 of 0.025, a conclusion supported observations of past literature as a more mature financial market, as explained in section 2, is believed to augment the efficiency of funding allocation and stimulate R&D activities. This also sheds light on the need for the government to enhance financial market development so as to fully reap the benefits of education spending.

However, a more interesting observation was made pertaining to Intellectual Property protection, as the regression summarized in Column (2) of Table 5 generates a negative interaction term of -0.024. This contradicts some existing literatures, which posit a positive correlation between IP protection and innovation on a societal level. One possible reason is that a strong patent system gives rise to increased transaction costs in the market for technological exchanges, as agents are required to obtain permissions to use patented technologies (Allred and Park, 2007). In addition, patent rights may be wielded for strategic defensive purposes by blocking rivals from accessing important technologies for innovations (Cohen et al., 2000; Ziedonis, 2004). Stronger patent rights may also reduce the incentives of patent holders themselves to innovate due to greater barriers to entry and reduced rivalry (Cadot and Lippman, 1995; Horowitz and Lai, 1996). An organizational approach suggest of costs evaluation suggests that patents net organizational advantage incentivises the divergence of organizational modes: integrated modes that lack the targeted incentives but may overcome transaction costs and licensing modes that facilitate the independent commercialization of inventions. Without Intellectual Property protection, a net advantage for integrated modes is observed, but as the strength of Intellectual Property protection increases, licensing eventually becomes the superior mode. In a heavily policy centric command-economy, the external transaction costs in licensing component markets outstrip the governance costs of integration, hence reducing the incentives for patents (Deepak and David, 2000).

Yet despite the theoretical explanations, we do feel that more substantive empirical studies may be needed to ascertain the exact implications of the level of IP protection in China's context, especially given that China's Intellectual Property regime is far from well-established or comprehensive. Nevertheless, such a finding could still serve as a reminder to the potential adverse impact an excessively strong IP protection system and encourage review of the intricacies of the current regulations and conducts of market players for a more informed understanding.

Table 5: Interaction between Institutional Factors and Education Spending

Models Variables	(1) lnpatent	(2) lnpatent
lnedu	0.281*	0.706***
	(1.70)	(4.62)
FIN	-0.121***	
	(-2.66)	
EDF	0.025***	
	(2.74)	
EDP		-0.024***
		(-3.71)
protect		0.171***
		(4.10)
Control variables	Yes	Yes
Year fixed effect	Yes	Yes
Province fixed effect	Yes	Yes
Constant	4.220*	2.204
	(1.80)	(1.07)
observations	340	370
R^2	0.983	0.984
Adjusted R^2	0.980	0.981

Note: Values in brackets are t-values. '***', '**' and '*' denote significant results at 1%, 5% and 10% significance level respectively. The independent variable and control variables are all lagged by one year to account for endogenous problem.

6. Conclusions and Direction for Future Research

This paper investigates the relationship between government education spending and innovation levels, as part of an attempt to answer the questions of how education contributes to economic growth and how innovations can be effectively fostered. Through our empirical models, we observed a strong positive relationship between education expenditure and indigenous innovation in the context of China, especially for provinces in the Western Regions which could potentially benefit from greater education investments. In addition, as an extension of the effort to contribute to the "how to promote growth" discussion, we examined two institutional factors, namely, financial market development and Intellectual Property protection, as well as their interactions with education spending. Our analysis shows that financial market development augments the pro-innovation effect of education expenditure while strong IP protection could potentially act as a hurdle to indigenous knowledge generation facilitated by education spending.

It thus follows that the national government should seek to encourage innovation by enhancing education investments---a recommendation in line with the policy agenda of the administration, which has mandated increases in education budget for the past 10 years. In light of the regional discrepancies in the effect of education spending on innovation, perhaps the central government should pledge greater support for education funding in the Western provinces to reduce funding shortages in the underdeveloped regions and achieve greater balance in education expenditure, considering that education budget is largely funded through local government income. Meanwhile, to create a favorable institutional environment for indigenous innovation, greater effort should go into constructing a mature financial landscape for efficient business investments, while attention should be paid to the potential adverse impact on innovation of strong IP protection regimes as well as the danger of exploitation.

However, the findings of this paper should be interpreted with a few limitations in mind. Firstly, in measuring the level of innovation, we adopted the blunt instrument of patent applications, which tends to be skewed towards technology-based discoveries yet excludes other types of innovations such as improvements in business processes that play an equally significant role in increasing productivity and promoting growth. In addition, in our analysis on the institutional factors affecting innovation, a single index on financial market development was used. However, an examination of studies on the financial market would reveal the heterogeneous effect of different types of financial instruments on innovative activities. For example, Hsu et al. (2010) concluded that while the development of equity markets encourages innovation, credit market development impedes innovation. Hence, the lack of nuances in our approach inevitably limits the scope of policy recommendations that this paper could offer. Lastly, due to limited data, we were unable to investigate the differentiated effects of different types of education spending on innovation. Future researchers may want to delve into the impact of education expenditure based on the level of institutions that the budget goes to (e.g. primary schools, secondary schools, undergraduate, post-graduate etc.). The efficiency at which such budget is used by the local government and institutions, as well as the possibility of misappropriation and wastage, are generally untouched by this paper, and represent another area that warrants further investigations to enhance the accuracy of our conclusions.

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