Government Brain Drain: Individual Earning, Firm Entry, and Talent Reallocation in Chinese Public Sector Hiring Reform[1]

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Most Recent Version

Abstract: To study the impacts of reducing public hiring on talent reallocation and private sector growth this paper exploits a 1994 reform of the Chinese tertiary graduate labor market. The reform terminated the government-oriented job allocation for tertiary graduates, and it greatly reduced the labor mobility cost across sectors. Using a generalized Difference-in-Differences framework and Regression Discontinuity Design to show the causal impacts of this deregulation, I find that after the reform, tertiary graduate earnings decreased, and it decreased more in cities that had higher levels of ex-ante public sector demand. The termination of guaranteed job allocation also led to a boom in the private sector. Prefectures with more tertiary students who graduated from industry-related majors had a larger number of private firm entries in that industry after the reform. The reform stimulated market-oriented innovation activities like design patents and trademarks, and it did not crowd out other types of innovations that were more closely related to long-term productivity growth.

Key words: Talent allocation, brain drain, firm entry, innovation
JEL Code: J45, J24, L26, P36

1 Introduction

Reallocation of economic activity from less efficient sectors and regions to more efficient ones is crucial to structural transformation and long-term development. Among those transitions, the reallocation from the public sector to the private sector is receiving increasing attention (Albrecht et al., 2021; Cavalcanti and Santos, 2021; Arnold, 2019). The public sector is of interest to researchers and policy makers in both developing countries and developed countries because it accounts for a substantial fraction of employment and outputs and disproportionately hires highly educated workers. However, how the pubic-private transformation contributes to the growth remains unclear due to both the conceptual ambiguity in theory and the data paucity in practice. I fill in an important gap in the literature by providing reduced form causal evidence that talent reallocation from the public sector to the private sector reduced the tertiary graduate wages but led to more firm entry and innovation.

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This paper studies the public-private sector transition in the context of China by exploiting a large-scale Chinese public sector hiring reform in 1994. China used to have a special public-sector hiring policy for its higher education graduates, which guaranteed public sector jobs for its tertiary graduates before 1990s. This policy was terminated in 1994, when "the government no longer guaranteed jobs for graduates, but instead provided information and guidance for independent job searching". About twenty years after the reform, the private sector had become dominant in China's labor market, and the majority of vocational school graduates and college graduates were employed in private-owned enterprises (Wang et al., 2021).

I use a toy model to illustrate the trade-off in the 1994 labor market deregulation and its impacts. The public sector prioritized employment before the reform, but after the reform, it focused more on profit. Thus, the public sector hired fewer workers after the reform, and more workers were forced to find a job in the private sector. As a result, the share of highly educated workers in the private sector increased, and the average wage for highly educated workers in both sectors decreased. In addition, because the average wage of tertiary graduates decreased, the opportunity cost and the hiring cost of running a private firm decreased; thus, there was more firm entry after the reform and more graduates chose to become entrepreneurs instead of employees.

I use three different identification strategies to study the causal impacts of this reform: DID, Regression-Discontinuity Design (RDD), and Difference-in-Regression-Discontinuity (DRD). In the individual-level DID specification, birth cohort and education level determine one's exposure to the public sector hiring reform. For example, upper rank vocational track (*dazhuan*) graduates tend to graduate at age 20 after three years of vocational study, so *dazhuan* students born in 1974 were the earliest cohort to graduate in 1994. The treatment group consists of individuals with a tertiary or post-tertiary education who had not finished schooling when the reform occurred. I compare the labor market outcomes of treated and control cohorts, controlling for prefecture fixed effects and age fixed effects. My RDD and DRD results reinforce the findings with DID, where one's birth month serves as the running variable.

For the prefecture-level aggregate impacts on firm entry and innovation, I construct a novel dataset of the tertiary graduate number in different majors across prefectures and pair it with administrative data of firm entry in particular industries. On the right-hand side, I interact the number of students in one major or a group of related majors with the year dummy. On the left-hand side, I use the number of firm entries in the industry that was paired with that major or group of majors. The coefficient of the interaction between the number of students in a particular major or group of majors and the year dummy captures the additional number of firm entries after the reform that can be attributed to the number of students in that major. In view of the burgeoning literature on the robustness of event-study design where the parallel trends assumption may be violated, I use the robust estimate proposed by Rambachan and Roth (2022), which guarantees uniformly valid inference under the imposed restrictions.

Exploiting the individual-level information from the 2005 one-percent population survey, I find that after the reform, tertiary graduate earnings decreased by about 4% to 5%, and the wage decreases are larger in the private sector. For the heterogenous treatment effects across regions, the decreases were larger in cities that had higher levels of ex-ante demand for primary and middle school teachers, which was an important component of public sector hiring. But there is no evidence for heterogeneous treatment effects across prefectures that had different exposures to tax-sharing reform and exchange rate reform. These results show suggestive evidence that after the reform there was more competition in the tertiary graduate labor market, which drove down the wage. The RDD and DRD specifications give qualitatively similar results.

Along with the wage decline, there was a talent reallocation from the public sector to the private sector. After the reform, the probability of working in the public sector decreased by 2.1 percentage points and they were 1.1 percentage points more likely to become entrepreneurs after the reform, and this impact was concentrated on vocational school graduates. The talent reallocation from the public sector to the private sector was driven by the decrease in SOE occupations rather than in government and public institutions jobs. In addition, the public sector hiring reform increased both the probability of being enterprise owners and being self-employed for tertiary graduates, although the coefficient on enterprise owners is less precisely estimated.

This talent reallocation led to a boom in the private sector and innovation. Combining the administrative data on prefecture-level firm registration and the newly constructed data set on prefecture-level student numbers across majors, this paper finds that prefectures in which more tertiary students graduated from industry-related majors had a larger number of private firm entries in that industry after the reform, and the effects were increasing over time. As a placebo test, similar results were not found in the entry or state-owned enterprises (SOEs) or private firm entries in industries that are unlikely to be related to those majors. Using a multi-dimensional index that reflects the temporal and spatial distribution of innovation and entrepreneurship activities, I show that the public sector hiring reform stimulated innovation activities. Prefectures with more tertiary graduates in science would both have higher scores and higher ranks of the patent after the reform. By decomposing the patent activities into detailed categories, I found evidence that the reform improved the market-oriented innovation activities, such as design patents and trademarks, but there is no crowding out effect for other types of innovation.

My findings suggest that the 1994 public hiring reform in China led to the intended structural transformation by reallocating talents from the public sector to the private sector. The ensuing boom in the private sector is likely attributable to more talented entrepreneurs starting their own businesses after leaving the public sector, and/or more highly educated workers were available in the private sector, which lowered the hiring costs of private firms. This transformation also contributed to long-term growth by promoting innovation activities. Complements the existing literature that studies China's economic boom from the perspective of SOE privatization and rural-urban migration, my paper provides a new angle by showing that the liberalization of the high-educated labor market and talents reallocation played an important role in the rapid growth of China's economy.

This research relates to several strands in the literature. First, my project is most closely related to a burgeoning literature on the effects of talent allocation (Findeisen et al., 2021; Hsieh et al., 2019). To the best of my knowledge, I provide the first piece of empirical evidence on how government policy stimulates structural transformation. Demonstrating that the termination of guaranteed job allocation facilitates talent reallocation from the public sector to the private could lead to a better understanding of how the private sector brain drain could be alleviated or reversed—a problem that is receiving increasing attention from both academics and policymakers (de Souza, 2019; Finan, Olken and Pande, 2017).

Second, my research contributes to the literature that examines how universities and research institutions influence entrepreneurship and industrial agglomeration (Hausman, 2022; Babina et al., 2020; Stern, 1995; Krugman, 1991). As Tartari and Stern (2021) observe, the existing literature provides limited evidence of the overall impacts of research institutions on the level and nature of entrepreneurship. To overcome the challenge that these institutions tend to locate in regions with characteristics that promote entrepreneurs, I utilize a unique policy shock in China that greatly increased the spillover of talent from higher education institutions to the private sector. My findings indicate that by facilitating a market-oriented system of education, governments can provide a better environment for the application of technological innovation and stimulate private sector growth.

Third, my paper adds to the long-standing examination of occupation choice and entrepreneurship (Bai et al., 2021; Azoulay et al., 2020; Levine and Rubinstein, 2017; Özcan, 2011; Dickens and Lang, 1995; Banerjee and Newman, 1993). I study a unique shock on outside options for in-demand talents and provide new causal evidence that government incentives can move people from the non-entrepreneurial to the entrepreneurial sector.

Finally, it contributes to the discussion of the effect of labor market deregulation. The existing literature has mainly focused on the impact of deregulation in developed countries (Amirapu and Gechter, 2020; Ciminelli et al., 2018; Chaurey, 2015; Betcherman, 2015; Blanchard, 2003; Peoples1998). My article fills an important gap in knowledge in the context of developing countries by studying China, the world's largest labor market. I study the costs and benefits beyond individual labor market outcomes by looking at firm entry and innovation. This study can provide a better understanding of the potential costs and benefits when a huge employment guaranteed program is terminated in a developing country.

2 Institution background

The labor market of tertiary graduates in China before the 1980s featured significant government intervention, and, following a host of marketization reforms in the 1990s, the market gradually transitioned to a market-oriented one. Figure 2.1 depicts the evolution of the tertiary graduates market, which contextualizes the role of 1994 public hiring reform in talent allocation.

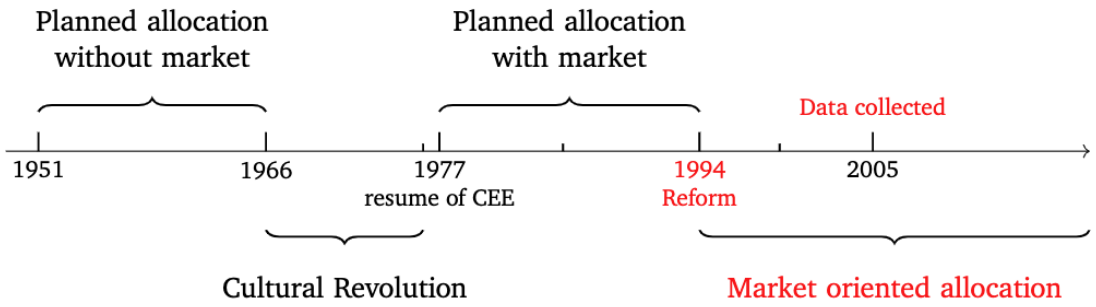

Figure 2.1: Timeline of labor market reform in China's higher education system

Shortly after the establishment of the People's Republic of China in 1949, the central government of China built a highly centralized higher education system. The government bore all the costs of higher education and decided the admission quotas according to the needs of the planned economy. Students were admitted into colleges or vocational schools based on their standardized college entrance exam scores. After graduation, the government allocated students to state-owned enterprises or other public institutions, which I refer to as "planned allocation without market". Tertiary graduates assigned to public sectors by governments were automatically categorized as "cadres", a privileged designation. The jobs held by tertiary school graduates were very desirable; they were referred to as *tie fanwan*, or "iron rice bowls," because they represented a virtually guaranteed income for life. Between 1951 and 1966, allocated public sector jobs were both preferable and lifetime guaranteed. One limitation during this period was the very limited freedom of search and matching. There was essentially no private labor market, and within the public sector, both students and employers had very limited choices during the allocation process.[3] This school entrance and job allocation system was interrupted by the Cultural Revolution. During this period, from 1966 to 1976, academic achievement was disregarded, and students were assigned to tertiary schools, and then employment, on the basis of their parents' *jieji beijing*, or class background"[4], rather than their academic qualifications.

A typical job allocation process before the Cultural Revolution can be described as follows. First, a department of the State Council, in charge of graduate distribution, would prepare the annual allocation plan and distribute it to all provinces and related ministries in the central government. Second, the provinces and ministries would then work out the details of the plan to specify each local school and employer. Third, schools would be responsible for placing the graduates one by one according to the plan. Schools and employers implemented but did not prepare the plan, and graduates and employers did not meet each

[3] Students who refuse the allocated job can be severely punished; they are required to pay the exempted tuition fee and are not allowed to be employed in the public sector in the following years.

[4] The term *jieji beijing*, "class background," was a designation that referred to the social status of family members. Those whose family members were in respected positions (e.g., farmers, factory workers) were grouped into a good class background, while those whose relatives engaged in disapproved jobs (e.g., entrepreneurs, landlords) were grouped into a poor class background.

other prior to employment. Hence, this distribution process was referred to as an “arranged marriage”.

When in 1977 the college entrance exam was resumed, it also witnessed a gradual transition from a government-controlled tertiary graduate labor market to a market-driven one. This reform was driven by both demand and supply. On the supply side, the rapid expansion of highly educated workers filled the vacancies in the public sector, and it led to excess supply over time. The number of graduates with vocational school or higher degrees increased from 61,429 in 1978 to 104,724 in 1985, and it further increased to 309,483 in 1995. Hence, the government became more willing to encourage tertiary graduates to find a job outside of the public sector. On the demand side, the booming of the private economy required more and more qualified and highly educated workers, and private firms were able to offer salaries that were competitive with public sector incomes. The reforms were taken step by step. In 1983, schools and employers participated in the distribution. In 1987, a “two-way search” was implemented nationwide, wherein the schools were responsible for recommendations, and employers directly met and negotiated with graduates. The rationale of the “two-way search” was that compared to the government, the market had more disaggregate information, and it could better match skills and job requirements. Between 1977 and 1994, an increasing fraction of tertiary graduates refused job assignments and found jobs on their own. I call this period "planned allocation with market".

The big transaction took place in 1994, when "the government no longer guaranteed jobs for graduates, but instead provided information and guidance for independent job searching" (State Education Commission of PRC, 1994) According to the new policy, which is still in effect today, job allocation in the labor market of tertiary graduates is not guaranteed. All types of employers in both the public and private sectors are encouraged to hire graduates based on their needs. A key difference between the market-oriented allocation period and the “planned allocation with market" is that, before 1994, graduates who did not find satisfactory jobs on their own could still receive allocated jobs from the government. Hence, because public sectors provided a safety net for the excess supply of tertiary graduates, the labor market continued to feature regulation. In fact, an important reason for guaranteed job allocation during this period was to support employment in urban areas. However, after 1994, graduates who failed to find a job in the market were no longer guaranteed a public sector job, and they became unemployed or self-employed.

As stated above, the reform of tertiary graduates’ job allocation did not happen overnight. But 1994 saw the most significant policy transition during this process. In 1993, the State Council promulgated the “Outline of educational reform and development in China”, henceforth referred to as the “Outline,” which clearly stated that the employment system of tertiary graduates should change from a guaranteed centralized job allocation to one in which most graduates choose their own career. In 1994, the State Education Commission issued the “Opinion on the pilot of further reforming the admission and graduate system of vocational schools and colleges,” henceforth referred to as “Opinion.” “Opinion” provided more details on the implementation of “Outline.” Specifically, it required a merge of the guaranteed job allocation (the traditional track) and the market-oriented job search (the new track). Authorities regarded these two policies as a major shift that had far-reaching

implications for the transition of the tertiary graduate labor market (Henan Provincial Education Commission, 1999).

The deregulation of the tertiary graduate labor market is an important component of Chinese economic reform and has inspired aggressive debates, pro and con, ever since its implementation. This deregulation imposes significant costs and benefits. On the one hand, the reform led to more efficient job searches and talent allocation, and it encouraged the development of the private sector, which at the time was thought to be more efficient than public sectors. Twenty years after the reform, the private sector is now dominant in China's labor market. Even in the highly educated segment of the labor market, which used to be dominated by the public sector, 54% of vocational school graduates and 68% of college graduates were employed in private-owned enterprises, based on a sample of 152 thousand tertiary graduates between 2014 to 2018 (Wang and Ma, 2019). On the other hand, there is much anecdotal evidence that the unemployment rates for tertiary graduates have increased and that wages decreased due to heightened competition, especially for less competitive individuals. Hence, this public hiring reform may be having a distributional effect.

In attempting to better understand the role of the 1994 public hiring reform, we should bear in mind that the 1990s was an era of reform, and many of those reforms may have been intertwined. Since 1992, there has been a mass reform of state-owned enterprises (SOEs). Many SOEs were privatized, which led to a boom in the private economy. Two other important reforms occurred in 1994: the tax-sharing reform that adjusted the tax distribution system plus the tax structure between the central and local governments; and the exchange rate reform, wherein China unified its dual exchange rates by aligning official and swap center rates, officially devaluing the RMB by 33 percent. The former directly influenced the financial resources of local governments on public hiring, while the latter stimulated exports. Both reforms might have influenced individual choices between the public sector and the private sector. Thus, it is important to disentangle the impacts of different policies when analyzing the overall effects of the 1994 public hiring reform.

3. Conceptual framework

In this section, I use a conceptual framework to capture the impacts of the 1994 reform on the tertiary graduate labor market and firm entry. Reducing public sector hiring quotas has the potential to impact the economy both negatively and positively. On the positive side, three types of talent misallocation can be avoided. (1) On the extensive margin, a potentially lucrative government job encourages candidates to divert time away from productive activity towards full-time study, which may increase aggregate unemployment (Banerjee and Duflo, 2019). (2) On the intensive margin, there might be insufficient qualified workers in the private sector, which impedes the growth of private economy and causes a private sector brain drain. (3) When (potential) high-ability entrepreneurs are hired in the public sector, entrepreneurship and private innovation become depressed and aggregate labor demand decreases. All three types of talent misallocation are more likely to occur in less developed countries, where a lack of a well-functioning private labor

market makes public sector jobs more attractive. On the negative side, the public sector contributes to productivity in two ways. (1) The public sector provides public goods which are irreplaceable by the private providers. Those public goods can be large-scale investments in infrastructure, fundamental science, and data-intensive innovation. (2) Because public sectors tend to hire skilled/highly educated workers, large public hiring encourages human capital investment as the return to higher education increases, which may have positive externalities. Thus, reducing the public sector labor force could be problematic.

The following model captures the idea that the public sector cared a lot about employment before the reform, but after the reform, it put more weight on profit. Since after the reform the public sector hired fewer tertiary graduates, more graduates were forced to find a job in the private sector. As a result, the share of working in the private sector for tertiary graduates increased, and the average wage for highly educated workers in both sectors decreased. In addition, because the average wage of tertiary graduates went down, the opportunity cost and hiring cost of running a private firm decreased, and more graduates chose to become entrepreneurs rather than employees.

3.1 Environment

There is a public sector g and a private sector p in the economy. Sectors are in a perfectly competitive product market but an imperfectly competitive labor market. Firms have marginal productivities of labor A_g, A_p, and they offer wages w_g, w_p, respectively. The production function is $y = Al$ for both sectors, assuming $A_p > A_g$, and the breakeven condition requires that $A_g > w_g$, $A_p > w_p$.

Workers differ in their preference for working in the public sector t. Denote the distribution function as $G(t) \sim U[0, T]$. Workers choose between the public sector and the private one. Parameter $t \geq 0$, the taste, can be viewed as compensation of wage difference. There is no disutility of labor, and the total labor supply is fixed T. A worker's payoff is $(w_g + t)$ if it is in the public sector, and it is w_p if it is in the private one. Hence, the labor supply to the public sector is $t \in [w_p - w_g, T]$ and to the private it is $t \in [0, w_p - w_g)$.

Assume a Stackelberg competition in which the public sector decides wage and employment first and the private sector acts as a follower. A firm in the public sector has the following utility maximization problem

$$\max U(\pi_g, L_g) = [y_g(l_g) - w_g(l_g) l_g]^{\alpha} l_g^{(1-\alpha)}$$

where π_g is the profit, y_g is the output, $w_g(l_g)$, and l_g are wage and employment. $\alpha \in (0,1)$ is the utility weight on profit. The production function is $y_g(l_g) = A_g l_g$. The labor supply curve is given by $w_g(l_g) = l_g - T - w_p$.

Consider a wage-posting model. The labor supply for private sector is $l_p = H(w_p) = w_p - w_g$, take w_g as given. The expected profits will be given by $\pi_p(w_p) = (A_p - w_p)H(w_p)$, and the first order condition for wages is

$$w_p(A_p)^* = \frac{\epsilon}{1+\epsilon}A_p = \frac{1}{2}A_p + \frac{1}{2}w_g$$

$$\epsilon\left(w_p(A_p)\right) = \frac{A_p + w_g}{A_p - w_g}$$

where ϵ is the elasticity of the labor supply function H.

Now consider the public sector. The first order condition of the Lagrangian equation gives us

$$l_g{}^* = \frac{2T + A_g - A_p}{2(1+\alpha)}$$

$$w_g{}^* = \frac{-2\alpha T + A_g + \alpha A_p}{1+\alpha}$$

Assume we have interior solution, $l_g{}^* > 0$, then

$$\frac{\partial l_g{}^*}{\partial \alpha} < 0;\ \frac{\partial w_g{}^*}{\partial \alpha} < 0$$

3.2 Impacts on individual wage and occupation choice

I discuss the impact of labor market deregulation from three perspectives: employment, wage, and profit. After the reform, the government puts more weight on profit by increasing α. Because $\frac{\partial l_g{}^*}{\partial \alpha} < 0$, employment in the public sector decreases as the weight put on profit α increases. In this parsimonious framework, there is no unemployment by assumption, and an individual in the public sector with a relatively low t will enter the private sector. Hence, employment in the public sector will decrease, and employment in the private sector will increase.

As for the wage, because $\frac{\partial w_g{}^*}{\partial \alpha}$, wage in the public sector will decrease as α goes up. Moreover, because the public and private sectors are competing in the same labor market, the equilibrium wage in the private sector is a weighted average of productivity in the private sector and the wage in the public sector: $w_p(A_p)^* = \frac{1}{2}A_p + \frac{1}{2}w_g$. In other words, when the government puts more weight on profit, the private sector wage will decrease.

The goal of labor market deregulation is to increase the public sector profit, and this is naturally achieved as the public sector wage goes down. For the private sector, we already know the private sector wage will decrease and the private sector employment will increase; because $\pi_p = (A_p - w_p)l_p$, private sector profit, too, will increase.

3.3 Impacts on firm entry

The above parsimonious model provides hypotheses that could be tested by empirical analysis. In this subsection, I discuss some implications of the current model.

The first implication is the impact on entrepreneurship. Assume there are N homogeneous firms in the private sector, each of which has the same marginal product of laborA_p and earns the same profit π_p. Denote the number of entrepreneur as E. Potential entrepreneurs differ in their outside option, denoted as $O(R, w_O)$, which is a function of risk aversion R and potential income as a worker w_O, measured by the income obtained in the private or public sector, whichever is higher. One would choose to become an entrepreneur if and only if $\pi_p > O(R, w_O)$. Assuming that $\frac{\partial O}{\partial R} > 0$ and $\frac{\partial O}{\partial w_O} > 0$, certeris paribus, the wage cost of highly educated workers goes down after the reform, and the profit of running an enterprise π_p goes up. Additionally, for tertiary graduates, the opportunity cost measured by potential income as a worker w_O decreases. Hence, more individuals will become entrepreneurs, and E increases.

Based on section 3.2 and section 3.3, I propose the following testable hypotheses:

H1: After the deregulation, the wage of tertiary graduates decreased and the wage premium over less-educated workers shrank.

H2: After the deregulation, there was a reallocation of tertiary graduates from the public sector to the private sector.

H3: After deregulation, there were more private firm entries.

4 Data

4.1 Individual data

The individual data used in this paper come from a subsample of a representative census of 1% of the population conducted by the National Bureau of Statistics in 2005 (henceforth referred to as "2005 mini census"). The 2005 mini census, which was collected about 10 years after the labor market deregulation of 1994, provides rich demographic characteristics. More importantly, unlike the regular census, it contains labor market outcomes, such as wages, industries, and occupations, which I have used to construct the education return, talents allocation, and entrepreneurship information for my empirical analysis. The 2005 mini census covers a population of 17 million, or 1.31 percent of the total population of China at the time. It includes 5.43 million households in 61,000 rural villages and urban neighborhood committees in 21,000 townships throughout China. Of

the people sampled, 51.53% were males and 48.47% were females. The proportion of the population by age group of 0-14 years, 15-59 years, and 60 years and over was 20.27%, 68.70%, and 11.03%, respectively. Urban residents constituted 42.99% of the total population (Feng, 2010). These ratios were approximately reflective of the country as a whole.

4.2 Firm entry and innovation data

For firm entry and exit pattern, I use the administrative information from the Database of Registration Information of Industrial and Commercial Enterprises (RIICE). I collapse the RIICE data into the city-year-ownership-sector level. More than 14 million firms were registered between 1986 and 2005, forming a 20-year panel at the city level. I use the firm registration number from RIICE to analyze the extensive margin adjustment of the private sector. For patent and innovation data, I use the Index of Regional Innovation and Entrepreneurship in China (IRIEC) constructed by Peking University. IRIEC is a multi-dimensional index that reflects the temporal and spatial distribution of innovation and entrepreneurship activities. I use the number of patents granted and trademark registration as measurements for prefecture-level innovation outcomes. To capture the ex-ante supply and demand of tertiary graduates before the 1994 deregulation, I use information on educational institutions from the China City Statistics Yearbook 1994 (National Bureau of Statistics, 1994). That information includes the number of primary schools and middle schools per capita, the number of scientific and technical personnel, and the share of education in fiscal expenditure. In addition, I collect prefecture-level information on trade and industrial output to address the concern that the 1994 tertiary graduate labor market deregulation may be intertwined with other reforms.

4.3 Student major data

To more accurately capture the impact of public hiring reform, I construct a dataset of the number of students in different majors across prefectures prior to the reform. For each prefecture, I collect the number of higher education institutions (vocational schools, colleges, and universities). For each school, I collect the number of students and major lists that was available immediately prior to the reform. Next, I allocate students in a school to different majors according to the number of majors in that school and the share of students in different disciplines (more general than majors) at the province level. For example, if a college in Hubei Province has 600 students and two majors, electronic engineering and accounting, and the share of Science and Technology (a discipline that includes electronic engineering) and Liberal Arts (a discipline that includes accounting) students in Hubei Province is 5:1, then I identify 500 students as electronic engineering students and 100 students as accounting students. Based on that, I construct the number of students for different majors for each prefecture prior to the reform. With the student major data in hand, I construct pairs between specific groups of majors and particular industries. I expect that the additional supply of skilled workers in certain majors will have salient impacts on the industries closely related to the majors. For example, the manufacturing industry is paired with materials, metallurgical, mechanical, and textile engineering majors.

Figure 4.1 shows the distribution of student numbers in manufacturing industry-related majors (Panel A) and medical industry-related majors (Panel B) across prefectures before the reform. The two distributions do not overlap perfectly with each other. The tertiary students in manufacturing-related majors were concentrated in north and northeast China, while the medical students were relatively evenly distributed across north, northeast, and south China. This difference helps me to identify the impacts on major-specific private firm entry and alleviate the concern that the number of high education institutions is strongly correlated with other social-economic characteristics.

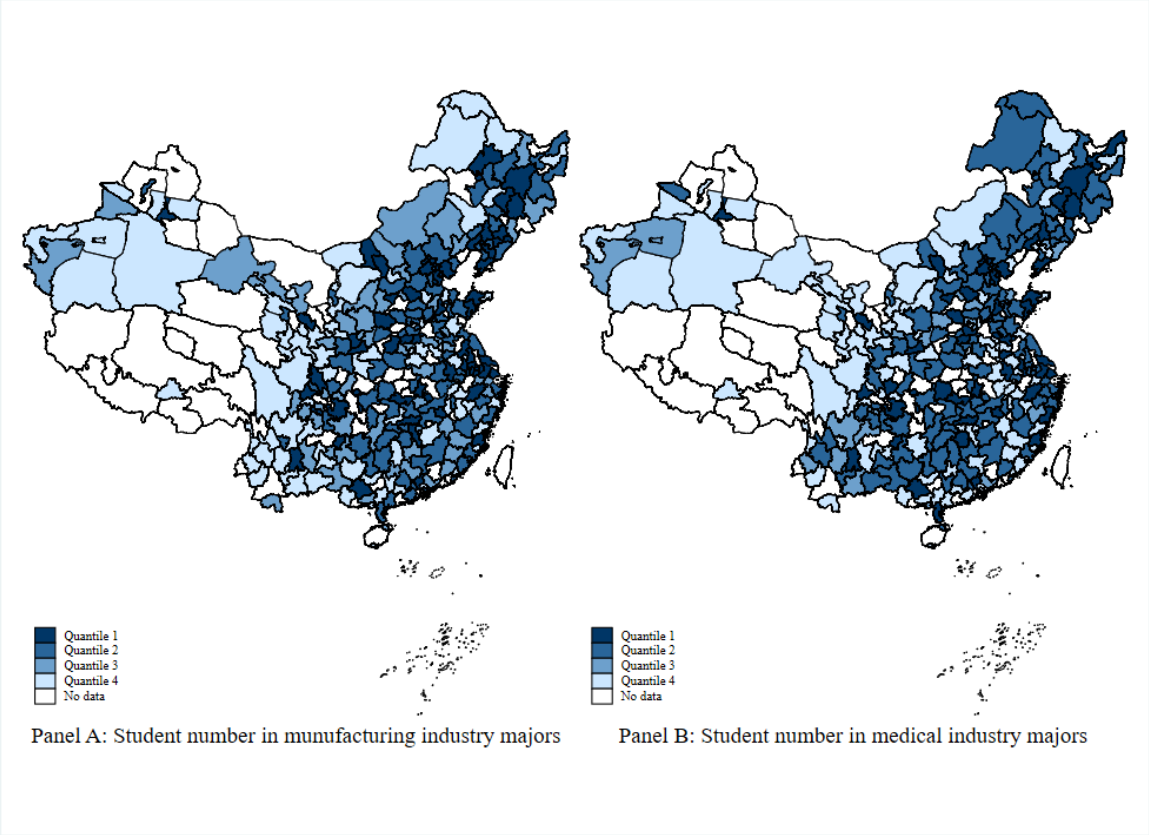

Figure 4.1: Distribution of student number in manufacturing and medical industries related majors before 1994

5 Identification

5.1 DID on individual outcomes

My identification strategy is informed by Duflo's study of school construction in Indonesia (Duflo, 2001). That is, I employ a generalized DID practice in which the birth cohort and the education level determine one’s exposure to the public sector hiring reform in 1994, when guaranteed job allocation for tertiary graduates was terminated.

After graduating from middle school, Chinese students may choose the vocational track (*zhuanke*) or the academic track (*benke*) if they continue their education. The vocational track students are further divided into a lower (*zhongzhuan*) and an upper (*dazhuan*) rank. For example, *dazhuan* graduates tend to graduate at age 20 after three years of vocational study; thus, *dazhuan* students born in 1974 were the earliest cohort and they graduated in 1994. The treatment group consists of individuals who obtained a tertiary or greater level of education and who at the time of the reform had not yet finished their schooling. All individuals who had less than tertiary education were not directly affected by this labor market reform, and they form the first part of the control group. Only those tertiary students who graduated after 1994 were influenced by deregulation. Since the 1970s, Chinese students have normally attended primary school after age six and a half. Thus, *dazhuan* graduates born before March of 1974 belong to the *old* cohort, and the graduates born after that date comprise the *young* cohort. The *old* cohort graduated and found jobs under the guaranteed job allocation regime, and they form the second part of the control group.

To determine how tertiary graduates were affected by the termination of guaranteed job allocation in China, I compare the labor market outcomes of individuals from the treatment group and the control group. In accordance with the following two assumptions, the difference can be interpreted as the causal effect of the deregulation: (1) in the absence of the deregulation, there was a parallel trend between the treatment group and the control group; (2) there was no selection for graduates before or after 1994.

The identification assumption should not be taken for granted. The pattern of labor market outcomes at a given age could vary systematically across individuals with different levels of education. An implication of the identification assumption can be tested because individuals born before March 1974 were not exposed to this deregulation. The outcomes in given ages across cohorts in this age group should not differ systematically across different educational attainments. Thus, I can examine the old cohort as a placebo treatment group to account for the potential systematic difference between the treated and the untreated groups. To test the second assumption, I run a robustness check by restricting my sample to the cohort graduates before 1996, who were enrolled in tertiary schools when the reform was announced in 1994.

In addition to the two identification assumptions identified above, the DID identification requires that I identify who graduated after 1994. Because the 2005 mini census did not explicitly ask these questions, I can only infer the years of graduation from an individuals' year and month of birth, assuming everyone starts school at age six and a half. This assumption may not always hold in practice. However, if the errors between the assumed enrollment age and the real one are distributed randomly, the measurement error will underestimate the true effect. If children from rich families are more likely to break the restriction and go to school early, and if I am observing the outcomes on individual earning, the selection will cause an upward bias of the estimation. This is because some young cohorts in my treatment group were not exposed to the labor market reform, although they should have been exposed, and those individuals are more likely to come from rich families.

In accordance with the points just discussed, I run the following regression to specify the impact of termination of guaranteed job allocation:

$$Y_{ijc} = \alpha + \beta_1 HighEdu_i + \beta_2 Post_{ic} + \beta_3 HighEdu_i \cdot Post_{ic} + \beta_\tau X_i + \theta_j + \mu_c + \epsilon_{ijc} \quad (5.1)$$

where Y_{ijc} is the labor market outcome of individual i, born in prefecture j and cohort c. $HighEdu_i$ is a dummy that indicates whether an individual has educational attainment beyond high school. $Post_{ic}$ is a dummy that indicates whether an individual is born after the cutoff and, thus, belongs to the young cohort. $HighEdu_i * Post_{ic}$ is the interaction term, which is a dummy that indicates whether an individual completed his or her tertiary education after 1994 and, hence, was exposed to labor market deregulation. The term X_i is individual controls, α is the constant, θ_j is prefecture fixed effect, μ_c is birth cohort fixed effect, and ϵ_{ijc} is the unobserved error term. The parameter of interest is β_3, which captures the average treatment effect of the tertiary graduate labor market reform. If the impacts of more fierce competition in the market dominate the impacts of better matching, β_3 should be negative. Otherwise, β_3 should be positive.

Because public hiring reform was implemented throughout the country at a single point in time, a potential concern regarding identification is that the effects we estimate were caused by other reforms that took place during the same year. In 1994 the government implemented two other important reforms: tax-sharing reform and exchange rate reform. Both reforms might have influenced individual incomes. Hence, it would be helpful to know how much of the changes in income can be attributed to public hiring reform, tax sharing reform, and exchange rate reform. I conduct the following Difference-in-Difference-in-Differences (DDD) analyses by interacting the treatment dummy with pre-determined characteristics that capture exposures to different reforms. I assume that if the impact on labor market outcomes is due to more fierce competition after labor market deregulation, then prefectures that experienced more ex-ante public demand for tertiary graduates were exposed to larger shocks. Alternatively, if instead the impact is caused by the exchange rate reform/tax-sharing reform, individuals in prefectures with more foreign capital utilized/tax revenue would experience larger treatment effects.

$$Y_{ijc} = \alpha + \beta_1 HighEdu_i \cdot Post_{ic} + \beta_2 HighEdu_i \cdot Post_{ic} \cdot Charactertistic_j + \beta_\tau X_i + \theta_j + \mu_c + \epsilon_{ijce} \quad (5.2)$$

where $Charactertistic_j$ measures the ex-ante prefecture-level characteristics, which, in turn, measures potential exposure to the reform(s) that took place in 1994. $HighEdu_{ice} \cdot Post_{ice} \cdot Charactertistic_j$ is the interaction of the treatment dummy $HighEdu_{ice} \cdot Post_{ice}$ and $Charactertistic_j$. The first-order terms of the triple difference are controlled in X_i. β_2 is the coefficient of triple difference. If there were heterogeneous treatment effects across prefectures with different exposure to reforms, the coefficient β_2 would be significantly different from zero.

5.2 DID with a continuous treatment on firm entry

To estimate the impacts of the 1994 tertiary graduate labor market reform on private firm entry, I exploit the administrative firm registration data and newly collected student major data. Identifying the number of tertiary graduates is challenging because it is likely to be correlated with other social economic characteristics, which cause an omitted variable bias. To alleviate this concern, I run a continuous DID specification that captures the additional number of firm entries after the reform due to the number of students in that major.

On the right-hand side, I interact the number of students in one major or a group of related majors with the treatment dummy. On the left-hand side, I use the number of firm entries in the industry that are paired with that major or group of majors. The idea is that while the total number of tertiary graduates was likely to be positively correlated with the economic condition and political status of the prefectures, the number of students with specific majors was less endogenous. In addition, the number of students who were majoring in specific fields had the most salient impacts on firm entries in industries closely related to those majors. For example, the manufacturing industry was paired with the materials, metallurgical, mechanical, and textile engineering majors. I also include prefecture and year fixed effects as well as other time-variant controls. Therefore, I run the following continuous DID.

$$Y_{sjt} = \alpha + \beta_1 MajorStu_j + \beta_2 MajorStu_j \cdot Post_t + \beta_\tau X_{jt} + \theta_j + D_t + \epsilon_{sjt} \qquad (5.4)$$

where Y_{jt} is the number of firm entries in industry s, prefecture j, and year t. $MajorStu_j$ is the number of students in majors related to industry s before the reform. $Post_{ic}$ is a dummy that takes the value of 1 if it was after 1994. $MajorStu_j \cdot Post_t$ is the interaction term. The term X_{jt} denotes prefecture-year level controls, α is the constant, θ_j is prefecture fixed effect, D_t is year fixed effect, and ϵ_{sjt} is the unobserved error term. The parameter of interest is β_2, which captures the additional number of private firm entries after the reform; those entries can be attributed to the number of students in the paired major. If firm entries are impacted by the availability in the private labor market of additional tertiary graduates in paired majors, then β_2 will be significant.

As in the individual level DID, I test the parallel pre-trend by interacting the number of students in a group of majors with the year dummy. If the number of tertiary graduates played a more significant role in private firm entries after the public sector hiring reform, the coefficients of the interaction terms would be significant only after 1994. However, we should keep in mind that parallel pre-trends were neither a necessary or a sufficient condition for the parallel counterfactual trends (Kahn-Lang and Lang, 2019). In view of the burgeoning literature on the robustness of event-study design where the parallel trends assumption may be violated, I use the robust estimate proposed by Rambachan and Roth (2022), which guarantees uniformly valid inference under the imposed restrictions.

5.3 Regression discontinuity design

I use regression discontinuity design (RDD) to reinforce my individual-level regression with DID, where one's birth month serves as the running variable. RDD identification can alleviate the concern that the estimated effects in DID are mainly driven by the change in control groups. Specifically, I restrict my sample to tertiary graduates and run the following timing regress discontinuity

$$Y_i = \alpha + \beta Reform_i + f(x_i) + \epsilon_i \tag{5.3}$$

$$\forall\, x_i \in (c - h, c + h)$$

where Y_i is the monthly income of individual i. $Reform_i$ is a dummy that indicates whether an individual graduated after 1994 and, thus, was exposed to the deregulation of the labor market. $f(x_i)$ is n-order polynomial in the running variable. ϵ_i is the unobserved error term. h is the neighborhood around cutoff score c, which is the bandwidth in RDD.

The estimated effects can be interpreted as causal with the following four classic sharp RDD assumptions. (1) Treatment assignment, $Reform_i$, is determined solely on the basis of a cutoff score, c , on an observed running variable, x_i. In this case, individuals with a birth date younger than the cutoff ($Reform_i$ = 0), i.e., the control group, were not affected by the reform. Those with birth dates older than the cutoff, i.e., the treatment group ($Reform_i$ = 1), were affected. (2) The probability of assignment jumps from 0 to 1 at cut-off. (3) Individuals close to cutoff with similar x_i values are comparable. This is described as local continuity. (4) Individual running variables are not manipulable. As in DID, I use the year and month of birth to infer the year of graduation. If there are random measurement errors between the assumed enrollment age and the real one, the true effect will be underestimated. If individual running variables are partly manipulable because children from rich families are more likely to break the restriction and go to school early, an upward bias caused by omitted variables will occur in the estimation of income.

Because I only know the month and year of birth, and not the exact birth date, the running variable I use is discrete. The traditional local polynomial regression is less desirable in this case because the number of mass points is not sufficiently large. Instead, I use as my main specification the local randomization approach proposed by Cattabeo et al. (2015) and Cattabeo et al. (2016), and I use as a robustness check the traditional local polynomial approach.

5.4 Difference-in-Discontinuity (DRD) estimation

I also use the Difference-in-Discontinuity (DRD) method following Gelman and Imbens (2014), Grembi et al. (2016), and Bertrand et al. (2021) as a robustness check for my individual-level results. The DRD estimator estimates the boundary points of four regression functions of the outcome on the running variable: on both sides of the cut-off points and for both the treatment and control groups.

$$Y_i = \alpha + \delta_1 Tertiary_i + \delta_2 Post_i + \beta Tertiary_i \cdot Post_i + Month_i(\delta_3 + \delta_4 Tertiary_i + \delta_5 Post_i + \delta_6 Tertiary_i \cdot Post_i) + \epsilon_i \quad (5.5)$$

where Y_i is the outcome of individual i, $Tertiary_i$ is a dummy for tertiary graduates directly exposed to the public sector hiring reform, $Post_i$ is an indicator for the posttreatment window of ± 6 months surrounding the cutoff birth cohort C corresponding to the first cohort that graduated after 1994, and $Month_i$ is the running variable measured as the month of birth minus the cutoff month. My main parameter of interest is β. The interaction with $Month_i$ allow slopes to vary arbitrarily on each side of the March cutoff as well as across reform versus control windows. The identification assumption is that unobserved characteristic evolves similarly around the cutoff C, compared with the academic yeas other than the reform year.

6. Impacts on monthly income

6.1 Difference-in-Differences results

Table 6.1 shows the impacts of 1994 public sector hiring reform on individual monthly income. The sample in column 1 consists of individuals born between 1969 and 1979 who worked during the week prior to the census and who were primary school, middle school, or tertiary school graduates. Tertiary students, both vocational track and academic track, graduated after 1994 form the treatment group. There were huge wage premia for tertiary graduates. Higher-rank vocational school (*zhuanke*) graduates earn 79.5% more than primary and middle school graduates; the premium increases to 99.4% for college (*benke*) graduates. Females on average earn 28.8% less than their male counterparts. The coefficient of the interaction term is negative and significant at the 1% level, suggesting that after the termination of guaranteed job allocation, the average income of tertiary graduates decreased by 7.2%. To alleviate the concern of a downward trend of earnings and potential selection of tertiary students after the reform, column 2 examines a narrower window of variables. The coefficient is much smaller when I only consider cohorts born two years before and after the cutoff. However, there is still a 3.9% decrease of earnings after the reform. Columns 3 and 4 include industry fixed effects and working unit type fixed effects[5]. The coefficients are smaller than those in column 2, suggesting that about one-fifth of the decrease could be explained by the change in industries or working unit type. When control both industry fixed effects and working unit type fixed effects in column 5, the coefficient remains largely unchanged, which probably occurs because there was overlap in the changes in industries and working unit types. However, even within specific industries and working units, tertiary graduates earned 3.1% less after the public hiring reform.

[5] The working units can be divided into 8 categories: land contractor, institution and organization (government), state owned enterprises, collective enterprises, self-employed, private owned enterprises, other unit type, and others.

Table 6.1 Impacts of the public hiring reform on income

VARIABLES	(1) Ln(income)	(2) Ln(income)	(3) Ln(income)	(4) Ln(income)	(5) Ln(income)
Public hiring reform exposure	-0.0720***	-0.0392***	-0.0313***	-0.0307***	-0.0310***
	(0.00554)	(0.00912)	(0.00918)	(0.00878)	(0.00909)
College degree (*benke*)	0.994***	0.978***	0.677***	0.694***	0.668***
	(0.0194)	(0.0209)	(0.0396)	(0.0454)	(0.0423)
Vocational school degree (*zhuanke*)	0.795***	0.778***	0.472***	0.481***	0.462***
	(0.0132)	(0.0143)	(0.0281)	(0.0336)	(0.0305)
Female	-0.288***	-0.294***	-0.222***	-0.251***	-0.222***
	(0.00684)	(0.00701)	(0.00588)	(0.00664)	(0.00588)
Birth cohort FE	√	√	√	√	√
Prefecture FE	√	√	√	√	√
5 years cohort window		√	√	√	√
Industry FE			√		√
Working unit type FE				√	√
Observations	236,799	113,670	113,669	113,670	113,669
R-squared	0.449	0.450	0.609	0.596	0.612

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used in column 1 consists of individuals born between 1969 and 1979 who worked one week prior to the survey and who completed either primary school, middle school, or tertiary education. In columns 2 to 5 the sample is restricted to individuals born between 1971 and 1975. Public hiring reform exposure is a dummy that indicates whether individuals were tertiary graduates and graduated after 1994. Individuals in the four municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Table 6.2 column 1 excludes primary school graduates and looks at a five-year window that encapsulates the cutoff birth cohort, which is my preferred specification. The shorter window also addresses another concern: that the earnings decline is driven by a selection among competent students who were less willing to obtain a tertiary education because they were already enrolled in schools when the reform was announced. Excluding farmers and non-employees in columns 2 and 3 does not significantly change the result. Table 6.2 columns 4 and 5 divide the treatment group into vocational school and college graduates, and the findings are similar in both groups. The coefficient of reform on vocational (college) graduates is 4.1%, which is close to a 3.8% decrease for bachelor graduates.

Table 6.2 Impacts of the public hiring reform on income (continue)

	(1)	(2)	(3)	(4)	(5)
	Vocational school + College			Vocational	College
VARIABLES	Ln(income)	Ln(income)	Ln(income)	Ln(income)	Ln(income)
Public hiring reform exposure	-0.0341***	-0.0331***	-0.0381***	-0.0409***	-0.0381***
	(0.00927)	(0.00910)	(0.00836)	(0.0118)	(0.0119)
Birth cohort FE	√	√	√	√	√
Prefecture FE	√	√	√	√	√
5 years cohort window	√	√	√	√	√
Exclude primary school graduates	√				
Exclude farmers		√	√		
Exclude non-employees			√		
Observations	87,510	63,985	45,594	102,169	108,475
R-squared	0.450	0.355	0.421	0.392	0.399

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used in columns 1 to 3 consists of individuals born between 1971 and 1975 who worked one week prior to the survey and who completed a primary school, middle school, or tertiary education. Column 1 excludes primary school graduates, column 2 excludes farmers, and column 3 excludes non-employees. Columns 4 and 5 divide tertiary graduates into vocational school and college graduates, respectively. Public hiring reform exposure is a dummy that indicates whether individuals were tertiary graduates and graduated after 1994. Individuals in the four municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

6.2 Event study

I further break down my sample of vocational school graduates and estimate equation (5.1) with every birth quarter group. Consider the new equation:

$$Y_{ijc} = \alpha + \sum_{l=0}^{30} \beta_1 (HighEdu_i \cdot D_{il}) + \beta_\tau X_i + \theta_j + \varepsilon_{ijc} \qquad (6.1)$$

where D_{il} is a dummy that indicates whether an individual i is born in cohort l and is a tertiary graduate. β_1 can be interpreted as an estimate of the impact of labor market reform on a given birth cohort group. Regression 6.1 can be viewed as a generalization of a classic test for a parallel trend. As in Duflo (2001), there should be a testable restriction on the pattern of β_1. Since individuals who graduated before 1994 were not impacted by the public sector hiring reform, the overall pattern of β_1 should be close to zero for old cohorts and negative for younger cohorts.

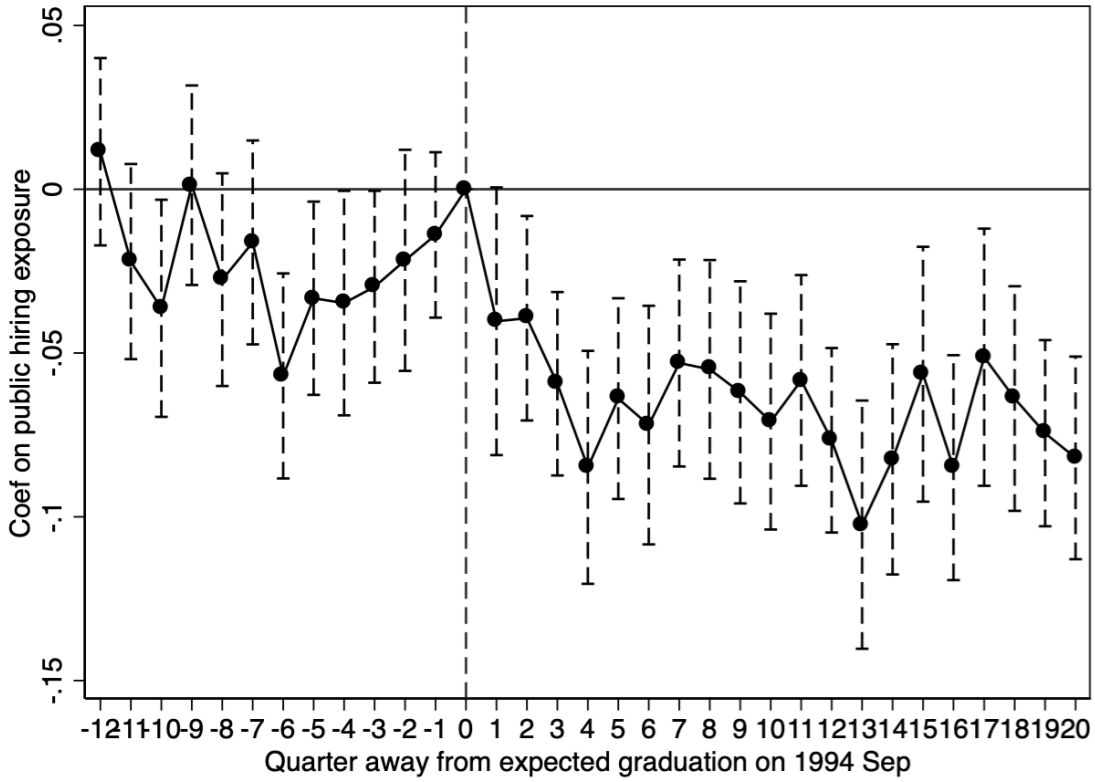

Figure 6.1 Impact of public hiring reform on earnings of tertiary graduates

Note: The sample used in this figure consists of individuals born between 1969 and 1977 who worked one week prior to the survey and who completed either primary school, middle school, or tertiary education. The cutoff of the birth cohort is the earliest cohort to obtain a tertiary degree and who graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Figure 6 plots the β_1 and 95% confidence interval, where x is the difference in the quarter of birth cohort from February 1971. The cutoff point of x is 13. An x larger than 13 means the individual was expected to graduate after 1994 if they completed their tertiary education and were exposed to the termination of guaranteed job allocation. Taking individuals born between November 1973 and February 1974 as the reference group, I see a consistently negative impact on individual earnings in all treated age groups. As expected, the reform did not affect old cohorts not exposed to it, but it decreased the monthly income of treated cohorts who had not graduated as of 1994. In addition, the parallel trend assumption in a DID means that, we want to see that the coefficient is insignificantly different from 0 if the x is smaller than 13, at least not a negative trend. We do not observe a clear negative trend here.

6.3 Heterogeneous treatment effects and other potentially intertwined shocks

As discussed in the identification strategy, one challenge of the DID specification is that other reforms that took place in 1994 could also have influenced individual earnings. To disentangle the effects of public hiring reform from other potentially intertwined policy

shocks, I use the DDD identification to test the heterogeneous treatment effects. If the impacts on labor market outcomes were due to more fierce competition after labor market deregulation, I would expect the negative effects to be larger in prefectures that after reform experienced a large decrease in demand for tertiary graduates.

I focus on the demand for a specific group of tertiary graduates, the normal school graduates[6], who have two characteristics that make them desirable for the analysis: (1) they were valued in the planned economy, but were less valued in the market, because private basic education was under-developed at the time; and (2) the number of normal school graduates was large enough to have potentially influenced the total labor demand in the market.

Before Chinese economic reform, there was a huge demand for primary and middle school teachers because of the government's goal to provide widely covered education resources. When hiring quotas were cut schoolteachers were more vulnerable than government and SOE employees. To make matters worse, in the 1990s, when the basic education system was dominated by public schools, private sector demand for teachers was much lower than demand for other vocational school graduates, such as nurses and accountants. Thus, normal school graduates faced fiercer competition in the market. I measure the heterogeneous demand by the number of primary and middle schools per capita in the prefecture prior to the reform. If competition among tertiary graduates after the public sector hiring reform had been the main channel, I would expect that prefectures with more schools would have experienced a larger decrease in earnings.

Table 6.3 shows the results of the DDD in equation (5.2). Column 1 shows that individuals in prefectures with one more primary school per million people experienced an additional 2.7% decrease in earnings after the reform, compared to an average treatment effect of 2.9%. This result is consistent with a scenario in which more intense competition in the market pulled down the income of tertiary graduates. In columns 2 and 3, I try different measurements of teachers' demand and use different cohort window and control groups. Throughout the specifications, the coefficients of the triple difference are significant.

Table 6.3 Heterogeneous treatment effect across prefectures

VARIABLES	(1) Ln(income)	(2) Ln(income)	(3) Ln(income)
Public hiring reform exposure	-0.0314**	-0.0310**	-0.0311**
	(0.0127)	(0.0126)	(0.0127)
Exposure*primary school per 100k people (centered)	-0.0273**		
	(0.0117)		
Exposure*middle school per 100k people (centered)		-0.156**	
		(0.0622)	
Exposure*primary and middle school per 100k people (centered)			-0.0237**
			(0.0100)

[6] Normal school graduates were educated following norms of pedagogy and curriculum and became teachers in different levels of primary and middle schools across China.

Lower interaction terms	√	√	√
Birth cohort FE	√	√	√
Prefecture FE	√	√	√
Observations	52,417	51,865	51,865
R-squared	0.411	0.411	0.411

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used consists of individuals born between 1971-1975 who worked one week prior to the survey and had a middle school or vocational school education. Public hiring reform exposure is a dummy that indicates whether individuals were vocational school graduates and graduated after 1994. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

I also run placebo DDD regressions to test whether other potential mechanisms influenced the decrease in tertiary graduate earnings. On the one hand, if the earnings decline was driven by a larger fluctuation in the exchange rate after exchange rate reform (which harmed the exports and increased firms' costs), prefectures with more utilized foreign capital or foreign trades would have experienced an increase in impacts. On the other hand, if the earnings decline was due to the local government's lack of funding after the 1994 tax-sharing reform, prefectures with more industrial output per capita (a proxy of tax base) would have been most influenced.

Table 6.4 reports the results of the placebo heterogeneous treatment effect by interacting the treatment dummy with foreign capital utilization per capita, foreign trade volume per capita, and fiscal revenue per capita. Through all the specifications, the coefficients of the triple difference are insignificant. Hence, There is no evidence that the earning decline experienced by tertiary graduates was caused by the exchange rate reform or the tax-sharing reform that happened the same year. The results of placebo tests alleviate (but cannot eliminate) the possibility that the effect of labor market deregulation was intertwined with other reforms.

Table 6.4 Placebo heterogeneous treatment effect

VARIABLES	(1) Ln(income)	(2) Ln(income)	(4) Ln(income)
Public hiring reform exposure	-0.0263*	-0.0351**	-0.0279**
	(0.0146)	(0.0145)	(0.0135)
Exposure*foreign capital per capita (centered)	-0.753		
	(0.521)		
Exposure*foreign trade per capita (centered)		-0.126	
		(0.134)	
Exposure*fiscal revenue per capita (centered)			-0.116
			(0.168)
Lower interaction terms	√	√	√
Birth cohort FE	√	√	√
Prefecture FE	√	√	√
Observations	47,504	50,884	52,169

R-squared	0.421	0.410	0.410

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used consists of individuals born between 1971-1975 who worked one week prior to the survey and had a middle school or vocational school education. Public hiring reform exposure is a dummy that indicates whether individuals were vocational school graduates and graduated after 1994. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

6.4 Regression-Discontinuity design results

Figure 6.2 shows the RDD figure of the deregulation's impact on vocational school graduates, which reinforces my findings in subsection 6.1. The results suggest a clear drop around the cutoff. After graphically showing the discontinuity of log monthly income, I run the local randomization specification using the triangle kernel and report the results in Table 6.5. As documented in column 1, when I look at an 8-year window around the cutoff, the termination of guaranteed job allocation decreased the 2005 earnings of tertiary graduates by 4.2%. As shown in column 2, this local average treatment effect (LATE) is close to the average treatment effect I found in the DID estimation, which is about 3.9%. The results are largely comparable when I change the bandwidth from 4 years to 2 years. Although the difference between cohorts around the cutoff is less distinctive, it is still significant at 5%, and the graphical results are shown in Figure 6.3.

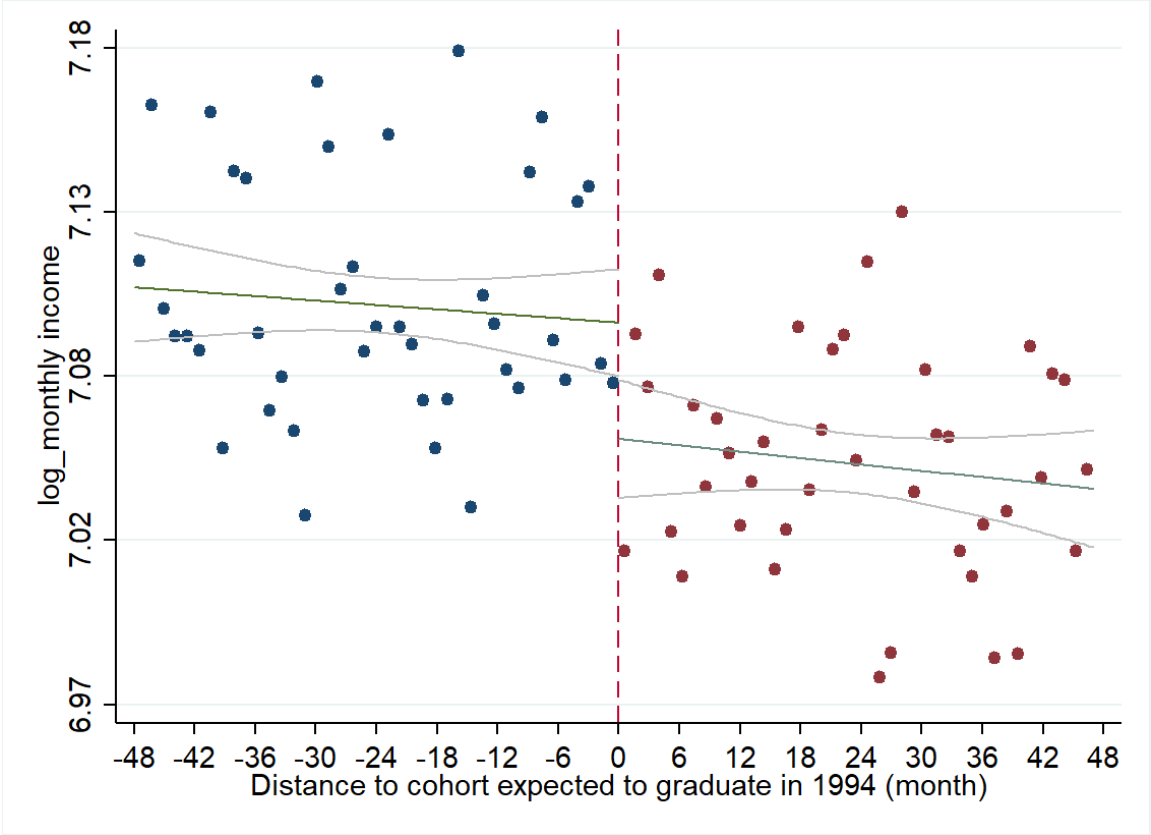

Figure 6.2 Impacts on monthly income of tertiary graduates (long bandwidth)

Note: The sample used in this figure consists of individuals born between 1969-1978 who worked one week prior to the survey and who had a tertiary education. The cutoff of the birth cohort is the earliest cohort with

tertiary degrees that graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

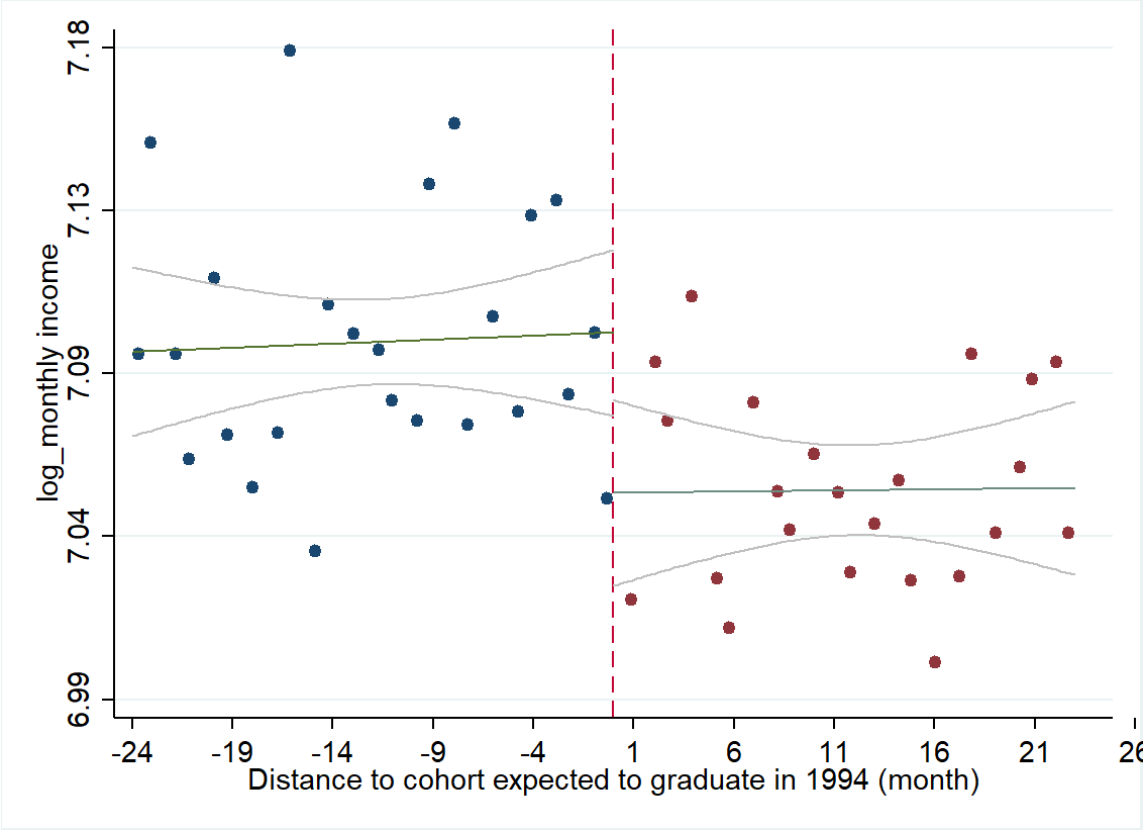

Figure 6.3 Impacts on monthly income of tertiary graduates (short bandwidth)

Note: The sample used in this figure consists of individuals born between 1971-1976 who worked one week prior to the survey and who had a tertiary education. The cutoff of the birth cohort is the earliest cohort with tertiary degrees that graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Table 6.5 RD Result of public hiring reform's impact on earnings

	Local randomization	
	(1)	(2)
RD estimand	-0.046***	-0.052***
	(0.001)	(0.009)
Kernel	triangular	triangular
Polynomial	1	1
Inference approach	large sample	large sample
Bandwidth type	-	-
Bandwidth (month)	96	48
Observations	26327	13382

Note: The sample used in column 1 consists of individuals born between 1969-1978 who worked one week prior to the survey and had a tertiary education. The cutoff of the birth cohort is the earliest cohort that had tertiary degrees and graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Column 2 looks at a narrower birth cohort: individuals born between 1971-1976. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Table 6.6 shows additional robustness checks. In columns 1 and 2, I use the uniform and epanechnikov kernel function and estimate the LATE in a 2-year bandwidth. In column 3, I use the triangle kernel function and a 5-year bandwidth, but I increase the order of the polynomial used to construct the point estimator and estimate the local quadratic regression. In column 4, I use the local polynomial approach instead of the local randomization approach, and I use the MSE-optimal bandwidth selector for the treatment effect estimator. The optimal bandwidth selected is 44 months, which is close to the 2-year bandwidth I use in the local randomization approach. All the regressions report results are comparable to the one estimated in Table 6.2 column 1.

Table 6.6 RD Result of public hiring reform's impact on earnings (robust)

	Local randomization			Local polynomial
	(1)	(2)	(3)	(4)
RD estimand	-0.054***	-0.053***	-0.054**	-0.048**
	(0.003)	(0.006)	(0.009)	(0.029)
Kernel	uniform	epan	triangle	triangle
Polynomial	1	1	2	1
Bandwidth type	-	-	-	mserd
Bandwidth (month)	48	48	96	38
Observations	13382	13382	26327	11045

Note: The sample used in this figure consists of individuals born between 1971-1976 who worked one week prior to the survey and who had a tertiary education. The cutoff of the birth cohort is the earliest cohort with tertiary degrees that graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded. *p* value is in the parenthesis.

6.4 Difference-in-Discontinuity results

Table 6.7 shows the results of Difference-in-Discontinuity estimates. The DRD result in column 1 is qualitatively similar to the estimation in Table 6.5 column 2, which reinforces my findings with RDD specification. Excluding farmers and non-employees in columns 2 and 3 does not significantly change the result. The DRD estimation suggests that the public

sector hiring reform mainly influenced the wage of tertiary graduates and had limited spillover effects on middle school graduates.

Table 6.7 DRD Result of public hiring reform's impact on earnings

VARIABLES	(1) Ln(income)	(2) Ln(income)	(3) Ln(income)
Public hiring reform exposure	-0.061*	-0.078**	-0.067*
	(0.034)	(0.037)	(0.037)
Birth cohort FE	√	√	√
Prefecture FE	√	√	√
Exclude primary school graduates	√	√	√
Exclude farmers		√	√
Exclude non-employees			√
Observations	45,976	29,014	21,071
R-squared	0.454	0.362	0.431

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used in this figure consists of individuals born between 1971-1976 who worked one week prior to the survey and who had a tertiary education. The cutoff of the birth cohort is the earliest cohort with tertiary degrees that graduated from vocational school in 1994, which is the birth cohort of 1974 March for vocational school graduates and 1973 March for bachelor graduates. Individuals in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

7. The boom in the private sector

I provide evidence in section 6 that after the public sector hiring reform, there was a significant decrease in the monthly income for tertiary graduates. In this section, I examine how this reform led to a boom in the private sector: (1) from the individual perspective, the reform enlarged the talent pool of the private sector and encouraged more tertiary graduates to become entrepreneurs; (2) from the firm perspective, prefectures with more tertiary graduates in specific majors had more firm entries in the related industries after the reform.

7.1 Occupational choice and entrepreneurship

Table 7.1 shows the impacts of the public sector hiring reform on talent reallocation. The outcome variable in columns 1 to 3 is the probability that an individual worked in the public sector. After the reform, the probability of working in the public sector decreased by 2.1 percentage points, which is a salient drop because the average probability of working in the public sector in my sample is only 17.2%. Columns 2 and 3 look at the vocational school graduates and college graduates, respectively, and find that the magnitude was larger for vocational school graduates than college graduates, although the difference is insignificant. The outcome in columns 4 to 6 is the probability of becoming entrepreneurs. Consistent with the findings on the probability of working in the public sector, tertiary graduates were 1.1 percentage points more likely to become entrepreneurs after the reform, and this impact was concentrated on vocational school graduates. Those findings suggest

that after the reform, two factors may contribute to a boom in the private sector: (1) more high-educated workers were available in the private sector at lower wages, which decreased the operation cost of running a private firm; (2) more high-educated individuals chose to become entrepreneurs rather than workers after the reform.

Table 7.1 More tertiary graduates worked in the private sector and became entrepreneurs

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Prob(Public sector worker)			Entrepreneur		
	All	Vocational	College	All	Vocational	College
Public hiring reform exposure	-0.0210***	-0.0241***	-0.0156	0.0106**	0.0150***	0.00185
	(0.00652)	(0.00893)	(0.00954)	(0.00448)	(0.00558)	(0.00553)
College degree (*benke*)	0.776***		0.762***	-0.157***		-0.153***
	(0.0235)		(0.0281)	(0.00550)		(0.00620)
Vocational school degree (*zhuanke*)	0.660***	0.659***		-0.114***	-0.115***	
	(0.0194)	(0.0196)		(0.00475)	(0.00499)	
Female	-0.00201	-0.00539***	-0.00603***	-0.0692***	-0.0719***	-0.0741***
	(0.00182)	(0.00187)	(0.00177)	(0.00340)	(0.00357)	(0.00369)
Birth cohort FE	√	√	√	√	√	√
Prefecture FE	√	√	√	√	√	√
5 years cohort window	√	√	√	√	√	√
Observations	98,506	93,155	86,840	98,506	93,155	86,840
R-squared	0.498	0.423	0.391	0.048	0.044	0.045

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used consists of individuals born between 1971 and 1975 who worked one week prior to the survey and who completed a middle school, or tertiary education. Public hiring reform exposure is a dummy that indicates whether individuals were tertiary graduates and graduated after 1994. Individuals in the four municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Table 7.2 columns 1 and 2 further explore the impacts on talent reallocation by decomposing the public sector occupation into government and public institutions and state-owned enterprises. After the reform, tertiary graduates are 2.6 percentage points less likely to work in the SOEs, but there is no decrease in the probability of working in the government and public institutions. The talent reallocation from the public sector to the private sector was driven by the decrease in SOE occupations. Columns 3 and 4 decompose the broadly defined entrepreneurs into enterprise owners and self-employment. The public sector hiring reform increased the probability of both types of entrepreneurs, although the coefficient on enterprise owners is less precisely estimated.

Table 7.2 More tertiary graduates worked in the private sector and became entrepreneurs (continue)

VARIABLES	(1)	(2)	(3)	(4)
	Prob(Public sector worker)		Entrepreneur	
	Gov and institution	SOE	Enterprise owner	Self-employment
Public hiring reform exposure	0.00539	-0.0264***	0.00430	0.00629*
	(0.00750)	(0.00657)	(0.00264)	(0.00352)

Controls	√	√	√	√
Birth cohort FE	√	√	√	√
Prefecture FE	√	√	√	√
5 years cohort window	√	√	√	√
Observations	98,506	98,506	98,506	98,506
R-squared	0.427	0.108	0.011	0.045

Note: Standard errors in parentheses are clustered at the prefecture level. *** p<0.01, ** p<0.05, * p<0.1. The sample used consists of individuals born between 1971 and 1975 who worked one week prior to the survey and who completed a middle school, or tertiary education. Public hiring reform exposure is a dummy that indicates whether individuals were tertiary graduates and graduated after 1994. Individuals in the four municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

7.2 Firm entry

In this subsection, I directly examine the impact on firm entry using an event-study design. On the left-hand side of my specification, I break down my sample of prefecture-level firm registration with every calendar group across industries. On the right-hand side, I interact year dummy with the number of ex-ante tertiary graduates in specific majors across prefectures. Consider the new equation:

$$Y_{sjt} = \alpha + \sum_{l=1990}^{1999} \beta_1 \left(MajorStu_j \cdot D_t \right) + \beta_\tau X_{jt} + \theta_j + D_t + \epsilon_{jt} \qquad (8.1)$$

where D_t is a calendar year dummy. β_1 can be interpreted as an estimate of the additional number of private firm entries after the reform due to the number of students in that major during a given calendar year. Regression 8.1 can be viewed as a generalization of the classic test for a parallel trend. If the number of tertiary students had more salient impacts on private firm entry only after the reform, then β_1 should be zero for $t \leq 1994$ and it should differ significantly from zero for + $t > 1994$.

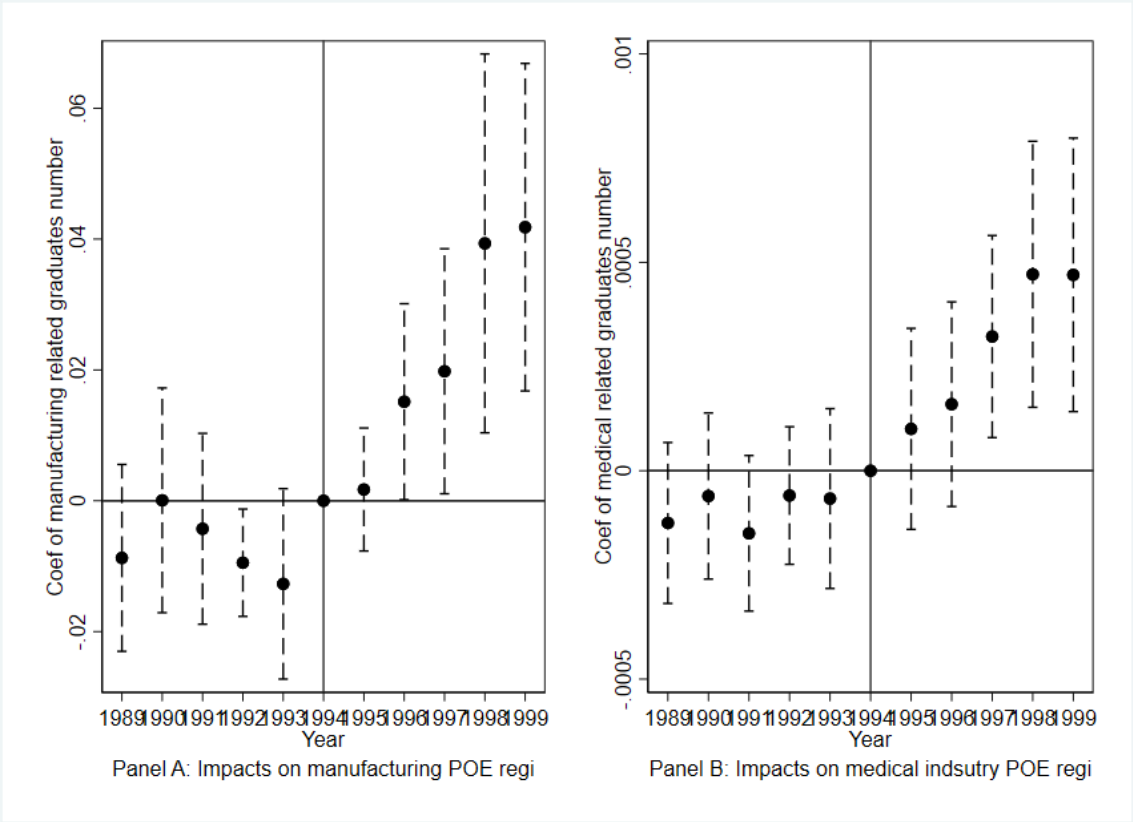

Figure 7.1 Impact of ex ante tertiary graduates in specific majors on private firm entries in related industries

Note: The sample used in this figure consists of private firm entries in the manufacturing industry and the medical industry between 1989 and 1999. The reference year is 1994. I also control the total foreign firm entries in a given prefecture year and the SOE exits in the manufacturing and medical industries in the previous year. Firm entries in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Figure 7.1 Panel A plots the β_1 and 95% confidence interval for the manufacturing industry, where x is the calendar year. The manufacturing industry is paired with students who majored in material, metallurgy, mechanics, and textile engineering. Taking firm entry in 1989 as the reference group, I see a consistently positive impact on firm entry in all treated years. As expected, the number of students in related majors did not significantly impact the firm entry before 1994, but it increased the private manufacturing firm entry after that. The parallel trend assumption in a DID means that I want the coefficient to be insignificantly different from 0 if the x is smaller than 1994, at least if the trend is not a positive one. I do not see a positive trend here. Panel B plots the estimates of the same specification for the medical industry, which is paired with students who majored in health and social work. I again see a parallel pre-trend that is insignificantly different from zero for years before 1994 and significant positive coefficients for year after the reform.

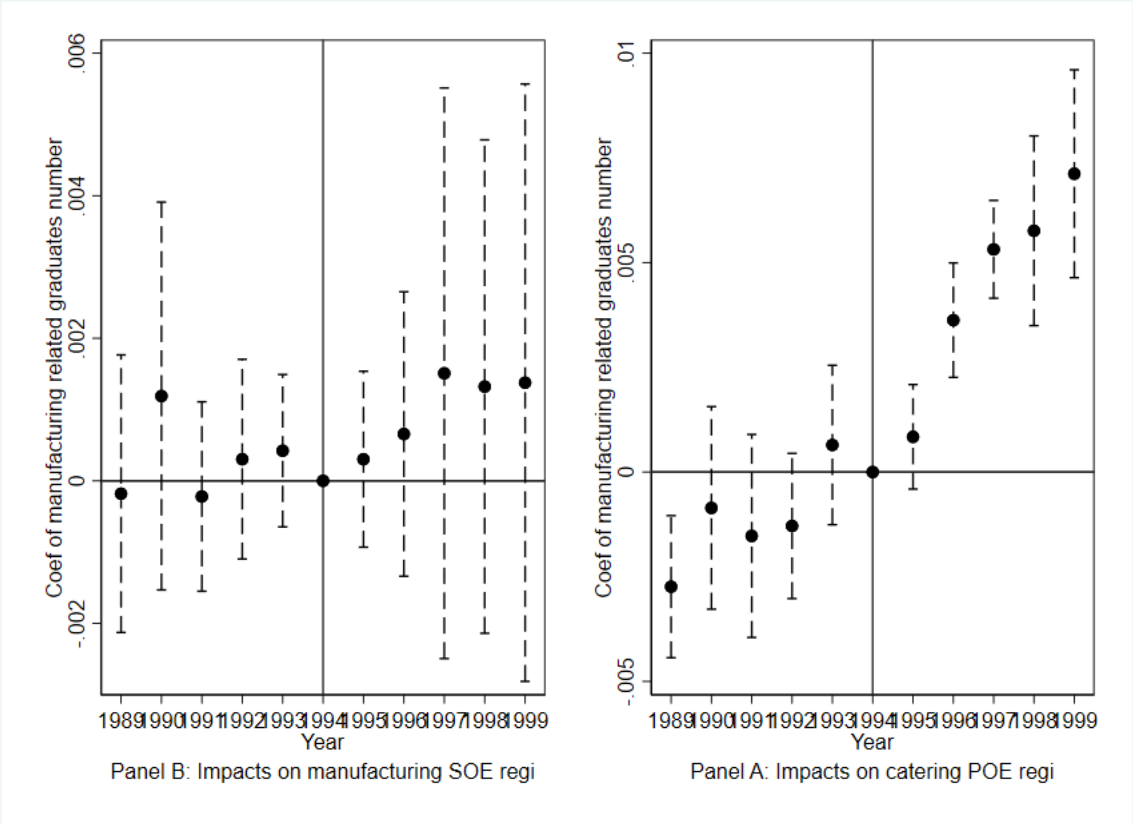

Figure 7.2 Impact of ex ante tertiary graduates in specific majors on state-owned firm entries or private firm entries in unrelated industry (placebo)

Note: Sample used in this figure are SOE entries in manufacturing industry and private firm entry in the catering industry between 1989 and 1999. The reference year is 1994. I also control the total foreign firm entries in a given prefecture-year, and the SOE exits in manufacturing and catering industries in the previous year, respectively. Firm entries in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Figure 7.2 shows the placebo event study for SOEs entry in the manufacturing industry. I do not expect that a reduction in the public hiring quota would lead to more firm entry of SOEs, and the empirical result is consistent with this expectation. As Figure 7.2 shows, during the sample period there is no clear pattern of SOE entry. Firm entry increased slightly after 1997, but the magnitude was much smaller than that of private firm entry, and the coefficient is not precisely estimated. The comparison between SOE and private firms is consistent with the story that the 1994 public sector hiring reform contributed to the boom in the private sector, possibly because more talent was available in the private sector or more tertiary graduates wanted to become entrepreneurs after the reform.

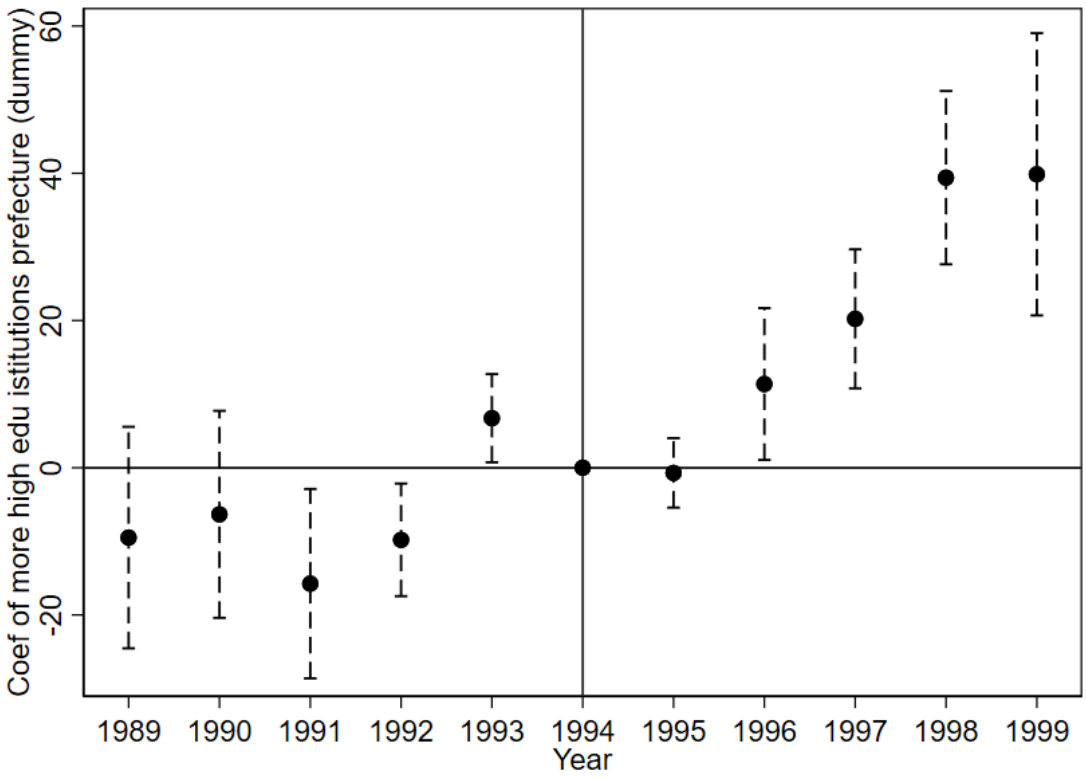

Figure 7.3 Impact of ex ante high education institutions on private firm entries in related industries

Note: The sample used in this figure consists of private firm entries in other industries related to tertiary graduates (industry code 1, 3, 13, 15, 16, 20) between 1989 and 1999. The reference year is 1994. Firm entries in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

As a robustness check, and in an event study similar to that found in Figure 7.1, Figure 7.3 Panel A pools different industries related to higher education together on the left-hand side[7], and it divides the prefecture into a treatment group (high-exposure) and a control group (low-exposure) on the right-hand side on the basis of the number of tertiary education institutions. There was a significant increase in private firm entry after the reform in prefectures that had more vocational schools and colleges. However, because there was a significant jump in year 1993, immediately prior to the public sector hiring reform, a positive pre-trend is a potential concern.

[7] The scientific research and technical service industry is excluded because this industry was affected by specific reforms in 1993 ("Science and Technology Progress Law of the People's Republic of China").

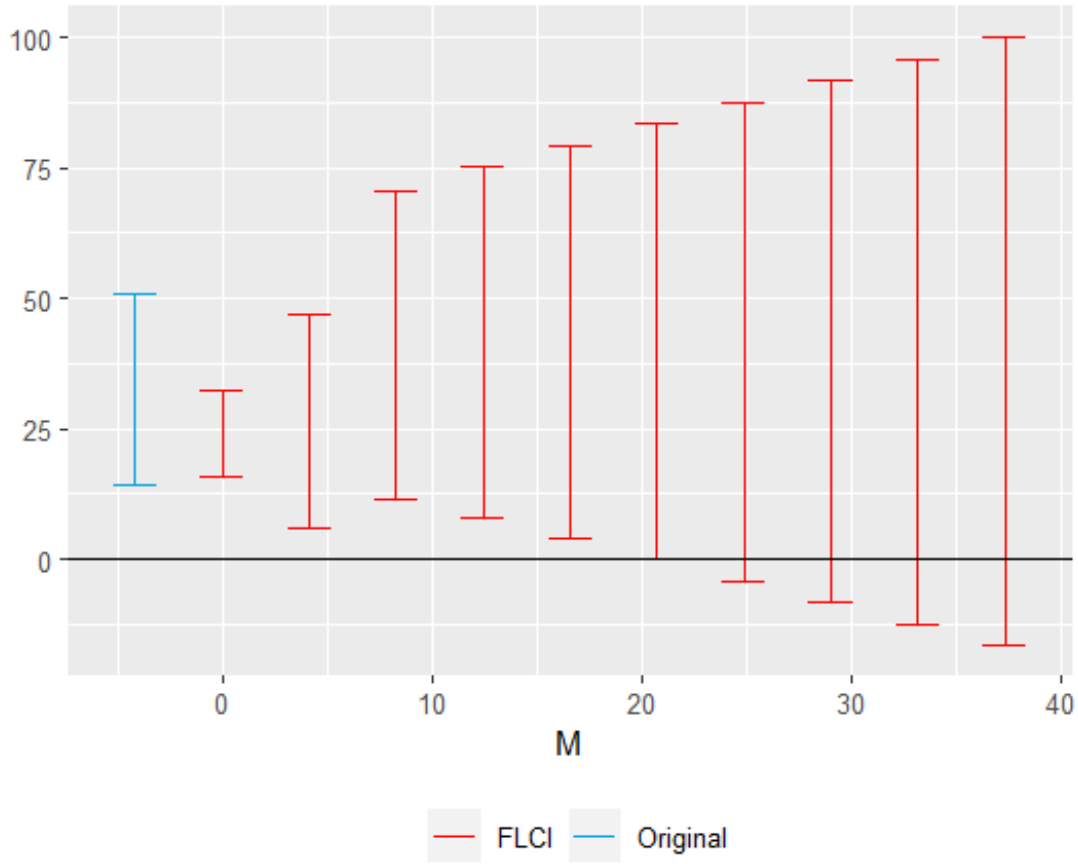

Figure 7.4 Impact of ex ante high education institutions on private firm entries in related industries with robust parallel trend (Rambachan and Roth's approach)

Note: The sample used in this figure consists of private firm entries in other industries related to tertiary graduates (industry code 1, 3, 13, 15, 16, 20) between 1989 and 1999. The reference year is 1994. Firm entries in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

To alleviate this concern, I use the robust estimate proposed by Rambachan and Roth (2022), which guarantees uniformly valid inference under the imposed restrictions. Figure 7.4 shows the result of the robust event study, allowing for a linear pre-trend and deviations from a linear pre-trend. The parameter $M \geq 0$ governs the amount by which the slope of the trend can change between consecutive periods. When $M = 0$, the trend is linear. The results suggest that after taking into consideration the linear pre-trend, the effect of the 1994 public sector hiring reform would be smaller in magnitude, but it would still be significant and more precisely estimated than the baseline regression. When allowing the deviation from the linear pre-trend, I still obtain a positive estimate until M is larger than 20, suggesting that my result is relatively robust to the pre-trend.

8. Innovation

In this subsection I look at whether the boom in the private sector contributed to, impeded, or had no influence on the innovation—an issue that is theoretically unclear. On the one hand, given that the reward structure is generally believed to be more pro-inventor in the

private sector than in the public sector, talented individuals might have had a stronger incentive to innovate. On the other hand, some scientific innovation requires large initial investment and a long period before payback, which is less desirable in the private sector. Therefore, I would expect a more salient increase in innovation that is market-oriented and less salient impacts on innovation that is related to the long-term productivity growth.

8.1 Patent

I first look at the impacts of public sector hiring reform on the number of patents, using an event study specification similar to the specification employed in Figure 7.1. The only difference is that on the right-hand side, I interact the year dummy with the number of students in Science and Technology rather than specific majors. Three types of patents are available in China: the invention patent, which is comparable with the utility patent in the US; the utility model patent, which is comparable to the petty patent in the US; and the design patent. The invention patent has the highest requirement for innovation and in general contributes more to long-term productivity, while the design patent is most market-oriented. I use two different measures of innovation on the left-hand side: (1) The **RANK** of prefectures in different innovation activities across years from IRIEC data; (2) The **SCORE** of prefectures in different innovation activities across years.

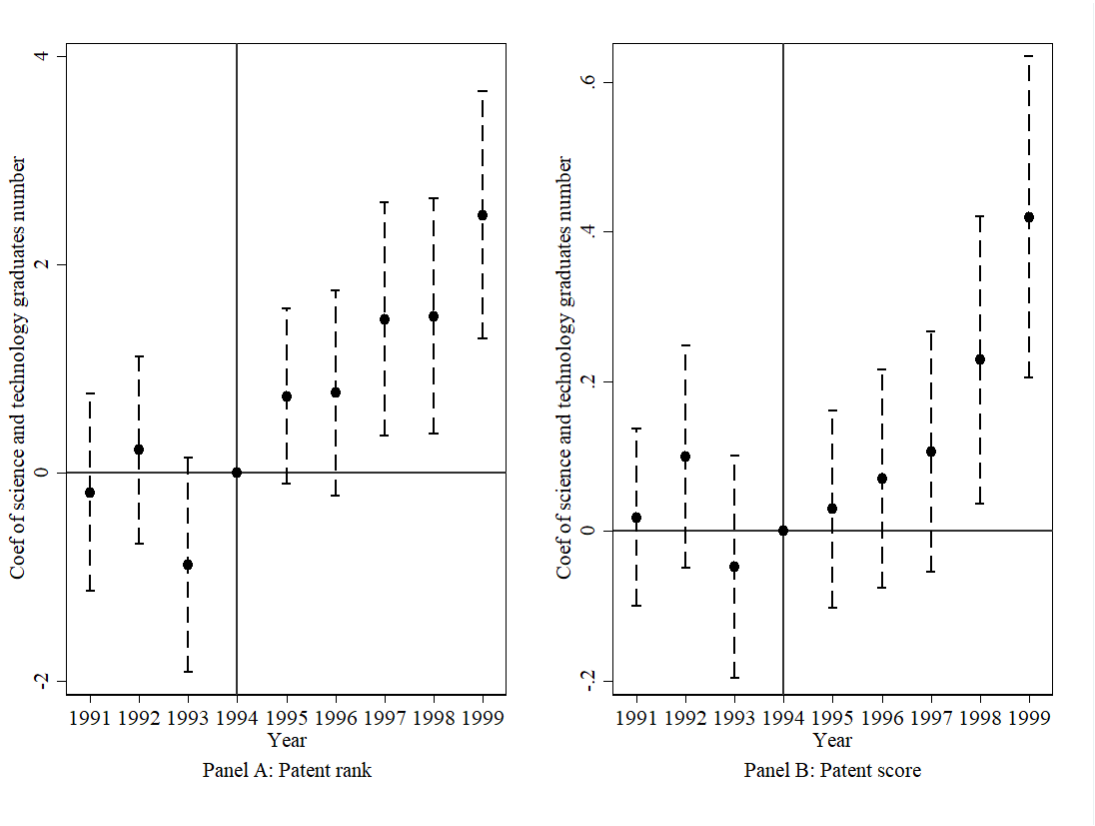

Figure 8.1 Impact of tertiary graduates in science and technology on patent

Note: The sample used in this figure consists of the patent rank and score between 1991 and 1999. The reference year is 1994. Patents in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

Figure 8.1 shows that after the reform, there was a significant increase in both the rank and score of patents in prefectures that had more tertiary graduates in Science and Technology and the impacts have increased over time. The outcome variable in the specification of patent rank is $(0 - rank)$, and a positive coefficient suggests that prefectures with more tertiary graduates climbed up the ladder of innovation. In terms of magnitude, Panel A suggests that right after the reform, if a prefecture had one thousand more tertiary graduates, its rank in patent increased by 0.7 compared with the control prefectures, and this number increased to 2.5 in 1999. And the similar trend is observed in Panel B.

To better understand what kinds of innovation were influenced by the reform, I decompose the total number of patents into different categories. Figure 8.2 looks at the impacts on the design patent. There is an increase in both the rank and score of the design patent in prefectures with more Science and Technology graduates after the reform, although the coefficients are less precisely estimated.

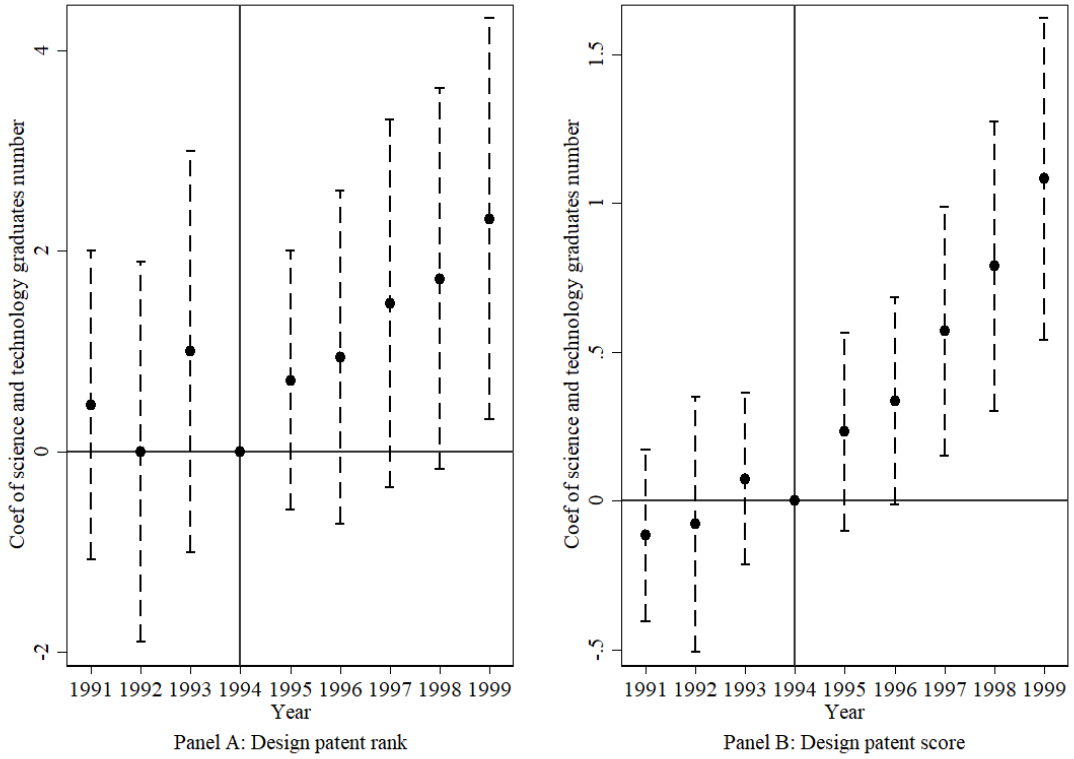

Figure 8.2 Impact of tertiary graduates in science and technology on design patent

Note: The sample used in this figure consists of the design patent rank and score between 1991 and 1999. The reference year is 1994. Patents in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

One might be concerned that the increase of market-oriented innovation may crowd out the resources and talents allocated to those innovation activities that are aimed at long-term productivity growth. If that is the case, we should be careful when interpreting the overall influences on innovation, because the overall impact on long-term growth was

undetermined. Yet Figure 8.3 and 8.4 shows that the reform did not have significant negative impacts on the invention patent in prefectures that had more tertiary education institutions. There was no significant impact on the number of utility model patents, either. This result is consistent with a story that the reallocation of talents from the public sector to the private sector stimulated innovations through short-term market returns.

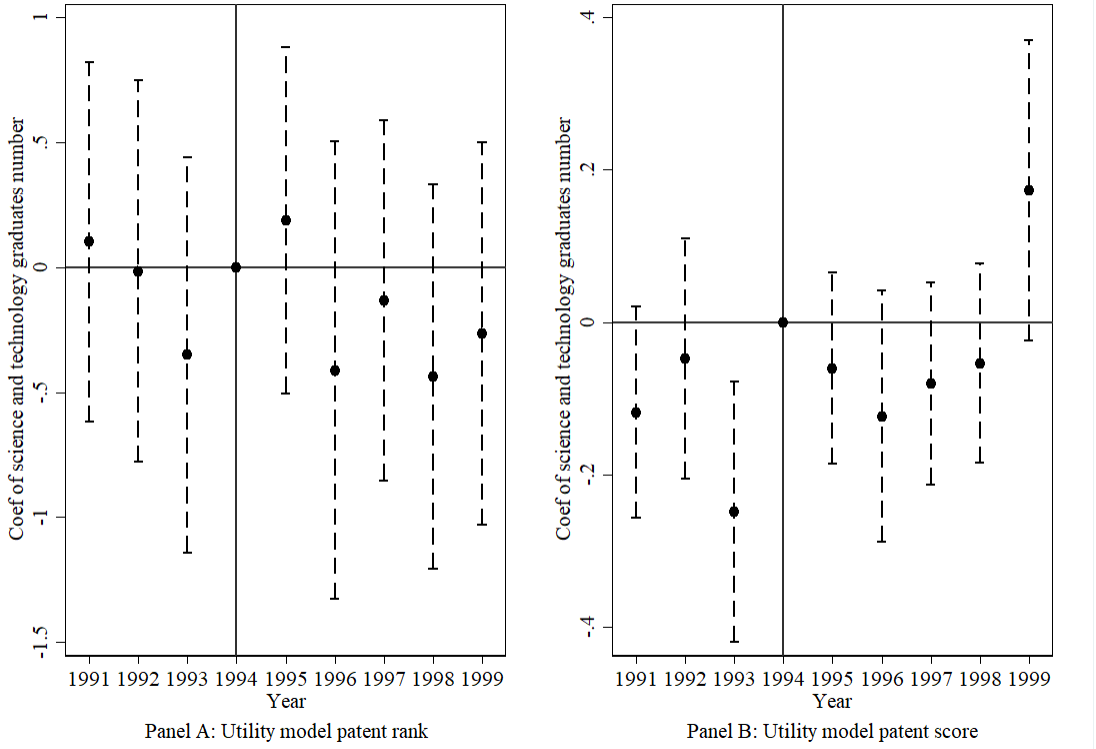

Figure 8.3 Impact of tertiary graduates in science and technology on utility model patent

Note: The sample used in this figure consists of the utility model patent rank and score between 1991 and 1999. The reference year is 1994. Patents in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

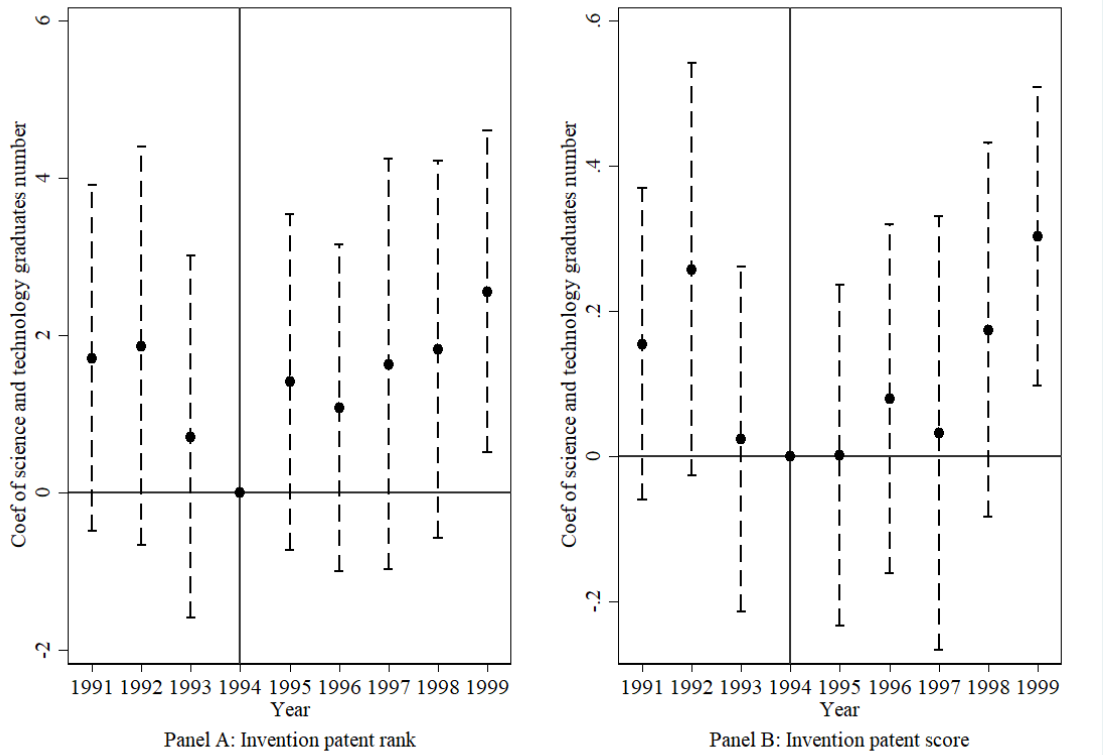

Figure 8.4 Impact of tertiary graduates in science and technology on invention patent

Note: The sample used in this figure consists of the invention patent rank and score between 1991 and 1999. The reference year is 1994. Patents in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

8.2 Trademark

Trademark is another important part of innovation. Successful branding recoups investments in research and development, and it encourages future investment. Additionally, trademarks protect and reward forms of innovation that cannot be accommodated in other IP fields, such as service or market innovation (Gangjee, 2021)

Figure 8.5 Panel A shows that after the 1994 public sector hiring reform, the rank of trademarks significantly increased in the prefectures that had more tertiary graduates in Science and Technology, and the impacts have increased over time. This result is consistent with my findings, presented in section 8.1, that the reallocation talents stimulated the innovations closely related to the market. A significant increase is also observed in Panel B when measured with trademark score. A noticeable difference is that in Panel B, the trademark score has a significant increase in 1994, which is one year prior to the change in trademark rank.

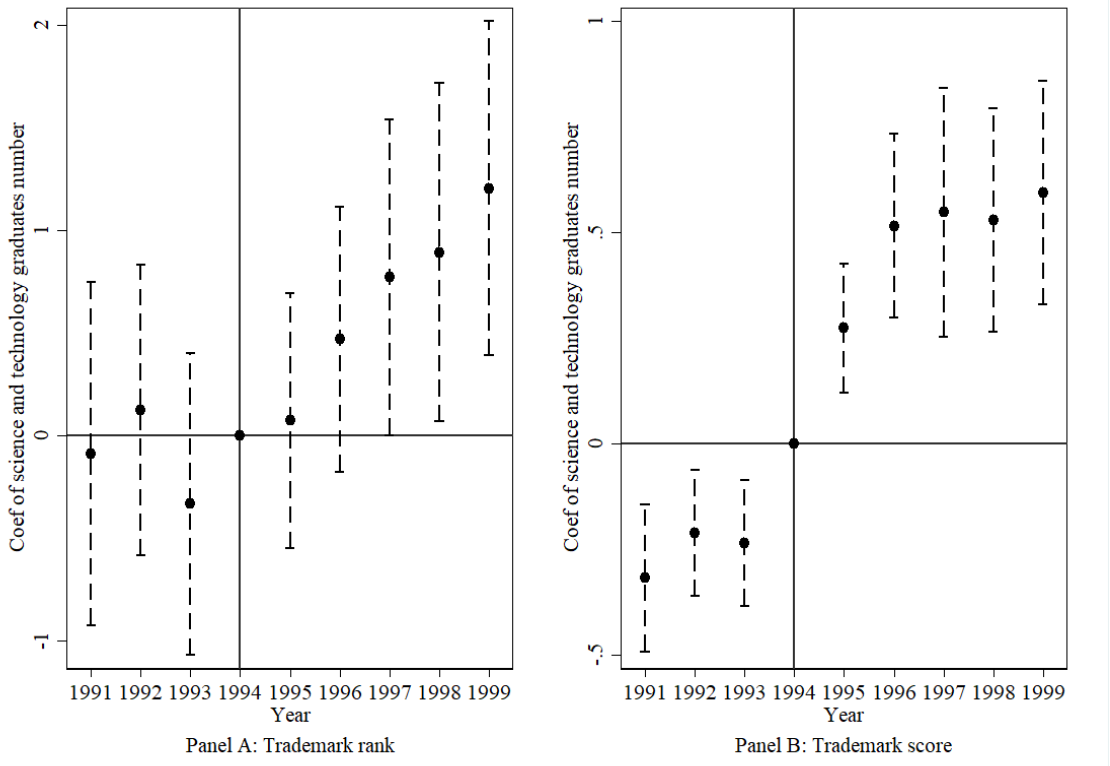

Figure 8.5 Impact of tertiary graduates in science and technology on trademark

Note: The sample used in this figure consists of the trademark rank score between 1991 and 1999. The reference year is 1994. Patents in the 4 municipalities (Beijing, Shanghai, Tianjin, Chongqing) are excluded.

9. Conclusion

This paper studies the impacts of 1994 public sector hiring reform on individual income, firm entry, and innovation. Since 1994, the Chinese government has not provided guaranteed job allocation for tertiary graduates, and it has encouraged them to find a job through a two-way search in the market. Using a generalized DID framework, I find that this reform decreased tertiary graduate earnings by 3% about 10 years after the deregulation, which is reinforced by my RDD specification.

Heterogeneous treatment effects occur across prefectures. Individuals in prefectures that have more ex-ante primary schools and middle schools experienced a larger earning decline. One standard increase in primary school numbers per million people further decreases the earnings by about 79% of the average treatment effect. But there is no evidence for heterogeneous treatment effects across prefectures that had different exposures to tax-sharing reform and exchange rate reform. These results alleviate my concern that the impacts of the reform on tertiary graduate markets might be intertwined with other reforms.

In addition, the termination of guaranteed job allocation led to a boom in the private sector. Prefectures in which more tertiary students graduated from industry-related majors had a larger number of private firm entries in that industry after the reform, which is not the case for the SOEs. Regarding innovation, the public sector hiring reform stimulated market-oriented innovation activities, such as design patent and trademarks. I do not find evidence that the increase in market-oriented innovation crowded out other types of innovation.

Overall, my findings suggest that the public sector hiring reform of 1994 caused a structural transformation that reallocated talents from the public sector to the private one. The talent pool of the private sector enlarged after the reform, which might provide an important explanation for the China boom that is largely overlooked in the existing literature.

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