Innovation in China: Estimating the Effectiveness of China's Science and Technology Industrial Parks

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Abstract

This paper utilizes province-level patent data and two-way fixed effects analysis to evaluate the impact of China's national science and technology industrial parks (STIPs) on Chinese innovation. The overall finding is that an additional STIP increases provincial patent applications by 6.1%. Effects of STIPs, however, are seen to vary across different measures of patents, and are most robust in predicting types of patent. Both measures of patent applications expected to be impacted most from STIP activity—invention patents and patents from enterprises—are found to be insignificantly related to the presence of STIPs.

I. Introduction

In the mid-1980s, China began to concentrate on its high-tech industrial base. Fundamental to that endeavor was the implementation of the Torch Program in 1988. The Torch Program sought to build a high-performing "enterprise-based innovation system", encouraging industry-science relationships and accelerating technology adoption and diffusion in China.[1] From 1988 to 1997, 53 national science and technology industrial parks (STIPs) were created throughout the country, with the majority of these parks established in 1991 and 1992 (see Appendix Tables 1 - 2). With the exception of Beijing, most of the STIPs were built greenfield, first setting aside the area and then attracting enterprises to the zone. Furthermore, many of the STIPs stimulated the creation of surrounding universities in order to facilitate collaboration between firms and researchers, establishing an environment where domestic enterprises could become technology leaders.

While China's innovation system has been surveyed extensively, few studies have been performed on China's STIPs themselves. Hu (2007) analyzes the location advantage of STIPs, finding no evidence that firms benefit by locating in technology parks and also reporting that the number of firms in China's STIPs has a negative impact on labor productivity growth within the STIPs.[2] Zhang (2009) similarly reports that firms located inside STIPs may benefit from agglomeration economies, but they are faced with congestion problems that outweigh any positive effect that agglomeration economies bring. He also finds that the productivity of high-

[1] OECD. *OECD Reviews of Innovation Policy: China*. (2008), pg. 39.
[2] Hu, Albert G. "Technology parks and regional economic growth in China." *Research Policy* 36 (2007), pp. 76-87.

tech firms, whether within or outside of STIPs, is positively associated with foreign direct investment and academic activities of local universities in the same city.[3]

In this paper, I analyze the effect of STIPs on Chinese innovation, using provincial patent applications as a measure of innovation. Along with total patent applications, multiple measures of patents are tested to more acutely define the effect of STIPs. These measures are broken down into patent types and patent origins. Patent types include inventions, utility models and designs. Patent origins include universities, research institutes, enterprises, state organizations and individuals. Motivation for this breakdown comes from Liu and White's (2001) hypothesis that patents originating from enterprises should have increased over the 1990s due to the large increase of in-house R&D departments in Chinese firms.[4] The quality of this increase in patents, however, is not determined. Liu and White state, for example, that a large fraction of enterprise patents are concentrated in design patents, which demand fewer technological inputs, rather than in invention or utility model patents.

This analysis seeks to identify the impact of high-tech development zones on patent applications by both patent type and patent origin. If STIPs are accomplishing their goal of building an enterprise-based innovation system, I expect the addition of a STIP to have the largest impact on patent applications from enterprises. Likewise, among patent types, invention patents should be affected the most. Due to the increased collaboration between enterprises and universities, university patents are also expected to increase.

II. Data

[3] Zhang, Haiyang and Tetsushi Sonobe. "Development of science and technology parks in China, 1988 – 2008." *Economics*: *The Open-Access, Open-Assessment E-Journal* 5 (2011).
[4] Liu, Xielin and Steven White. "Comparing innovation systems: a framework and application to China's transitional context." *Research Policy* 30 (2001). In-house R&D departments increased from 7,000 in 1987 to over 24,000 in 1998.

China's current patent law became effective in 1985, just a few years before the first STIP was created in Beijing. In this study, I use data on patent applications from 1985 to 2006 from China's State Intellectual Property Office (SIPO). In 2007 and the following years, a new wave of national STIPs was created as part of the Torch Program. Thus, data past 2006 is not used due to the lack of sufficient data to account for these new STIPs.

SIPO only divides domestic patents by provinces, thus precluding the option of including foreign patents in the analysis. Applications for patents are used instead of granted patents in order to eliminate bias in the patent approval process. This is a limitation, however, since some patent applications may be duplicates of already existing patents and thus are not true innovation. If this is a significant fraction of patents, it would have a positive bias on my estimates, possibly inflating the results. Provincial-level data used for controls in the analysis come from China's Provincial Yearbooks and are obtained from the China Data Online website.

III. Empirical Methodology

As this study uses panel data, a fixed effects regression is employed for estimation. This method compares patents in provinces before and after a STIP was created with the patents over the same time period in provinces that did not receive a STIP. The basic econometric model is as follows:

$$\log(Y_{it}) = \alpha_i + \delta_t + \beta_1 P_{it} + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the dependent variable (log patents in its various measurements) in province i during year t; α is a vector of province dummy variables (province-fixed effects); δ is a vector of year dummy variables (year-fixed effects); P_{it} is a measure equal to the number of STIPs in province i in year t; and ε_{it} is the idiosyncratic error term. The province-level fixed effects should control for any aspects of individual provinces that might affect innovation and application for patents, including unchanging differences in institutional, economic, or demographic characteristics of provinces. This initial estimate, of course, rests on the assumption that institutions, etc. change similarly across provinces over the sample period. Yearly fixed effects should control for any national-level macroeconomic effects.

Although implemented as a treatment variable, P_{it} is better defined as a count variable than as a dummy variable indicating when a STIP was inaugurated. This is due to some provinces receiving multiple STIPs over the sample period (some within the same year). Under this specification, the coefficient on P_{it} estimates the percentage increase (or decrease) in patent applications in a province from the addition of one STIP.

While fixed effects corrects many problems created by differences in provincial characteristics that are persistent over the sample period, the use of additional controls is needed to minimize the effects of other factors that may influence patent applications and change across the sample over time. In order to retain the full explanatory power of the STIP measure, these controls must also be exogenous to the addition of a STIP to a province. Three controls are implemented in the following expanded model:

$$\log(Y_{it}) = \alpha_i + \delta_t + \beta_1 P_{it} + \beta_2 \log(output_{it}) + \beta_3 \log(empl_{it}) + \beta_4 \log(prof_{it}) + \varepsilon_{it}$$

(2)

where $output_{it}$ is gross industrial output value in province *i* at time *t; $empl_{it}$* is total labor employment in province *i* and year *t*; and $prof_{it}$ is the number of teachers at institutes of higher education in province *i* and year *t* and is used to control for university professors, a subset of the population engaged in patent creation.

IV. Estimation Issues

In what follows, I walk through a number of transformations considered in the estimation in order to arrive at the final estimation equation.

Dependent Variable Transformation

Many observations had zero patent applications for certain years. In taking the log of patents (needed to control for increasing variance over the sample period and for ease of interpretation), this created missing values. No single solution exists to deal with this issue. One recommended method is to simply drop the observations containing zero. This methods seems unreasonable for my data, however, and would result in an unbalanced panel. In order to preserve the full data set, I add a small number to each observation. To prevent the arbitrary addition of extreme outliers resulting from taking the log of a small decimal (a major issue in Tibet, for example), I add 0.5 to each observation, the stated convention in biological statistics.[5] However, the decision upon what number to add in order to prevent the dropping of observations is subject to opinion. Results from the final model using unlogged variables, as shown in equation 3 below[6], are therefore provided near the end of the appendix to allow the reader to apply their own discernment in how to accept these results (see Table 10).

$$Y_{it} = \alpha_i + \delta_t + \beta_1 P_{it} + \beta_2 output_{it} + \beta_3 empl_{it} + \beta_4 prof_{it} + \varepsilon_{it} \qquad (3)$$

Province-Specific Trends

Heterogeneity is inherent in performing cross-province analysis in China. In my analysis, only the far western provinces of Qinghai, Ningxia and Tibet received no STIPs during the sample period, making them the only provinces for comparison as the counterfactual. This

[5] John H. McDonald. *Handbook of Biological Statistics*. 2009. <http://udel.edu/~mcdonald/statpermissions.html>.
[6] Autocorrelation, explained later in the paper, is also controlled for in this model.

embeds severe bias into the analysis, due to fundamental differences in economic and institutional characteristics that exist between these provinces and provinces that received STIPs. Chinese placement of STIPs is in no way thought to be random, and it is expected that the economic and technological level of a province predetermined its receiving a STIP. Additional endogeneity likely exists between other provinces in determining whether a province receives one STIP or multiple STIPs over the sample period. Within provinces receiving treatment, however, no significant difference is observable when plotted against an event window (see Appendix Figure 2).

Yet another form of endogeneity presents itself when looking at patent applications in pre-treatment periods. Provinces that received STIPs had significantly larger growth in total patent applications prior to STIP creation than did provinces that did not receive a STIP (see Appendix Figure 3). This would appear to be strong evidence for the need to include province-specific trends in the estimation, thus controlling for the different trends existing between provinces. However, when the same relationships are shown with logged patent applications, the pre-treatment trends disappear (see Appendix Figure 4). Since logged patent applications are used in this analysis, province-specific trends are not deemed necessary. Some small differences, however, still exist among various treatment provinces and the controls (i.e. Beijing and Xinjiang), so results showing province-specific trends are included for the reader's reference (see Appendix Table 11).

Region Interactions

Beyond differences in provincial output of patent applications, patent applications are also thought to differ between regions in China. A roadblock presents itself, however, from the situation of having all provinces that did not receive a STIP located within one region. Ningxia, Qinghai and Gansu all lie within the west region (if China is divided into three regions) or the northwest region (if divided into six regions). Appendix Tables 12 and 13 present the results from including region interactions with number of STIPs. Coefficients on the interaction terms indicate whether or not other regions are statistically significant from the omitted category, in this case the west and the northwest, respectively.

In the end, however, the more simple equation appears to be the best fit for this estimation. In performing the final analysis, therefore, I use a fixed effects model for provinces and time, controlling for provincial-level economic and demographic characteristics, as shown in Equation 2 above.

V. Estimation Results

Baseline Model

Before including provincial-level economic and demographic factors, the effect of a province receiving an additional STIP is significantly and positively correlated for all measures of patent applications (see Table 5). Total patents rise by 12.8% in response to a STIP. Surprisingly, though, among measures of patent origins, patents from enterprises receive the *smallest* impact from the addition of a STIP, while patents from individuals increase the most. These results may partially come from ambiguity in the composition of patents from individuals. In filing a patent, an individual can select to file a service patent or a non-service patent. Service patents refer to one of the four entities defined under patent origins, while non-service patents refer to patents from individuals. Patents from individuals then likely includes a mixture of patent applications from individuals operating individually as well as patents from individuals located in universities, research institutes, enterprises and state organizations. It is unclear what percentage of patents in enterprises might be filed by individuals. Among measures of patent types, however, there exists no ambiguity. Design patents receive the largest boost from a STIP with a 14.1% increase, while invention patents rise by only about 6.2%.

Expanded Model

When controlling for provincial-level economic and demographic factors, coefficients on number of parks for all measures of patents decrease, with the exception of patents from state organizations (see Appendix Table 6). The impact of a STIP on total patents decreases by about half from the baseline model to 6.1%. Invention patents, design patents, and patents from enterprises all become insignificant. Among patent types, unit model patents now receive the highest impact from a STIP, and invention patents still receive the smallest impact. In patent origins, patents from universities increase by 10.2% for each STIP added to a province, but patents from enterprises seemingly are not impacted from the creation of a STIP.

In looking at coefficients on controls, interestingly, increases in gross industrial output value are only statistically insignificant for patents from state organizations, a possible sign of setbacks in the state-run arm of the innovation sector. Number of professors is of course endogenous with patents from universities, but its impact on other organizations is notable—large decreases in patents from all entities are seen, while individual patents increase with the addition of professors to a province.

VI. Robustness Checks

Autocorrelation

Using panel data over a long range of years and a dependent variable that is slow-moving in some provinces, it is reasonable to assume that autocorrelation may be present in the residuals of these model specifications. To test for this, I estimate the predicted residual using its lags and find strong autocorrelation in the first lag among all measures of patents. I thus compute Newey-

West standard errors, which assumes the error structure to be heteroskedastic and autocorrelated up to the first lag. This changes my model to:

$$\log(Y_{it}) = \alpha_i + \delta_t + \beta_1 P_{it} + \beta_2 \log(output_{it}) + \beta_3 \log(empl_{it}) + \beta_4 \log(prof_{it}) + \beta_5 \log(Y_{i,t-1}) + \varepsilon_{it} \quad (4)$$

Inclusion of autocorrelation increases standard errors, but all coefficients on the treatment, the number of STIPs, retain their same level of statistical cutoffs (see Appendix Table 7).

Five-Year Intervals

Thinning my sample to five-year intervals ranging from 1985 to 2005, I test further to see if residuals in the estimation are characterized by non-normality while still controlling for autocorrelation (see Appendix Table 8). Coefficients on the results are slightly different, although they retain most of the same patterns between different measurements of patents that exist in the full model. Patent origins seem most sensitive to this robustness check, with only patents from research institutes remaining significant. Patent types, while decreasing slightly in magnitude, still show unit model patents as receiving the greatest effect when a STIP is added to a province.

Last-First

A third test to check for robustness is performed by simple OLS regression using a single observation for each province created by subtracting the first observation (1985) from the last observation (2006) (see Table 9). In this test, all measures of patents become insignificant with the exception of patents from state organizations.

VII. Summary and Discussion

The purpose of China's Torch Program, of which China's Science and Technology Industrial Parks (STIPs) are central, is to build an "enterprise-based innovation system." In this paper, I evaluate the impact that a STIP has on innovation using patent applications. Using panel data and two-way fixed effects at the provincial level, I estimate whether or not STIPs have been successful in developing innovation-oriented enterprises. If successful, invention patents should increase the most among patent types, and patents from enterprises should increase the most among patent origins.

Findings reported in Appendix Table 7 show that neither of these hypotheses is correct. Total patent applications increase by 6.1% when a STIP is added, but, among patent types, only unit model patents are statistically significant. Results found among patent types are robust both when correcting for autocorrelation and when using five-year intervals.

Results among patent origins are less clear. Much of this uncertainty possibly arises from the filing system between service and non-service patents and the inability to discern what portion of patents from individuals are from individuals within organizations. Assuming that individuals within each organization proportionately decide to file individually, my findings show that patent applications from enterprises receive no impact from the addition of a STIP. The greatest increase in patent applications by origin is observed in universities, which see a 10.2% increase in patent applications. However, while conducting robustness checks this finding disappears.

This study is subject to several limitations, and future research could add measurably to these findings. First, the use of patent applications, while having merits in controlling for possible corruption in the granting of patents, may still not be as good a measure as patents granted. This would eliminate patent duplications and provide a more accurate measure of refereed innovation in China. Still, owing to the large application costs of filing patents, measures of patent applications are considered a reliable measure of innovation.

The exclusion of foreign patents also limits the effects of my study. STIPs attract large numbers of multinational enterprises, and these enterprises often form the backbone of the STIP clusters. Due to the inability to track foreign patents to specific provinces, they are omitted from the study. These limitations are left to be addressed through additional research.

Appendix

Table 1. Number of STIPs per province

Number of Total Parks/Province	1988	1991	Year 1992	1996	1997
0	30	10	3	3	3
1	1	17	14	14	14
2	0	4	10	10	9
3	0	0	1	1	2
4	0	0	1	1	1
5	0	0	2	1	1
6	0	0	0	1	1
Total Provinces	**31**	**31**	**31**	**31**	**31**
Total STIPs	**1**	**25**	**51**	**52**	**53**

Table 2. Number of provinces with new STIPs added

Number of New Parks/Province	1988	1991	Year 1992	1996	1997
+0	30	11	11	30	30
+1	1	16	17	1	1
+2	0	4	0	0	0
+3	0	0	3	0	0
Total Provinces	**31**	**31**	**31**	**31**	**31**
Total STIPs	**1**	**25**	**51**	**52**	**53**

Table 3. Descriptive Statistics, 1985 - 2006

	Mean (Standard Deviation)		
	All Provinces	**Provinces with STIP**	**Provinces without STIP**
Total Patents	3,745	4,135	147
	(7,679)	*(7,985)*	*(151)*
Patents by Type			
Invention	759	837	36
	(1747)	*(1,821)*	*(41)*
Unit Model	1,738	1,918	71
	(2,452)	*(2,515)*	*(62)*
Design	1,249	1,380	41
	(3,914)	*(4,098)*	*(65)*
Patents by Origin			
University	149	164	2
	(362)	*(378)*	*(4)*
Research Institute	120	132	7
	(244)	*(254)*	*(9)*
Enterprise	1,041	1,150	34
	(2,910)	*(3,043)*	*(54)*
State	62	68	3
	(140)	*(146)*	*(5)*
Individual	2,375	2621	102
	(4,763)	*(4,951)*	*(98)*
Control Variables			
Gross Industrial Output Value	282,609	311,437	16,794
(million RMB)	*(495,035)*	*(512,566)*	*(24,738)*
Total Employment	19,552,690	21,436,130	1,992,940
(individual)	*(13,406,930)*	*(12,738,800)*	*(636,688)*
Number of Professors	16,350	17,902	1,931
(individual)	*(12,524)*	*(12,177)*	*(2,014)*
Number of Provinces	31	28	3

Table 4. Applications for Patents by Province, 1985 - 2006

Region/Province	Total Patents	Invention	Unit Model	Design	University	Research Institute	Enterprise	State	Individual
Yangtze River Delta									
Jiangsu	9767	1643	4353	3771	471	146	3264	107	5779
Zhejiang	10640	1377	4149	5113	372	66	2229	76	7896
Shanghai	8573	2414	2813	3346	623	462	5218	191	2080
Anhui	1473	291	859	323	68	64	294	19	1029
Mean	**7613**	**1432**	**3043**	**3138**	**383**	**184**	**2751**	**98**	**4196**
Bohai									
Shandong	8870	1378	4813	2679	193	218	2219	156	6084
Beijing	8891	3390	4230	1271	668	957	2202	207	4857
Liaoning	6414	1236	4052	1125	213	296	824	109	4972
Tianjin	3224	1067	1535	623	229	106	1180	77	1633
Hebei	3151	556	2001	594	53	72	540	55	2430
Mean	**6110**	**1525**	**3326**	**1258**	**271**	**330**	**1393**	**121**	**3995**
Pearl River Delta									
Guangdong	19403	2868	5524	11011	253	137	7285	302	11425
Sichuan	4129	811	2013	1305	159	151	875	77	2868
Hunan	3733	812	2218	703	110	72	595	51	2905
Fujian	3230	357	1196	1678	70	38	781	50	2291
Chongqing	1810	257	863	690	83	31	729	22	944
Jiangxi	1307	282	715	309	22	18	206	14	1047
Guangxi	1309	253	767	289	22	19	246	17	1006
Yunnan	1172	283	553	336	45	61	251	28	787
Guizhou	803	219	418	167	9	55	201	11	527
Hainan	301	78	100	122	2	7	92	6	194
Mean	**3720**	**622**	**1437**	**1661**	**77**	**59**	**1126**	**58**	**2399**
Central									
Hubei	3539	728	1934	877	304	105	692	117	2320
Henan	3275	626	2024	625	63	86	609	42	2475
Shaanxi	2013	522	1203	288	226	100	338	43	1307
Shanxi	1114	286	677	151	50	60	143	21	840
Mean	**2485**	**541**	**1459**	**485**	**161**	**88**	**445**	**56**	**1735**
Northeast									
Heilongjiang	2803	606	1852	346	136	72	341	39	2215
Jilin	2009	487	1214	308	90	152	323	33	1412
Mean	**2406**	**547**	**1533**	**327**	**113**	**112**	**332**	**36**	**1813**
Northwest									
Xinjiang	797	137	515	145	10	39	111	12	625
Inner Mongolia	786	160	451	175	6	19	143	10	608
Gansu	623	189	363	71	30	63	103	14	413
Ningxia	244	53	133	58	4	6	55	4	175
Qinghai	128	35	69	24	2	9	24	3	92
Tibet	20	5	5	10	0	1	6	1	13
Mean	**433**	**96**	**256**	**81**	**9**	**23**	**74**	**7**	**321**
All Provinces	115551	23408	53610	38534	4584	3686	32120	1913	73248
Mean	**3727**	**755**	**1729**	**1243**	**148**	**119**	**1036**	**62**	**2363**

Table 5. Baseline Models of Log Patents, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.128***	0.0616***	0.136***	0.141***	0.135***	0.0924***	0.0747**	0.0778*	0.152***
	(0.0202)	(0.0219)	(0.0177)	(0.0347)	(0.0318)	(0.0334)	(0.0292)	(0.0423)	(0.0199)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678
R-squared	0.900	0.881	0.890	0.910	0.757	0.414	0.882	0.652	0.900

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Expanded Models of Log Patents, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.0606***	0.0118	0.0830***	0.0538	0.102***	0.0737**	-0.0128	0.0853*	0.0844***
	(0.0194)	(0.0222)	(0.0175)	(0.0343)	(0.0332)	(0.0348)	(0.0274)	(0.0440)	(0.0192)
Gross Industrial Output Value (Ln)	0.741***	0.550***	0.537***	1.037***	0.453***	0.357***	1.104***	0.147	0.627***
	(0.0656)	(0.0753)	(0.0594)	(0.116)	(0.112)	(0.118)	(0.0928)	(0.149)	(0.0650)
Total Employment (Ln)	0.144	0.135	0.209	0.265	-0.700**	-0.207	-0.0400	0.284	0.507***
	(0.186)	(0.213)	(0.168)	(0.329)	(0.318)	(0.334)	(0.263)	(0.422)	(0.184)
Number of Professors (Ln)	-0.0596	-0.0519	0.0964	-0.344**	-0.138	-0.462***	-0.480***	-0.833***	0.269***
	(0.0771)	(0.0884)	(0.0697)	(0.137)	(0.132)	(0.138)	(0.109)	(0.175)	(0.0764)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678
R-squared	0.918	0.892	0.904	0.922	0.765	0.434	0.907	0.665	0.917

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Expanded Models of Patents, Controlling for Autocorrelation, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.0606**	0.0118	0.0830***	0.0538	0.102***	0.0737**	-0.0128	0.0853*	0.0844***
	(0.0288)	(0.0319)	(0.0243)	(0.0390)	(0.0355)	(0.0371)	(0.0353)	(0.0474)	(0.0283)
Gross Industrial Output Value (Ln)	0.741***	0.550***	0.537***	1.037***	0.453***	0.357**	1.104***	0.147	0.627***
	(0.0937)	(0.0966)	(0.0774)	(0.178)	(0.123)	(0.142)	(0.116)	(0.184)	(0.0941)
Total Employment (Ln)	0.144	0.135	0.209	0.265	-0.700*	-0.207	-0.0400	0.284	0.507**
	(0.245)	(0.345)	(0.221)	(0.429)	(0.379)	(0.397)	(0.329)	(0.494)	(0.240)
Number of Professors (Ln)	-0.0596	-0.0519	0.0964	-0.344**	-0.138	-0.462**	-0.480**	-0.833***	0.269**
	(0.115)	(0.126)	(0.0919)	(0.160)	(0.170)	(0.211)	(0.222)	(0.244)	(0.120)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Robustness Check -- Expanded Models of Patents, Controlling for Autocorrelation, Five Year Intervals (1985, 1990, 1995, 2000, 2005)

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.0280	-0.0133	0.0727*	0.0320	0.0440	0.0980**	-0.0386	0.149	0.0556
	(0.0511)	(0.0525)	(0.0420)	(0.0847)	(0.0702)	(0.0475)	(0.0669)	(0.0951)	(0.0485)
Gross Industrial Output Value (Ln)	0.777***	0.608***	0.548***	1.413***	0.463*	0.314*	1.442***	0.219	0.609***
	(0.169)	(0.182)	(0.136)	(0.396)	(0.276)	(0.173)	(0.240)	(0.323)	(0.154)
Total Employment (Ln)	0.176	0.176	0.291	-0.339	-0.190	0.134	-0.466	-0.0557	0.635
	(0.487)	(0.630)	(0.441)	(0.950)	(0.784)	(0.558)	(0.624)	(0.918)	(0.460)
Number of Professors (Ln)	0.0239	-0.0828	0.154	-0.0279	-0.0250	-1.015***	-0.748**	-1.543***	0.525*
	(0.321)	(0.297)	(0.272)	(0.451)	(0.439)	(0.251)	(0.308)	(0.581)	(0.274)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	153	153	153	153	153	153	153	153	153

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9. Robustness Check -- Expanded Models of Log Patents, First-Last (2006 minus 1985)

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.0572	0.0878	0.0822	0.136	0.0193	0.161	0.00500	0.400*	0.0875
	(0.112)	(0.0974)	(0.0999)	(0.182)	(0.0941)	(0.126)	(0.117)	(0.207)	(0.102)
Gross Industrial Output Value (Ln)	1.015**	0.710**	0.816**	2.292**	0.537	0.0432	1.736***	0.454	0.892**
	(0.379)	(0.328)	(0.335)	(0.843)	(0.326)	(0.458)	(0.405)	(0.944)	(0.399)
Total Employment (Ln)	0.280	0.688	0.236	-2.332	0.183	0.815	0.461	-0.131	0.988
	(0.924)	(0.970)	(0.924)	(2.298)	(1.152)	(1.696)	(1.303)	(2.920)	(0.924)
Number of Professors (Ln)	0.0447	-0.0841	0.0936	-0.297	0.104	-0.784**	-1.069**	-1.885*	0.401
	(0.427)	(0.362)	(0.332)	(0.699)	(0.475)	(0.355)	(0.415)	(0.914)	(0.374)
Province Fixed Effects	No	No	No	No	No	No	No	No	No
Year Fixed Effects	No	No	No	No	No	No	No	No	No
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	No	No	No	No	No	No	No	No	No
Observations	29	29	29	29	29	29	29	29	29
R-squared	0.407	0.418	0.431	0.478	0.163	0.133	0.492	0.238	0.504

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10. Expanded Models of Patents (Pre-Log Transformation), Controlling for Autocorrelation, 1985 - 2006

		Type of Patent			*Origin of Patent*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	-737.6*	-353.1***	4.072	-388.6	-61.38***	-6.892	-188.7	21.92	-502.6*
	(379.6)	(103.5)	(92.81)	(245.1)	(18.95)	(12.06)	(170.1)	(14.67)	(282.4)
Gross Industrial Output Value	1.701***	0.369***	0.432***	0.900***	0.0608***	0.0212***	0.667***	-0.00229	0.955***
(100 million RMB)	(0.173)	(0.0534)	(0.0418)	(0.0948)	(0.0117)	(0.00509)	(0.0915)	(0.00550)	(0.135)
Total Employment	1.120	0.114	0.134	0.873	-0.250***	-0.0548	0.0354	-0.00495	1.395
(10,000 persons)	(1.268)	(0.383)	(0.295)	(0.686)	(0.0686)	(0.0341)	(0.525)	(0.0339)	(0.881)
Number of Professors	-1,195**	-500.3**	80.03	-774.4**	-29.05	-105.4***	-1,305***	-17.87	263.1
(10,000 persons)	(589.0)	(211.4)	(130.2)	(325.1)	(65.26)	(32.52)	(415.9)	(30.27)	(404.4)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11. Expanded Models of Log Patents, Controlling for Province-Specific Trends, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.0498*	0.0472	0.0459	0.0372	-0.0952*	-0.00241	-0.0638	0.349***	0.0582**
	(0.0257)	(0.0300)	(0.0296)	(0.0500)	(0.0499)	(0.0425)	(0.0403)	(0.0885)	(0.0282)
Gross Industrial Output Value (Ln)	0.246***	0.153***	0.232***	0.554***	0.104	0.0506	0.312***	0.364**	0.252***
	(0.0450)	(0.0525)	(0.0517)	(0.0874)	(0.0873)	(0.0742)	(0.0705)	(0.155)	(0.0493)
Total Employment (Ln)	1.984***	1.324***	2.473***	2.591***	-0.161	1.092**	1.273***	5.121***	2.314***
	(0.260)	(0.303)	(0.298)	(0.505)	(0.504)	(0.429)	(0.407)	(0.893)	(0.284)
Number of Professors (Ln)	0.191***	0.798***	0.0388	-0.496***	1.916***	0.560***	0.168*	0.593***	0.0479
	(0.0587)	(0.0685)	(0.0674)	(0.114)	(0.114)	(0.0969)	(0.0920)	(0.202)	(0.0643)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	No	No	No	No	No
Province-Specific Trends	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678
R-squared	0.920	0.891	0.849	0.909	0.706	0.535	0.889	0.254	0.902

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12. Expanded Models of Patents, Controlling for Autocorrelation and Three-Region Interactions, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	-0.0709	-0.0635	0.0106	0.00366	0.0483	0.184***	-0.0891	0.0630	-0.0168
	(0.0462)	(0.0517)	(0.0454)	(0.0786)	(0.0667)	(0.0632)	(0.0552)	(0.0950)	(0.0468)
Interaction: East*Num Parks	0.145***	0.0813**	0.0767**	0.0593	0.0615	-0.111**	0.0923*	0.0348	0.109***
	(0.0374)	(0.0384)	(0.0373)	(0.0716)	(0.0542)	(0.0521)	(0.0544)	(0.0848)	(0.0392)
Interaction: Middle*Num Parks	0.0329	0.0439	0.0638*	-0.0509	-0.0265	-0.178***	-0.110**	-0.154	0.0606
	(0.0328)	(0.0312)	(0.0385)	(0.0733)	(0.0601)	(0.0665)	(0.0560)	(0.0936)	(0.0368)
Gross Industrial Output Value (Ln)	0.637***	0.505***	0.507***	0.958***	0.387***	0.352**	0.965***	0.0314	0.568***
	(0.0961)	(0.102)	(0.0801)	(0.186)	(0.136)	(0.144)	(0.123)	(0.187)	(0.0968)
Total Employment (Ln)	0.210	0.167	0.233	0.307	-0.662*	-0.223	0.0321	0.336	0.549**
	(0.248)	(0.347)	(0.227)	(0.434)	(0.382)	(0.401)	(0.330)	(0.499)	(0.246)
Number of Professors (Ln)	-0.0633	-0.0573	0.0884	-0.337**	-0.134	-0.439**	-0.465**	-0.813***	0.262**
	(0.112)	(0.125)	(0.0918)	(0.164)	(0.173)	(0.205)	(0.212)	(0.237)	(0.121)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13. Expanded Models of Patents, Controlling for Autocorrelation and Six-Region Interactions, 1985 - 2006

	(Ln)	*Type of Patent (Ln)*			*Origin of Patent (Ln)*				
Regressors	**Total Patents**	**Invention**	**Unit Model**	**Design**	**University**	**Research Institute**	**Enterprise**	**State**	**Individual**
Number of Parks	0.112	0.0542	0.356***	0.187	0.0311	0.190	0.110	-0.0275	0.253**
	(0.108)	(0.120)	(0.110)	(0.199)	(0.175)	(0.154)	(0.171)	(0.191)	(0.109)
Interaction: Northeast*Num Parks	-0.100	-0.0529	-0.241**	-0.121	-0.0618	-0.0331	-0.241	-0.0985	-0.156
	(0.0992)	(0.104)	(0.105)	(0.189)	(0.164)	(0.146)	(0.167)	(0.188)	(0.102)
Interaction: Bohai*Num Parks	-0.0822	-0.0513	-0.275***	-0.159	0.0407	-0.0724	-0.194	0.0756	-0.180*
	(0.0993)	(0.110)	(0.104)	(0.189)	(0.166)	(0.142)	(0.168)	(0.176)	(0.102)
Interaction: Central*Num Parks	-0.145	-0.0875	-0.294***	-0.258	0.0659	-0.0666	-0.255	0.0562	-0.228**
	(0.0975)	(0.105)	(0.104)	(0.187)	(0.163)	(0.137)	(0.165)	(0.181)	(0.102)
Interaction: Yangtze*Num Parks	-0.0500	-0.0484	-0.277***	-0.0536	0.112	-0.182	-0.0252	0.239	-0.195*
	(0.102)	(0.111)	(0.106)	(0.189)	(0.170)	(0.144)	(0.168)	(0.175)	(0.106)
Interaction: Pearl*Num Parks	0.0198	-0.0114	-0.238**	-0.0878	0.101	-0.152	-0.0143	0.141	-0.113
	(0.0999)	(0.107)	(0.104)	(0.188)	(0.166)	(0.145)	(0.168)	(0.177)	(0.102)
Gross Industrial Output Value (Ln)	0.651***	0.513***	0.509***	0.950***	0.387***	0.430***	0.934***	0.0252	0.577***
	(0.0963)	(0.100)	(0.0835)	(0.185)	(0.132)	(0.159)	(0.118)	(0.190)	(0.0998)
Total Employment (Ln)	0.0817	0.111	0.231	0.374	-0.743*	-0.196	-0.0408	0.346	0.462*
	(0.247)	(0.359)	(0.226)	(0.436)	(0.393)	(0.414)	(0.332)	(0.515)	(0.238)
Number of Professors (Ln)	-0.0742	-0.0591	0.0846	-0.343**	-0.146	-0.463**	-0.495**	-0.838***	0.254**
	(0.115)	(0.127)	(0.0914)	(0.162)	(0.171)	(0.215)	(0.225)	(0.240)	(0.118)
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-Specific Trends	No	No	No	No	No	No	No	No	No
Lagged Dependent Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	678	678	678	678	678	678	678	678	678

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Location of STIPs, 1988 – 1997

Source: Author

Figure 2

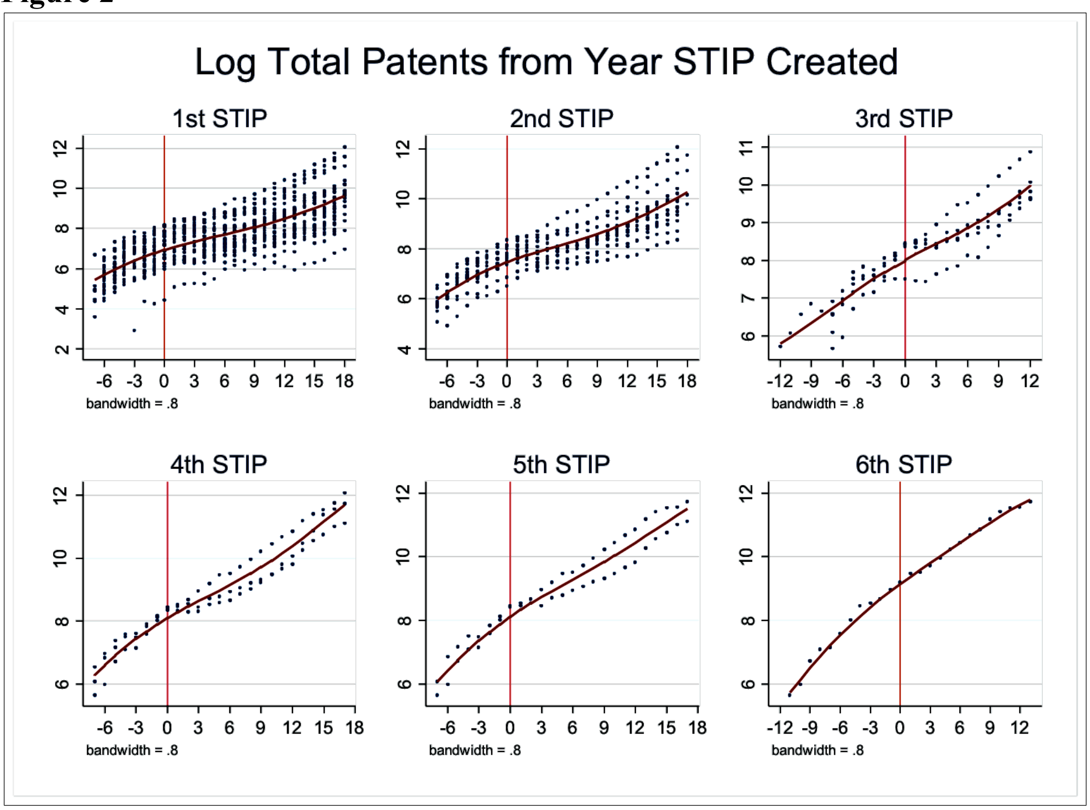

Figure 3

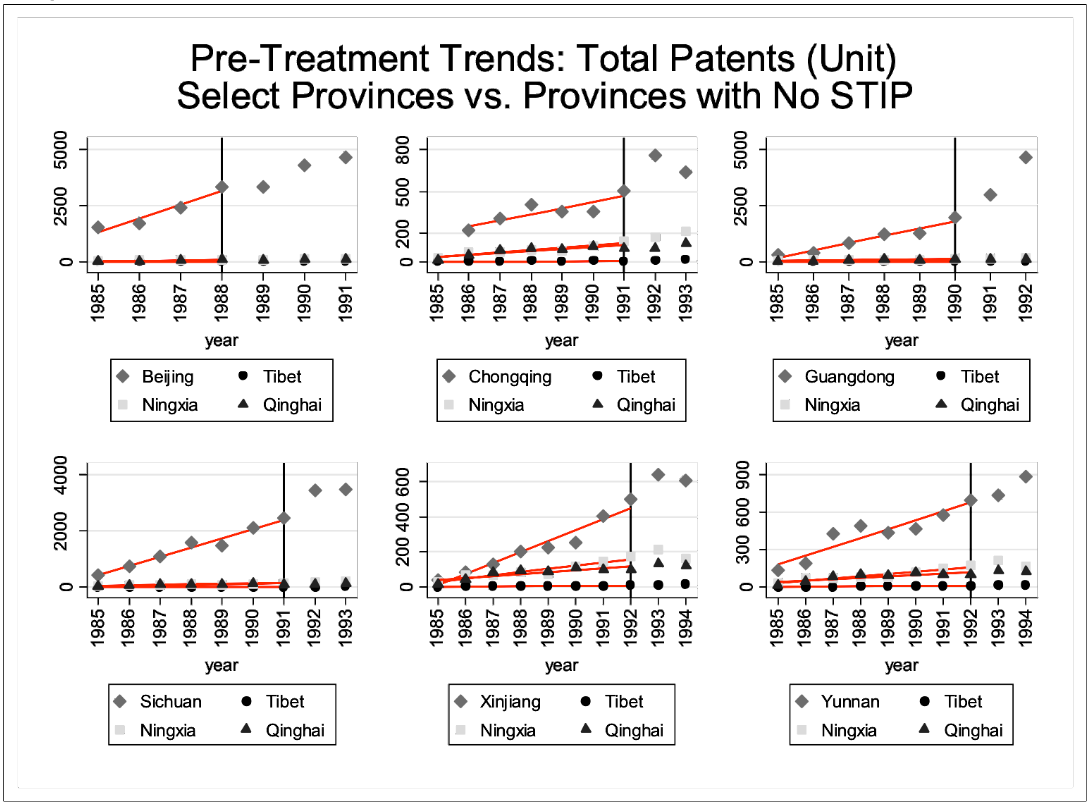

Figure 4