Essays on Political Economy of Development

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To my parents - Dianliang and Yingzi

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Abstract

This thesis consists of three chapters on topics in development economics. In the first chapter, I study the impact of family planning policies on gender-specific outcomes. I find positive impacts of the FPP on improving the education attainment as well as the gender attitudes of females. In the second chapter, I study what drives mobility and why some areas have higher mobility than others. I characterize the features of intergenerational mobility in China based on education and occupation for cohorts born from 1949 to 1977. Moreover, I empirically investigate how intergeneration-transmitted aspirations can contribute to the emergence and persistence of social mobility. In the third chapter, My coauthor and I model and quantify firms' search and contracting problems in participating in global trade. We provide empirical evidence for the hypothesis that using trade platform significantly improve suppliers' trade performance by mitigating the contracting problem.

Resum

Aquesta tesi consta de tres captols sobre temes d'economia del desenvolupament. Al primer captol, estudia l'impacte de les poltiques de planificacifamiliar sobre els resultats especfics de gnere. Trobo els impactes positius de l'FPP en la millora del nivell d'educacii de les actituds de gnere de les dones. En el segon captol, estudio quimpulsa la mobilitat i per qualgunes rees tenen una mobilitat ms gran que altres. Caracteritzo les caracterstiques de la mobilitat intergeneracional a la Xina basades en l'educacii l'ocupacide les cohortes nascudes entre 1949 i 1977. A ms, investiguo empricament com les aspiracions de transmissiintergeneracional poden contribuir a l'aparicii la persistncia de la mobilitat social. En el tercer captol, El meu coautor i jo modelitzem i quantifiquem els problemes de recerca i contractacide les empreses en la participacien el comermundial. Proporcionem evidncies empriques de la hiptesi que l's de la plataforma de comermillora significativament el rendiment comercial dels provedors mitigant el problema de la contractaci.

Preface

Development economics has been defined as the study of the economic structure and behavior of less developed countries (W.A. Lewis,1984). It generally focuses on topics on the reduction of poverty, improvements in the well-being of the population, and an increase in productivity. China, as one of the largest developing countries in the world, provides an ideal environment to study these topics. In spite of China's fast growth in the past 40 years, socioeconomic problems arise and accompany. Studying the socioeconomic problems in the context of China is important not only for improving our understanding of China itself but also for drawing policy implications for developing countries as a whole.

In this thesis, I undertake the theoretical and empirical investigation of several topics of the development economics of China. In summary, in the first chapter, I focus on gender inequality and study how family planning policy can alleviate it; In the second chapter, I study intergenerational mobility in China and its determinants; The third chapter is set in a more modern setting, in which I study Chinese exporting firms' barriers to participating in global value chains.

In the first chapter, I develop a theoretical framework to study the impact of family planning policies on gender-specific outcomes. Empirically, I use China's Family Planning Policy (FPP) since 1971 to understand how a reduction in the number of children in a family can generate gender-specific outcomes. I mainly use diff-in-diff strategy to compare the education outcomes between boys and girls before and after the FPP. I find that while post-FPP-born children generally stay in school longer, this effect is particularly stronger for girls. This finding is robust to (1) using diff-in-diff-in-diff strategy by incorporating another dimension of variations — different fertility constraints imposed by the FPP on the ethnic majority *Han* and the minorities; (2) using a different measure of education outcomes — the probability of continuing education beyond the compulsory education period. In addition, I document that FPP also has an impact on changing women's preference for family size and gender attitudes. Post-FPP-born women show a more pronounced change in

gender attitudes and exhibit less son preference than men.

In the second chapter, I study the questions about what drives mobility and why do some areas generate higher rates of mobility than others? First, using individual data from censuses and surveys, I characterize the features of intergenerational mobility in China based on education and occupation for cohorts from 1949 to 1977. Second, guided by a simple model built on aspiration-based poverty theory, I empirically investigate how intergeneration-transmitted aspirations can contribute to the emergence and persistence of social mobility. I report several findings. First, I show that there are substantial geographic variations in education- and occupation-based intergeneration mobility across prefectures in China. Second, I empirically examine the role of aspiration in explaining contemporary social mobility. Using the plausibly exogenous success rate for the bureaucrat selection examination (*Keju*) in ancient China as a proxy for historical aspirations and taking advantage of the extensive changes in prefecture boundaries since the founding of the People's Republic of China (PRC) in 1949, I find that aspirations increase upward mobility, and the effect happens to individuals in the low-to-middle quintiles in the education distribution. Third, using the victims of the anti-intellectual movement (the *Cultural Revolution*) in the 1970s as a proxy for the perceived drop in return to education, I show that return to education had a positive impact on determining upward mobility. Finally, I find that in environments with more aspiration, individuals' upward mobility is more responsive to changes in the perceived return to education.

In the third chapter, My coauthor and I focus on buyers and suppliers search and contracting problem. We focus on intermediate goods and we quantify the two trade costs separately by exploiting suppliers' different degrees of online exposure. We build a theoretical model of buyers and suppliers with information frictions. We test the model predictions using both reduced-form analysis and structural estimation. Empirically, we find that using trade platform significantly improve the suppliers' trade performance by mitigating the contracting problem. The reduced-form results show that suppliers that use Alibaba.com have higher trade values, trade with a wider range of countries and perform more transactions.

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Chapter 1

IMPACT OF FAMILY PLANNING POLICY ON GENDER INEQUALITY: EVIDENCE FROM CHINA

1.1 Introduction

Parental investment in children can be gender-specific. Previous research has shown that this sort of discrimination can happen in every phase of life. For instance, Bharadwaj and Lakdawala (2013) showed that boy-girl discrimination begins in the womb: in regions where son preference is strong, mothers visit antenatal clinics and receive tetanus shots more frequently when pregnant with a boy. Sex-selective investments also take place in after-birth childcare. A large body of literature has looked at various outcomes. Chen et al. 1981, Gupta 1987, Basu 1989 and Hirve and Ganatra 1994 document that boys receive more nutrition and healthcare than girls. Some recent papers find the same in vaccination rate (Borooah 2004), breastfeeding (Jayachandran and Kuziemko 2011) and parents' childcare time (Barcellos et al. 2014). Papers that look at anthropometric outcomes (Arnold et al. 1998; Marcoux 2002) or spending on children goods (Deaton 1997), however, find no boy-girl discrimination. Among all, boy-girl inequality in education has particularly received continuing attention because gender inequality in education and employment has been shown to have direct negative impact on economic growth by lowering the average level of human capital[1].

This paper aims to provide evidence on how family planning policy (FPP hereinafter) can "push" parents to invest in daughters and improve girls' education as an outcome. The FPP in China started in 1971 and has been effective since then with some adjustments[2]. It imposes different birth constraints based on an individual's ethnicity and *Hukou* status[3]. Using the birth constraints as an exogenous negative shock to the family

[1] Dollar and Gatti (1999); Klasen (2002); Klasen and Lamanna (2009) provide cross-country evidence. Hsieh et al. (2013) and Cavalcanti and Tavares (2016) quantify the negative effect with macroeconomic models.

[2] In 1978, the One Child Policy was adopted, imposing one-child birth over the country. In 1982 One Child Policy was revised to allow some families to have a second child. Please see Section 1.2.1 for more details.

[3] *Hukou* is the household registration system in China. It classifies every Chinese resident to either *Agricultural* or *Non-Agricultural*. This classification is originated from the 1950s and passed from generation to generation. Section 1.2.2 provides more details.

size, I look at how boys and girls are affected differently by the reduction in the number of children in a family. Specifically, using data from the 1% sample of the 2000 China Population Census, I exploit difference-in-difference strategy to compare the changes in the educational attainment of girls to that of boys. The sample includes cohorts from 1961 to 1981, 10 years before and after the implementation of the FPP in 1971. The result shows that, post-FPP-born children on average stay in school for one more year, the FPP additionally contributed at least 0.54 years to girls' education. The result is robust and significant after controlling for sex ratios at prefecture-year level, local education resources at province-year level, cohorts fixed effects and birth prefecture fixed effects.

In addition, as aforementioned the FPP imposes different birth constraints based on an individual's ethnicity and *Hukou* status. Though the education pattern of *Agricultural* individuals may systematically differ from that of *Non-Agricultural* individuals, ethnicity can lend another dimension of variation. As a matter of fact, the FPP is more lenient for the ethnic minorities than the majority *Han*. This difference in fertility constraints provides another dimension of variation, which makes it possible to use diff-in-diff-in-diff strategy to compare the effects of the FPP on the ethnic minorities to that on *Agricultural* and *Non-Agricultural Han*. The data shows that during the period 1971-1977, the average number of children ever born in *Agricultural* families has decreased from 6 to 3, in *Non-Agricultural* families from 3 to 1.7, and in *ethnic minority* families from 6 to 4. It suggests that though the FPP imposes the most strict birth quota on *Non-Agricultural Han*, given the already low fertility rate of *Non-Agricultural Han* women, the post-1971 FPP affects the *Agricultural Han* the most, less on *ethnic minorities*, and the least on the *Non-Agricultural Han*. In that event, we would expect the largest effect of the FPP on girls' education in *Agricultural Han*, less effect in*ethnic minorities* and the least effect in *Non-Agricultural Han*. The result is consistent with this prediction.

One major potential confounding factor on the supply side of education might be the Nine-Year Compulsory Education policy which took effect in 1986. This policy aims to keep all school aged children (6-15

years old) in school for a minimum of nine years. To disentangle this supply-side effect from the demand-side effect induced by the FPP, I further examine the effect of the FPP on education attainment beyond nine years. The result is consistent with the main finding, implying that the main result is not just picking up the effect from the Nine-Year Compulsory Education policy. In addition, result from multinomial logit estimation shows that the observed improvement in girls' education takes place not only in basic education, but also in higher education, which is a necessary investment for females to participate in high-skilled labor market and an essential step to reduce gender inequality in the labor market.

One may wonder about sex-selection behaviors and its potential influence on the exogeneity of the gender of a child. It is worth mentioning that recent papers(Chen et al. (2013) and Lin et al. (2014)) suggest that the availability of sex detection technology is the prominent cause for the increase of sex ratio in China in the 1980s. The sex ratio (shown in Figure 1.A2) remained between 1 and 1.07 before 1982. Given the natural rate of 1.06, it should not be interpreted as aberrant. Therefore, it should not undermine my identification strategy given the period of the study is 1961-1981. Nevertheless, given that sex ratio may come into play through marriage market, I include prefecture-year sex ratio as an additional control in the regressions.

There are several possible channels through which FPP may asymmetrically affect the education of male and female. This paper focuses on the two mechanisms. First, through gender-specific Quantity-Quality tradeoff. Since Becker and Lewis (1973) proposes the idea that *quantity* and *quality* of children might be inversely related to each other, economists have been trying to find evidence in favor of this hypothesis. The findings so far are quite mixed, though. Some find evidence in support of this hypothesis. Rosenzweig and Wolpin (1980) and Hanushek (1992) find a negative correlation between family size and children's schooling performance. Rosenzweig and Zhang (2009) finds that an extra child significantly decreases the schooling performance and the health of all children in the family. Some find evidence against this hypothesis. Angrist et al. (2005) finds no evidence in support of this kind of trade-off in Israel.

So, the empirical question remains open. Moreover, Becker and Lewis's framework assumes that parental resources are equally shared among all children in a family, thus all the children will have the same "quality", regardless of their gender. Nevertheless, parents in reality can choose to improve the quality of some selected children and keep the others at a lower quality. This happens especially when a family has strong gender preferences and/or has a tight budget. In the context of the FPP in China, I find that a reduction in the number of children in a family will make all children in the family better off, and in particular it does good to previously resources-deprived girls.

The second channel does not assume parents' altruism as in the first channel but assumes that parents make decision in response to economic incentives. Previous literature has shown that to some extent parents can perceive returns to investment and make investment decisions accordingly. Jensen (2010); Nguyen (2008); Attanasio and Kaufmann (2009) show that sons are invested more than daughters because sons are expected to bring more returns to parents, given the fact that girls have more constrains on the labor market. Munshi and Rosenzweig (2006) and Jensen (2012) find that the increased employment opportunities for women in the labor market in India can translate into rapid increase in girls' education and school enrolment. Jayachandran and Lleras-Muney (2009) find that parents in Sri Lanka started to make more investment in daughters following a sudden reduction in maternal mortality because they expect daughters to live longer and thereby bring back more returns. Qian (2008) uses price of tea and orchard to proxy for the sex-specific income and shows that in areas where men have higher earnings, girls survival rate is lower. The above-mentioned studies point out a reasonable mechanism through which family planning policy can positively influence girls. In societies with a lack of well-implemented social security and pension system, parents very often choose to invest in children to secure future income. In China, kinship transfer is the major income source for people who are older than 65. Therefore, children are seen as a main investment mean. Prior to FPP, parents can choose from a larger set of children and decide which one to invest. FPP limits parents' options.

Many post-FPP parents invest in daughters due to lack of alternative options.

There might be other channels, such as through labor market, though not addressed in the theoretical framework, may also play a role. For instance, FPP may affect the education of female by shifting women's fertility expectation. A school-aged girl in the post-FPP period may anticipate that she would bear and raise less children in future than the earlier cohorts and participate more in the labor market, which may incentivize her to invest more time in education. By this way the actual impact of the FPP may be even larger because it also affects cohorts born before the FPP. If in absence of this channel, the education of the pre-FPP-born girls might be even lower. It is probably one of the reasons why we do not observe a sharp growth in girls' education right after the initiation of the FPP, but a smoother, though accelerating growth curve. This channel should make the effect underestimated because the effect on the pre-FPP-born cohorts were not taken into account.

In addition to the effect of FPP on the education of girls, I examine the long-term impact of FPP in changing females' preferences for family size and gender attitudes. Understanding the determinants of women's fertility is a particularly relevant topic to population growth and economic growth. Fernandez and Fogli (2009) and Fernández and Fogli (2006) find that both personal experience and culture matter to a woman's fertility. In particular, Fernández and Fogli (2006) uses woman's number of siblings as a proxy of her direct family experience and finds it have a significant positive effect on her fertility. Using data from 2014 China Family Panel Studies (CFPS), I study woman's fertility choice with regard to whether to have more than one child in relation to her number of siblings. In my data I find that woman's fertility is positively correlated to her number of siblings, even after controlling for many of her personal characteristics. This piece of evidence suggests that the effect of FPP in reducing family size is multiplying —a policy-directed decrease in the number of children in a family may produce a shrink in family size greater than the intended reduction. This finding may be of particular policy interest to countries that are concerned with population growth.

Next, I find that FPP has a positive effect on changing women's gender attitudes. Using son preference as a proxy, I look at son preferences of male and female before and after the implementation of the FPP, and I find that changes in females' son preferences are more pronounced than that in males'. A plausible explanation is that post-FPP girls, if compared to the older cohorts, have more opportunities and are less likely to have been mistreated for gender reason in the process of growing up. In other words, by reducing the number of children, the FPP creates a fairer environment as a byproduct. As the environment is only fairer to girls, not to boys who are used to be treated fairly, girls will be more inclined to reverse the traditional mindset of male superiority. This finding has policy implications especially for societies with a dominant gender preference. For example, in India 57 percent parents wanted their sons to study as far as possible while only 28 percent wanted the same for daughters[4]. Parents' different treatments to sons and daughters would lead to different outcomes in education and earnings, and consequentially different economic and social status in adulthood. The unequal status again reinforces male dominance and leads to persistent gender inequality.

In addition to the aforementioned literature, this paper is also related to the family planning literature. While previous studies mostly focus on the negative effects that may result from family planning policies, the positive effects of FPP are generally overlooked. Qian (2009) identifies the only-child disadvantage in school enrolment in rural China. Zhu et al. (2009) show how sex selective abortion and the One Child Policy together drive the abnormal sex ratio in rural China. Edlund et al. (2013) associates the abnormal sex ratio in China to criminal activities. This paper aims to fill this gap by looking at some positive impacts of family planning policy in improving girls' education and changing gender attitudes.

This paper will contribute to the literature in multiple ways. First, I develop a theoretical framework for gender-specific investment in children, and then I show empirically that family planning policy can have gender-specific outcomes and reduce gender inequality. Second, I provide more evidence to the classic children quality-quantity trade-off puz-

[4]The statistics are from 1991 Public Report on Basic Education

zle, and what makes this paper different from previous studies is that I consider the gender-specific impact of a reduction in quantity of children on the quality of children. Third, I find that family planning policy can have long-term impact in changing women's fertility and positive impact in changing gender attitudes. The findings can help researchers and policy makers to better understand the underlying relationships between fertility and gender inequality.

It should be mentioned that this paper is closely related to Huang et al. (2015), who independently studied a similar question - impact of the One Child Policy on education of girls in China - using a different empirical methodology. My paper is different from theirs in two important respects. First, my paper is not limited to a reduced-form empirical analysis, but provides a general theoretical framework for gender-specific parental investment in children and subsequent gender preferences. Second, in addition to an immediate effect on fertility, my paper also studies a long-term impact of the FPP by looking at changes in females' preferences for family size and changes in gender attitudes between women and men.

The paper is organized as follows: Section 1.2 provides background information about the family planning policy in China and how it relates to the *Hukou* registration system. In Section 1.3, I develop two theoretical frameworks for family planning policy's immediate impact on gender-specific education outcomes and its long-term impact on women's fertility preference. The corresponding empirical evidence are shown in Section 1.4 and 1.5. Section 2.7 is conclusion.

1.2 Background

1.2.1 Family Planning Policy

Family planning in China has gone through three stages:

1. 1962-1970 Early Attempts Stage

Concerned about the rapid population growth after the 1959-1961 Great Famine, in 1962 the State Council of China issues a policy document encouraging families to use birth control. The document points that "Family

planning should be encouraged in populous regions to make procreation gradually move from an unplanned state to a planned state". In 1964 the Family Planning Commission is set up. In particular, family planning offices have been established in some urban areas. This period is a preliminary to the subsequent extensive implementation of the family planning programs.

2. 1971-1977 Family Planning Policy Implementation Stage

The family planning programs receives more attention as the State Council of China approves *The report on the work of the family planning policy* in 1971 and includes the family planning policy into the 4th *Five-Year Plan(1971-1975)*. Following this, Family Planning Offices are set up at all administrative levels and birth control work is carried out. The predominant way of birth control at that time is by inserting IUD (Intrauterine Device). Other methods include Tubal ligation and vasectomy. Forced abortions also take place in some circumstances when a woman is found to carry an out-of-quota child. Figure 1.1 plots the volume of the different types of birth control surgeries (in millions) since 1971 as a consequence of the family planning policy. Campaign slogan at that time is "one is not too few, two is perfect, and three is too many". Later, in the 1973 national family planning symposium, a more explicit policy "Later, less frequent and fewer" ("晚、稀、少")[5] is introduced. "Later" means woman must not get married before 23 and give the first birth before 24; "Less frequent" means the birth spacing must be no less than three years. "Fewer" means a couple cannot have more than two children. The family planning work at this stage has controlled the population growth to a considerable extent. Figure 1.A1 shows that the population growth in China has greatly slowed down since the start of the family planning policy in 1971. During the first five years of the implementation of the family planning policy, the population growth fell from 2.7% in 1970 to 1.5% in 1976.

It is worth mentioning that in this period the family planning policy does not stipulate a concrete plan for the ethnic minorities, though it does point that "In less populated minority areas, technical guidance for family

[5]The central government website provides brief population policy evolution chronicles, see $http://www.gov.cn/zhengce/2015-02/09/content_2816919.htm$

planning should be given to those who have birth control willingness". In practice the number of children an ethnic minority family is allowed to have is largely subject to the autonomous regions or the provinces where they live. In a word, the policy is more lenient for the ethnic minorities than the majority *Han*.

3. 1978- One Child Policy Stage

In March 1978, a stricter policy, later commonly known as the One Child Policy, was adopted in the Fifth National People's Congress and enshrined in the constitution. Since the second half of 1979, many places have revised the family planning regulations in accordance with the requirements of one-child birth. Except for some less-populated ethnic minorities, one-child birth is fully implemented in urban and rural areas across the country. Only difficult households in rural areas in some western provinces (Yunnan, Qinghai, Ningxia and Xinjiang) can have two children. As of the first half of 1980, with the exception of Xinjiang and Inner Mongolia, all provinces, cities, and districts have issued interim regulations for family planning (Xinjiang and Inner Mongolia introduced regulations in 1981 and 1982 respectively), which imposes severe economic and administrative penalties on offenders.

In this period a more specific policy is made for ethnic minorities, "For ethnic minorities, exceptions to the one child birth can only be granted to those with a population of 10 million or less. Couples of those ethnics can have two children, and some may have three, but four children are not allowed."

Qian (2009) shows that for rural areas, the four-year birth spacing law combined with the One Child Policy meant that it was, in practice, binding for cohorts born in 1976 and later. In 1982 One Child Policy was re-emphasized and revised to allow some families to have a second child. The conditions for obtaining a second-child permit are discussed in detail in the next section. The second-child permit emerged to alleviate the unexpected sex-selection behaviors that took place in some son-preferring places following the implementation of the strict One Child Policy. The consequential skewed sex ratio and its unintended impacts have been documented in previous studies (for example, see Angrist (2002)). Fig-

ure 1.A2 plots the sex ratio time series in China. In the 1970s and early 1980s, sex ratio is still nearly normal, because during that period sex-selection behavior mostly took the form of female infanticide, which was not as effective. The sex ratio then became more skewed with the introduction of the ultrasonic fetal sex diagnosis in the 1980s.

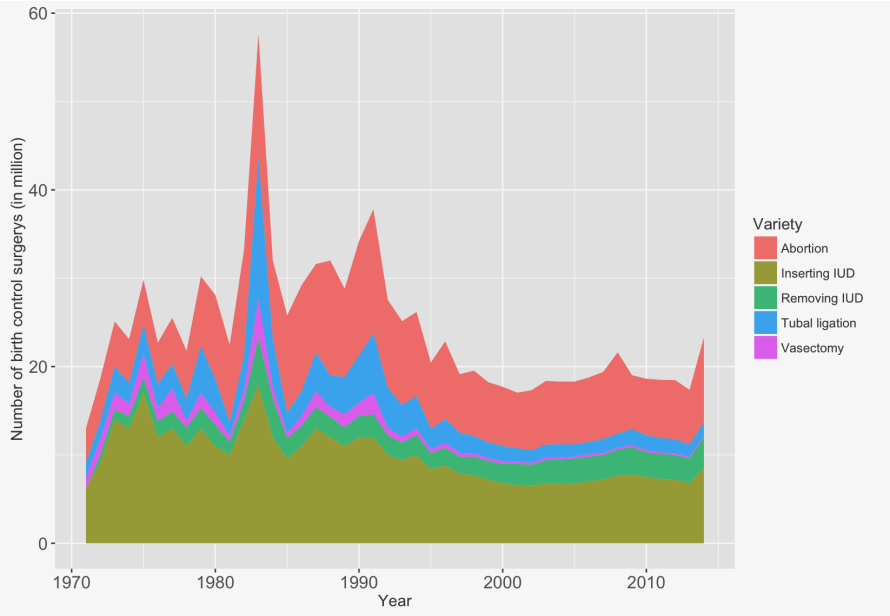


Figure 1.1: The Volume of The Birth Control Surgeries (In Millions)
Note: This figure shows the volume of the birth control surgeries (in millions) in China as a requirement of the family planning policy from 1971 on.
Source: 2015 China Health and Family Planning Policy Statistics Yearbook

1.2.2 The Household Registration (*Hukou*) System

The conditions for obtaining a second-child permit are closely linked to an individual's *Hukou* status, I herewith briefly explain the *Hukou* system. The household registration system was established in cities in 1951, extended to rural areas in 1955, and formalized as a permanent system in

1958. Every Chinese resident is classified by the 'status' of his/her *Hukou* registration, essentially referred to as *Agricultural* or *Non-Agricultural*. This classification used to determine a person's entitlements to state prerogatives. It originated from the occupational division in the 1950s. The designation of *Hukou* registration status for a person is inherited from that of his or her mother. This is very much a 'birth-subscribed' system. Changes in the *Hukou* registration were strictly controlled before the 1990s. The main channel is by employment in state-owned corporations or by admission to higher education institutions. Very limited quotas are granted every year. The classification of *Hukou* registration facilitated the state's control of rural-urban migration by requiring anyone seeking officially sanctioned rural-urban migration to complete a dual approval process. (for more details, please see Chan and Zhang (1999) which provides a complete summary of the *Hukou* system).

1.2.3 Conditions for obtaining a second-child permit

The target of the family planning policy is the main ethnic group in China - *Han*, which accounts for 93% population. The ethnic minorities, in contrast, have had the privilege to have two or three children. As from 1982, the policy was revised to allow some *Han* families to have a second child. The conditions are summarized in Table 1.1. It can be thought of as a two-criteria process. A family can have a second child if it meets either of the criteria. The first criterion depends on whether the parents are both singletons. If parents are both singletons (the only child in their own families), the couple is eligible to apply for a second-child permit. This criterion can be seen as a reward to singletons, though it seldom applied before the 2000s because of the scarcity of singletons. The chance of marrying another singleton is therefore very low.

When neither parent is singleton, the second criterion applies, which depends on the *Hukou* of the mother and the sex of the first child. Only *Agricultural* mother with the firstborn child being a girl is eligible to have a second child. In contrast, *Non-Agricultural* mother cannot apply to have a second child regardless of the sex of the first child. The conditions may

appear odd at first because it seems to favor *Agricultural* families. This conditional privilege is determined by two facts specific to *Agricultural* family: (1) *Agricultural* families generally have a stronger desire for sons as men are more productive in agricultural activities; (2) rural areas are where most sex-selection behaviors take place. This condition thus provides an incentive for strong son-preferred families to keep the first child when it is a girl.

If a family does not meet the conditions but insists on having more children, an economic penalty will apply. To give an idea of how large the fine is, in Beijing it is roughly 3 to 10 times an individual's annual income[6], which is a fairly large amount of money to an ordinary family. In addition to the economic penalty, anyone who works for the government or any state-owned corporations would face the risk of being dismissed if he/she had out-of-quota children. There are some other exceptions for which parents are free to have a second child. For example, when the first child has an intellectual disability. Since these are minor cases that are not representative of the population, they are not considered in the analysis.

Table 1.1: The Two-Criteria Process to Obtain A Second-Child Permit

First Criterion: Whether Parents Are Both Singletons

Mother	**Father**	**Eligibility**
Singleton	Non-singleton	No. Go to the 2nd criterion
Non-Singleton	Singleton	No. Go to the 2nd criterion
Singleton	Singleton	Yes

Second Criterion: The *Hukou* Of Mother and The Sex Of The First Child

The Hukou of Mother	**The sex of the first child**	**Eligibility**
Agricultural	Boy	No
Agricultural	Girl	Yes
Non-Agricultural	Boy	No
Non-Agricultural	Girl	No

[6]Beijing Municipal Peoples Government Order No.111, Section 5

1.2.4 The Impact of the FPP on family size

Though estimating how much the reduction in the population is due to the FPP is not within the scope of this paper, I hereby provide some evidence for it. Figure 1.2 plots the average number of children ever born by women at fertile age (15-49). It shows that the FPP effectively reduces the average family size since its implementation in the 1971, and the *Agricultural* family is more affected by the FPP than the *Non-Agricultural* family. In 1970 the average number of children in *Agricultural* family was 6.2 and in *Non-Agricultural* family was 3.2. By 1980 the average number of children in *Agricultural* family dropped to 2.5 and in *Non-Agricultural* family dropped to 1.3. Specifically, before the 1959-1961 Great Famine the birth rate remained stable at between 5 and 6 with small difference between *Agricultural* and *Non-Agricultural* women, and it then dropped dramatically to 3 during the Great Famine and bounced back afterwards. While the birth rate of *Non-Agricultural* women has shown a declining trend since 1964, that of *Agricultural* women did not go down until the implementation of the FPP in 1971. By 1980 the average birth rate of *Agricultural* women has dropped to below 3 and that of *Non-Agricultural* women has dropped to below 2. The total fertility rate(TFR) in Figure 1.A3 displays a similar pattern. It also shows the TFR pattern in the United States and Japan. In contrast to China, the rates of the US and Japan in the 1970s were quite stable, implying that the reduction of family size in China in the 1970s is not simply a world trend, but a consequence of the family planning policy.

(a) Whole Population

(b) By Group

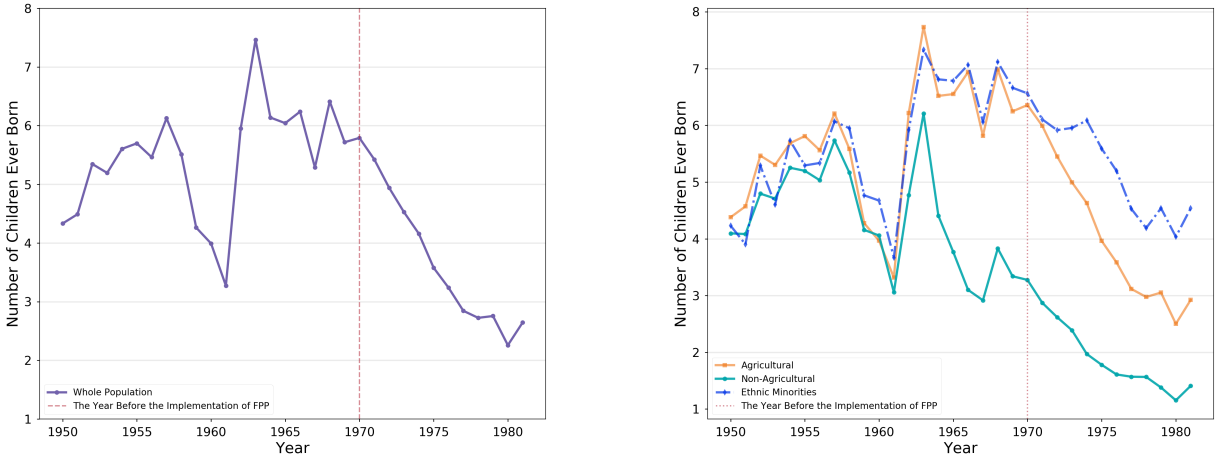


Figure 1.2: Number of Children Ever Born

Note: This figure shows the time trend of the average number of children ever born by a woman at fertile age (15-49). The left subfigure shows the whole population. The right subfigure is by group. The yellow line represents the *Agricultural Han*, the green line represents the *Non-Agricultural Han* and the blue line represents ethnical minorities. Before the 1959-1961 Great Famine the birth rates remained stable at between 5 and 6 with small difference between *Agricultural*, *Non-Agricultural* and ethnical minorities women. The birth rate then dropped dramatically to 3 during the Great Famine and bounced back afterwards. While the birth rate of *Non-Agricultural* women has shown a declining trend since 1964, that of *Agricultural* women did not go down until the implementation of the FPP in 1971. The decline in the birth rate of ethnical minorities women took place several years later in the mid-1970. By 1980 the average birth rate of *Agricultural* women has dropped to below 3 and that of *Non-Agricultural* women has dropped to below 2, and ethnical minorities keep their birth rates at 4. The figure shows that the FPP effectively reduces the average family size since its implementation in the 1971. Additionally, it shows that though the FPP imposes the most strict birth quota on *Non-Agricultural Han*, given the already low fertility rate of *Non-Agricultural Han*, the post-1971 FPP affects the *Agricultural Han* the most, less on ethnic minorities, and the least on the *Non-Agricultural Han*.

Source: 1986 China Family Planning Policy Statistics Yearbook

1.3 Theoretical Framework

In this section, I develop two theoretical frameworks. Section 1.3.1 describes a model for gender-specific investment decisions on education. Section 1.3.2 contains a model for women's fertility preference in relation to her gender attitudes.

1.3.1 Gender-specific education outcomes

Starting with Becker's framework, consider a parent with some level of altruism. Children's consumption enters her utility function.

$$\max \;\; U^p(X_p, X_c) \tag{1.1}$$

$$s.t. \;\; PX_p + t_c \leq I_p$$

$$PX_c \leq t_c$$

where X_p is the private good consumed by parent, and X_c is private good consumption by children, which is a sum of all children. $X_c = \sum_i^n X_{ci}$. I_p is family income. $t_c = \sum_i^n t_{ci}$ is the transfer of resources from parents to children. It can be interpreted as money invested and time cost to raise children. At equilibrium, the budget constraints bind. The equilibrium condition for maximizing the utility function given by Equation 1.1 subject to the income constraint is $\frac{MU_p}{MU_c} = \frac{P}{P} = 1$. A parent would transfer just enough resources to children so that parents would receive the same utility from increments to his own or to children's consumption.

Now introduce a parameter δ to capture parent's gender preference. $\delta > 1$ if a family prefers sons to daughters.

Assume sons have priority to claim resources. The remaining will be shared by daughters. The resources distribution then follows:

$$\begin{cases} t_{cs} = \delta \dfrac{t_c}{n} \;\; for\ each\ son \\ t_{cd} = \dfrac{t_c - \delta \frac{t_c}{n} n_s}{n_d} \;\; for\ each\ daughter \end{cases}$$

Where n is the number of children in the family $n = n_s + n_d$, and n_s is the number of sons, and n_d is the number of daughters.

Proposition 1: *With all the other conditions hold equal, daughters who have fewer siblings (smaller n) get more resources (higher t_{cd}) than those who have many siblings.*

Substituting $n_s = n - n_d$ into the resource distribution and rearrange, each daughter's resource can be rewritten as:

$$t_{cd} = (\frac{1-\delta}{n_d} + \frac{\delta}{n})t_c$$

Comparing it with t_{cs}, the difference comes from the part $\frac{1-\delta}{n_d}t_c$. As fore mentioned, a boy-preferred family will have a $\delta > 1$, thus $\frac{1-\delta}{n_d}t_c < 0$, and so $t_{cd} < t_{cs}$. A higher δ will lead to a larger difference between daughters and sons. This part can be interpreted as a substitution effect: a parent substitutes the consumption on daughters with consumption on sons. The larger the δ is, the more parent would prefer sons, and the less resources a daughter would obtain.

When the total number of children n increases, the resource shares t_{cd} and t_{cs} both decrease, implying less resources to each group.

To link it to education attainment, think of education attainment as an increasing function of parental investment and personal characteristics: $f^{edu}(t_{ci}, e_{pi})$, where e_{pi} include all the individual characteristics that may affect an individual's education attainment. Essentially, education outcome is assumed to have a diminishing return to investment. $\frac{\partial f^{edu}(t_{ci},e_{pi})}{\partial t_{ci}} > 0$ and $\frac{\partial^2 f^{edu}(t_{ci},e_{pi})}{\partial t_{ci}^2} < 0$. This is intuitive. With all the other conditions hold equal, individuals who get more investments are more likely to obtain better education outcome. As shown earlier, since girls are usually at disadvantage in obtaining resources, their education attainment is on average lower than boys. With diminishing return to investment, the same amount of increase in investment will lead to a larger improvement in girls' education.

Then it can be shown that the education attainment gap between boys

and girls is deepening in the number of children in a family. Mathematically,

$$\frac{\partial}{\partial n}\left[f^{edu}(t_{cs}, e_{pi}) - f^{edu}(t_{cd}, e_{pi})\right] > 0 \tag{1.2}$$

Proof is in Appendix B.

Hypothesis 1. The difference between boys and girls in educational attainment should become smaller as the number of children in a family becomes less.

1.3.2 Women's fertility preference and gender attitudes

In this section I develop a model to show how gender attitudes can interfere in women's fertility decisions.

There are three periods, t, t+1 and t+2, representing young, middle and old ages respectively. Individuals supply labor at young and middle, make fertility decisions in the end of period t, raise children in period t+1, and retire in period t+2. Consider an individual born at t, the individual earns the competitive wage $w_{y,t}$ at young and $w_{m,t+1}$ at middle age. $q(n_t)$ is the probability of having at least a son in all the children. Intuitively, it is an increasing concave function with n_t. For example, suppose the unconditional probability of bearing a son or a daughter is equal. When a family chooses to have only one child, the probability of having a son is 0.5; when a family chooses two children, the probability of having at least a son becomes higher at 0.75, and similarly, for a family with 3 children, the probability $q(n_t)$ is 0.875.

I normalized the utility of having daughters to 1, and the utility of having sons to γ. Thus a boy-preferred family will have a $\gamma > 1$. Since child sex is ex-ante unknown, a family makes decision only on how many children n_t to have . The expected utility from son is $q(n_t)log(\gamma)$.

Assume there is no tax. The utility of the individual takes the following term:

$$\max_{c_{y,t},c_{m,t+1},n_t} U_t = log(c_{y,t}) + 1_{n_t>0}\big(vlog(n_t) + q(n_t)log(\gamma)\big) + \beta log(c_{m,t+1}) + \beta^2 log(c_{o,t+2}) \tag{1.3}$$

$$s.t. \quad c_{y,t} + a_{y,t} = w_{y,t}$$
$$c_{m,t+1} + a_{m,t+1} = w_{m,t+1} + R_{t+1}a_{y,t} - T_{m,t+1}$$
$$c_{o,t+2} = R_{t+2}a_{m,t+1} + T_{o,t+2}$$

The discount rate $0 < \beta < 1$. $1_{n_t>0} = 1$, if an individual has child $n_t > 0$; else, $1_{n_t>0} = 0$, if an individual does not have child. $v > 0$ represents preference for children in general.

At young, an individual can borrow a fraction θ of the present value of his future labor income. Assume that the credit constraint on the young is binding. The net asset holding at the end of period t is

$$a_{y,t} = -\theta \frac{w_{m,t+1}}{R_{t+1}} \tag{1.4}$$

$T_{m,t+1}$ is the total transfer from middle age individuals at t+1 to parents and children.

$$T_{m,t+1} = w_{m,t+1}(\phi_{t+1}n_t + \psi_{t+1}) \tag{1.5}$$

Where ϕ and ψ are the proportion of wage transfered to the individual's children and parents, respectively.

Similarly, $T_{o,t+2}$ is the transfer received from children when old.

$$T_{o,t+2} = \psi_{t+2}w_{m,t+2}n_t \tag{1.6}$$

Solve this maximization problem (proof in Appendix B), and get the optimal consumption at t+1 .

$$c_{m,t+1} = \frac{1}{1+\beta}[(1-\theta)w_{m,t+1} - T_{m,t+1} + \frac{T_{o,t+2}}{R_{t+2}}] \tag{1.7}$$

The first order condition with respect to n_t implies that

$$[log(\gamma)\frac{\partial q(n_t)}{\partial n_t}+\frac{v}{n_t}]R_{t+2}c_{m,t+1}+\frac{\beta}{1+\beta}R_{t+2}(-w_{m,t+1}\phi_{t+1})+\beta^2(\psi_{t+2}w_{m,t+2})=0 \tag{1.8}$$

Proposition 2: *Individuals with higher gender preference (larger γ) will want to have more children (larger n_t)*

From Equation 3.2, we can get an expression for $\frac{\partial n_t}{\partial \gamma}$ (proof in Appendix B),

$$\frac{\partial n_t}{\partial \gamma}=-\frac{\frac{1}{\gamma}\frac{\partial q(n_t)}{\partial n_t}}{\frac{\partial^2 q(n_t)}{\partial {n_t}^2}log(\gamma)-\frac{v}{n_t^2}}>0$$

As aforementioned, $q(n)$ is an increasing concave function of n, thus $\frac{\partial q(n)}{\partial n}>0$ and $\frac{\partial^2 q(n)}{\partial n^2}<0$. A boy-preferred family will have $\gamma>1$, and thus $log(\gamma)>0$. Besides, $v>0$ is parents' preference for children in general, thus $-\frac{v}{n^2}<0$. Putting together leads to $\frac{\partial n_t}{\partial \gamma}>0$. The positive relationship shows that individual with high γ will have a high n_t, that is, to have more children.

Hypothesis 2. When making fertility decisions, women with more neutral gender attitudes would prefer fewer children.

The Next section will show the empirical results for the two proposed hypotheses above. Section 1.4 shows the empirical result for Hypothesis 1 and Section 1.5 shows the empirical result for Hypothesis 2.

1.4 The Impact of the Family Planning Policy on Gender-specific Education Outcome

1.4.1 Data

The main data used in this section are from the 1% sample of the 2000 China population census, which incorporates basic demographic and educational information. I restrict the sample to *Han* individuals born during 1961-1981, which is 10 years before and after the implementation of the FPP in 1971. The 10-year period should be long enough to establish a trend that can be extrapolated into the post-FPP period. The upper bound is set at 1981 so that by the time the survey was conducted all the individuals in the sample are at least 18 or older, by which age an individual should have completed high school; Otherwise the sample would contain individuals who would complete high school but had not yet done it, and the effect of interest would be underestimated. The education outcome is measured by the schooling years based on individual's highest education degree. Table 1.2 shows the summary statistics of the sample.

Figure 1.3 displays the trends in education years for boys and girls of *Agricultural* (panel A) and *Non-Agricultural* (panel B) for the period 1955-1981. The lower panel shows that in 1955 *Agricultural* girls got less than 5 years' education, not even amounted to primary school degree (six years), while boys got more than 7 years' education. The education attainment experienced a downward trend in the middle of the 1960s due to the Cultural Revolution, in which period schools did not engage in normal teaching activities, but instead encouraged students to work on farm. The trends of boys and girls are quite parallel before the implementation of the FPP in 1971. Since the implementation of the FPP girls' education has grown faster. In the following ten years since 1971, boys' average education has increased to 9 years - equivalent to junior high school degree, and girls' education has risen to 8.7 years. The gender gap has been extensively narrowed. The same pattern can be observed on *Non-Agricultural* children. Boys got on average 10.7 years of education in 1955, and girls got 9.5 years. Since the implementation of the FPP in 1971, girls' educa-

tion has grown at a faster rate than boys. By 1981 the gender gap is barely noticeable.

The parallel pre-trends in the graph suggests that my estimation strategy should not pick up differential trends across groups. To examine the parallel trend assumption, I performed several trend checks in section 1.4.5.

Table 1.2: Descriptive Statistics

	Male					*Female*				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Han										
Agricultural										
Age	1,414,911	29.47	5.697	18	39	1,418,168	29.48	5.717	18	39
Education Years	1,414,911	8.276	2.315	0	19	1,418,168	7.376	2.628	0	19
Literacy	1,414,911	0.989	0.103	0	1	1,418,168	0.968	0.177	0	1
Household Size	1,414,911	3.838	1.570	1	25	1,418,168	3.996	1.520	1	25
Migration	1,414,911	0.123	0.329	0	1	1,418,168	0.165	0.371	0	1
Employment	1,414,911	0.963	0.188	0	1	1,418,168	0.879	0.326	0	1
Ever Married	1,414,911	0.732	0.443	0	1	1,418,168	0.840	0.367	0	1
First Marriage Age	1,036,342	22.57	2.584	13	39	1,191,335	21.23	2.401	13	39
Non-Agricultural										
Age	552,754	29.40	5.900	18	39	527,427	29.22	5.833	18	39
Education Years	552,754	11.85	2.803	0	19	527,427	11.41	2.749	0	19
Literacy	552,754	0.998	0.0437	0	1	527,427	0.997	0.0551	0	1
Household Size	552,754	3.129	1.490	1	22	527,427	3.250	1.433	1	22
Migration	552,754	0.271	0.445	0	1	527,427	0.288	0.453	0	1
Employment	552,754	0.789	0.408	0	1	527,427	0.684	0.465	0	1
Ever Married	552,754	0.672	0.469	0	1	527,427	0.759	0.428	0	1
First Marriage Age	371,481	24.36	2.735	13	39	400,056	22.84	2.449	13	39
Non-Han										
Age	187,668	28.79	5.825	18	39	174,782	28.78	5.823	18	39
Education Years	187,668	7.827	3.547	0	19	174,782	6.826	3.943	0	19
Literacy	187,668	0.949	0.219	0	1	174,782	0.879	0.326	0	1
Household Size	187,668	4.124	1.862	1	20	174,782	4.251	1.783	1	20
Migration	187,668	0.115	0.319	0	1	174,782	0.155	0.362	0	1
Employment Status	187,668	0.933	0.250	0	1	174,782	0.860	0.347	0	1
Ever Married	187,668	0.678	0.467	0	1	174,782	0.821	0.383	0	1
First Marriage Age	127,236	22.51	3.137	13	39	143,519	20.83	2.886	13	38

Note: The table reports the summary statistics by ethnicities, *Hukou* status and gender. The sample is restricted to individuals born during 1961-1981. Literacy, Migration, Employment and Ever Married are binary variables.

1.4.2 Identification Strategy(DID and DDD)

1. Difference in Difference
The assumption for identifying the causal effect of family size on gender-specific education is that if in absence of the FPP, the education attainment of *Han* boys and girls should have parallel trend over time. Hence, the identification for this paper comes from the exogenous changes in the number of children per family imposed by the FPP. This makes it possible to use a Difference-in-Difference identification strategy. Specifically, the identifying assumption underlying the DID estimator is that the change in education from before to after the treatment (the implementation of the FPP) would be the same in the treatment group (*Han* girls) as in the comparison group (*Han* boys), in the absence of treatment. The counterfactual mean education of *Han* girls in the post-FPP period is then $\mu_{g_1}^{DD} = \mu_{g_0} + (\mu_{b_1} - \mu_{b_0})$, where μ_g denotes the mean of girls, and μ_b the mean of boys. The mean impact estimate of the FPP is $\mu_{g_1} - \mu_{g_1}^{DD}$.

$$Y_{ist} = \phi_1 Girl_i + \phi_2 Post_t + \beta(Girl_i \times Post_t) + X'_{st} + P_s + F_t + \epsilon_{ist} \quad (1.9)$$

The outcome Y_{ist} is schooling years based on individual's highest education degree. $Girl_i$ is 1 if the individual is a female. $Post_t = 1$ if an individual is born in 1971 or later. X_{st} are controls including sex ratio and the number of primary school teacher at year t in prefecture s. P_s is birth prefecture fixed effect and F_t is birthyear fixed effect to control for all time-invariant differences between birth prefectures and changes over time that affect all individuals similarly.

One may wonder about sex-selection behaviors and its potential influence on the exogeneity of the gender of a child. Previous literature has looked at the ways sex ratio may have an influence on education outcome. For instance, Angrist (2002) observes that the sex ratio may affect the way marriage markets work and thus can have a differential impact on the education of men and women. A high sex ratio (more men than women) may make the marriage market more competitive for men, and thus incentivize them to improve their attractiveness by attaining higher

education. The opposite would happen for women because of a less competitive marriage market. Thus, we would expect the education level of men to increase and that of women to decrease. Another view argues the opposite: A high sex ratio will make the average education of girls higher because girls born during post-FPP period are more likely to be the surviving girls whose parents are themselves more progressive. In the context of China, the sex ratio was not strongly imbalanced until the 1980s. Figure 1.A2 plots the sex ratio during 1955-2000. It shows that the sex ratio remains between 1 and 1.07 before 1982. Given the natural rate of 1.06, it should not be interpreted as very aberrant. Recent papers such as Chen et al. (2013) and Lin et al. (2014) suggest that the availability of sex detection technology may have been the prominent cause for the increase of sex ratio in the 1980s. Nevertheless, to take sex ratio into account, I include the prefecture-year sex ratio in the regression.

Another factor I control for is the regional variation in education resources over time. I proxy the availability of regional education resources by the number of primary school teachers at the province-year level[7]. Before the 1990s, almost all the schools are public schools sponsored by the state, so the government education expenditures should be highly correlated with the number of teachers hired.

2. Difference in Difference in Difference(DDD)

As mentioned in the Section 1.2.1, the timing and the specifics of the FPP are different for *Han* and *Ethnic minority* groups. As a consequence, the impacts on family size of *Han* and *ethnic minority* groups are different, as shown in Figure 1.2b. This makes it possible to use a Difference-in-Difference-in-Difference strategy to examine whether the gender-specific effects are different for *Han* and for *ethnic minorities*. The underlying assumption is that if in absence of the FPP, the change in girls' education relative to boys' from before 1971 to after should be the same for *Han* and for *ethnic minorities*. θ in the equation 1.10 is thus the coefficient of interest.

[7]Data is from the National Bureau of Statistics in China

$$
\begin{aligned}
Y_{ist} =& \phi_1 Girl_i + \phi_2 Post_t + \phi_3 Han_i \\
&+ \beta_1(Girl_i \times Post_t) + \beta_2(Girl_i \times Han_i) + \beta_3(Han_i \times Post_t) \\
&+ \theta(Girl_i \times Han_i \times Post_t) + X'_{st} + P_s + F_t + \epsilon_{ist} \qquad (1.10)
\end{aligned}
$$

where *Han* $= 1$ if individual i belongs to the majority ethnic group *Han*, 0 if he/she belongs to other ethnic groups in China. All other variables are the same as Equation 1.9. θ is thus the coefficient of interest here.

Figure 1.2b shows that during the period 1971-1977, the average number of children ever born in *Agricultural* families has decreased from 6 to 3, in *Non-Agricultural* families from 3 to 1.7, and in *ethnic minority* families from 6 to 4. It suggests that though the FPP imposes the most strict birth quota on *Non-Agricultural Han*, given the already low fertility rate of *Non-Agricultural Han* women, the post-1971 FPP affects the *Agricultural Han* the most, less on *ethnic minorities*, and the least on the *Non-Agricultural Han*. In that event, we would expect the largest effect of the FPP on girls' education in *Agricultural Han*, less effect in*ethnic minorities* and the least effect in *Non-Agricultural Han*.

1.4.3 Results

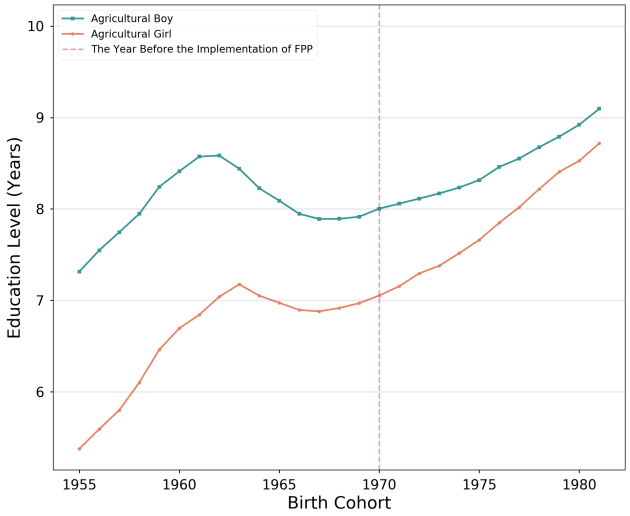
The Difference-in-Difference estimates from Equation 1.9 are shown in Table 1.3. The variable of interest here is $Girl_i \times Post_t$, which is the estimated mean impact of the FPP on girl's education. Take *Agricultural* as an example, the result in column (3) shows that from before to after the implementation of the FPP, boys' education increases by 1.025 years. The counterfactual mean of girls' education in the post-FPP period then should be $\mu_{g_1}^{DD} = \mu_{b_0} + 1.025 - 1.099$, while the actual mean of girls' education in the post-FPP period is 0.544 years more than the counterfactual. Similar result can be found in *Non-Agricultural.* The estimated mean impact of the FPP on girls is 0.383 years, all statistically significant at 1% level. The magnitudes of the point estimates of *Agricultural* and *Non-Agricultural* are quite similar.

Table 1.4 presents the regression results estimated by Equation 1.10. The significantly positive coefficient of $Girl_i \times Han_i \times Post_t$ in column (3) indicates that the effect of the post-1971 FPP on the education of *Agricultural Han* girls is significantly larger than that of *ethnic minority* girls, and the difference is sizable. The same coefficient in column (6) is negative, indicating that the effect of the post-1971 FPP on the education of *ethnic minority* girls is significantly larger than that of *Non-Agricultural Han* girls. The magnitudes of the effect on different groups are the same as expected: the largest effect happens in *Agricultural Han*, less effect in*ethnic minorities* and the least effect in *Non-Agricultural Han*.

These results are also economically significant. An increase in the mean implies either an increase in the education of previously education-deprived women, who would probably still get little education, if in absence of the FPP, or, an increase in the education of those who would otherwise have no chance to get into high education institutions, or, both. On the right tail, because of the FPP, there have been more women with junior or even senior high school degree, which will significantly increase their bargaining power on the labor and marriage market and improve labor participation. This finding may help to explain China's relatively high female labor participation rate among Asian countries[8] and contribute to China's fast economic growth in the 1990s. On the left tail, because of the FPP, there have been fewer illiterate women. This is particularly important to the intergenerational transmission of education. A large body of literature has found that mother's education is more closely related, than fathers', to children's welfare. Therefore, improvement in mother's education will have intergenerational effect on next generations. The narrowed gender gap in education will bring about long-lasting effect on the gender inequality in the society and on the economic growth.

[8]According to the Human Development Report by the United Nations, China's female labor participation rate is 72.7 in 1990 in contrast to 47.2 in Hong Kong, 47.1 in South Korea, 50.1 in Japan, and 50.7 in Singapore.

A. *Agricultural* Individuals



B. *Non-Agricultural* Individuals

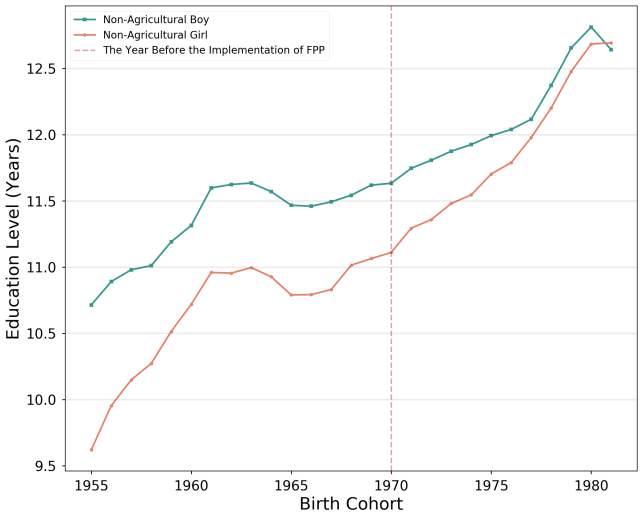


Figure 1.3: Years of Education by Gender

Note: This figure shows the schooling years of *Han* boys and girls born during 1955-1981, classified by *Agricultural* and *Non-Agricultural* based on their *Hukou* status. It shows that since the implementation of the Family Planning Policy in 1971 the education of girls has grown faster than boys and the gender gap in education has been narrowing. *Source:* 1% sample of the 2000 China population census

Table 1.3: Difference in Difference Result

	Agricultural			*Non-Agricultural*		
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.317***	1.051***	1.025***	0.584***	0.930***	0.895***
	(0.027)	(0.034)	(0.032)	(0.042)	(0.060)	(0.057)
Girl	-1.139***	-1.136***	-1.099***	-0.616***	-0.614***	-0.695***
	(0.040)	(0.040)	(0.076)	(0.033)	(0.033)	(0.041)
Post × Girl	0.513***	0.491***	0.544***	0.338***	0.357***	0.383***
	(0.024)	(0.019)	(0.021)	(0.024)	(0.021)	(0.024)
Additional Controls	No	No	Yes	No	No	Yes
Birth Year Effect	No	Yes	Yes	No	Yes	Yes
Birth Prefecture Effect	No	Yes	Yes	No	Yes	Yes
Observations	2,833,079	2,833,079	2,352,986	1,080,181	1,080,181	908,353
Adjusted R^2	0.047	0.145	0.152	0.025	0.091	0.096

Note: The table reports the effects of the Family Planning Policy on the education of girls. The sample is restricted to *Han* individuals born during 1961-1981. The dependent variable is an individual's schooling years. *Girl* and *Post* are binary variables for individual being a girl and born during the post-1971 period. Additional controls include quantiles of sex ratio at prefecture-year level and the number of primary school teachers at province-year level. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.4: Difference in Difference in Difference Result

	Agricultural			*Non-Agricultural*		
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.032	0.870***	0.900***	0.259***	0.568***	0.540***
	(0.055)	(0.046)	(0.044)	(0.069)	(0.076)	(0.075)
Girl	-1.370***	-1.347***	-1.181***	-0.678***	-0.687***	-0.843***
	(0.086)	(0.085)	(0.102)	(0.052)	(0.051)	(0.062)
Han	1.289***	0.478***	0.499***	-0.058	-0.256***	-0.292***
	(0.138)	(0.081)	(0.081)	(0.074)	(0.062)	(0.066)
Post × Girl	0.417***	0.396***	0.396***	0.579***	0.585***	0.600***
	(0.040)	(0.034)	(0.037)	(0.047)	(0.044)	(0.046)
Girl × Han	0.231***	0.210**	0.064	0.062	0.072	0.146***
	(0.087)	(0.085)	(0.083)	(0.050)	(0.049)	(0.050)
Post × Han	0.285***	0.186***	0.128***	0.325***	0.350***	0.343***
	(0.053)	(0.039)	(0.038)	(0.063)	(0.052)	(0.054)
Post × Girl × Han	0.095**	0.095**	0.149***	-0.241***	-0.227***	-0.216***
	(0.039)	(0.037)	(0.041)	(0.048)	(0.043)	(0.045)
Additional Controls	No	No	Yes	No	No	Yes
Birth Year Effect	No	Yes	Yes	No	Yes	Yes
Birth Prefecture Effect	No	Yes	Yes	No	Yes	Yes
Observations	3,123,398	3,123,398	2,616,073	1,150,897	1,150,897	973,925
Adjusted R^2	0.073	0.186	0.194	0.024	0.089	0.094

Note: The table reports the effects of the Family Planning Policy on the education of *Han* girls, compared to the effects on the *ethnic minority* girls. The sample is restricted to individuals born during 1961-1981. The dependent variable is an individual's schooling years. *Girl*, *Post* and *Han* are binary variables for individual being a girl, born during the post-1971 period, and belonging to the major ethnic group *Han*. Additional controls include quantiles of sex ratio at prefecture-year level and the number of primary school teachers at province-year level. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

1.4.4 Discussion

There are several possible channels through which the FPP may asymmetrically affect the education of male and female. This paper focuses on the two mechanisms derived from the theoretical model. First, through gender-specific Quantity-Quality tradeoff. A reduction in the number of children in a family makes all children in the family better off, and in particular it does good to previously resources-deprived girls. Second channel does not assume parents' altruism but assume that parents make decision in response to economic incentives. In societies with a lack of well-implemented social security and pension system, parents very often choose to invest in children to secure future income. In China, the old heavily rely on kinship transfer. Figure 1.4 displays the kinship income as a share of an individual's total income. It shows that kinship transfer is the major income source for people who are older than 65. This share increases as age grows. Therefore, children are seen as a main investment mean. Prior to the FPP, parents can choose from a larger set of children and decide which one to invest. The FPP limits parents' options. Many post-FPP parents invest in daughters due to lack of alternative options. An intuitive check would be to exploit the regional variation in the kinship income and examine its relations to parents' investment in education. Theoretically in places where the old rely more on kinship income, parents would be more sensitive to the family planning policy and the effect on girls' education would be larger. If one could find historical data on the kinship income prior to the setup of the social security system, or other exogenous variations in the parents-children dependency, it would be promising to provide more scientific evidence. Admittedly, other channels, such as through labor market, though not addressed in the theoretical framework, may also play a role. For instance, the FPP may affect the education of female by shifting women's fertility expectation. A school-aged girl in the post-FPP period may anticipate that she would bear and raise less children in future than the earlier cohorts and participate more in the labor market, which may incentivize her to invest more time in education. By this way the actual impact of the FPP may be even

larger because it also affects cohorts born before the FPP. If in absence of this channel, the education of the pre-FPP-born girls might be even lower. It is probably one of the reasons why we do not observe a sharp growth in girls' education right after the initiation of the FPP, but a smoother, though accelerating growth curve. Relating to the estimation of the FPP effect, this channel may have made the effect underestimated because the effect on the pre-FPP-born cohorts were not taken into account.

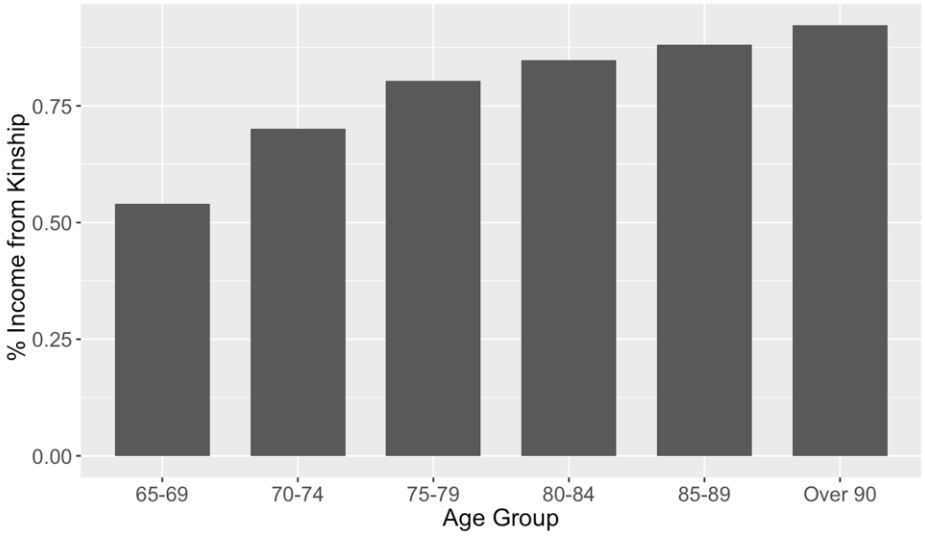


Figure 1.4: Share of Income From Kinship

Note: This figure displays the kinship income as a share of an individual's total income. It shows that kinship transfer is the major income source for people who are older than 65. This share increases as age grows.

Source: 1994 Chinese Household Income Project (CHIP).

1.4.5 Pre-trend Assumption Check

When the sample includes many years, the DiD model lends itself to a test for causality in the spirit of Granger (1969). Granger causality in my context would imply a check on whether, conditional on the sex of the

individual and birth cohort, past-born $Girl_i$ predicts growth in education achievement while future-born $Girl_i$ does not. If Family Planning Policy causes education achievement to grow faster but not vice versa, then pre-FPP cohorts should not matter in an equation like:

$$Y_{ist} = \gamma Girl_i + \sum_{\tau=1}^{m} \beta_{-\tau}(Girl_i \times d_{t-\tau}) + \sum_{\tau=1}^{q} \beta_{+\tau}(Girl_i \times d_{t+\tau}) + \sum_{\tau=1}^{T} v_\tau(X'_{st} \times d_\tau) + \theta_t + \delta_{Girl} \times \theta_t + P_s + F_t + \epsilon_{ist} \quad (1.11)$$

where it allows for m post-treatment effects ($\beta_{-1}, \beta_{-2}, \ldots, \beta_{-m}$) and q anticipatory effects ($\beta_{+1}, \beta_{+2}, \ldots, \beta_{+q}$). The year of 1971 is left as a comparison. In addition, I also include a linear time trend θ_t and a flexible girl-specific trend: $\delta_{Girl} \times \theta_t$. This is flexible because we allow potential pre-existing gender-specific trends with the assumption that pre-existing trends should be extrapolated into post- periods if in absence of the FPP. The identification will be validated if we observe a significant change in slope around the implementation of the FPP.

Figure 1.5 visualizes the year-by-year coefficients of $Girl_s \times d_{t-\tau}$ and $Girl_s \times d_{t+\tau}$, where the solid line connects the estimates and the capped lines indicate the 95% confidence intervals with standard errors clustered at the prefecture level. The upper panel shows that there is some growth in *Non-Agricultural* girls prior to the FPP, probably due to the early stage of the birth controls in the urban area in the 1960s. Nevertheless, the growth becomes much more substantial and significant in the post-FPP period. The lower panel shows that *Agricultural* girls born prior to the FPP have no predictive power to the later education growth if discounting the first two years. The effects show up immediately after the implementation of the FPP in 1971. As time passes and more new families become subject to the FPP, we may expect the effect to grow. The graph is consistent with this conjecture.

1.4.6 Alternative Measure of Education

One major potential confounding factor on the supply side of education might be the Nine-Year Compulsory Education policy which took effect in 1986. This policy aims to keep all school aged children (6-15 years old) in school for a minimum of nine years. The bill authorizes to reduce the cost of tuition and supplies in public school and targets a tuition-free nine-year education. To disentangle this supply-side effect from the demand-side effect induced by the FPP, I further examine the effect of the FPP on education attainment beyond nine years. One may be concerned that since government covers most of the education expenses up to ninth grade, parents could save the money to invest in education beyond nine years. However, this is unlikely to happen in China. The tuition fee saved from primary school and junior high is not comparable to the cost of senior high. According to a report by Rural Education Action Project (REAP), China has the highest tuition in the world on public senior high, nearly three times the world's second-highest tuition in Indonesia. It costs on average 1100 RMB (approx. 160 US dollars) per student per year in rural regions[9] and three years of high school tuition in rural China accounts for 82 percent of the net per capita income of rural people (NBS, 2008). Therefore, Continuing education beyond nine years is not simply a result of reallocating education budget. Instead parents need to make a serious investment decision and adjust family consumption and saving accordingly.

In estimation of the effect of the FPP on education attainment beyond nine years, I use the same specification as in the DID regressions with the outcome variable Y_{it} substituted by a binary value, equal to 1 if an individual has education beyond 9th grade, and 0 otherwise. Since the outcome is a discrete choice, I estimated the effect using both OLS and Logit model. Table 1.5 displays the regression results. A back-of-envelope calculation based on the Logit estimation shows that the chance of an *Agricultural* girl getting more than nine years' education, relative to *Agricultural* boy, is 1.52 times higher during the post-FPP period than

[9]This amount does not include costs such as housing and everyday living expenses.

during the pre-FPP period, and that of an *Non-Agricultural* girl is 1.2 times higher. It suggests that in the post-FPP period, parents are more likely to invest in daughter's higher education. The results here are consistent with the previous results using schooling years, implying that the previous result is not just picking up the effect from the Nine-Year Compulsory Education policy. In addition, the result implies that the observed improvement in girls' education takes place not only in basic education, but also in higher education, which is a necessary investment for females to participate in high-skilled labor market and an essential step to reduce gender inequality in the labor market.

1.5 Women's Fertility Preference and Gender Attitudes under Family Planning Policy

Economists have long considered the determinants of women's fertility decisions, because population growth is one of the fundamental drivers of economic growth due to its close relation to labor force participation. For instance, Fernandez and Fogli (2009) and Fernández and Fogli (2006) find that both personal experience and culture matter to a woman's fertility. In particular, Fernández and Fogli (2006) uses woman's number of siblings as a proxy of her direct family experience and finds it have a significant positive effect on her fertility. Nevertheless, previous literature seems to have not attempted to provide an explanation to this phenomenon – why women with more siblings would like more children, and likewise, women with less siblings would like fewer children. In this section, I will first examine whether the aforementioned relation (that is, woman's number of siblings and her fertility choice) holds in the context of China under the family planning policy, and then I will try to answer this question from the perspective of gender attitudes.

Table 1.5: Alternative Measure: Education Beyond 9th Grade

	Agricultural		*Non-Agricultural*	
	(1)	(2)	(3)	(4)
	OLS	Logit	OLS	Logit
Post	0.109***	1.167***	0.206***	1.155***
	(0.005)	(0.048)	(0.006)	(0.048)
Girl	-0.056***	-0.789***	-0.073***	-0.331***
	(0.003)	(0.045)	(0.008)	(0.034)
Post × Girl	0.023***	0.419***	0.044***	0.172***
	(0.002)	(0.019)	(0.004)	(0.015)
Additional Controls	Yes	Yes	Yes	Yes
Birth Year Effect	Yes	Yes	Yes	Yes
Birth Prefecture Effect	Yes	Yes	Yes	Yes
Observations	2,352,986	2,352,976	908,353	908,353
Adjusted(Pseudo) R^2	0.042	0.069	0.079	0.064

Note: This table reports the effects of the Family Planning Policy on girls with an alternative measure of education. The dependent variable is whether an individual has more than nine years' education. The sample is restricted to *Han* individuals born during 1961-1981. *Girl* and *Post* are binary variables for individual being a girl and born during the post-1971 period. Additional controls include quantiles of sex ratio at prefecture-year level and the number of primary school teachers at province-year level. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

1.5.1 Data

The data I use in this section are from China Family Panel Studies (CFPS), funded by the 985 Program of Peking University and carried out by the Institute of Social Science Survey of Peking University. The baseline data were collected in 2010 and were followed up in 2012 and 2014. One advantage of this data is that its questionnaire includes plentiful questions on attitudes and perceptions, which enables me to pinpoint the underlying views that might drive the observed phenomenon.

I restrict the ages of individuals in the sample to be older than 32, at which ages the family structure has very likely been determined[10]. Moreover, I restrict the upper age limit at 58, because older cohorts are not affected by the One Child Policy. I regress woman's fertility choice with regard to whether to have more than one child on the number of her siblings, and I find a strong positive relationship even after controlling for many of her personal characteristics, including her age, education level, *Hukou* status (*Agricultural* or not), the sex of her first child and birth year and birth fixed effects. Figure 1.6 visualizes the fitted probability to have more than one child against number of siblings after controlling for personal characteristics. The regression result is in Table 1.A1. This piece of evidence suggests that the effect of FPP in reducing family size is multiplying —a policy-directed decrease in the number of children in a family may produce a shrink in family size greater than the intended reduction. This finding may be of particular interest to countries that are concerned with population growth.

1.5.2 Identification and Result

As discussed earlier, the FPP reduces family size and especially benefits girls with resources acquisition. Compared to the older cohorts, post-FPP girls have more opportunities and are less likely to have been mistreated for gender reason in the process of growing up. In other words, by re-

[10]previous study (Fu et al.,2013) has documented that more than 75% of women in China choose to have a second child before age 32.

ducing the number of children, the FPP creates a fairer environment as a byproduct, making the competition between boys and girls more equal. It is worth noticing that this is also a critical period when girls shape their values and attitudes. A fairer environment may help reverse the traditional mindset of male superiority. In addition, because the FPP has larger impact on girls and because *"privilege is usually invisible to those who have it"*, we will expect a larger change in girls' gender attitudes than in boys'.

I use son preference as a proxy of gender attitudes. The CFPS survey contains a relevant question *"How much do you agree with the statement 'A family must have at least one son'?"*. Respondents then answer on a 1 to 5 scale with 1 representing *"I do not agree at all"* and 5 representing *"I completely agree"*. I then examine the difference in the gender attitudes between male and female before and after the implementation of the FPP using a similar specification as in Equation 1.9:

$$Y_{ist} = \phi_1 Girl_i + \phi_2 Post_t + \beta(Girl_i \times Post_t) + X'_{st} + P_s + F_t + \epsilon_{ist} \quad (1.12)$$

Where Y_{ist} is individual's answer to the question on son preference. $Post_t = 1$ if an individual is born in 1971 or later. X'_{st} includes individual's age, education level, *Hukou* status (*Agricultural* or not). P_s and F_t indicate province and year fixed effects to control for all time-invariant differences between provinces and changes over time that affect all individuals similarly.

The results are presented in Table 1.6. It shows that since the implementation of the FPP in 1971 changes in females' son preferences are more pronounced than in that in males'. Figure 1.7 plots the time trends of the son preferences of males and females. It shows that pre-1971-born males and females do not differ in son preference, and post-1971-born males do not show significant changes in son preferences while that of females show an accelerating decline. As a result, post-FPP born females period has a more neutral and unbiased gender attitudes. The Multinomial Logistics regression result in TABLE 1.A2 reveals that during the post-FPP period more women than men change their gender attitudes to 1 or 2 (*"I do not agree at all"* or *"I do not agree most of the time"*). This finding suggests that Family Planning Policy has positive effects in changing

gender attitudes, though mostly on females. Still, it implies that gender attitudes in a society is not immutable and it can be changed by creating a fairer growing environment for boys and girls and by freeing women from excessive fertility and child care. It is reasonable to believe that changes in women's gender attitudes will eventually change the gender attitudes of the whole society.

Table 1.6: DID Regression Result on Gender Attitudes

	(1)	(2)
Post	0.050	-0.047
	(0.045)	(0.134)
Female	-0.112***	-0.121***
	(0.030)	(0.032)
Post × Female	-0.291***	-0.285***
	(0.051)	(0.048)
Controls	Yes	Yes
Birth Year and Birth Place FE	No	Yes
Observations	18,592	18,592
Adjusted R^2	0.136	0.189

Note: This table reports the DID Regression results for gender attitudes. Individuals answer on a 1 to 5 scale how much they agree with the statement *"A family must have at least one son"*. 1 represents *"I do not agree at all"*, and 5 represents *"I completely agree"*. *Post* is equal to 1 if an individual is born in the post-FPP period. The result shows that women have changed more in gender attitudes than men in the post-FPP period. The controls include an individual's age, education level, *Hukou* status (*Agricultural* or not). Standard errors in parentheses are clustered at the province level: * significant at 10%; ** significant at 5%; *** significant at 1%

1.6 Conclusion

Parental investment in children can be gender-specific. This paper looks at how family planning policy can, by reducing the number of children in a family, make parental investments more gender-insensitive and improve girls' education as an outcome. Also, it shows that family planning policy can have long-term impact in changing women's fertility and positive impact in changing gender attitudes.

The theoretical model in this paper lies its foundation on Becker and Lewis's framework that *quantity* and *quality* of children might be inversely related to each other. Instead of assuming that parents' resources are equally shared by every child in a family, my model considers parents' gender preferences in making investment decision and shows how a reduction in the number of children in a family can benefit girls more in the presence of son preference.

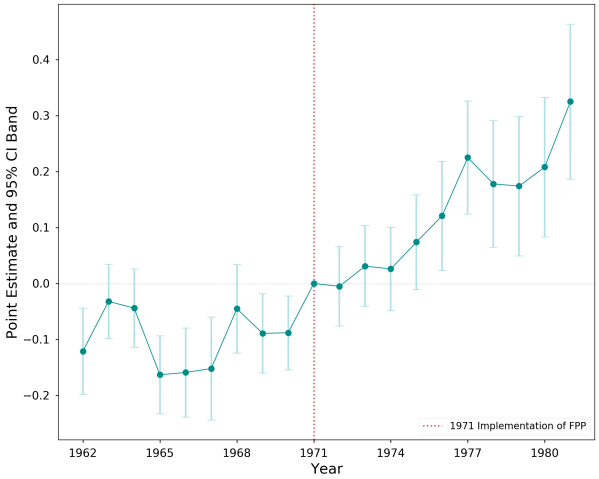
Using the family planning policy in China since 1971 as an exogenous negative shock to the family size, I use difference-in-difference strategy to compare the changes in girls' schooling years to that of boys in the period of 1961-1981. I find that while post-FPP-born children generally stay in school longer, this effect is particularly stronger for girls. This finding is robust to (1) using diff-in-diff-in-diff strategy by incorporating another dimension of variations — different fertility constraints imposed by the FPP on the ethnical majority *Han* and the minorities; (2) using a different measure of education outcomes — probability of continuing education beyond the compulsory education period. In addition, I document that FPP also has an impact in changing women's preference for family size and gender attitudes. Post-FPP-born women show a more pronounced change in gender attitudes and exhibit less son preference than men.

As children are seen as a main investment mean, many post-FPP parents invest in daughters because of a reduction in alternative options. This reduction in options leads to a shift in the role of daughters from being neglected to a pillar of the household who should be responsible to parents. In this way FPP will create incentives for parents to invest in daughters. As post-FPP girls have more equal opportunities and are less likely

to have been mistreated for gender reason in the process of growing up, girls will be more inclined to reverse the traditional mindset of male superiority. Though FPP seems to have a positive effect in changing the gender attitudes of females only, it is reasonable to believe that changes in women's gender attitudes will eventually change the gender attitudes of the whole society.

This paper reports some of the previously overlooked social benefits of family planning policy in respect of improving female education and reducing son preference. By these means family planning policy may help direct more human capital investment to women and make a contribution to economic growth. The findings will have significant policy implications for societies with a high fertility rate and a dominant gender preference. Identifying and quantifying how human capital investment in women can translate into economic growth seems like promising revenues for future research.

A. *Non-Agricultural*



B. *Agricultural*

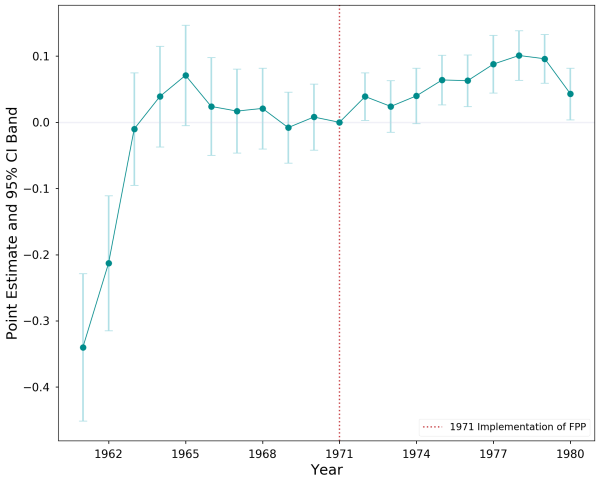


Figure 1.5: Coefficient Plot of $Girl_s \times d_t$

Note: This figure plots the year-by-year coefficients of $Girl_s \times d_t$ as specified in Equation 1.11. the solid line connects the estimates and the capped lines indicate the 95% confidence intervals with standard errors clustered at the prefecture level. The upper panel shows that there is some growth in *Non-Agricultural* girls prior to the FPP, probably due to the early stage of the birth controls in the urban area in the 1960s. The growth becomes much more substantial and significant in the post-FPP period. The lower panel shows that *Agricultural* girls born prior to the FPP have no predictive power to the later education growth if discounting the first two years. The effects appear immediately after the implementation of the FPP in 1971.

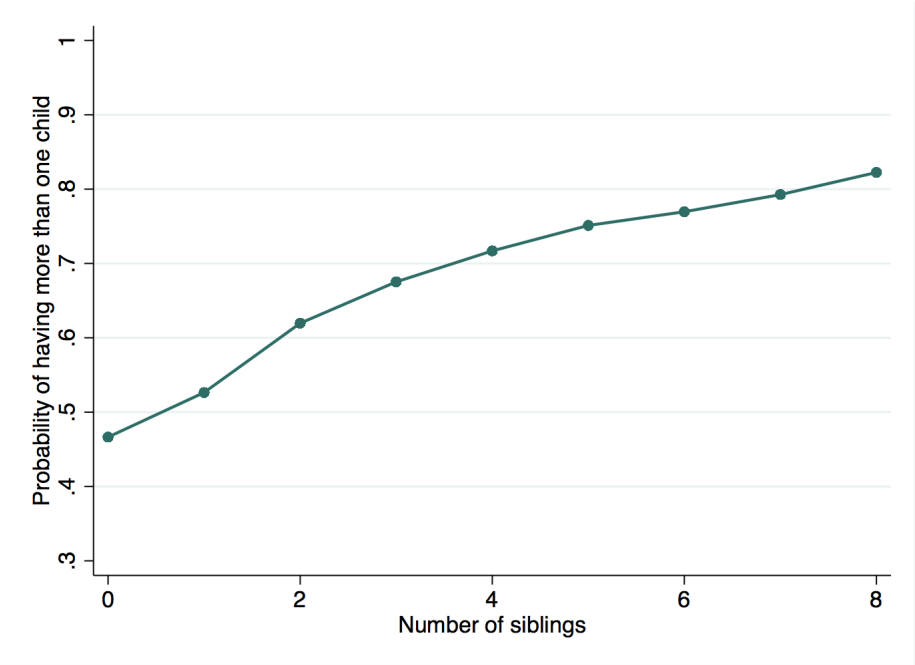


Figure 1.6: Women's Fertility Choice

Note: The figure shows a positive relationship between woman's number of siblings and her fertility, even after controling for the individual's age, education level, *Hukou* status (*Agricultural* or not) and the sex of her first child and clustering the standard errors at the province level. The regression result can be found in Table 1.A1.
Source: CFPS 2014

Figure 1.7: Son Preference of Male And Female over Time
Note: This figure plots the average son preference across birth cohorts by gender. It shows that male and female do not have distinguishable differences in son preference until the implementation of the FPP in 1971. During the post-FPP period females' son preference declines more than males'. Consequently, females possess significantly weaker son preference than males. *Source:* 2014 China Family Panel Studies (CFPS)

A Additional Tables and Figures

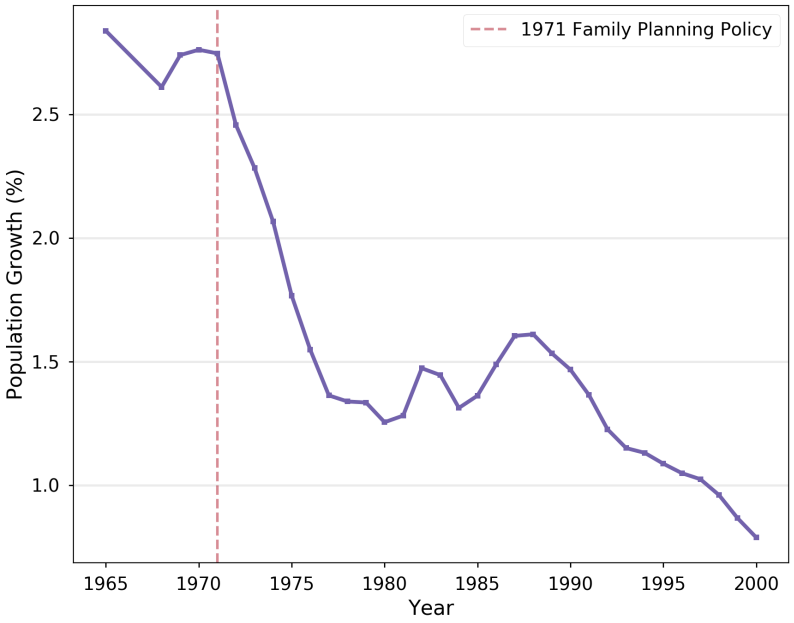


Figure 1.A1: Population Growth

Note: This figure shows the population growth from 1965 to 2000. The population growth in China has greatly slowed down since the start of the family planning policy in 1971.

Source: The statistics from 1968 to 2000 is from the World Bank. The statistic for 1965 is from the 2015 China Health and Family Planning Policy Statistics Yearbook.

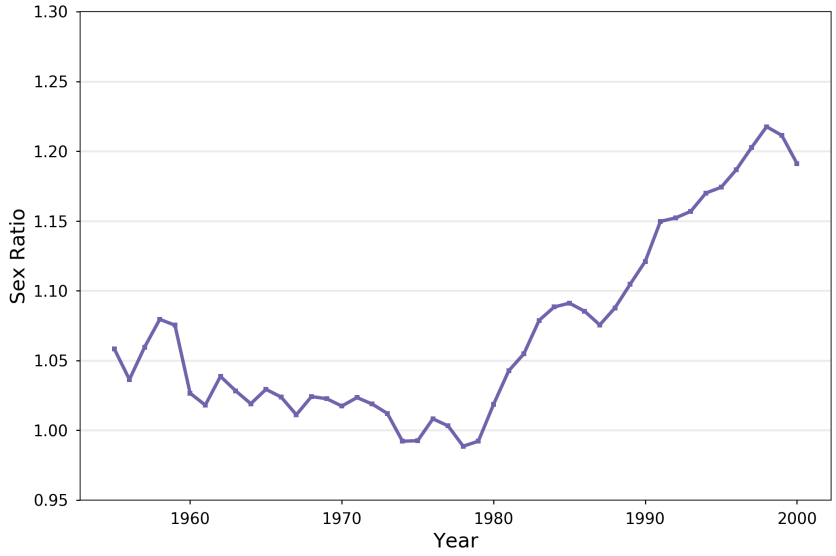


Figure 1.A2: Sex Ratio Over Time

Note: This figure depicts the sex ratio over time. It is calculated as $\frac{Number\ of\ male}{Number\ of\ female}$. The data are from the 1% sample of the 2000 China population census. It shows that the sex ratio remains between 1 and 1.07 before 1982. Given the natural rate of 1.06, it should not be interpreted as very aberrant. The sex ratio becomes more skewed with the introduction of ultrasonic fetal sex diagnosis in the 1980s.
Source: 1% sample of the 2000 China population census.

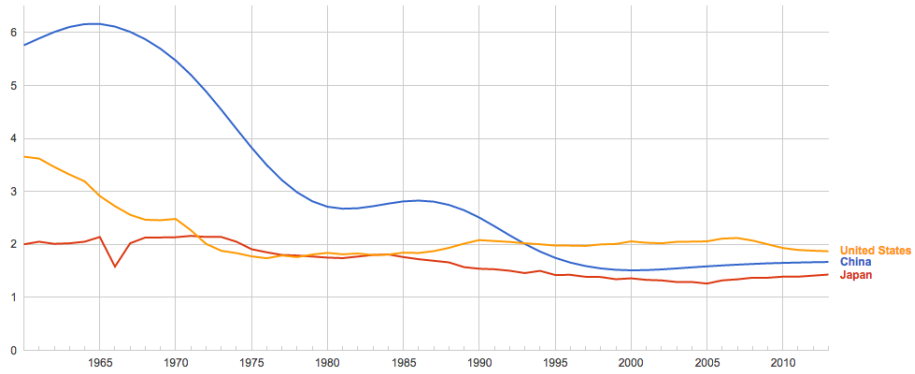


Figure 1.A3: Total Fertility Rate (TFR)

Note: This figure depicts the total fertility rate (TFR) by China, the US and Japan. The TFR is defined as the number of children who would be born per woman if she were to pass through the childbearing years bearing children. The stable TFR of the US and Japan in the 1970s constitute a contrast to the big drop in China, implying that the reduction of family size in China since the 1970s is not simply a world trend, but a consequence of the family planning policy. *Source:* The World Bank

Table 1.A1: Number of Siblings and Fertility Decisions

D.V.=1 if individual has more than one child	(1)	(2)
Number of siblings	0.0345***	0.0166***
	(6.56)	(3.95)
Observations	7475	7332
Controls	No	Yes
Birth Year FE	Yes	Yes
Birth Place FE	Yes	Yes

Note: This table shows a positive relationship between the number of an woman's sibilings and her fertility decisions regarding whether to have more than one child. TIndividual's age in the sample are restricted between 32 and 58. Controls include age, education level, *Hukou* status (*Agricultural* or not) and the sex of her first child. Standard errors in parentheses are clustered at the province level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 1.A2: Multinomial Logistics DID Regression Results on Gender Attitudes

	(1)	(2)
1		
Post	-0.033	-4.468
	(0.104)	(7.528)
Female	0.286***	0.301***
	(0.054)	(0.063)
Post × Female	0.509***	0.555***
	(0.084)	(0.091)
2		
Post	-0.239**	-5.856
	(0.113)	(8.551)
Female	0.092	0.132*
	(0.072)	(0.078)
Post × Female	0.385***	0.391***
	(0.096)	(0.091)
3		
Post	-0.144**	-3.025
	(0.067)	(7.472)
Female	-0.055	-0.033
	(0.084)	(0.084)
Post × Female	0.217*	0.227**
	(0.113)	(0.114)
4		
Post	-0.173**	-0.307
	(0.087)	(7.492)
Female	-0.026	-0.004
	(0.075)	(0.075)
Post × Female	0.193**	0.187**
	(0.093)	(0.089)
Controls	Yes	Yes
Birth Year and Birth Place FE	No	Yes
Observations	18,592	18,592
Pseudo R^2	0.049	0.078

Note: This table reports the Multinomial Logistics DID Regression results on males' and females' gender attitudes before and after the implementation of the FPP in 1971. Individuals answer on a 1 to 5 scale how much they agree with the statement *"A family must have at least one son"*. 1 represents *"I do not agree at all"*, and 5 represents *"I completely agree"*. The result shows that post-OCP born women are more likely than men to choose 1 - *"I do not agree at all"* or 2 - *"I do not agree most of the time"*, implying that from before to after the implementation of the FPP women have changed more than men in gender attitudes. The controls include an individual's age, education level, *Hukou* status (*Agricultural* or not). Standard errors in parentheses are clustered at the province level: * significant at 10%; ** significant at 5%; *** significant at 1%

B Mathematical Appendix

Proof of Equation 1.2: $\frac{\partial}{\partial n}\big[f^{edu}(t_{cs}, e_{pi}) - f^{edu}(t_{cd}, e_{pi})\big] > 0$

$$\begin{aligned}\frac{\partial}{\partial n}\big[f^{edu}(t_{cs}, e_{pi}) - f^{edu}(t_{cd}, e_{pi})\big] &= \frac{\partial f^{edu}(t_{cs}, e_{pi})}{\partial t_{cs}}\frac{\partial t_{cs}}{\partial n} - \frac{\partial f^{edu}(t_{cd}, e_{pi})}{\partial t_{cd}}\frac{\partial t_{cd}}{\partial n} \\ &= \underbrace{\big[\frac{\partial f^{edu}(t_{cs}, e_{pi})}{\partial t_{cs}} - \frac{\partial f^{edu}(t_{cd}, e_{pi})}{\partial t_{cd}}\big]}_{(1)}\underbrace{\frac{\partial t_{ci}}{\partial n}}_{(2)}\end{aligned}$$

$(1) < 0$ because of the concavity of $f^{edu}(t_{ci}, e_{pi})$ and $t_{cs} > t_{cd}$
$(2)\frac{\partial t_{ci}}{\partial n} = -\frac{\delta}{n^2}t_c < 0$
Therefore $\frac{\partial}{\partial n}\big[f^{edu}(t_{cs}, e_{pi}) - f^{edu}(t_{cd}, e_{pi})\big] > 0$

Utility Maximization Problem in Equation 2.1
Substituting Equation 1.4 into the three constriants,

$$\begin{aligned} c_{y,t} &= w_{y,t} + \theta\tfrac{w_{m,t+1}}{R_{t+1}} \\ a_{m,t+1} &= (1-\theta)w_{m,t+1} - c_{m,t+1} - T_{m,t+1} \\ c_{o,t+2} &= R_{t+2}[(1-\theta)w_{m,t+1} - T_{m,t+1} - c_{m,t+1}] + T_{o,t+2} \end{aligned} \tag{B1}$$

The F.O.C with respect to $c_{m,t+1}$ gives the relationship between $c_{m,t+1}$ and $c_{o,t+2}$:

$$c_{o,t+2} = \beta R_{t+2} c_{m,t+1} \tag{B2}$$

Equation (B1) and (B2) together can pin down the consumption at period t+1 and get the Equation 1.7:

$$c_{m,t+1} = \frac{1}{1+\beta}[(1-\theta)w_{m,t+1} - T_{m,t+1} + \frac{T_{o,t+2}}{R_{t+2}}]$$

The F.O.C with respect to n gives:

$$log(\gamma)\frac{\partial q(n)}{\partial n} + \frac{v}{n} + \frac{\beta}{c_{m,t+1}}\frac{\partial c_{m,t+1}}{\partial n} + \frac{\beta^2}{c_{o,t+2}}\frac{\partial c_{o,t+2}}{\partial n} = 0$$

Where $\frac{\partial c_{m,t+1}}{\partial n} = \frac{1}{1+\beta}(-w_{m,t+1}\phi_{t+1})$, and $\frac{\partial c_{o,t+2}}{\partial n} = \psi_{t+2}w_{m,t+2}$.
Substitute $c_{o,t+2}$ from equation (B2) and rearrange to get Equation 3.2:

$$[log(\gamma)\frac{\partial q(n)}{\partial n}+\frac{v}{n}]R_{t+2}c_{m,t+1}+\frac{\beta}{1+\beta}R_{t+2}(-w_{m,t+1}\phi_{t+1})+\beta^2(\psi_{t+2}w_{m,t+2}) = 0$$

Proof of Proposition 2
To examine the relationship between a family's gender preference and the number of children to bear, take the first difference w.r.t γ on Equation 3.2,

$$vR_{t+2}c_{m,t+1}[\frac{1}{\gamma}\frac{\partial q(n)}{\partial n} + log(\gamma)\frac{\partial^2 q(n)}{\partial n^2}\frac{\partial n}{\partial \gamma} - \frac{v}{n^2}\frac{\partial n}{\partial \gamma}] = 0$$

Then,

$$\frac{\partial n}{\partial \gamma} = -\frac{\frac{1}{\gamma}\frac{\partial q(n)}{\partial n}}{\frac{\partial^2 q(n)}{\partial n^2}log(\gamma) - \frac{v}{n^2}}$$

As aforementioned, $q(n)$ is an increasing concave function of n, thus $\frac{\partial q(n)}{\partial n} > 0$ and $\frac{\partial^2 q(n)}{\partial n^2} < 0$. A boy-preferred family will have $\gamma > 1$, and thus $log(\gamma) > 0$. Besides, $v > 0$ is parents' preference for children in general, thus $-\frac{v}{n^2} < 0$. Putting together,

$$\frac{\partial n}{\partial \gamma} > 0$$

Chapter 2

INTERGENERATIONAL MOBILITY IN CHINA ACROSS SPACE AND TIME

2.1 Introduction

Socioeconomic inequality is one of the most important challenges facing a modern society, and socioeconomic inequality has been closely associated with economic efficiency and growth[1]. One of the key mechanisms for alleviating inequality is intergenerational mobility – a child's chance of moving up in the socioeconomic distribution relative to her parents. Although many previous works have documented and compared the level of intergenerational mobility across countries (see Black and Devereux, 2010; Björklund and Salvanes, 2011; Corak, 2013, for reviews), we know little about where intergenerational mobility comes from (Chetty et al., 2014b).

Is a person's chance of success the same everywhere in a country? Why do we observe intergenerational mobility to be higher in some places and lower in other places? In this paper, to understand what drives the regional differences in China in intergenerational mobility, I focus on within-country comparisons of intergenerational mobility across regions. At the heart of the argument is the idea that aspiration—one's desire to move upward—may differ across space, and aspiration could be transmitted from one generation to the next. Thus, spatial differences in the local aspiration level could lead to the persistence of spatial variations in intergenerational mobility. In addition, perceived return to education may also have an impact on intergenerational mobility, and this impact may vary across aspiration levels.

In this paper, I use the 1% sample of the 1982, 1990 and 2000 China population censuses to characterize the features of education- and occupation-based intergenerational mobility within China across prefectures[2] and among cohorts of Chinese children born between 1949 and 1977. Next, using the historical bureaucrats' selection exam in ancient China as an exogenous shock to the historical local aspiration level, I investigate the role of aspi-

[1] See, for instance, Forbes (2000); Aghion et al. (1999); Benabou (1996); Alesina and Rodrik (1994); Perotti (1996, 1994, 1992); Persson and Tabellini (1994).etc

[2] Prefectural-level cities form the second level of the administrative structure in China, equivalent to metropolitan areas in the United States.

ration in determining persistent cross-space variations in intergenerational mobility. In addition, exploring the regional variations in the victims of the anti-intellectual movement (the Cultural Revolution) in China during the 1970s, I examine the impact of the drop in return to education on intergenerational mobility and how aspiration amplifies this impact.

Following previous literature (e.g. Hertz et al., 2007; Chetty et al., 2014b), I begin by estimating the intergenerational correlation of education by regressing a child's education on her parents' education. I argue that education is the most relevant category for transmission of wealth in the context that I study – China in the 20th century. I restrict the age of individuals in the sample to be older than 23, at which age individuals should have completed university. Additionally, to mitigate concerns about changing distributions of education across time distorting the comparisons of mobility across cohorts, I measure educational attainment using a child's education rank in the national distribution within her birth cohort, as well as her most educated parent's rank among the parents in that cohort.

My data is from the 1% samples of the 1982, 1990 and 2000 China Population Censuses, which are based on co-resident households. Co-residency, as pointed out in previous literature (e.g. Deaton, 1997; Emran et al., 2017), is a major challenge in estimating intergenerational mobility because co-resident-based data often suffers from truncation. Nevertheless, the 1% samples from population censuses are believed to yield more precise estimates than household surveys. I argue that the co-resident-based truncation is not a critical issue to the research questions studied in this paper. My results are most likely to be biased downward by the truncation. When estimating the intergenerational mobility, individuals with less education, compared to those with more education, are more likely to stay with their parents. For this reason, individuals with less education are more likely to be observed in the sample. Thus, the estimated mobility, which is based on co-habiting parents and children, should be an underestimate of the actual mobility. Moreover, individuals born and raised in places with a high social aspiration environment may be more likely to seek higher education and move out of their parent's house to big cities.

Therefore, the actual effect of the local aspiration environment on social mobility should be more than the estimated effect using the co-resident-based data in this paper.

I do several things to partially alleviate the sample selection problem raised by truncation. First, I use individuals who are between 23 and 33 years old in each census, because in China individuals in this age range are still likely to live with their parents[3]. I compare the demographic characteristics (e.g. education, living in urban/rural place, household registration type(*Hukou*) of individuals who live with their parents and individuals who live alone, and the between-group differences are not numerically large. Second, I use multiple methods to measure intergenerational mobility. In addition to the main measure of upward mobility (a binary variable indicating whether children's education rank exceeds their parents'), I use alternative measures, including the conventional intergenerational regression coefficient (IGRC) and the intergenerational correlation (IGC). Previous work(Emran et al., 2016) has shown that the selection bias in the IGC, compared to the IGRC, is much smaller, and is less sensitive to the co-residency rate. All three measures yield consistent and similar results.

I find that the regression coefficients of parents' education as a predictor of children's education attainment increased from, on average, 0.20 in 1982 to 0.27 in 1990 and to 0.33 in 2000. For the country as a whole, the magnitude of the estimates for 1982 and 1990 are considered low—comparable to Scandinavian countries where societies are considered more equal. The magnitude of the estimate for 2000 is similar to those of the United States and the United Kingdom, ranked in the middle among countries with documented intergenerational correlation coefficients (Black and Devereux, 2010). The findings suggest that social mobility in China is not immutable and that the education disparity of children of low and high education parents is increasing: the upward mobility of children of low education parents is decreasing.

In the spatial analysis, I characterize the spatial differences in inter-

[3]The co-residency rate is roughly 40% for the 23- to 32-year-old cohorts according to the Population Census and the World Value Survey in 1995. This rate drops to 30% if the upper age limit is extended to 43.

generational mobility across China. I focus on the relative mobility rate, which is 100 times the regression coefficient. I find that the upward mobility of the 1949—1959 birth cohorts is, on average, 1.16 times larger than that of the 1957—1967 and 1967—1977 birth cohorts. Over time, the average upward mobility rate is decreasing, suggesting again that social stratification in China has become more consolidated since the 1980s and that climbing up the social ladder has become more difficult. Likewise, the standard deviation is also getting larger, implying that the spatial disparity of upward mobility is persistent and even intensifying. Geographically, upward mobility exhibits substantial variations across and within regions. Western China shows lower upward mobility than the eastern regions. The east-west spatial disparity disappears after controlling for province fixed effects. However, great within-province variations remain.

Next, I ask why mobility may vary across space and where the differences come from. The previous literature identified a set of possible correlates: segregation, income inequality, school quality, family structure, social capital (Chetty et al., 2014a), investments in infrastructure, railroads and roads, democracy and religion (Cogneau et al., 2007) and others. In addition, a growing body of literature is studying the association of social inequality and poverty traps with psychological constraints. For example, Banerjee and Mullainathan (2010) and Bernheim et al. (1999, 2015) find that in some situations poverty is due to lack of self-control. Mani et al. (2013) finds that poverty impedes cognitive functions through stress.

Inspired by this literature and the aspiration-based theory of poverty traps (Gilboa and Schmeidler, 1995; Genicot and Ray, 2009; Dalton et al., 2016; Genicot and Ray, 2017), I extend the theoretical model in Genicot and Ray (2017), in which they examine the relationship between an individual's aspiration and inequality. Specifically, I incorporate the local aspiration environment in the process of forming aspiration, so that an individual's aspiration is determined by her local aspiration environment, her own education and the education distribution of the society. The local aspiration environment then enters, through aspiration, the individual's utility function and affects her utility maximization decision. The model

implies that places with a high social aspiration environment should have high upward mobility. My model also delivers two new predictions. First, individuals who are located in the low-to-middle quintiles in the education distribution should be influenced by the local aspiration environment the most. Second, the perceived return to education should have an impact on determining upward mobility, and this impact should be intensified by the local aspiration environment. Thus, in an environment with more aspiration, an individual's upward mobility should be more responsive to changes in the perceived return to education.

To empirically test the impact of the aspiration environment on social mobility, ideally one needs an exogenous shock to the aspiration environment. In the third section of this paper, I exploit a plausibly exogenous event that determined the local aspiration level—the success rate on the entry-level *Keju* exam since the 14th century in imperial China. The *Keju* exam is a meritocracy-based examination system established by the feudal rulers during the imperial period to select bureaucrats. The system was initially established in 605 during the Sui Dynasty and survived until 1905 in the Qing Dynasty. The *Keju* examination system has a long-lasting impact on local aspiration, because the gentry were the most honored and usually the wealthiest class in China, and the *Keju* exam was the sole gateway to the gentry class, as well as to the associated great social prestige and wealth. As a consequence, for more than one thousand years the highest ambition of every Chinese men was to pass one or more of the examinations and enter the gentry class (Ho, 1962; Liu, 2016; Bai and Jia, 2016).

My analysis uses the prefecture-level variations in the success rate in the entry- level exam, which, as I argue, are quasi-exogenous. More specifically, the success rate in each prefecture was governed by the quota assigned by the feudal ruler, and the quota assignment was based on the size and population of the prefecture in the 14th century. The quota did not change over time and did not respond to changes in the population or development in a prefecture. The data for the quotas comes from the Imperially Established Institutes and Laws of the Great Qing Dynasty (Kun et al., 1991).

One identification challenge is the possible endogeneity problem of the *Keju* exam quota allocation. As the quotas assigned in the 14th century were mainly dependent on the size and the population of each prefecture, it is natural to think that more populated places might be fundamentally different from those that were not. In this way, variations in the quota would capture only time-invariant differences across historical prefectures. I test this possibility by examining the relationship between the population and the assigned quota at the prefecture level. As expected, there is an obvious positive relationship in the 14th century when the quotas were initially assigned. Nonetheless, this positive relationship disappeared in the late Qing period. This evidence suggests that the quota neither predicted nor stimulated local development or growth. Next, I use the massive adjustment and restructure of administrative divisions in China since 1949 to dilute additional prefecture-specific characteristics. During the restructuring process, the boundaries of numerous prefectures changed. If any historical prefecture-specific characteristics persist to today, they should have been diluted to a considerable extent during the restructuring of contemporary prefectures. To match historical prefecture-based quotas to contemporary prefectures, I divide the quotas by the population in each county in the 19th century and then aggregate them to the contemporary prefecture level by a weighted average.

In the end, for the cohorts examined in this study, I find that the *Keju* exam quota has the strongest effects on the youngest cohorts (1967—1977), some moderate effects on the oldest cohorts (1949—1959) and no effects on the intermediate cohorts (1957—1967). An alternative specification with the data aggregated at the county level yields similar results. On average, one standard deviation increase in the exam quota increases mobility by about 1.5 percentage points, an approximate 23% standard deviation of mobility. In addition, consistent with the model predictions, I find that in places with higher quotas, parents with elementary education, who are located in the bottom-to-middle quintiles in the education distribution, are more likely to be motivated by the quota and to set higher aspiration. Thereafter, the next generation is more likely to achieve upward mobility.

Finally, to test the impact of the perceived return to education and

how this impact may vary across the aspiration environment, I exploit the severity of the political persecutions during the anti-intellectual movement (the *Cultural Revolution*) to measure the perceived return to education. During the 1966—1976 *Cultural Revolution* period, intellectuals, scholars and educated youth were targeted and persecuted as objects of class warfare. Higher education was associated with high political risk. Thus, return to education was perceived to be low in places where persecutions were severe. In particular, I use the number of victims per one thousand population in a prefecture as the proxy for the perceived drop in return to education[4]. I then look at the main effect of victims and the interaction effect of victims and the exam quota on upward mobility. The result shows that one standard deviation increase in victims decreases the upward mobility rate by 1.6 percentage points, about 4% of the standard deviation. The interaction effect of victims and the quota magnifies the victims' main effect by 4 times. I then perform the same exercise on the 1949—1959 and 1957—1967 cohorts and use the exercises as placebo tests. I find that the effect exists only for the 1967—1977 cohorts, implying that the spatial variations in the number of victims not only captures province differences but also reflects the severity of the political persecution.

This paper is related to Bai and Jia (2016), who study how the abolition of the *Keju* exam affects political stability in the early 20th century. This paper is also closely related to Chen et al. (2017), who independently study the impact of the Keju exam on human capital persistence, using the variation in the density of the highest qualification in the exam. My paper is different from theirs in two important respects. First, my paper studies a different topic: the origin of intergenerational mobility. Second, my paper is not limited to a reduced-form empirical analysis but provides a general theoretical framework for understanding how the aspiration environment can persist and affect intergenerational mobility in the long run. Third,

[4]One endogeneity concern is that the number of victims in the *Cultural Revolution* might be correlated with the quota assigned for the *Keju* exam. I examine the relation between the two. The result shows that the *Keju* quota has no predictive power for the number of victims in the *Cultural Revolution*.

in addition to the impact of aspiration on intergenerational mobility, this paper studies the effect of return to education and its interaction with the aspiration environment on intergenerational mobility.

This paper contributes to several strands of literature. First, as mentioned above, it relates to the vast literature on social mobility and intergenerational transmission. Although many studies are available for the United States and Europe, understanding of social inequality and its intergenerational transmission for developing countries is lower (Solon, 1999; Jantti et al., 2006; Corak, 2006; Hertz et al., 2007; Aaronson and Mazumder, 2008; Lee and Solon, 2009; Black and Devereux, 2010; Long and Ferrie, 2013; Clark, 2014; Clark and Cummins, 2014; Chetty et al., 2014a,b, 2016). In contrast to these papers, I not only provide descriptive results but also study the origin of intergenerational mobility, by examining the causal effect of historical aspiration and combining it with a theoretical model of the transmission of aspiration. Second, this paper is related to the growing body of literature on China's economic and social inequality. Recent work includes Gong et al. (2012); Guo and Min (2008); Knight and Shi (1993); Knight et al. (2009, 2013); Chen et al. (2015). However, these authors reached contrasting conclusions on the rates of social mobility in China. In contrast to these largely descriptive papers, this paper focuses on studying the causal impact of historical aspiration, guided by a theoretical model of the transmission of aspiration. Third, this paper extends the theoretical framework and provides empirical evidence for the psychological constraints-induced poverty trap, especially to aspiration-induced poverty (Akerlof and Kranton, 2000; Appadurai, 2004; Bernheim et al., 1999, 2015; Banerjee and Mullainathan, 2010). Last but not least, this paper contributes to the growing body of literature on long-term persistence. Previous work has shown that persistence takes place in individual preferences, trust, social norms, cultural attitudes and institutions (Algan and Cahuc, 2010; Nunn and Wantchekon, 2011; Voigtländer and Voth, 2012; Michalopoulos and Papaioannou, 2013; Alesina et al., 2013; Alesina and Giuliano, 2015; Guiso et al., 2016). This paper contributes to this literature by introducing aspiration as a potential channel for long-term persistence.

This paper contributes to the literature by documenting intergenerational transmission patterns in China over time and across regions, providing suggestive evidence that aspiration has an impact on social mobility. The findings in this paper suggest that intergenerational mobility is shaped by the environment and therefore, may be affected by policies. Meaningful policy implications regarding social inequality may be drawn from this study. For instance, instead of through various methods of redistribution, policies that aim to alleviate social inequality could consider cutting the costs of education and promoting the local aspiration environment, for instance, through marketing campaigns or a local role model.

The paper is organized as follows. Section 2.2 lays out the theoretical framework for aspiration and upward mobility, which guides the empirical research. Section 2.3 describes the data and intergenerational mobility in contemporary China over time and across space. Section 2.4 gives background information on the *Keju* exam and describes the data for the success rate for the first level of the exam. Section 2.5 presents the main empirical strategy and the results for testing the three predictions of the model using various specifications. Section 2.6 discusses the complementarity of the perceived return to education and the aspiration environment in affecting social mobility. Section 2.7 concludes the paper.

2.2 Theoretical Framework

The model draws on the growing literature of aspiration-based poverty trap (Gilboa and Schmeidler, 1995; Genicot and Ray, 2009; Dalton et al., 2016). Among all, the model is mostly related to Genicot and Ray (2017), in which they develop a theory of socially determined aspirations. Specifically, they let an individual's aspiration be determined by the individual's own income and the distribution of income within the society. They show that moderate aspirations (aspirations that lie at a moderate distance from the individual's current situation, large enough to incentivize but not so large as to induce frustration) provide the "best" incentives and generate a higher growth rate. Those who choose not to cross the aspirations will

fall in the "frustration zone" and have a lower growth rate.

The novelty in my framework is that I allow individual's aspiration to be influenced by local aspirational environment, and I investigate how parents' education, local aspirational environment and the perceived return to education affect child's education and upward mobility.

2.2.1 Model Setup

Consider a parent with an lifetime income y, realized by some positive return to education function $R(e)$. She chooses her lifetime consumption c and investments in her child's education to affect the child's educational outcome e_c to maximize her utility:

$$U = u(c) + w_0(R(e_c)) + w_1(b) \tag{2.1}$$

The utility function is composed of three additive components. The first component is the utility from own consumption c. The second component $w_0(R(e_c))$ is an altruistic utility that parent derives from the achievements of the child. The third component $w_1(b)$ represents the extra utility derived from crossing the aspiration, where $b = max\{e_c - a, 0\}$, the excess of child's achievement over the aspiration a of the parent.

2.2.2 The formation of aspirations

Individual's aspirations on the next generation depend on both personal and social circumstances.

$$a_{lt} = \Theta(e, A_{lt}) \tag{2.2}$$

where e is individual's own education, A_{lt} reflects social aspirational environment in locality l at time t. Let $\Phi(e, a_t)$ be the set of maximizers of the individual's utility maximization problem in Equation (2.1). A_{lt} is an aggregate of all the individual's aspirations a_{it-1} in the last generation $t-1$ such that, for every t, A_t is generated from A_{t-1} by some transition probablity p_t, that is,

$$A_{lt} = \int_0^{e_c} p_t(e, [0, e_c]) dA_{lt-1} \tag{2.3}$$

where p_t agrees with Φ_t and A_{lt-1}. Because aspirations and education evolve jointly, these effects interwine as an *equilibrium* sequence of aspirations distribution $\{A_{lt}\}$ with some initial distribution A_{l0}.

2.2.3 Individual's maximization problem

In a dynamic setting, each person lives for a single period. A parent-child sequence forms a dynasty. A society is populated by a large number of parent-child families. A parent that lives in dynasty t divides her wealth y_t between consumption c and investment in her child k. The investment yields the achievement e_c of the child according to some positive function: $e_c = g(k)$. The achievement e_c then maps to the wealth of the next generation by some positive mapping function: $y_{t+1} = R(e_c)$, which is assumed to be unbiasedly perceived by individuals when making educational investment decisions. The individual then chooses e_c to maximize her utility:

$$\max\ U = u(y_t - k(e_c)) + w_0(R(e_c)) + w_1(max\{e_c - a\}, 0) \tag{2.4}$$

The individual solves the maximization problem by comparing two payoffs generated by two scenarios: (1) $e_c > a$, the chosen optimal education exceeds the aspiration a. The individual is said to be *satisfied*; (2) $e_c \leq a$, the chosen optimal education falls short of a. The individual is said to be *frustrated*.

$$\begin{aligned} U(e_c > a) &= u(y_t - k(e_c)) + w_0(R(e_c)) + w_1(e_c - a) \\ U(e_c \leq a) &= u(y_t - k(e_c)) + w_0(R(e_c)) \end{aligned} \tag{2.5}$$

The model will produce the following result: For any given distribution of education, there is a unique threshold value of aspirations a^* above which aspirations are satisfied, and below which they are frustrated.

Next, I impose a function form on the utility to demonstrate how parents' education, local aspirational environment and the perceived return to education can affect a child's education.

Assume that individuals have the same elasticity for each utility indicator:

$$u(c) = c^{1-\sigma}, \quad w_0(R(e_c)) = \rho R(e_c)^{1-\sigma}, \quad w_1(e_c - a) = \rho\pi(e_c - a)^{1-\sigma}$$

where $\sigma \in (0, 1)$, $\rho > 0$ is a measure of discounting, $\pi_{A_l t} > 0$ is a measure of the additional value of crossing the aspiration, depending on the aspirational environment of the society.

Recall that education achievement e is yielded from parental investment k by some positive function: $e = g(k)$. It is assumed to take the simplest linear function form: $e = \delta_i k$, where δ_i represents heterogeneity in individual's abilities. The return to education function $R(.)$ is assumed to take linear function form, too: $y = \lambda_t e$, where λ_t is the return to education. Assume $\lambda_t > 1$ to ensure some minimum incentives for individuals to invest in education, and this return to education coefficient is assumed to be unbiasedly perceived by individuals when making educational investment decision.[5]

Individual i chooses the education of her child, e_c, to maximize her utility:

$$\left(e_i\lambda_{t-1} - \frac{e_c}{\delta}\right)^{1-\sigma} + \rho\left[(\lambda_t e_c)^{1-\sigma} + \pi(max\{e_c - a_i, 0\})^{1-\sigma}\right] \tag{2.6}$$

2.2.4 Solution

Similar to Genicot and Ray (2017), let $r_i := \frac{a_i}{e_i}$ denote the aspirations ratio: the ratio of aspirations of individual i to her own education. The

[5]Linearity is assumed for simplicity. The results are robust to using any positive increasing concave functions.

maximization problem is equivalent to choosing a growth rate $\frac{e_c}{e_i}$, denoted by $m(r)$. This growth rate is essentially the upward mobility rate. The individual then maximizes:

$$\left(\lambda_{t-1} - \frac{m(r)}{\delta}\right)^{1-\sigma} + \rho\left[(\lambda_t m(r))^{1-\sigma} + \pi(max\{m(r) - r, 0\})^{1-\sigma}\right] \tag{2.7}$$

In the case of $e_c > a_i$, i.e. the aspirations of individual i are met, $m(r) > r$. The optimal $m(r)$ is given by the unique solution to the first order condition:

$$\left(\lambda_{t-1} - \frac{m(r)}{\delta}\right)^{-\sigma} = \rho\delta\left[\lambda_t^{1-\sigma} m(r)^{-\sigma} + \pi(m(r) - r)^{-\sigma}\right] \tag{2.8}$$

2.2.5 Comparative Statistics

Proposition 1 *The upward mobility $m^*(r)$ is increasing in the aspirations ratio r : $\frac{\partial m^*(r)}{\partial r} > 0$.*

Proof is in Appendix **??**. Since local aspirational environment A_l is assumed to positively influence individual's aspiration, that is, $\frac{\partial a_i}{\partial A_l} > 0$, a corollary then follows:

Corollary 1 *Holding parent's education e_i constant, since $\frac{\partial a_i}{\partial A_{lt}} > 0$, the upward mobility rate $m^*(r)$ is increasing in the local aspirational environment A_l : $\frac{\partial m^*(r)}{\partial A_{lt}} > 0$.*

Although the impact of the local aspirational environment on the upward mobility rate is positive for any e_i, it is not constant along the education distribution. Proposition 2 and its corollary formalize this discussion:

Proposition 2 *As long as aspirations are satisfied, the intergenerational mobility $m^*(r)$ is decreasing in parent's education e_i : $\frac{\partial m^*(r)}{\partial e_i} < 0$.*

Since $m(r) = \frac{e_c}{e_i}$, the proof is straigtforward.

Corollary 2 *As long as aspirations are satisfied, since* $\frac{\partial m^*(r)}{\partial e_i} < 0$*, the positive impact of the local aspirational environment on the chosen upward mobility rate, that is,* $\frac{\partial m^*(r)}{\partial A_{lt}}$*, is decreasing in parent's education* e_i *:* $\frac{\partial^2 m^*(r)}{\partial A_{lt} \partial e_i} < 0$.

The next proposition and its corollary discuss the impact of the perceived return to education on upward mobility choice.

Proposition 3 *The upward mobility rate* $m^*(r)$ *is increasing in the perceived return to education :* $\frac{\partial m^*(r)}{\partial \lambda_t} > 0$.

The proof is in Appendix **??**.

Corollary 3 *Since* $\frac{\partial m^*(r)}{\partial \lambda_t} > 0$*, the responsiveness of* $m(r)$ *to the perceived return to education is increasing in local aspirational environment:* $\frac{\partial^2 m^*(r)}{\partial A_{lt} \partial \lambda_t} > 0$.

2.2.6 The evolution of aspirations

Proposition 4 *Assume that aspirations are range-bound, scale-invariant, and socially monotone. Than a steady state is concentrated on just two positive values of aspirations.*

Corollary 4 *Holding the initial education distribution constant, a positive shock to the initial aspiration distribution* A_0 *will induce a higher convergence level in the steady state.*

To illustrate this corollary, I use a simple example: beginning with a uniform distribution of aspirations A_0 with an initial shock ϕ, so the starting distribution is ϕA_0. Aspirations are the average of one's own education and the mean aspiration environment of the society. In the simplest

case, parents choose the education of child just equal to their aspiration. Iterating the distribution over several periods, the simulated distributions converge rapidly to a bimodal distribution shown in Figure 2.A1. It plots the evolution of aspirations of individuals with the lowest education and at every 10th percentile thereafter, up to the individuals with the highest education in an economy of 1000 population. Higher curves represent individuals with higher education. Panel(a) and (b) start with the same initial uniform distribution of aspirations with the only difference in the initial shock ϕ. Panel (a) uses $\phi = 1.05$, and Panel (b) uses $\phi = 1.2$. After 50 iterations, the aspirations in Panel (a) converge to 0.62 and the aspirations in Panel (b) converge to 0.68.

2.3 Data and Intergenerational Mobility in contemporary China

2.3.1 Contemporary Data

Education

To measure intergenerational mobility in contemporary China, I use the 1% sample of the 2000, 1990 and 1982 China Population Censuses. For each sample, I restrict the age of individuals in the sample to be older than 23, as younger individuals might not have completed their education at the time of the survey. The samples allow me to link the household head to her parents and to her children, but only if they live in the same household. Biases from truncation caused by co-residency restrictions have been the main challenge for research on intergenerational mobility. Thus, to alleviate the sample selection problem, I use only the 10 youngest cohorts (given that age is restricted to be older than 23), who are still very likely to live with their parents.

To mitigate concerns about changing distributions of education across time distorting the comparisons of mobility across cohorts, I measure educational attainment using a child's education rank within her birth cohort,

as well as her most educated parent's rank among the parents in that cohort, following Chetty et al. (2014a)'s approach for incomes. I choose education attainment as the main proxy for social status for several reasons. First, education has been the metric for social status in China for more than one thousand years, and the selection of bureaucrats in imperial China is closely associated with exam performance (see section 2.4). In addition, using education as the proxy has several advantages. First, compared to yearly income, education is less sensitive to measurement methods and has less noise. Thus, comparisons across institutional regimes and data sources are possible. Second, education attainment does not change with age, experience, etc. Once completed, an individual's education remains static, thus avoiding influence from life cycles. Finally, it is not possible to get data on incomes for a comparable sample of individuals, as the census does not collect this data, and historical tax data for the period of study, unfortunately, is not available. In addition, tax evasion is a large concern. In the next subsection, I discuss which income proxy can be used.

Income

The census data contains information on individuals' occupation, classified by the International Standard Classification of Occupations (ISCO). With the occupation information in the census, I link each occupation to the average wage of that occupation in the National Bureau of Statistics' China Labour Statistical Yearbook. The average wage is the estimated income for each occupation. Then I estimate the income quantile of individuals in the sample and use the income quantile as a complement proxy for social status. The empirical results using estimated income are reported in the Appendix as a robustness check.

2.3.2 Intergenerational mobility in contemporary China

This section presents stylized facts on the mobility rates in contemporary China over time and across regions.

Spatial patterns

In this section, I examine the spatial differences in the mobility rates across China. Upward mobility is defined as the proportion of individuals whose education rank exceeds their most educated parent's among all the individuals in the same cohort. Figure 2.3 presents heat maps of the upward mobility rates across prefectures from the 1982, 1990 and 2000 censuses. The relevant cohorts are 1949—1959, 1957—1967 and 1967—1977. Purple represents prefectures with low upward mobility, and green represents high upward mobility. Prefectures with too few (less than 50) observations are excluded. With the summary statistics shown in Table 2.1, we can infer the spatial change over the three decades.

The upward mobility rates of the 1949—1959 cohorts exhibit the highest mean, and the distribution is more centered. A quick calculation shows that the upward mobility of the 1949—1959 birth cohorts is, on average, 1.16 times larger than the 1957—1967 and 1967—1977 birth cohorts. Over time, the mean of the upward mobility rate is decreasing, suggesting that since the 1980s social stratification in China has been becoming more consolidated, and climbing up the social ladder has become more difficult. Likewise, the standard deviation is also increasing, implying that the spatial disparity in upward mobility is persistent and even intensifying. Geographically, upward mobility exhibits substantial variations across and within regions. Western China shows less upward mobility than the eastern regions. The east-west spatial disparity disappears after controlling for province fixed effects. However, great within-provinces variations remain.

Mobility Trends

Following the previous literature (e.g., (Hertz et al., 2007), (Chetty et al., 2014b)), I estimate the intergenerational correlation in education by regressing child education on parent education. In Figure 2.1, the scatter points of the quantile ranks of individuals and their most educated parent in the national distribution from the three census samples are plotted. The regression coefficients of parents' education as a predictor of children's

education attainment increase from 0.21 in 1982 to 0.29 in 1990 and to 0.40 in 2000. The magnitude of the estimates for 1982 and 1990 are considered low – comparable to Scandinavian countries where societies are considered more equal. The magnitude of the estimate for 2000 is similar to those for the US and UK, ranked in the middle among countries with documented intergenerational correlation coefficients.

In 2000, the absolute upward mobility, if computed as in Chetty et al. (2014a), at the 25th percentile is 28.60, lower than in 1990 (31.30) and 1982 (33.98). The findings suggest that social mobility in China is not immutable and that the education disparity of children of low and high education parents is increasing: Upward mobility for children of low education parents is becoming more difficult.

A breakdown by parents' education level, as shown in Figure 2.2, reveals that children of low education parents are likely to have the same low education. In contrast, children of high education parents have considerably higher education attainment in 2000 than in 1990 and 1982. This evidence reinforces the previous finding that upward mobility in 2000 is more parent-dependent than in 1990 and 1982.

2.4 Historical Data

2.4.1 Imperial Civil Service Exam and the Assignment of Quotas

The imperial civil service examination system (the *Keju*) is a meritocracy-based examination system established by the feudal rulers during the imperial period to select bureaucrats. The system was initially established in 605 during the Sui Dynasty, flourished during the Ming and Qing dynasties and survived until 1905 (Elman and Woodside, 1994; Elman et al., 2000).

The civil service examinations were conducted in three stages: The first, the *Sheng-yuan* ("cultivated talent") examination, was held at the local prefecture level. The second, the *Ju-ren* ("recommended man")

examination, was held in the prefectural capital. The third, the *Jin-shi* examination, was held at the national level. All candidates had to start from the first stage, and only after passing the current stage were candidates allowed to participate in the next stage. The ultimate goal was to pass the final stage of the exam. Then the successful candidates (*Jin-shi* degree-holders) would be guaranteed to be appointed to mid-to-high-level government administration positions.

This institution provided very strong incentives for common men to participate. The incentives are two-fold: First, for more than one thousand years, the gentry were the most honored and usually the wealthiest class in China, and the *Keju* exam was the sole gateway to the gentry class. Although other social classes, such as merchants and traders, from time to time amassed large fortunes, these classes never had great social prestige in Chinese society. The social prestige is reflected in all aspects of life. For example, passing the first level (*Sheng-yuan*) means getting rid of the identity of "commoner", as documented in (Cressey, 1929): "He would have the right to wear a special costume, to fasten a symbolic button on his cap, and to erect a pair of 'dragon poles' in front of his home". Second, the degrees granted after passing the exams were associated with great political and economic privileges and wealth. Although only passing the final-level (*Jin-shi*) examinations was the requirement for high office, the other degrees also bestowed privileges. For example, a *Sheng-yuan* degree-holder was exempted from Corve (statute labor) and received a monthly stipend, and he had the right to speak directly to a local magistrate.

In fact, the education program was adapted to meet the purpose of the exam. The liberal professions of law, medicine and religion as they are known in the West never existed in China (Cressey, 1929). The sole criterion for scholarship and the one certain road by which a man might become a respected member of the society was successfully passing the *Keju* examinations. As portrayed in Tcheng (1885):

Nothing can give an idea of the demonstrations of joy at the news of success in the examinations ... . The family rejoicings are as pompous as

on the occasion of a marriage ... . The successful candidate is carried in triumph. He is acclaimed by the people like a king who has gained a great victory.

The *Keju* system was not a minor technical political device. It had omnipresent and pervasive impacts on Chinese society[6]: The examination system begot changes in social structure, assisted the mobility of society, and formed social norms. The most distinctive feature of the *Keju* exam system was its universality and non-heritability. . This system allowed every man (women were excluded) to participate in the examinations, regardless of his origin and wealth. More than 80% of *Jin-shi* degree-holders in the early Ming Dynasty were recorded as coming from commoner families (the family had no more than one *Sheng-yuan* in the past three generations and no one had ever got any degrees higher *Sheng-yuan*) (Ho, 1962, pp. 112-113). The ratio declined in the Late Ming and Qing Dynasties but was still very high. The average ratio in the Ming Dynasty is 50% and in Qing Dynasty is 37.2%. The openness and the universality of the *Keju* exam thus improved recruiting efficiency by keeping the candidate pool open and promoted social mobility by enabling lower-class people to enter the upper social stratum. Because the degree and the social and economic privileges attached to success on any level of the exam were not hereditary, each generation had to stand on its own merits and prove its right to rank and privilege. Thus, the exam system broke the previous monopoly of the clan and the genetic relationship between blood and descent.

Due to the universality and non-heritability of the exam system, the aspirations of the entire nation were bound up in this institution. For more than one thousand years, the highest ambition of every Chinese man was to pass one or more of the examinations and to enter the gentry class. Competition was fierce. In 1850, around twenty million men participated

[6]The impact of the *Keju* system was not limited within China. W. A. P. Martin pointed out in his paper *The Chinese* that the introduction of the civil service examination system in Western nations in the 19th century represents a direct borrowing from the Chinese practice.

in the first-level examinations that selected *Sheng-yuan*, and only 1.5% of them passed. Table 2.2 summarizes the selection rates and the percentage of the male population of the three types of degree-holders at all levels of the examination. It was estimated that the *Sheng-yuan* degree-holders accounted for between 0.4% and 0.7% of the male population between the mid-Ming and late Qing Dynasties (Hao and Clark, 2012). Only after passing the lowest-level exam was one eligible to participate in the second level. The second-level examinations at the provincial level selected the degree-holders for the *Ju-ren* who accounted for 0.02% to 0.035% of the total male population between the Ming and Qing Dynasties according to Hao and Clark (2012)'s estimation. The final as well as the highest level of the civil exam was the national selection for the *Jin-shi* degrees, and *Jin-shi* degree-holders accounted for between 0.004% and 0.007% of the total male population (Hao and Clark, 2012).

However, the imperial government had considerable control over the selection process. In particular, the government controlled the size and regional distribution of degree-holders through the quota system (Elman, 2013). The quota system determined the number of successful candidates at each level of the exam. The *Sheng-yuan* quota was binding at the prefecture level. All the prefectures (*Fu/Zhou/Ting*) were assigned specific quotas that determined the number of candidates who passed the *Sheng-yuan* exam. The *Sheng-yuan* in the Ming dynasty were assigned by the central bureaucracy and fixed by geographic location, based on the size and population of the prefecture in the early Ming Dynasty (Ho, 1962). Then the Qing Dynasty inherited the *Sheng-yuan* quotas assignment from the Ming Dynasty with minor adjustments[7].

[7]The assigned quotas were very stable during the Qing Dynasty. It changed only once due to the fighting during the Taiping Rebellion in the mid-19th century. After the conflict, the revised quota assigned during the Taiping Rebellion persisted until the examination system was abolished.

2.4.2 Historical aspirations and exam quotas

The quota assignment was fixed and essentially followed a stepwise rule (8, 12, 15 and 20), unchanging over time and non-responsive to changes in the population or development in a prefecture. The persistence of the quota system played an important role in manipulating social opportunities through the *Keju* system and creating geographic stratification that had a long-run impact on social mobility in Chinese society. The *Jin-shi* quota varied at the regional level in the early Ming Dynasty. For instance, in 1425 the quota was 6:4 for southern and northern candidates, and in 1427, it was modified to 55:35:10 for southern, northern and central candidates in metropolitan examinations (Elman et al., 2000, p. 359). This simple quota system was maintained until 1712 when the Qing Dynasty assigned quotas to provinces.

My main analysis uses the prefecture-level variations in the *Sheng-yuan* quotas to measure the difficulty of upward mobility in a prefecture through the civil exam system. The data on the quota comes from the Imperially Established Institutes and Laws of the Great Qing Dynasty (Kun et al., 1991). Because the administrative divisions have mostly completely changed since the People's Republic of China was founded in 1949 (please see section 2.5.1 for more discussions and the identification strategy), it will be very inaccurate to use the old prefecture division (*Fu/Zhou/Ting*) in the Qing Dynasty. Instead, I link the more than 2,200 counties in contemporary China in 2000 to the historical prefectures (*Fu/Zhou/Ting*) to which they belonged in the Qing Dynasty. Because the quota was binding at the historical prefecture (*Fu/Zhou/Ting*) level in the Qing Dynasty, all the counties in the same historical prefecture then had the same level of upward mobility, determined by the quota assigned to the prefecture.

Quotas are then aggregated using two different rules: 1) average weighting by the population of contemporary counties and 2) majority weighting by the population of contemporary counties [8]. Figure 2.4 shows a map of

[8] Suppose contemporary prefecture A is composed of a set of counties, each of which was affiliated with historical prefectures $\Lambda, M, N, \ldots$, if the majority counties in prefec-

the spatial distribution of the population-weighted aggregated *Sheng-yuan* quota density across contemporary prefectures. The figure exhibits great geographic variations in the quota per capita

2.4.3 The *Keju* exam quota and aspirations

As discussed extensively in Section 2.4, the aspirations of the entire nation in the imperial period were bound up in the *Keju* institution. For more than one thousand years, the highest ambition of every Chinese man was to become a scholar, to pass one or more of the examinations and to enter the gentry class. In addition, the construction of the examination (its universality and non-heritability) provided this possibility. Approximately half of the highest degree-holders (and accordingly mid-to-high-level administrative positions) had no ancestors holding any degrees or positions. The belief that one could get rid of one's "commoner" background and move up the social ladder with one's own efforts was deeply embedded. Thus, the *Keju* examination laid the foundation for the aspirations of the nation, and the quota system, which governed the chance of passing the exam and moving upward, determined the aspiration level in each geographic unit.

To provide some evidence for the relation between the *Keju* exam system and aspiration, I employ data from the China Family Panel Study (CFPS). In particular, I use two survey questions regarding an individual's aspirations. The first question is for individuals who have school-aged children: "*What education level do you expect your child to obtain?*". The second question is for children aged 10—15: "*What education level do you expect to obtain?* ". The first question reflects parents' aspirations for the next generation, and the second question reflects an individual's own aspirations. I examined the relation between an individual's answers to the two questions and the historical quota in the individuals' region. The results are shown in Table 2.3. To isolate the effect, I control for an

ture A belonged to historical prefecture Λ, then the quota for prefecture A is equal to the quota for historical prefecture Λ. If no majority exists, then the quota for prefecture A is equal to the population-weighted average of all the counties composing prefecture A.

individual's age and education, urbanization rate and consumption level in the province where the individual lives. The positive relations suggest that people in places where a higher quota was granted for the historical *Keju* exam, on average, have higher aspirations even in contemporary society.

To demonstrate that the observed relation between the *Keju* quota and aspiration is not simply due to cross-province differences or other omitted variables, I perform several placebo tests. If the *Keju* quota affects contemporary social mobility not through setting the aspiration level but through changing the local perceptions of social inequality, then we should observe a relation between the quota and an individual's perception of social inequality. Therefore, I look at the effect of the *Keju* quota on the view of social inequality. The result shows no relation. In addition, I also check the quota's relation with trust of local politicians, whether to purchase commercial insurance for children and whether to join the Chinese Communist Party (CCP). Table 2.A2 shows that none of the above are correlated with the *Keju* quota.

2.5 Empirical Strategy and Results

In this section, I test the hypotheses derived from the propositions. I first show the empirical estimation and the identifying assumptions. Then I discuss potential threats to identification. In the end, I present cross-section and individual estimation results.

2.5.1 Reduced Form Estimation

The estimation equation is as follows:

$$Mobility_{ip} = \beta Quota_p + X_p + \gamma_{prov} + \lambda_i + \epsilon_{ip} \tag{2.9}$$

where $Mobility_{i,p}$ is the upward mobility for individual i in prefecture p and is equal to 1 if the individual's education rank exceeds her parent's education rank, 0 otherwise. Alternatively, I also use the IGRC

and the IGC to measure mobility[9]. $Quota_p$ is the standardized *Keju* exam quota per capita in prefecture p. X_p is a series of covariates, including the population and urbanization at the prefecture level. λ_i is a series of individual characteristics, including an individual's age, parent's age and parent's education rank. γ_{prov} denotes province fixed effects that control for all time-invariant differences between provinces. This way, I use only within-province variations in exam quotas. As the key independent variable, *quota*, is measured at the prefecture level, and correspondingly, errors are expected to be correlated within a prefecture, standard errors are clustered at the prefecture level.

2.5.2 Identifying Assumptions

To estimate the causal impact of aspiration on social mobility, the identifying assumption is that the quotas are not correlated with other historical prefecture- specific characteristics that may persist in the error term. For this assumption to hold, ideally one would need an exogenous shock to aspiration. Thus, I exploit a plausibly quasi-exogenous event that determined the regional aspirational level—the quota allocation in the entry-level *Keju* exam since the 14th century in the imperial period. Next I discuss why this assumption could be violated and why quotas based on contemporary prefectures may not violate this assumption.

As extensively discussed in the background section 2.4, the quotas assigned in the 14th century were conditional on the size and the population of the prefectures in the 14th century. The quotas did not change over time and did not respond to changes in the population or development in prefectures. It is natural to think that more populated places in the 14th century might be fundamentally different from those that were not. In this way, the variations in quota would capture only time-invariant differences across historical prefectures. Thus, I examined the relation between the assigned quota and the population at the prefecture level in the early Ming and late Qing periods, respectively. In Figure 2.5, this relationship is plotted in 1394 (the early Ming period) and in 1895 (the

[9] All the measures yield similar results, which are shown in the Appendix

late Qing period). The figure shows that during the early Ming period a prefecture's assigned quota and its population had an obvious positive relationship with an R-square at 30%, whereas this positive relationship had disappeared in the late Qing period when the quota seemed completely orthogonal to the population. As the assigned quota was almost fixed, the change in the relationship must result from changes in population. This comparison suggests that the quota neither predicted nor stimulated local development or growth. Next, I use the extensive restructuring of prefectures since 1949 to dilute further prefecture-specific characteristics.

China's administrative division experienced many adjustments and changes over the past 70 years. The changes can be roughly classified into three periods: The first period was from the founding of the People's Republic of China in 1949 to the promulgation of the first Constitution in 1954. With the main objective to establish and consolidate local citizens' political power at all levels, the old administrative division system was restructured. With a focus on village- and township-level administrative units, large townships were split, and small townships were merged. The second period was the following 20 years, from 1955 until the market economy reform in 1978. The aim of the administrative adjustments in this period was to facilitate the establishment of the people's commune system. As a consequence, the township system was completely abolished and replaced with politically and economically integrated people's communes. In addition, local adjustments happened in counties and cities. The third period was from the 1978 market reform until 1997. The main change during this period was the extensive adjustments of counties and cities. One hundred ten new prefecture-level cities and 312 county-level new cities have been set up since 1982. By the end of 1998, the total number of cities across the country had reached 668, more than three times the 193 cities before the 1978 reform (Dai, 1999). The massive founding of new cities and counties was finally halted in 1997 by the central government due to noticeable rent-seeking behaviors of local politicians during the process.

To give an example, Figure 2.6 displays maps of Hebei and Shandong

provinces[10]. The solid black line draws the county boundary, and each color represents a prefecture. The maps on the left(2.6b and 2.6d) show the historical prefectures(*Fu/Zhou/Ting*) in the Qing Dynasty in the 19th century. The maps on the right (2.6a and 2.6c) show the prefectures in 2015.

I acknowledge that the identification strategy using changes in prefecture boundaries may not be perfect. The restructuring of the administrative units can dilute but not completely offset historical prefecture-specific characteristics. The validity of the identification would be threatened if any historical prefecture-specific characteristics persisted until today and correlated with contemporary prefectures. Although I control for many contemporary prefecture-level features, there may still be omitted variables left in the errors[11].

2.5.3 Results

The Substitutability of the Aspiration Environment and Parents' Education

Hypothesis 1. Upward mobility rates are higher in places with higher aspiration.

I divided the sample into three periods based on an individual's birth cohort. Results are presented in Table 2.5. On average, one standard deviation increase in the exam quota increases mobility by about 1.5 percentage points, an approximate 23% standard deviation in upward mobility. Moreover, the *Keju* exam shows the strongest effects on the 1967—1977 cohorts, some moderate effects on the 1949—1959 cohorts and no effects on the 1957—1967 cohorts. These results are reasonable because due to

[10]Due to space limitations, only two provinces are shown as examples. The maps of the other provinces are available upon request.

[11]An ideal identification, thus, is to compare the mobility rates of a pair of counties that belonged to different historical prefectures(*Fu/Zhou/Ting*) but now belong to the same contemporary prefecture. Unfortunately, the census data does not allow me to pinpoint individuals' county of residence; thus, I cannot use this identification strategy.

the interruption of primary and secondary school, it was especially difficult for the 1957—1967 cohorts to obtain education beyond their parents' levels.

Table 2.6 shows the estimation results of a multinomial logit regression with the child's education as the outcome. The results show that individuals in places with a high social aspiration environment are more likely to move upward from the bottom and achieve a higher education level (Education level 6 and 7, equivalent to completing grade 12 or college). These results accommodate the survey answers on parents' aspiration on children in Table 2.3.

Heterogeneity along education distribution

Hypothesis 2. Individuals who are located in the low-to-middle quintiles in the education distribution are influenced the most by the local aspiration environment.

When testing Hypothesis 2, I compare the effects among various levels of parents' education. The specification is as follows:

$$\begin{aligned} Mobility_{ip} =& \delta Quota_p + \sum_{edu} d_{edu}\phi_{edu} + \sum_{edu} (d_{edu} \times Quota_p)\beta_{edu} \\ &+ X_p + \gamma_{prov} + \lambda_i + \epsilon_{ip} \end{aligned} \tag{2.10}$$

where d_{edu} is a dummy variable for parent's education level. $\sum_{edu} d_{edu}$ include all the levels except the lowest education level(Illiterate or semi-illiterate) which is left as the reference group. X_p is a series of covariates, including the population and urbanization at the prefecture level. λ_i is a series of individual characteristics, including an individual's age, parent's age and parent's education rank. γ_{prov} denotes province fixed effects that control for all time-invariant differences between provinces. Standard errors are clustered at the prefecture level.

Table 2.7 presents the results for the 1967—1977, 1957—1967 and 1949—1959 cohorts, respectively. In the 1967—1977 and 1949—1959

cohorts, individuals whose parents have an elementary school (Education level 3, equivalent to completing Grade 6) education are significantly more influenced by the *Keju* quota. Table 2.A3 presents the distribution of parents' education. The table shows that parents with elementary school education are located in the low-to-middle percentile in the education distribution. In places with higher quotas, parents with elementary education are more likely to be motivated by the quota, to set higher aspirations and thereafter, are more likely to achieve upward mobility in the next generation. This finding is consistent with Hypothesis 2. In addition, similar to the results in Table 2.5, the 1957—1967 cohort does not show a statistically significant difference in any parents' education levels. Due to the interruption of primary and secondary school, it was especially difficult for the 1957—1967 cohorts to obtain education beyond their parents' levels.

2.5.4 Robustness Check

In this section, I show that the results are robust to alternative specifications.

Cross-Sectional Results

The cross-section regression equation is as follows:

$$Mobility_p = \beta Quota_c + X_{cp} + \gamma_{prov} + \epsilon_c \tag{2.11}$$

where $Mobility_p$ is upward mobility in prefecture p. $Quota_c$ is the standardized *Keju* exam quota per capita in county c. X_{cp} is a series of covariates, including population at the county level and urbanization at the prefecture level. γ_{prov} denotes province fixed effects that control for all time-invariant differences between provinces. This way, I use only within-province variations in exam quotas. As errors may be correlated within a prefecture, standard errors are clustered at the prefecture level.

The key coefficient of interest is β. The estimate results for Equation (2.11) are shown in Table 2.A5, the coefficients in percentage points.

Column 1 shows the ordinary least squares (OLS) result without controlling for fixed effects. Column 2 shows the result with all the controls. Column 3 presents the result after controlling for province fixed effects, whereas column 4 presents the results with controls and province fixed effects. The estimates are stable across different specifications. On average, one standard deviation increase in the exam quota increases mobility by about 0.67 percentage points, an approximate 11% standard deviation in upward mobility. The estimated effects are consistent to the individual-level results, only of smaller size.

Alternative Measures of Mobility Using the IGRC and the IGC

Alternatively, I use the Intergenerational Regression Coefficient (IGRC) and the Intergenerational Correlation(IGC) to measure mobility. Previous work(Emran et al., 2016) has shown that the selection bias in the IGC, compared to the IGRC, is much smaller, and is less sensitive to the co-residency rate. The specification is the same as in Equation 2.11 with the dependent variable using the IGRC and the IGC. The results are shown in Tables 2.A6 and 2.A7. The coefficients are negative because the outcome variable in this alternative specification represents the correlation between parents and children, the inverse of mobility. The estimated effects using the IGRC and the IGC are consistent with and greater than the estimates using the binary upward mobility: On average, one standard deviation increase in the exam quota increases mobility by about 0.8 percentage points, an approximate 10% standard deviation in mobility.

Alternative Measures of Mobility Using Income

I repeat the exercises using income-based measure of mobility. The specification is the same as in Equation 2.9. Table 2.A8 shows the income-based regression results. The estimated effects are significant for cohorts 1967—1977 and not significant for the other cohorts probably due to the noisier measure of income[12] for earlier cohorts. Yet, the magnitudes of

[12]The income is estimated from the average wage of the occupation.

the estimates using income are similar to the ones using education.

2.6 Intergenerational mobility and returns to education

In this section, I examine the role of perceived return in forming aspiration, corresponding to Proposition 3 in the theoretical framework.

2.6.1 The *Cultural Revolution*, the Persecution of Intellectuals and the Perceived Costs of an Education

The *Cultural Revolution* was a 10-year nationwide sociopolitical movement, which negatively affected the economy and society to a highly significant degree. The movement was launched in May 1966 by Mao Zedong, then chairman of the the Communist Party of China (CCP) to preserve true Communist ideology in the country by purging capitalist remnants within the CCP and traditional elements from Chinese society. The masses were called on to participate in an insurgency that targeted party officials, intellectuals and school officials who were alleged to be reactionary and to engage in anti-party and anti-socialism activities.

China's youth responded to Mao's appeal by forming Red Guard groups all over the country and traveling to Beijing to learn revolutionary experiences[13]; all travel expenses were borne by the government. The Red Guards then brought their revolutionary fever and experience back to their hometowns and spread out locally. FThe crusade against reactionaries spread throughout the country. Accused reactionaries were subjected to brutal and humiliating public struggle sessions that often included beatings, torture and killings.

In 1968, the government decided to curtail the destructive insurgencies and restore the order by establishing local revolutionary committees

[13] On August 18, 1966, hundreds of thousands of Red Guards from all over the country gathered in and around Tiananmen Square in Beijing for a personal audience with Mao.

to guide the revolutionary activities. However, local revolutionary committees were soon employed all over the country as a tool of factionalism, and the suppression campaigns developed into cleansing campaigns (analogous to the Soviet campaigns of the Stalinist era) that generated more severe and massive political persecutions. From that point on, the political persecution took various forms: imprisonment, coercive interrogation, expulsion from homes and charges of counter-revolutionary activity (Walder, 2014). Estimates of victims throughout the decade-long *Cultural Revolution*, including those imprisoned and otherwise persecuted, are close to 30 million (Walder and Su, 2003).

In this paper, I employ the data from the China Political Events Dataset, 1966—1971 which exploits local annals (*difang zhi*) and records the number of victims of various forms of political persecution that included imprisonment, public beatings, expulsion from homes and charges of counter-revolutionary activity during the *Cultural Revolution*. The dataset contains 2,040 county-level jurisdictions. Table 2.A9 provides a summary table for the number of victims. I aggregate the data to the prefecture level. Figure 2.A3 shows a map of the number of victims for every thousand population. The map shows great spatial variations, especially across provinces. One concern about the data is that there may be political biases in exposing the persecutions of the *Cultural Revolution* in the local annals. Before the political upheaval of 1989, some of the material from post-Mao investigations subsequently found its way into local annals published as part of a coordinated effort to document the history and accomplishments of the People's Republic (Walder, 2014). Moreover, if there were any cover-up in the data, my results would tend to underestimate the effect. The actual effect would be even larger.

Another concern is identification. The number of victims in the *Cultural Revolution* might be correlated with the quotas for the *Keju* exam, and the spatial variations in the number of victims captured only time-invariant province differences. As mentioned above, the severity of political persecutions in the first phase depends on the activity of local Red Guards and how close they were in distance to Beijing. The severity during the second phase depends on the faction compositions within the local

CCP committees and the political background of each faction, the distribution of which was related to the *Long March*[14] in the 1930s. In Section 2.6, I address these potential concerns by examining the relation between the quota and victims in the *Cultural Revolution*, and I find that the quota has no predictive power for the victims.

2.6.2 Estimation and Results

The main estimation strategy is an OLS regression:

$$Mobility_{ip} = \beta Quota_p + \phi Victim_p + \delta(Quota \times Victim)_p + X_p + \lambda_i + \epsilon_{ip} \tag{2.12}$$

where $Mobility_{ip}$ is the same as before, upward mobility for individual i in prefecture p. $Quota_p$ is the standardized *Keju* exam quota per capita in prefecture p. $Victim_p$ is the number of victims in the *Cultural Revolution* in prefecture p divided by the population of that prefecture (times one thousand for easy interpretation). δ is the parameter of interest, which can be interpreted as the intensifying effect of the change in the perceived return to education in forming aspiration. X_p is prefecture-level controls, including prefecture population and the urbanization rate. λ_i represents a series of personal characteristics, including the individual's age, his/her most-educated parent and the quantile rank of the parent in the national distribution. Standard errors are clustered at the prefecture level.

Hypothesis 3. An individual's upward mobility is more responsive to changes in the perceived return to education in a more aspiring environment

To test Hypothesis 3, I use the severity of political persecutions during the *Cultural Revolution* to measure the perceived return to education. As mentioned above, during the *Cultural Revolution* period, intellectuals, scholars and educated youth were targeted and persecuted as objects

[14]The Long March was a series of military retreats undertaken by the Red Army of the CCP to evade pursuit by the Kuomintang (KMT) army.

of class warfare. Higher education was considered associated with high political risk. Return to education was thus perceived to be low in places where persecutions were severe. In particular, I use the number of victims per one thousand population in a prefecture as the proxy for the perceived return to education.

The first endogeneity challenge is that the number of victims in the *Cultural Revolution* might be correlated with the quota for the *Keju* exam. One possible channel might be that places historically with higher quotas have more intellectuals and educated youth in the 1960s. This is hardly true for several reasons. First, the quota in the *Keju* exam determined only the successful candidates in the entry-level exam, which was not necessarily predictive of the number entering the gentry class after the second and third exams. Second, the number of victims in the later phase of the *Cultural Revolution* was mostly an outcome of faction competition within the local CCP committees. The geographic distribution of the two competing factions depended on the consequences of the *Long March* and power redistribution after the founding of the PRC. Nevertheless, I examine the relation between the two. The result is shown in Table 2.8. The *Keju* Quota has no predictive power for the number of victims during the *Cultural Revolution*.

A second challenge is that the spatial variations in the number of victims may capture only time-invariant prefecture differences. I address this concern by looking at different cohorts. If this concern was valid, I should find similar effects in cohorts before and after the *Cultural Revolution*.

Table 2.9 presents the results. Columns 1 and 2 show the results for cohorts born in 1967—1977. The estimates show that in places with a higher initial aspiration level (as represented by a higher quota), perceived return to education (as implied by the number of victims in the political persecutions during the *Cultural Revolution* period) has a stronger effect on determining upward mobility. In particular, the estimate in column 2 shows that one standard deviation increase in victims decreases the upward mobility rate by 0.016 percentage points, about 4% of the standard deviation. Furthermore, the interaction effect of victims and the quota increases the victim's main effect by 3.7 times.

In addressing the second challenge, I conduct the same exercise on the 1949—1959 and 1957—1967 cohorts and use these exercises as placebo tests. The results show that the effect exists only for the 1967—1977 cohorts, implying that the spatial variations in the number of victims not only captures province differences but also reflects the severity of the political persecution during the *Cultural Revolution*. Moreover, because the *Cultural Revolution* spanned 10 years between 1966 and 1977, cohorts born earlier than 1948 were already adults and witnessed and experienced the whole *Cultural Revolution*. Some might even have been persecuted themselves and suffered during the period. Therefore, the perceived negative return to education during the *Cultural Revolution* period should be assimilated by the witnesses, alter their viewpoint in making education investment in the next generation and be reflected in the upward mobility of their children. The 1967—1977 cohorts are mostly the children of the pre-1948 cohorts. I believe that the same effects can be found on later cohorts if more data is available.

2.7 Conclusion

Why do some areas generate higher rates of mobility than others? This question has received continuing attention from economists. In this paper, I identify and highlight one important causal mechanism that determines social mobility: aspiration. I develop a simple aspiration-based theoretical framework that produces three pre- dictions to guide empirical tests.

In the first part of this paper, I present long-run patterns of intergenerational mobility in China as a whole and across regions. The results suggest that the education disparity of children of low and high education parents is increasing, and upward mobility for children of low education parents is becoming more difficult. In addition, I find substantial geographic variation in upward mobility across prefectures in China and in the cohorts, suggesting that the spatial disparity in upward mobility is persistent and even intensifying.

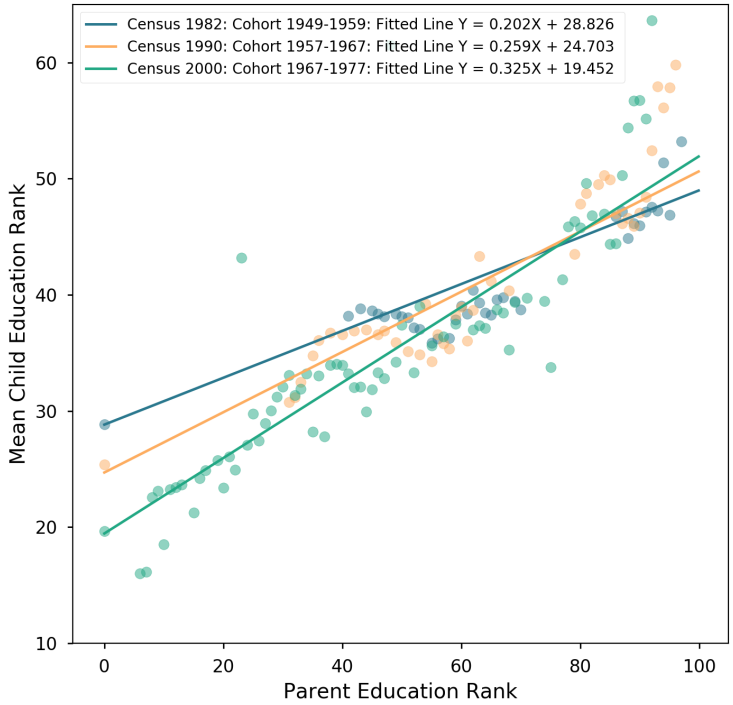
In the second part of this paper, I use the plausibly quasi-exogenous

success rate in the *Keju* examination in the 19th century to measure aspiration. By taking advantage of the extensive boundary changes in prefectures since the founding of the PRC, I empirically examine the role of aspiration in explaining contemporary social mobility. I find that aspiration incentivizes upward mobility. Places with a high social aspiration environment have high upward mobility. In addition, this effect happens only to individuals in the low-to-middle quintiles in the education distribution, consistent with the model prediction.

Next, using the variations in the victims during the Cultural Revolution in the 1970s, I show that perceived return to education has an impact in determining upward mobility, and this impact is intensified by the local aspiration environment. In a more aspiring environment, an individual's upward mobility is more responsive to changes in perceived returns to education.

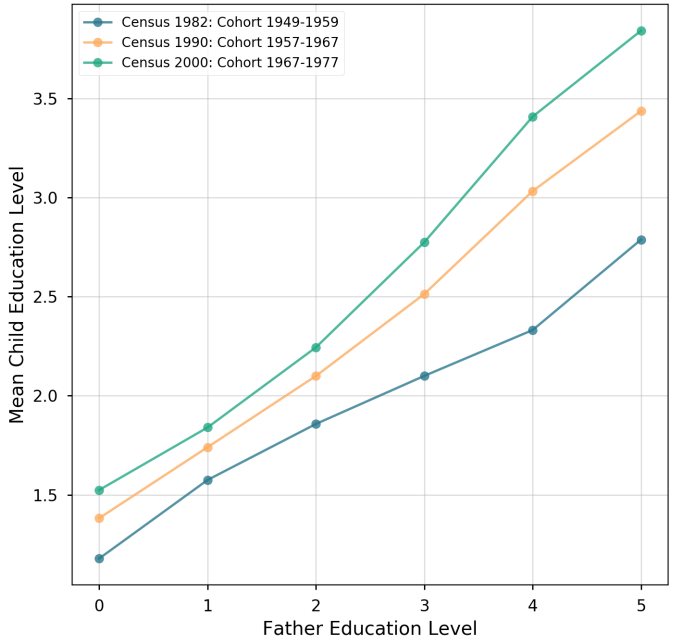
This paper sheds light on one causal mechanism—aspiration—drives the emergence and persistence of social mobility across regions. I believe that these findings have realistic implications for making public policy on social inequality. However, the observed spatial inequality of social mobility is an outcome of the interactions of many factors. Future researchers can work on discovering and identifying additional causal factors.

Figure 2.1: The Intergenerational Correlation of Education in 1982, 1990 and 2000



Notes: This figure displays a scatterplot of parent's and child's education in 1982, 1990 and 2000. It shows that the intergenerational education correlation has been rising over time.
Source: The 1% sample of the 1982, 1990 and 2000 China Population Censuses

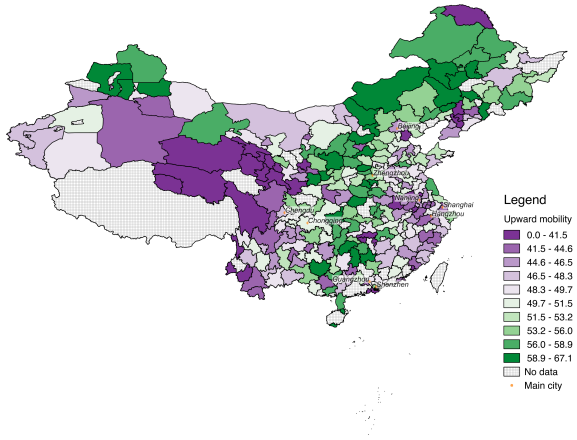
Figure 2.2: The Intergenerational Correlation by Parent's Education



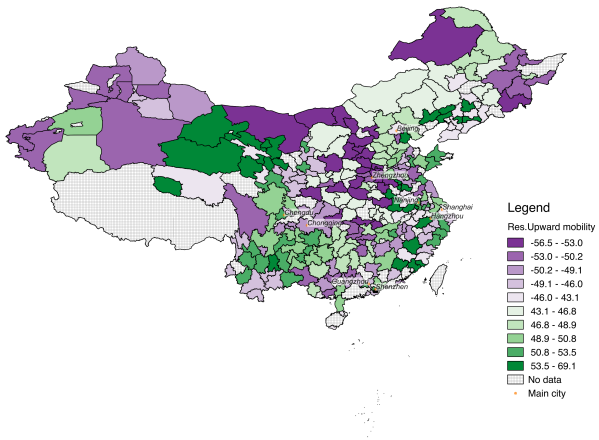
Notes: This figure shows the education correlation between parents and children at each level of parent's education. Over-time comparison suggests that the upward mobility in 2000 is more parent-dependent than in 1990 and 1982.
Source: The 1% sample of the 1982, 1990 and 2000 China Population Censuses

Figure 2.3: The Spatial Pattern of Upward Mobility Rate

(a) 1982 Census



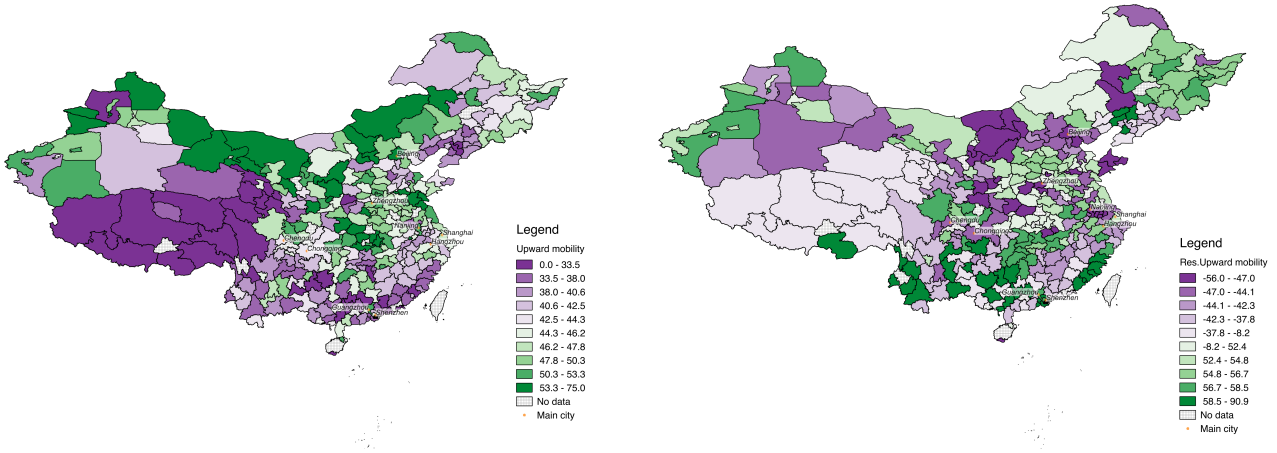
(b) 1982 Census, Residuals



Notes: The subplot (a) plots the upward mobiliy rate across prefectures in China in 1982. Upward mobility rate in a prefecture is measured as the proportion of individuals who move up in the education distribution relative to her parents (whose education rank in the national distribution within the same cohort exceeds her most educated parent's rank among all the parents in that cohort). The subplot (b) plots the residuals after controling for province fixed effects. Great spatial variations remain even after controling for province fixed effects.
Source. The 1% sample of the 1982 China Population Censuses

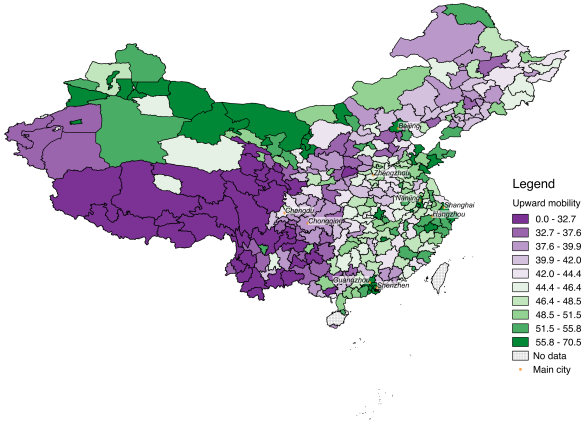
(c) 1990 Census

(d) 1990 Census, Residuals

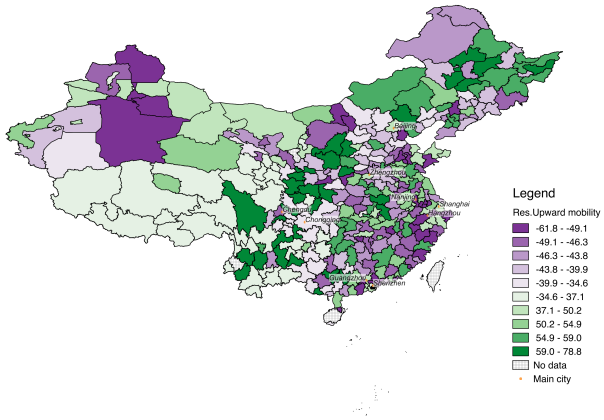


Notes: Subplot (a) plots the upward mobiliy rate across prefectures in China in 1990. Upward mobility rate in a prefecture is measured as the proportion of individuals who move up in the education distribution relative to her parents (whose education rank in the national distribution within the same cohort exceeds her most educated parent's rank among all the parents in that cohort). It seems to exhibit apparent east-west spatial disparity. Subplot (b) plots the residuals after controling for province fixed effects. It shows that the east-west spatial disparity disappears after controlling for province fixed effects. Yet, great within-provinces variations still remain.
Source: The 1% sample of the 1990 China Population Censuses

(e) 2000 Census

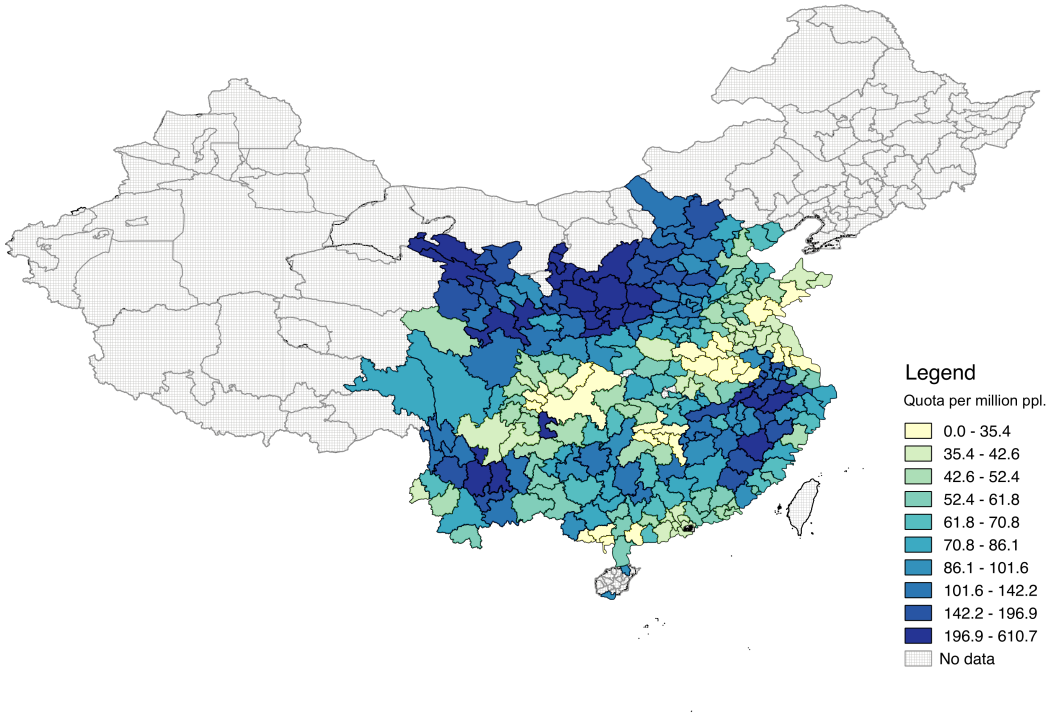


(f) 2000 Census, Residuals



Notes: Subplot (a) plots the upward mobiliy rate across prefectures in China in 2000. Upward mobility rate in a prefecture is measured as the proportion of individuals who move up in the education distribution relative to her parents (whose education rank in the national distribution within the same cohort exceeds her most educated parent's rank among all the parents in that cohort). It seems to exhibit apparent east-west spatial disparity. Subplot (b) plots the residuals after controling for province fixed effects. It shows that the east-west spatial disparity disappears after controlling for province fixed effects. Yet, great within-provinces variations still remain.
Source: The 1% sample of the 2000 China Population Censuses

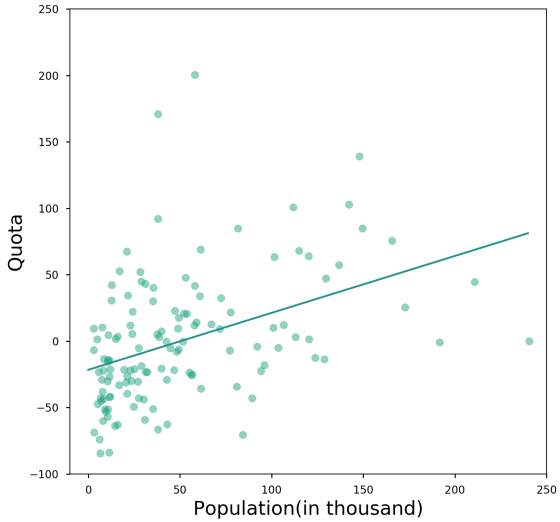
Figure 2.4: The Spatial Distribution of the Quota Density



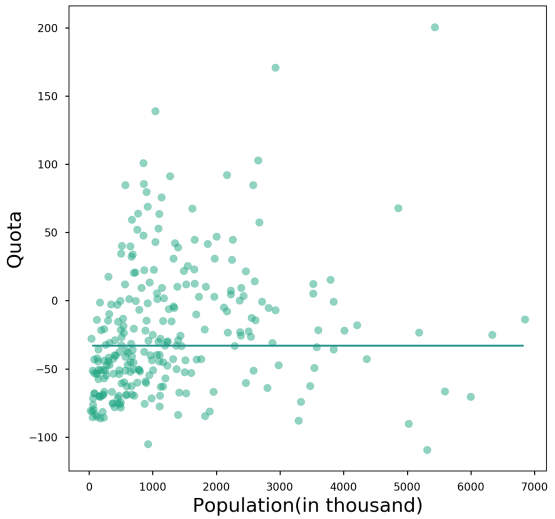
Notes: The *Sheng-yuan* quotas in historical prefectures are linked to contemporary counties and aggregated at contemporary prefecture level. This figure shows that there are great regional variations in quotas per capita.
Source: the Imperially Established Institutes and Laws of the Great Qing Dynasty (Kun, Gang et al. 1899).

Figure 2.5: Scatter Plot of the Quota against the Population at Prefecture Level in Ming and Qing Period

(a) in 1394 (Early Ming Period)



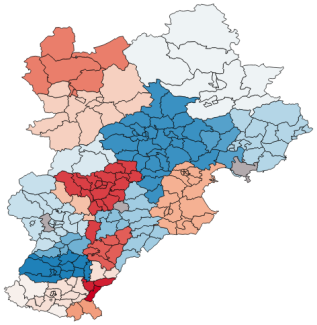
(b) in 1895 (Late Qing Period)



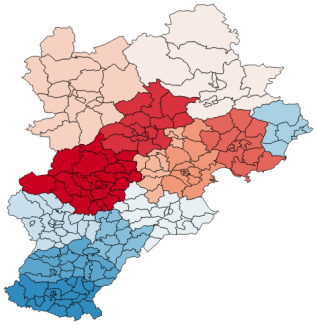
Notes: This figure plots the relationship between the exam quota and the population in 1394 and 1895, respectively, after controlling for province fixed effects. It shows that in early Ming period a prefecture's assigned quota and its population had an obvious positive relationship with an R-square at 30%, whereas this positive relationship had disappeared in the late Qing period when the quota seemed completely random to the population. This comparison suggests that quota could neither predict nor stimulate local development or growth. *Source:* The population data come from Cao (2000).

Figure 2.6: Examples of Boundary Change

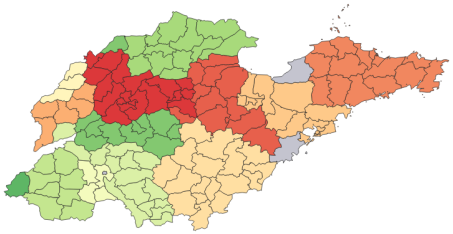
(a) Hebei Province in Qing Dynasty



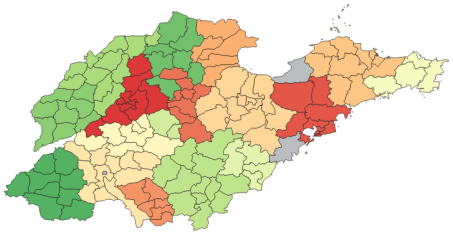
(b) Hebei Province in 2015



(c) Shandong Province in Qing Dynasty



(d) Shandong Province in 2015



Notes: This figure shows two examples of the extensive administrative divisions adjustment in China since 1949. With each color representing a prefecture, the subplots (a) and (c) show the maps of counties in Hebei and Shandong province and the historical prefectures to which they belonged in Qing Dynasty in the late 19th century. The subplots (b) and (d) show the maps of the counties and prefectures in 2015. The contrasting maps show that the boundaries have completely changed for most prefectures. *Source:* The population data come from Cao (2000).

Table 2.1: Summary Statistics for the Intergenerational Mobility Rates Across Prefectures in China

	Census		
	1982	1990	2000
# of Prefectures	273	322	339
Min	17.4	2.1	2.7
25th Percentile	45.9	39.1	38.6
50th Percentile	49.7	44.3	44.4
75th Percentile	54.8	49.1	50.1
Max	67.1	75.0	70.5
Mean	49.7	43.3	43.6
Std. Dev.	7.4	9.7	10.9

Notes: This table displays some prefecture-level main statistics for the intergenerational mobility rates across prefectures in China. Over time the mean of the upward mobility is getting lower, suggesting that the social stratification in China is getting more consolidated since the 1980s and that climbing up the social ladder has become more difficult. Likewise, the standard deviation is also getting larger, implying that the spatial disparity of upward mobility is persistent and even magnifying.

Table 2.2: The selection rates and the percentage of the population of all types of degree-holders

Examinations	Type of degree-holders	Success rate	Percentage of male population
County	Sheng-yuan	By quota	0.4-0.7[1]
Provincial	Ju-ren	0.33-0.5[2]	0.02-0.035[1]
National	Jin-shi	0.00016[3]	0.004-0.007[1]

[1] *Hao and Clark(2012)*
[2] *Campbell and Lee (2010, 2011)*
[3] *Chen et al. (2015)*

Notes: This table displays the success rate of passing each level of the *Keju* exam and the percentage of each type of degree-holders in the entire population. In the empirical analysis I use the success rate of *Sheng-yuan* which accounts for less than 1% population and its selection rate is determined by the quasi-exogeneous allocation of quota.
Source: Y. Liu, Higher Education, Meritocracy and Inequality in China

Table 2.3: Keju Exam and Aspirations Today

	Parent: What education level you expect *your child* to obtain?	Child: (age 10—15) What education level you expect to obtain?
Success chance	0.041*	0.092***
	(0.022)	(0.031)
Observations	6979	2110
Controls	Y	Y

Notes: This table shows the correlation between quota and individual's aspiration in contemporary society. Controls include child's age and parent's age, parent's education level, urbanization rate and consumption level at the living province. Standard errors in parenthesis are clustered at province level: * significant at 10%; ** significant at 5%; *** significant at 1%.
Source: China Family Panel Study (CFPS) 2016.

Table 2.4: Summary Statistics

	1967-1977		1957-1967		1949-1959	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Individual-level						
Individual's age	27.32	3.03	26.70	2.87	27.19	2.70
Individual's edu.	4.15	1.17	3.68	1.21	3.29	1.27
Parent's age	57.82	7.42	58.75	7.64	58.57	7.65
Parent's edu.	3.27	1.44	2.33	1.39	2.04	1.28
Living in urban place	0.22	0.42	N/D	N/D	N/D	N/D
Ethnicity(*Han*=1)	0.92	0.27	0.93	0.25	0.95	0.21
Hukou(Agricultural=1)	0.75	0.43	0.77	0.42	N/D	N/D
Observations	433654		521783		465826	
Prefecture-level						
Education	3.54	0.39	1.25	0.32	0.92	0.29
Population	4153.46	3451.24	4244.35	3378.64	4817.79	3420.65
Urbanization	0.23	0.26	0.25	0.28	0.22	0.27
Observations	267		253		222	

Notes: This table shows the summary statistics at individual and prefecture level. The population is in millions. N/D means no data is available.
Sources: The 1% sample of the 1982, 1990 and 2000 China Population Censuses

Table 2.5: The Effect of Keju Exam on Individual-level Education-based Upward Mobility

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success chance	1.130***	1.579***	0.305	0.619	0.796***	1.457***
(Measure for historical aspirations)	(0.272)	(0.454)	(0.334)	(0.565)	(0.262)	(0.520)
Individual Controls		Y		Y		Y
Prefecture Controls		Y		Y		Y
Province FE	Y	Y	Y	Y	Y	Y
Observations	433654	433654	521783	521783	465826	465826

Notes: The dependent variable $Mobility_i$ is a dummy variable, equal to 1 if the education rank of the individual exceeds that of her parents. $Quota_p$ is the standardized ***Keju*** exam quota in prefecture p. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age, parent's age and parent's education rank. The results are consistent with Prediction 1: Places with high level of social aspiration environment have high upward mobility, suggesting that ***Keju*** quota incentivizes upward mobility. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.6: The Effect of Keju Exam on Upward Mobility, by Child's Education Level

	(1)	(2)	(3)
1			
	-0.083**	-0.085**	-0.233*
	(0.039)	(0.039)	(0.134)
2			
	0.089	0.090	-0.438***
	(0.057)	(0.058)	(0.121)
3			
	0.003	0.007	-0.104**
	(0.038)	(0.038)	(0.044)
5			
	0.030	0.029	0.020
	(0.023)	(0.023)	(0.018)
6			
	0.051	0.051	0.062**
	(0.055)	(0.057)	(0.025)
7			
	0.062	0.062	0.077*
	(0.059)	(0.060)	(0.042)
8			
	0.082	0.080	0.054
	(0.118)	(0.118)	(0.076)
Individual controls		Y	Y
Prefecture controls		Y	Y
Province FE			Y
Observations	433178	433178	433178

Notes: This table shows the estimation results of a multinomial logit regression with the child's education as the outcome. The specification is similar to Equation 2.9. Education level 4 is used as the base outcome. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age, parent's age and parent's education rank. The results show that individuals in places with a high social aspiration environment are more likely to move upward from the bottom and achieve a higher education level(education level 6 and 7, equivalent to completing grade 12 or college). Standard errors in parenthesis are clustered at province level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.7: The Effect of Keju Exam on Upward Mobility, by Parent's Education Level

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success chance	0.601	1.421***	0.810	0.886	1.219*	1.200*
	(0.572)	(0.540)	(0.686)	(0.568)	(0.620)	(0.625)
$Edu = 2\times$ Succ.	0.103	0.752	0.120	0.729		
	(0.740)	(0.713)	(0.683)	(0.569)		
$Edu = 3\times$ Succ.	1.101	1.261***	0.677	0.679	1.298	1.541*
	(0.992)	(0.468)	(0.814)	(0.813)	(0.904)	(0.857)
$Edu = 4\times$ Succ.	1.016	0.892	1.298	1.041	1.167	1.166
	(1.012)	(0.918)	(1.014)	(0.904)	(0.798)	(0.794)
$Edu = 5\times$ Succ.	1.046	1.022	0.945	1.008	1.254	1.232
	(0.731)	(0.726)	(0.703)	(0.864)	(0.835)	(0.805)
$Edu = 6\times$ Succ.	1.015	1.006	0.875	1.143		
	(0.926)	(0.833)	(0.688)	(0.953)		
$Edu = 7\times$ Succ.	1.015	1.002	0.798	1.106		
	(0.924)	(0.836)	(0.714)	(1.022)		
$Edu = 8\times$ Succ.	-1.021	-1.007	1.063	1.756	1.180	1.155
	(0.935)	(0.881)	(0.697)	(1.495)	(0.799)	(0.793)
$Edu = 9\times$ Succ.	1.023	1.021				
	(0.941)	(0.933)				
Individual controls	Y	Y	Y	Y	Y	Y
Prefecture controls	Y	Y	Y	Y	Y	Y
Province FE		Y		Y		Y
Observations	433654	433654	521767	521767	465780	465780

Notes: This table shows the estimation results of specification (2.10). Controls include population and urbanization at prefecture level. Individual characteristics include individual's age, parent's age and parent's education rank. The results show that for cohorts 1967-1977 and 1949-1959 parents with elementary school education (education level 3, equivalent to completing grade 6) are more likely to be motivated by the quota and to set higher aspirations and thereafter more likely to achieve upward mobility in the next generation. This finding is consistent with Hypothesis 2. Cohort 1957-1967 does not show the same result probably due to the interruption of primary and secondary school in the *Cultural Revolution* period, hence it was especially difficult for 1957-1967 cohorts to obtain education beyond their parents. Standard errors in parenthesis are clustered at province level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.8: No Correlation between the Keju Exam and the Victims

	(1)	(2)	(3)
Success chance	0.016	0.010	0.010
	(0.012)	(0.012)	(0.010)
Prefecture controls.		Y	Y
Cluster			Y
Observations	174	174	174

Notes: The dependent variable $Mobility_p$ represents the average upward mobility in prefecture p. The main variable $Successchance_c$ is the standardized ***Keju*** exam quota per capita in county c. Controls include population and urbanization at prefecture level. This table suggest that the ***Keju*** quota has no predictive power of the number of victims in the *Cultural Revolution* movement. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

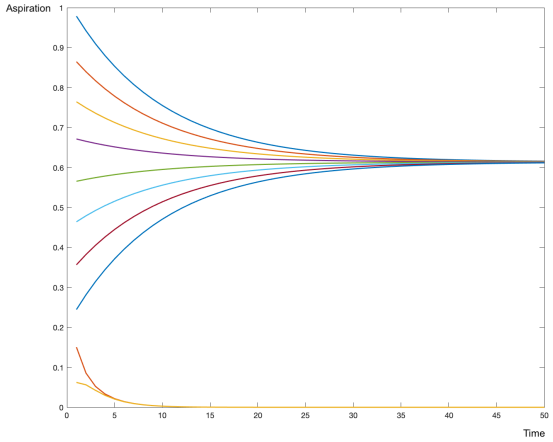
Table 2.9: The Complementary Effect of the *Keju* Exam and Return to Education on Upward Mobility

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success chance	1.049*	2.401***	0.584	0.728	0.782	0.639
(measure for hist. asp.)	(0.616)	(0.842)	(0.625)	(0.666)	(0.890)	(0.706)
Victims per capita	-0.017**	-0.016***	-0.001	-0.008	-0.011	-0.011
(proxy for the perceived drop in return to edu.)	(0.008)	(0.006)	(0.008)	(0.006)	(0.014)	(0.010)
Success × Vic.	-0.026**	-0.059**	-0.000	-0.008	0.007	-0.004
	(0.013)	(0.026)	(0.018)	(0.014)	(0.023)	(0.012)
Individual ctl.		Y		Y		Y
Prefecture ctl.	Y	Y	Y	Y	Y	Y
Observations	373974	373974	451270	451270	424739	424701

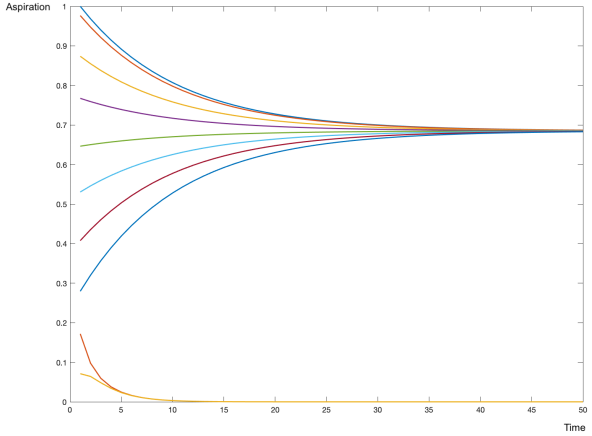
Note: Victim is the number of victims in a prefecture in the *Cultural Revolution* divided by the population of that prefecture (times one thousand for easy interpretation). Controls include population and urbanization at prefecture level. Individual characteristics include individual's age, parent's age and parent's education rank. The results in column 1 and 2 show that the impact of observing negative shock to education return is intensified by local aspiration environment. The cohorts 1949-1959 and 1957-1967 serve as placebo tests and show no effect, suggesting that the spatial variations in the number of victims are not simply capturing time-invariant prefecture differences. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

A Additional Tables and Figures

Figure 2.A1: An Illustration of Corollary 4



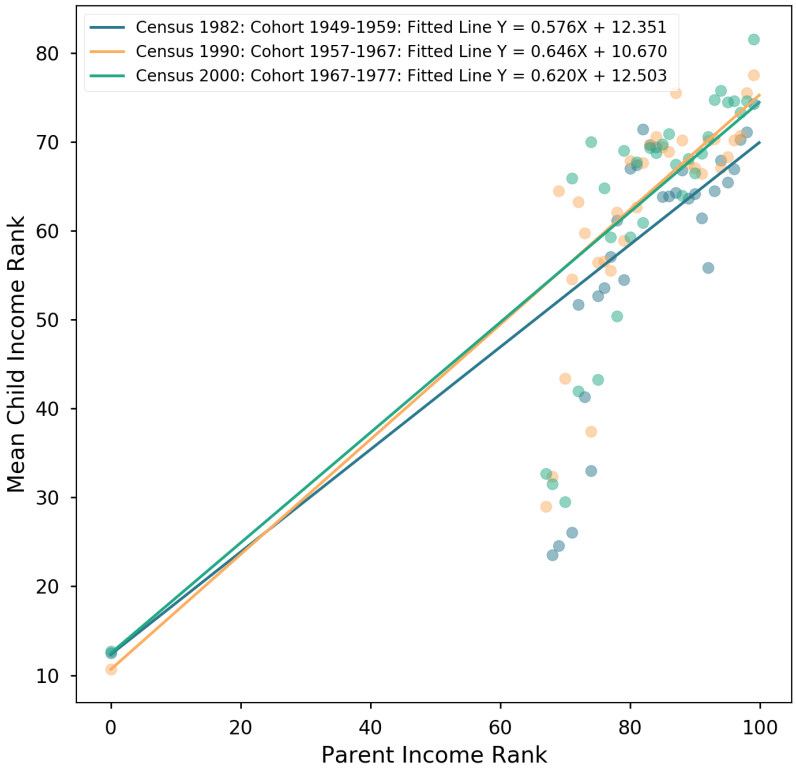
(a) ϕ=1.05



(b) ϕ=1.2

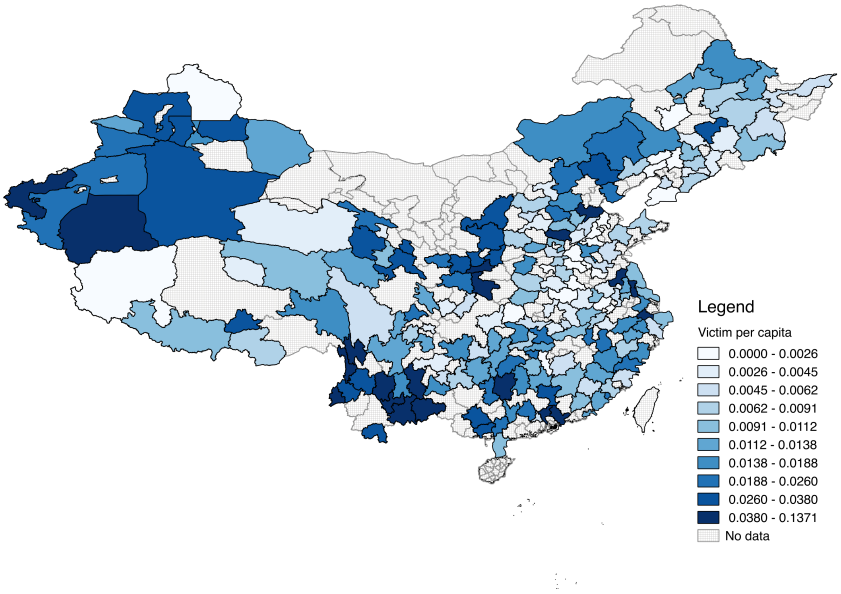
Notes: This figure illustrates Corollary 4. It shows that as long as aspirations are met, a positive shock(higher ϕ) to the initial aspiration distribution A_0 will induce a higher level of society-wide aspiration environment in steady state.

Figure 2.A2: The Intergenerational Correlation of Income (Rank)



Notes: This figure displays the scatterplot of the income of parent and children in 1982, 1990 and 2000. Individual's income is inferred from the reported occupation in the census. It suggests that the intergenerational income correlation in China is fairly high and has been increasing over time.
Source: The 1% sample of the 1982, 1990 and 2000 China Population Censuses, China Labour Statistics Assembly 1949-1985, China Labour Statistical Yearbook 1991, 1999.

Figure 2.A3: The Number of Victims in the Cultural Revolution



Notes: This map shows the number of victims every one thousand people in a prefecture under the circumstances of political persecutions during the *Cultural Revolution*. The map exhibits spatial variations, especially across provinces.
Source: China Political Events Dataset, 1966-1971

Table 2.A1: Coresidents v.s. Non-Coresidents

	Coresidents		Non-Coresidents	
	Mean	S.D.	Mean	S.D.
Educational attainment	4.04	1.17	4.10	1.30
Living in urban place	0.22	0.42	0.29	0.45
Hukou(Agricultural=1)	0.76	0.43	0.72	0.45
Ethnicity (*Han*=1)	0.91	0.28	0.92	0.27
Gender (Male=1)	0.55	0.50	0.39	0.48
Observations	535971		847406	

Notes: This table shows the education, living place, *Hukou*(Chinese household classification system, classified as agricultural and non-gricultural.), ethnicity and gender of the coresidents and the non-coresidents for the age cohort 23-32.
Source: The 1% sample of the 2000 China Population Census.

Table 2.A2: Placebo Test: Success Chance and Other Characteristics

	View of social inequality	Trust to local politicians	Purchase commercial insurance for child	CCP member
Success Chance	-0.022	0.008	-0.005	0.000
	(0.030)	(0.045)	(0.007)	(0.006)
Observations	6861	2042	6992	7010
Controls	Y	Y	Y	Y

Notes: This table shows that the *Keju* success chance has no effect on other characteristics than aspiration, implying that the observed relation between the success chance and aspiration is not simply due to cross-province differences or other omitted variables. Controls include individual's age and education, urbanization rate and consumption level in the living province. Standard errors in parenthesis are clustered at province level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.A3: The Distribution of Parent's Education

Edu. Level	Obs.	Percent	Cumulative Percent
1	64676	14.91	14.91
2	15892	3.66	18.58
3	198113	45.68	64.26
4	103343	23.83	88.09
5	19532	4.50	92.60
6	15516	3.58	96.18
7	9106	2.10	98.28
8	7273	1.68	99.95
9	203	0.05	100.00
Total	433654	100.00	100.00

Notes: This table shows the distribution of parent's education in 2000. Individuals with education level 3 (elementary school) constitutes the low-to-middle quintiles in the distribution.
Source: The 1% sample of the 2000 China Population Census.

Table 2.A4: The Effect of *Keju* Success Chance on Individual-level Education-based Upward Mobility, No College

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success Chance	1.083***	1.572***	0.315	0.637	0.801***	0.801***
	(0.246)	(0.414)	(0.334)	(0.565)	(0.263)	(0.267)
Individual Controls		Y		Y		Y
Prefecture Controls		Y		Y		Y
Province FE	Y	Y	Y	Y	Y	Y
Observations	426076	426076	518484	518468	464177	464177

Notes: This table shows the results excluding colleage graduates.The dependent variable $Mobility_i$ is a dummy variable, equal to 1 if the education rank of the individual exceeds that of her parents. $SuccessChance_p$ is the standardized ***Keju*** exam quota in prefecture p. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age, parent's age and parent's education rank. The results are consistent with Prediction 1: Places with high level of social aspiration environment have high upward mobility, suggesting that ***Keju*** quota incentivizes upward mobility. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.A5: The Effect of *Keju* Success Chance on County-level Upward Mobility in 2000

	(1)	(2)	(3)	(4)
Success Chance	0.619*	0.922***	0.637**	0.672**
	(0.350)	(0.302)	(0.307)	(0.287)
Controls		Y		Y
Province FE			Y	Y
Observations	2191	2191	2191	2191

Notes: The dependent variable $Mobility_p$ represents the average upward mobility in prefecture p. The main variable $SuccessChance_c$ is the standardized ***Keju*** exam quota per capita in county c. Controls include population at county level, and urbanization at prefecture level. The results are consistent with Prediction 1: Places with high level of social aspiration environment have high upward mobility, suggesting that ***Keju*** quota incentivizes upward mobility. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.A6: Alternative Measure of Mobility Using IGRC

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success Chance	-0.865**	-0.542*	-0.212	-0.404	-0.673**	-0.817***
	(0.386)	(0.294)	(0.509)	(0.501)	(0.327)	(0.313)
Prefecture Controls		Y		Y		Y
Individual Controls	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Observations	2191	2191	2132	2132	1991	1991

Notes: The dependent variable $Mobility_i$ is the intergenerational regression coefficient obtained from regressing parents' education rank on children's education rank. $SuccessChance_p$ is the standardized ***Keju*** exam quota in prefecture p. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age and its square, parent's age and its square, parent's income rank. The estimated coefficients are of similar magnitudes as those estimated using binary upward mobility. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%;

Table 2.A7: Alternative Measure of Mobility Using IGC

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success Chance	-0.882*	-0.702*	-0.314	-0.157	-0.715*	-0.811***
	(0.486)	(0.394)	(0.389)	(0.295)	(0.423)	(0.298)
Prefecture Controls		Y		Y		Y
Individual Controls	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Observations	2191	2191	2132	2132	1991	1991

Notes: The dependent variable $Mobility_i$ is the intergenerational correlation between parents and children ($IGRC \cdot \frac{\sigma_p}{\sigma_{ch}}$). $SuccessChance_p$ is the standardized ***Keju*** exam quota in prefecture p. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age and its square, parent's age and its square, parent's income rank. The estimated coefficients are of similar magnitudes as those estimated using binary upward mobility. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%;

Table 2.A8: The Effect of Quota on Individual-level Income-based Upward Mobility

	1967-1977		*1957-1967*		*1949-1959*	
	(1)	(2)	(3)	(4)	(5)	(6)
Success Chance	0.536*	0.497	0.222	0.224	0.104	0.119
	(0.321)	(0.345)	(0.457)	(0.463)	(0.383)	(0.411)
Individual Char.		Y		Y		Y
Prefecture Controls	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y
Observations	300998	300998	337879	337879	345011	345011

Notes: The dependent variable $Mobility_i$ is a dummy variable, equal to 1 if the income rank of the individual exceeds that of her parents. $SuccessChance_p$ is the standardized ***Keju*** exam quota in prefecture p. Controls include population and urbanization at prefecture level. Individual characteristics include individual's age and its square, parent's age and its square, parent's income rank. The estimated coefficients are of similar magnitudes as those estimated from education-based data. The results are not significant due to large standard errors, which is possibly a result of the noisy measure of income. Standard errors in parenthesis are clustered at prefecture level: * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.A9: Summary Statistics for Victims in the Cultural Revolution

	Obs.	Mean	Std.
Anhui	337	7.62	11.78
Beijing	158	29.51	23.54
Fujian	290	16.81	13.85
Gansu	451	33.03	29.69
Guangdong	701	49.59	155.91
Guangxi	565	33.58	25.38
Guizhou	469	16.89	36.70
Hebei	946	29.33	58.38
Heilongjiang	343	11.96	12.16
Henan	485	16.34	25.59
Hubei	511	13.30	44.86
Hunan	737	21.93	34.10
Inner Mongolia	296	61.69	73.55
Jiangsu	686	75.90	390.63
Jiangxi	295	25.53	42.21
Jilin	291	8.99	15.25
Liaoning	314	24.65	28.97
Ningxia	86	9.27	7.83
Qinghai	124	21.77	24.24
Shaanxi	1330	49.77	64.98
Shandong	443	12.37	25.72
Shanghai	167	62.92	32.03
Shanxi	370	24.38	60.11
Sichuan	1338	14.62	23.26
Tianjin	17	24.43	14.29
Tibet	21	30.49	20.82
Xinjiang	439	28.95	23.91
Yunnan	779	62.53	80.61
Zhejiang	323	39.60	66.08

Notes: This table shows the number of victims under the circumstances of political persecutions during the *Cultural Revolution* period. The dataset contains 2,040 county-level jurisdictions. This table summarizes the numbers by province.
Source: China Political Events Dataset, 1966-1971

B Mathematical Appendix

Recall the firts order condition as in equation 2.8:

$$\left(\lambda_{t-1} - \frac{m(r)}{\delta}\right)^{-\sigma} = \rho\delta\left[\lambda_t^{1-\sigma} m(r)^{-\sigma} + \pi(m(r) - r)^{-\sigma}\right]$$

Proof of Proposition 1

Take derivative with respect to the aspirations ratio r:

$$\begin{aligned}
&\frac{\sigma}{\delta}\left(\lambda_{t-1} - \frac{m(r)}{\delta}\right)^{-\sigma-1}\frac{\partial m(r)}{\partial r} \\
=&\rho\delta\left[\left(-\sigma\lambda_t^{1-\sigma} m(r)^{-\sigma-1} - \sigma\pi(m(r) - r)^{-\sigma-1}\right)\frac{\partial m(r)}{\partial r} + \sigma\pi(m(r) - r)^{-\sigma-1}\right]
\end{aligned}$$

Rearrange,

$$\begin{aligned}
&\frac{\partial m(r)}{\partial r}\left[\rho\delta\left(\lambda_t^{1-\sigma} m(r)^{-\sigma-1} + \pi(m(r) - r)^{-\sigma-1}\right) + \frac{1}{\delta}\left(\lambda_{t-1} - \frac{m(r)}{\delta}\right)^{-\sigma-1}\right] \\
=&\rho\delta\pi(m(r) - r)^{-\sigma-1}
\end{aligned}$$

Since
(1) $\lambda_{t-1} - \frac{m(r)}{\delta} = \lambda_{t-1}(1 - \frac{k}{y}) > 0$, and
(2) Aspirations are assumed to be met, $m(r) > r$,

$$\frac{\partial m(r)}{\partial r} > 0. \;\; Q.E.D.$$

Proof of Proposition 3

Take derivative with respect to the aspirations ratio λ_t:

$$\begin{aligned}
&\frac{\sigma}{\delta}\left(\lambda_{t-1}-\frac{m(r)}{\delta}\right)^{-\sigma-1}\frac{\partial m(r)}{\partial \lambda_t} \\
=&\rho\delta\left[(1-\sigma)\lambda_t^{-\sigma}m(r)^{-\sigma}-\sigma\lambda_t^{1-\sigma}m(r)^{-\sigma-1}\frac{\partial m(r)}{\partial \lambda_t}-\sigma\pi(m(r)-r)^{-\sigma}\frac{\partial m(r)}{\partial \lambda_t}\right]
\end{aligned}$$

Rearrange,

$$\begin{aligned}
&\frac{\partial m(r)}{\partial r}\left[\frac{\sigma}{\delta}\left(\lambda_{t-1}-\frac{m(r)}{\delta}\right)^{-\sigma-1}+\rho\delta\left[\sigma\lambda_t^{1-\sigma}m(r)^{-\sigma-1}+\pi\sigma(m(r)-r)^{-\sigma}\right]\right] \\
=&\rho\delta(1-\sigma)\lambda_t^{-\sigma}m(r)^{-\sigma}
\end{aligned}$$

Again, since
(1) $\lambda_{t-1}-\frac{m(r)}{\delta}=\lambda_{t-1}(1-\frac{k}{y})>0$, and
(2) Aspirations are assumed to be met, $m(r)>r$,

$$\frac{\partial m(r)}{\partial \lambda_t}>0.\ \ Q.E.D.$$

Chapter 3

BARRIERS TO PARTICIPATING IN GLOBAL VALUE CHAINS

with Yimei Zou

3.1 Introduction

Search problem and contracting problem are major challenges for buyers and sellers across geographic distance to participate in global value chains (Jensen, 2007; Stigler, 1961; Trefler, 1995) [1]. Previous literature (for example, Jensen, 2007; Aker, 2010; Allen, 2014; Brynjolfsson and Smith, 2000; Brown and Goolsbee, 2002; Hortaçsu et al., 2009; Overby and Forman, 2014) has shown that the development of internet technology in the past decades has helped mitigate the search problem by reducing the cost of global search and match. Nonetheless, contracting problem can still arise when buyers and sellers are in distance. In essence, the uncertainty about product quality and traders' credibility may impede the efficiency of trade. Consider a clothing producer in Spain who is considering sourcing fabrics from China. Suppose she has managed to find several suppliers in China through web searches, however, because she cannot directly examine the product, she might be more cautious in making transactions with unknown sellers online than in a face-to-face trade.

In practice, the search problem and the contracting problem are often mixed together, making it difficult to disentangle the two effects. Understanding the empirical sizes of the two effects is very important because without a clear understanding of the trade barriers to participating in global value chains, it is difficult for policymakers to design appropriate e-market policies. In this paper, we quantify the two trade costs separately by exploiting suppliers' different degrees of online exposure. The suppliers with the lowest degree are those that rely totally on the offline market and have zero online presence. The second-degree group consists of the suppliers with the minimum online presence - they usually have their own company websites but they do not use any search engine services (such as Google AdWords) or online trade platform (such as Alibaba.com). The third group is those who use search engine services to improve online exposure, and the highest degree ones are the ones that use both search engine services and trade platform.

[1] See examples in Albornoz et al. (2012); Hummels and Schaur (2013); Evans and Harrigan (2005)

We focus on intermediate goods rather than final goods as intermediate goods is a key component in global value chains. We build a theoretical model to model the behaviors of buyers and suppliers in trade settings with information frictions. A representative buyer combines intermediate varieties according to a CES production function, and she chooses intermediate input demand to minimize her cost. The information frictions are imposed on the suppliers to prevent them from perfectly revealing their true quality to the buyers. A supplier can improve its chance of meeting the buyer by means such as increasing its online exposure. The model delivers two predictions: First, better-quality suppliers are more likely to improve their online presence; Second, the two types of marketing strategies (search engine and trade platform) are complements for the better-quality suppliers.

Our data comes from various sources. 1) The trade data comes from Chinese customs. We choose the fiber and yarn industry because the fabric is one of the commonly traded intermediate goods in global value chains. In particular, our data contains all the exporting transactions from China with HS code 5402 (Synthetic filament yarn) and 5509 (Yarn of fibers). The dataset contains 232570 entries of 11889 suppliers for the period 2013-2017. 2) We choose Alibaba.com as the representative of trade platforms for two reasons. First, Alibaba.com is the world' s largest B2B marketplace. It is the main marketplace for Chinese exporters who do e-commerce; Second, it provides a wide range of services including electronic payment services (AliPay) to enforce the post-contract delivery and payment, improving the safeness of online commerce, as well as the trustworthiness evaluation service (Alibaba Trustpass) to the exporting suppliers to help signal the quality. 3) We measure suppliers' online exposure by analyzing the web traffic of the suppliers' webpages. The web traffic data contains information about where the visitors to the website are directed from, so we know whether a supplier uses trade platform such as Alibaba.com, or search engine services such as Google Adwords.

Our data allows us to have three treatment groups by their degrees of online exposure. Using suppliers that have no online presence as control group, treatment group 1 is suppliers that have their own websites on

which most of the traffic come from Google search; treatment group 2 is suppliers that present on Alibaba.com and have most of its traffic from Alibaba search; the third treatment group are those who have Alibaba presence and also have a considerable proportion of traffic come from Google search.

In the reduced-form analysis, we focus on two groups - the ones that use Alibaba.com and the rest of the suppliers. Alibaba.com as a trade platform can mitigate the contracting problem thanks to its safety electronic payment service and supplier trustworthiness evaluation service. We find that after controlling for supplier's location, company type and time effect, Alibaba-listed suppliers have significantly higher trade values. Moreover, we find that suppliers that use Alibaba.com trade with a larger range of countries than average exporting suppliers and Alibaba-listed suppliers conduct more transactions per year than average exporting suppliers.

However, due to the lack of exogenous variation in the use of the trade platform, it is hard to precisely identify the effect of the trade platform as a quality signal. Since good quality suppliers may have good trade performance regardless of using trade platforms, suppliers' unobservable quality may be left in the errors and correlated with the use of the trade platform. So, to quantify the effect of using trade platform to signal quality, to provide causal inference, and to do some counterfactual analysis, a structural model may be needed.

The paper is organized as follows: Section 3.2 lays out the theoretical model that guides our empirical identification and estimation. In Section 3.4, We describe our data source as well as the measurement. Section 3.5 explains the identifying assumption and shows the reduced-form results. Section 3.6 is conclusion. Finally, in Section **??** we propose future research plan.

3.2 Theoretical Model

3.2.1 The Buyer

A representative buyer combines intermediate varieties according to a CES production function:

$$X = \left(\int_0^N z_i x_i^{\beta} \mu_i di \right)^{\frac{1}{\beta}} \tag{3.1}$$

where z_i is the expected quality of the supplier i; $\mu_i \in [0, 1]$ is the probability that the buyer meets supplier i. The buyer chooses intermediate input demand $\{x(\theta)\}$ to solve

$$\begin{aligned} &\min \int_0^N p_i x_i \mu_i di \\ \text{s.t.} \qquad &X = \left(\int_0^N z_i x_i^{\beta} \mu_i di \right)^{\frac{1}{\beta}} \end{aligned}$$

First order condition with respect to x_i:

$$\begin{aligned} p_i \mu_i &= \lambda \frac{1}{\beta} \left(\int_0^N z_i x_i^{\beta} \mu_i di \right)^{\frac{1}{\beta}-1} \beta z_i x_i^{\beta-1} \mu_i \qquad (3.2) \\ p_i &= \lambda X^{1-\beta} z_i x_i^{\beta-1} \\ \left(\frac{p_i}{\lambda X^{1-\beta} z_i} \right)^{\frac{\beta}{\beta-1}} &= x_i^{\beta} \end{aligned}$$

where λ is the Lagrange multiplier. Substituting the above FOC into

the production function:

$$
\begin{aligned}
X &= \left[\int_0^N z_i \left(\frac{p_i}{\lambda X^{1-\beta} z_i}\right)^{\frac{\beta}{\beta-1}} \mu_i di\right]^{\frac{1}{\beta}} \\
X &= \left(\lambda X^{1-\beta}\right)^{\frac{1}{1-\beta}} \left(\int_0^N z_i^{\frac{1}{1-\beta}} p_i^{\frac{\beta}{\beta-1}} \mu_i di\right)^{\frac{1}{\beta}} \\
1 &= \lambda^{\frac{1}{1-\beta}} P^{\frac{1}{\beta-1}}
\end{aligned}
$$

where $P \equiv \left(\int_0^N z_i^{\frac{1}{1-\beta}} p_i^{\frac{\beta}{\beta-1}} \mu_i di\right)^{\frac{\beta-1}{\beta}}$ is the producer price index. The last line implies that $\lambda = P$, which implies that intermediate input demand for supplier i is

$$x_i = \left(\frac{p_i}{P X^{1-\beta} z_i}\right)^{\frac{1}{\beta-1}} \tag{3.3}$$

3.2.2 Suppliers

There is a exogenous measure N of monopolistically competitive suppliers indexed by i. Suppliers produce differentiated input varieties using labor:

$$x_i = l_i$$

Information frictions prevent suppliers from perfectly revealing their true quality[2] to the buyer. With probability σ_i, the quality of supplier i's product perceived by the buyer is the true quality θ_i; with probability $1 - \sigma_i$, the perceived quality of supplier i is some constant $\overline{\theta}$. This implies that the buyer's expected quality of supplier i is

$$z_i = \sigma_i \theta_i + (1 - \sigma_i)\,\overline{\theta}$$

[2]In practice, supplier quality can be interpreted by the quality of the supplier's products, its credibility, its capacity and so on

Monopolistic pricing implies a constant markup over marginal cost:

$$p_i = \frac{w}{\beta}$$

A supplier can improve its chance of meeting the buyer by means such as increasing its online presence, which requires labor. We assume that, to achieve a matching probability μ_i with the buyer, supplier i must pay a cost of $\kappa_\mu \mu_i^{\rho_\mu}$ in units of labor where $\kappa_\mu, \rho_\mu > 0$. A supplier can also spend resources to better reveal its quality to the buyer, such as paying to use trading platforms that cerfity supplier quality. We assume that, to achieve a probability σ_i of correctly revealing its quality to the buyer, supplier i must pay a cost of $\kappa_\sigma \sigma_i^{\rho_\sigma}$ in units of labor where $\kappa_\sigma, \rho_\sigma > 0$.

Profit of supplier i consists of sales profits minus the two types of marketing costs:

$$\begin{aligned}\pi_i &= (p_i x_i - l_i w)\,\mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \qquad (3.4)\\ &= (1-\beta)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w\end{aligned}$$

Proof is in Appendix.

Labor market clearing:

$$L = \int_0^N \left(l_i + \kappa_\mu \theta_i^{\gamma_\mu} \mu_i^{\rho_\mu} + \kappa_\sigma \theta_i^{\gamma_\sigma} \sigma_i^{\rho_\sigma}\right) di$$

Supplier i chooses μ_i and σ_i to maximize profit:

$$\max \pi_i = (1-\beta)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w$$

First order condition with respect to μ_i:

$$(1-\beta)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}} = \rho_\mu \kappa_\mu \mu_i^{\rho_\mu - 1} w$$

$$\mu_i^{\rho_\mu - 1} = \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}}$$

$$\mu_i = \left\{\left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}}\right\}^{\frac{1}{\rho_\mu - 1}}$$

First order condition with respect to σ_i:

$$\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}} \left(\theta_i - \overline{\theta}\right)\mu_i = \rho_\sigma \kappa_\sigma \sigma_i^{\rho_\sigma - 1} w$$

If $\theta_i \leq \overline{\theta}$, the left-hand-side of the above FOC is non-positive, so that the supplier chooses $\sigma_i = 0$.

If $\theta_i > \overline{\theta}$ and the supplier chooses $\sigma_i \in (0,1)$, then the above FOC holds with equality. Substituting the FOC with respect to μ_i into the FOC with respect to σ_i:

$$\left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu - 1}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)} \left(\theta_i - \overline{\theta}\right)\left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)^{\frac{1}{\rho_\mu - 1}}$$
$$= \rho_\sigma \kappa_\sigma \sigma_i^{\rho_\sigma - 1} w \tag{3.5}$$

Proof is in Appendix.

Determine the sign of $d\sigma_i / d\theta_i$ by applying the Implicit Function Theorem. Define the LHS of the above FOC as a function of σ_i and θ_i:

$$F(\sigma_i, \theta_i) \equiv$$
$$\left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu - 1}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)} \left(\theta_i - \overline{\theta}\right)\left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)^{\frac{1}{\rho_\mu - 1}}$$
$$- \rho_\sigma \kappa_\sigma \sigma_i^{\rho_\sigma - 1} \tag{3.6}$$

Proof is in Appendix.

The FOC w.r.t θ_i:

$$\begin{aligned}&\frac{\partial F\left(\sigma_i,\theta_i\right)}{\partial\theta_i}\\&=\left(\frac{\sigma_i}{\theta_i-\overline{\theta}}\right)\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}}\right]+\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}\\&>0\end{aligned}\tag{3.7}$$

Proof is in Appendix.

The FOC w.r.t σ_i:

$$\begin{aligned}&\frac{\partial F\left(\sigma_i,\theta_i\right)}{\partial\sigma_i}\\&=\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}}\right]-\left(\rho_\sigma-1\right)\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}\end{aligned}\tag{3.8}$$

Proof is in Appendix.

Provided that the exogenous parameters satisfy $\rho_\sigma > \frac{1}{1-\beta}\left(\frac{\rho_\mu}{\rho_\mu-1}\right)$, we have that $\frac{\partial F(\sigma_i,\theta_i)}{\partial\sigma_i}<0$ and therefore

$$\frac{d\sigma_i}{d\theta_i}=-\frac{\frac{\partial F(\sigma_i,\theta_i)}{\partial\theta_i}}{\frac{\partial F(\sigma_i,\theta_i)}{\partial\sigma_i}}>0\tag{3.9}$$

Proof is in Appendix.

To determine the sign of $d\mu_i/d\theta_i$, we totally differentiate the FOC with respect to μ_i:

$$\mu_i=\left\{\left(\frac{1-\beta}{\rho_\mu\kappa_\mu w}\right)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right\}^{\frac{1}{\rho_\mu-1}}\left[\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}\right]^{\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)}$$

$$\frac{d\mu_i}{d\theta_i} > 0 \tag{3.10}$$

The exogenous parameter κ_μ regulates the costs of overcoming search frictions to meet the buyer. We assume that parameter κ_μ is sufficiently large such that $\mu_i < 1$ for all suppliers. The exogenous parameter κ_σ regulates the costs of overcoming information frictions to reveal supplier quality to the buyer. We assume that parameter κ_σ is sufficiently large such that $\sigma_i < 1$ for all suppliers.

3.3 Predictions

Suppliers marketing strategies are as follows:

- For suppliers with true quality $\theta_i \leq \overline{\theta}$, they choose not to use the trading platform ($\sigma_i = 0$). They spend the same amount on online presence and achieve the same matching probability:

$$\mu_i = \left[\left(\frac{1-\beta}{\rho_\mu \kappa_\mu w} \right) \left(\frac{w}{\beta} \right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta} \right)^{\frac{1}{1-\beta}} \overline{\theta}^{\frac{1}{1-\beta}} \right]^{\frac{1}{\rho_\mu - 1}}$$

$$\frac{d\mu_i}{d\theta_i} = 0$$

- For suppliers with true quality $\theta_i > \overline{\theta}$, they spend on improving both their online presence and certifying their quality ($\sigma_i > 0$). In particular, both types of marketing spending increase in the supplier's true type θ_i:

$$\frac{d\mu_i}{d\theta_i} > 0$$
$$\frac{d\sigma_i}{d\theta_i} > 0$$

Thus better quality suppliers are more willing to improve their online presence and adopt trading platforms, suggesting that these two types of marketing strategies are complements for the better-quality suppliers.

3.4 Data

3.4.1 Trade data

Our Trade data comes from Chinese customs data. We choose a subset - fiber and yarn - in the fabric industry because fabric is one of the commonly traded intermediate goods in global value chains[3]. In particular, our data contains all the export transactions from China with HS code[4] 5402 (Synthetic filament yarn)[5] and 5509 (Yarn of fibers)[6]. The dataset contains 232570 entries of 11889 suppliers during the period 2013-2017.

3.4.2 Trade Platform - Alibaba.com

We choose *Alibaba.com* as the representative of trade platforms for two reasons. First, *Alibaba.com* is the world's largest B2B marketplace. Its online sales and profits surpassed all US retailers (including Walmart, Amazon and eBay) combined since 2015[7]. It is the main marketplace for Chinese exporters who do e-commerce. Second, It is owned and managed by *Alibaba Group*, which is the world's largest retailer and e-commerce company. It provides a wide range of sales services via web portals, as

[3] in future research we would like to include more intermediate industries to study the heterogeneous effect across industries.

[4] HS Codes are used by customs and logistics providers to unify trade goods categories across the 182 member countries in the World Customs Organization.

[5] 5402 - Synthetic filament yarn (other than sewing thread), not put up for retail sale, including synthetic monofilament of less than 67 decitex.

[6] 5509 - Yarn (other than sewing thread) of synthetic staple fibers, not put up for retail sale.

[7] $https://www.institutionalinvestor.com/article/b1505pjf8xsy75/alibaba-vs-the-world$

well as electronic payment services (*AliPay*)[8] to enforce the post-contract delivery and payment, improving the safeness of online commerce. Moreover, based on its huge transaction and payment data, *Alibaba Group* also provides trustworthiness evaluation service (*Alibaba Trustpass*) to the exporting suppliers on the *Alibaba.com*. This service is to evaluate the credibility of suppliers and issue evaluation report. High evaluation score is often regarded as a quality signal.

3.4.3 Matching Trade Data to Supplier Data

To find out which suppliers use Alibaba.com, we first collect the supplier list under the category of fiber, yarn and thread on Alibaba.com. Then we go to the homepage of each supplier on the Alibaba.com and scrape the company information including company name, telephone, mobile, fax and address. Figure 3.A1 shows an example of product showcase page and Figure 3.A2 shows a typical company overview page on Alibaba.com. We then match with our customs data by company name. We successufully matched 330 of all the 845 suppliers in the category of fiber, yarn and thread. In theory, all the suppliers on the Alibaba.com should be found in the customs data. The reason we cannot match all is that some alibaba-listed suppliers do not trade in HS code 5402 and 5509. If we had the universe of customs data, we should expect an almost 100% match rate.

With the matched data in hand, we report descriptive statistics of the Alibaba-listed suppliers and all the exporting suppliers in our customs dataset. The summary statistics is shown in Table 3.1.

[8] $https://en.wikipedia.org/wiki/Alibaba\_Group$

3.5 Identification and Estimation

3.5.1 Identifying Assumption

Predicted by the theoretical model, we hypothesize that better-quality suppliers are more likely to use online trade platforms. However, since suppliers' quality is unobservable, we cannot directly observe if suppliers on trade platforms have better quality in reality. What we can observe is suppliers' trade performance, such as trade values, trade destinations and the number of transactions, and their geographical location.

We assume that supplier quality and its trade performance are positively correlated. To establish this link, we need to assume that this is a repeated game, so better-quality supplier can build up higher trade values, have more trade partners and perform more transactions over time.

In the first part of the empirical exercise we perform reduced-form regressions to examine whether suppliers that use Alibaba.com are systematically different in trade performance from suppliers that do not use Alibaba.com. If suppliers that use Alibaba.com are found to have better trade performance, with our assumption that supplier quality and its trade performance are positively correlated, it would suggest that suppliers on Alibaba.com generally have better quality.

Specifically, we use trade performance as the main outcome variable. The regression specification is as following:

$$Y_{it} = \beta Alibaba_i + X_i + Time_t + \alpha + u_{it} + \epsilon_{it} \tag{3.11}$$

Where Y_{it} is the trade performance of supplier i at month-year t. X_i is a series of time-invariant supplier characteristics. $Time_t$ is either a time trend or time fixed effects. u_{it} is between-supplier error and ϵ_{it} is within-supplier error.

3.5.2 Reduced-form Results

The regression result estimated for Equation 3.11 is shown in Table 3.2. We use trade frequency as the main measure of trade performance. The re-

sult shows that after controling for supplier's location, company type and time effect, alibaba-listed suppliers have significantly higher trade values, though it should be noticed that the effect disappears when clustering by supplier.

In addition, we have alternative measures of trade performance using trade values and trade destinations. Shown in Table 3.4 and Table 3.3, the regression results show consistent result. Visualized using histograms, Figure 3.1 shows histograms of trade countries per supplier. Apparently suppliers that use Alibaba.com trade with a larger range of countries than average exporting suppliers. Figure 3.2 shows that Alibaba-listed suppliers conduct more transactions per year than average exporting suppliers.

3.6 Conclusion

In this paper, we study the search and contracting problems in firms' participation in global value chains. We focus on intermediate goods. We quantify the two trade costs separately by exploiting suppliers' different degrees of online exposure. We build a theoretical model of buyers and suppliers with information frictions. We test the model predictions using reduced-form analysis. We find that the trade platform significantly reduce the contracting cost. The reduced-form results show that suppliers that use Alibaba.com have higher trade values, trade with a wider range of countries and perform more transactions. Moreover, we find that though suppliers overall are mostly located along the east coast, Alibaba-listed suppliers are located more sparsely and there is a larger proportion of suppliers located in inland places.

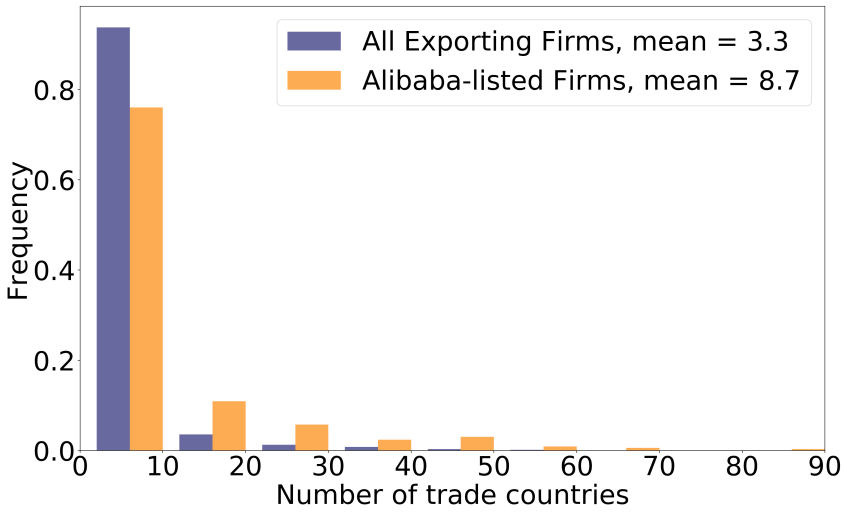


Figure 3.1: Histogram of Trade countries per Supplier

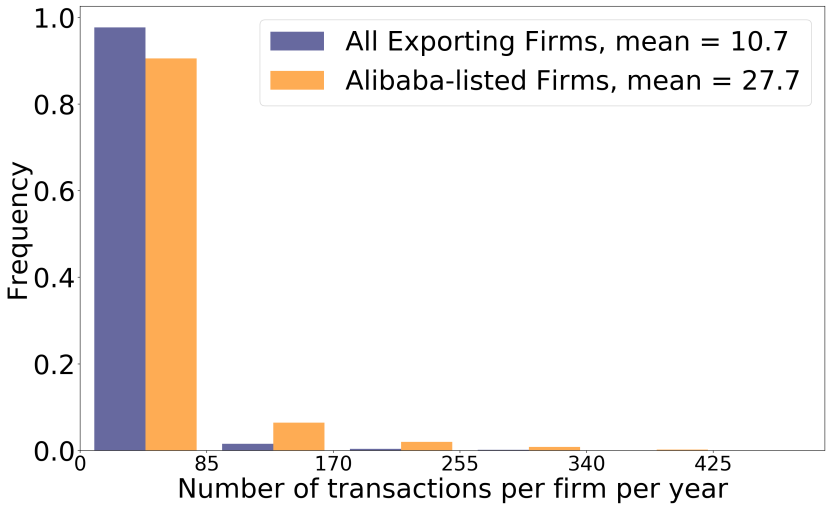


Figure 3.2: Histogram of Transactions per Supplier per Year

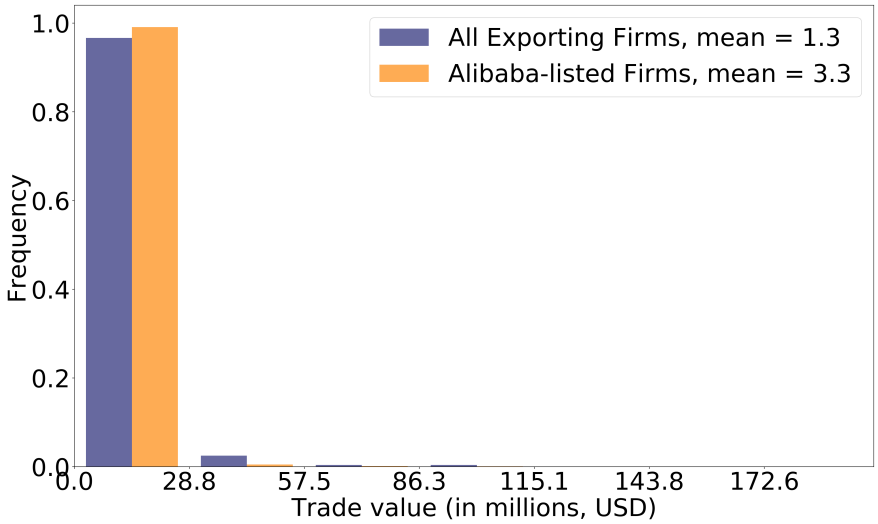


Figure 3.3: Histogram of Trade value per Supplier per Year

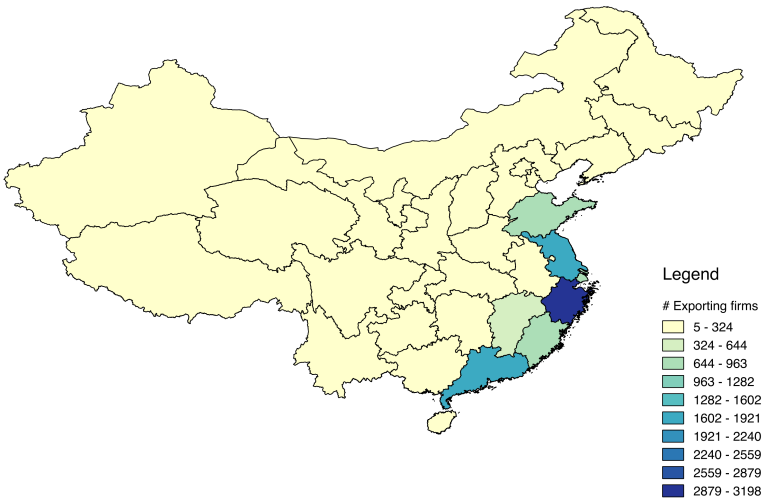


Figure 3.4: Spatial Distribution of All the Exporting Suppliers

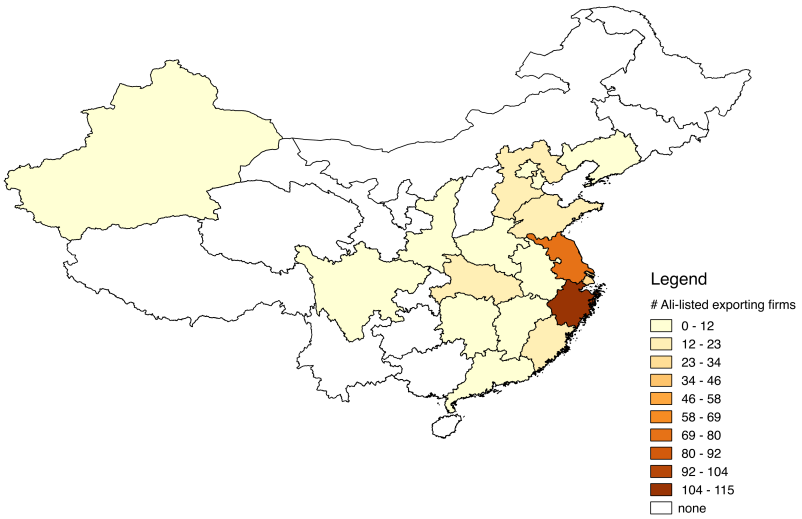


Figure 3.5: Spatial Distribution of Exporting Suppliers on Alibaba.com

Table 3.1: Statistics Summary

	All exporting firms			Alibaba-listed firms		
	#Cty	Value	#Trans	#Cty	Value	#Trans
Mean	3.27	1.28	10.75	8.66	3.32	27.72
Std	6.13	8.35	31.09	12.72	10.36	50.56
Min	1.00	0.00	1.00	1.00	0.00	1.00
0.25	1.00	0.01	1.00	1.00	0.03	2.00
0.50	1.00	0.04	3.00	3.00	0.21	7.00
0.75	3.00	0.22	8.00	10.00	1.80	27.00
Max	91.00	287.66	859.00	91.00	98.70	360.00
Count	11889.00	11889.00	11889.00	330.00	330.00	330.00

Note: This table reports some descriptive statistics for the whole exporting firms and for firms that use Alibaba.com.

Table 3.2: The Effect of Using Alibaba.com on Trade Frequency

	(1)	(2)	(3)	(4)	(5)
Using	4.352*	4.367*	6.103**	6.088**	6.088*
Alibaba.com	(2.637)	(2.639)	(2.605)	(2.605)	(3.348)
N	21640	21639	21639	21639	21639
Year Trend	N	Y	Y	N	N
Year FE	N	N	N	Y	Y
Other Controls	N	N	Y	Y	Y
Clustering	N	N	N	N	Y

Note: The table reports the effects of using Alibaba.com on suppliers' trade frequency. The outcome variable is a supplier's trade frequency in a given year. Other controls include geographical location(province) fixed effect and company type (State-owned, Privately owned, Foreigned owned, Chinese-foreign equity, Collectively owned.eta) fixed effect. Standard errors are in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%. The standard errors in column(5) are clustered at individual supplier level.

Table 3.3: The Effect of Using Alibaba.com on Trade Destinations

	(1)	(2)	(3)	(4)	(5)
ali	8.487	8.485	10.053*	10.027*	10.027
	(5.748)	(5.748)	(5.735)	(5.735)	(6.287)
N	21639	21639	21639	21639	21639
Year Trend	N	Y	Y	N	N
Year FE	N	N	N	Y	Y
Other Controls	N	N	Y	Y	Y
Clustering	N	N	N	N	Y

Note: The table reports the effects of using Alibaba.com on suppliers' trade destinations. The outcome variable is the number of trade countries that the supplier trades to in a given year. Other controls include geographical location(province) fixed effect and company type (State-owned, Privately owned, Foreigned owned, Chinese-foreign equity, Collectively owned.eta) fixed effect. Standard errors are in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%. The standard errors in column(5) are clustered at individual supplier level.

Table 3.4: The Effect of Using Alibaba.com on Trade Values

	(1)	(2)	(3)	(4)	(5)
ali	77427.566	77493.033	112650.627**	112650.627**	112650.627
	(55706.165)	(55707.030)	(55442.307)	(55442.307)	(85356.550)
N	85367	85367	85367	85367	85367
Year Trend	N	Y	Y	N	N
Year FE	N	N	N	Y	Y
Other Controls	N	N	Y	Y	Y
Clustering	N	N	N	N	Y

Note: The table reports the effects of using Alibaba.com on suppliers' trade performance. The outcome variable is a supplier's trade value in a given month. Other controls include geographical location(province) fixed effect and company type (State-owned, Privately owned, Foreigned owned, Chinese-foreign equity, Collectively owned.eta) fixed effect. Standard errors are in parenthesis: * significant at 10%; ** significant at 5%; *** significant at 1%. The standard errors in column(5) are clustered at individual supplier level.

A Additional Tables and Figures

Figure 3.A1: An Example of Product Showcase Page on Alibaba.com

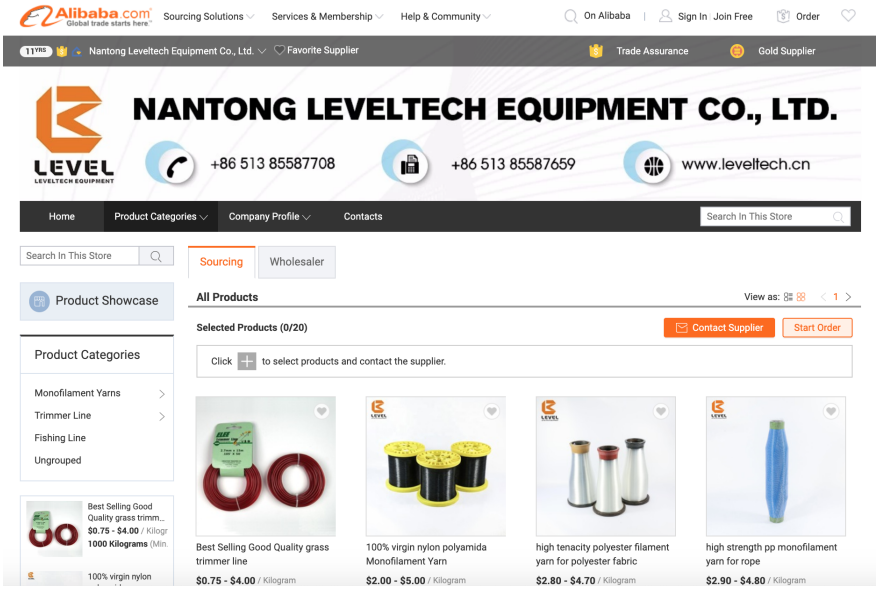
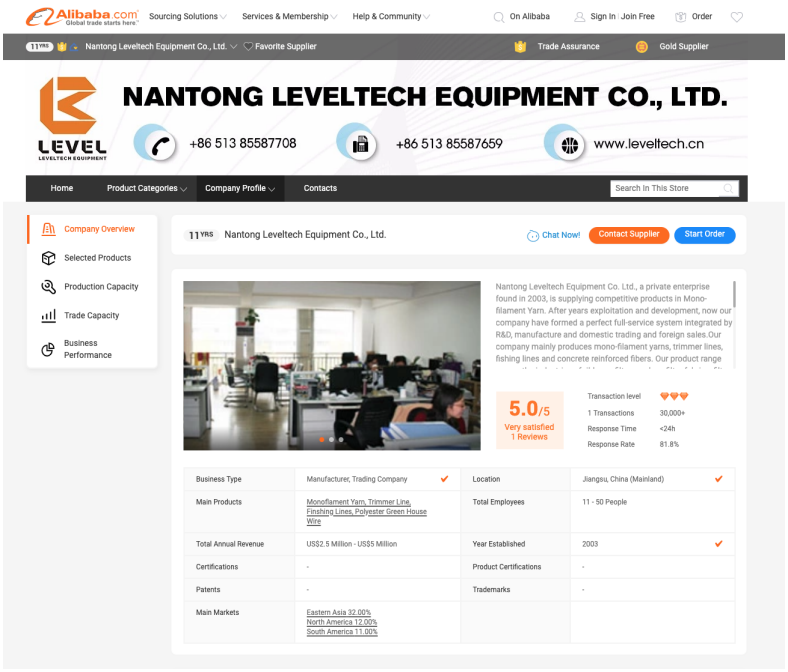


Figure 3.A2: An Example of Company Overview Page on Alibaba.com



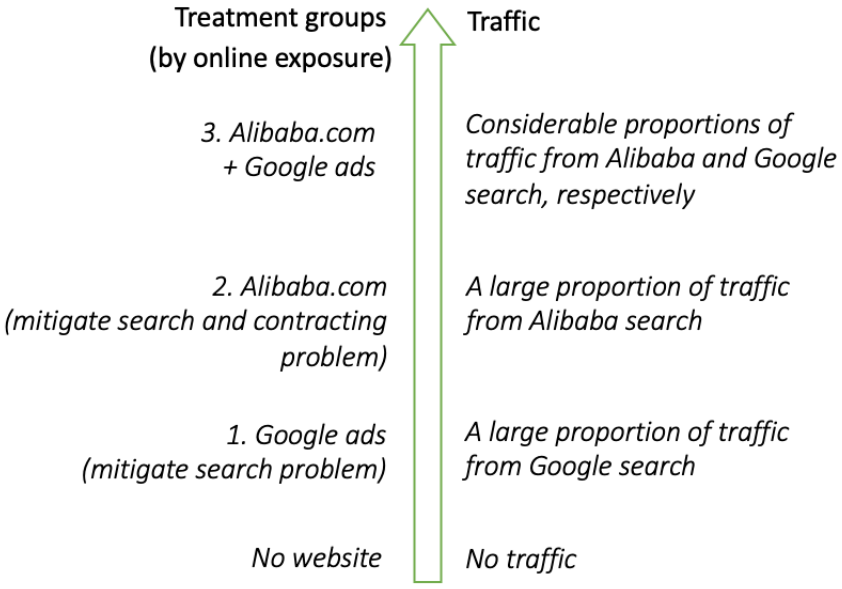


Figure 3.A3: Degrees of Online Exposure

B Mathematical Appendix

The FOC in Equation 3.2 obtained as following:

$$
\begin{aligned}
X &= \left[\int_0^N z_i \left(\frac{p_i}{\lambda X^{1-\beta} z_i}\right)^{\frac{\beta}{\beta-1}} \mu_i di\right]^{\frac{1}{\beta}} \\
X &= \left(\lambda X^{1-\beta}\right)^{\frac{1}{1-\beta}} \left(\int_0^N z_i^{\frac{1}{1-\beta}} p_i^{\frac{\beta}{\beta-1}} \mu_i di\right)^{\frac{1}{\beta}} \\
1 &= \lambda^{\frac{1}{1-\beta}} P^{\frac{1}{\beta-1}}
\end{aligned}
$$

Supplier's profit as in Equation 3.4:

$$
\begin{aligned}
\pi_i &= \left(p_i x_i - l_i w\right) \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \\
&= \left(\frac{w}{\beta} x_i - x_i w\right) \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \\
&= \left(\frac{1-\beta}{\beta}\right) w \left(\frac{p_i}{P X^{1-\beta} z_i}\right)^{\frac{1}{\beta-1}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \\
&= \left(\frac{1-\beta}{\beta}\right) w \left(\frac{\frac{w}{\beta}}{P X^{1-\beta} z_i}\right)^{\frac{1}{\beta-1}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \\
&= (1-\beta) \left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(P X^{1-\beta} z_i\right)^{\frac{1}{1-\beta}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w \\
&= (1-\beta) \left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(P X^{1-\beta}\right)^{\frac{1}{1-\beta}} \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}} \mu_i - \kappa_\mu \mu_i^{\rho_\mu} w - \kappa_\sigma \sigma_i^{\rho_\sigma} w
\end{aligned}
$$

The proof for Equation 3.5:

$$\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\left[\sigma_i\theta_i+(1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}}\left(\theta_i-\overline{\theta}\right)\mu_i$$
$$=\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}w$$
$$\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\left[\sigma_i\theta_i+(1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}}\left(\theta_i-\overline{\theta}\right)$$
$$\left\{\left(\frac{1-\beta}{\rho_\mu\kappa_\mu w}\right)\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\left[\sigma_i\theta_i+(1-\sigma_i)\,\overline{\theta}\right]^{\frac{1}{1-\beta}}\right\}^{\frac{1}{\rho_\mu-1}}$$
$$=\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}w$$
$$\left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu-1}}\left[\sigma_i\theta_i+(1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)}$$
$$\left(\theta_i-\overline{\theta}\right)\left(\frac{1-\beta}{\rho_\mu\kappa_\mu w}\right)^{\frac{1}{\rho_\mu-1}}$$
$$=\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}w$$

The FOC w.r.t θ_i as in Equation 3.7:

$$\frac{\partial F\left(\sigma_i,\theta_i\right)}{\partial\theta_i}=\left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu-1}}A\left(\frac{1-\beta}{\rho_\mu\kappa_\mu w}\right)^{\frac{1}{\rho_\mu-1}}$$

where $A=\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)-1}\sigma_i\left(\theta_i-\overline{\theta}\right)+\left[\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)}\right\}$

Continue,

$$\begin{aligned}\frac{\partial F\left(\sigma_i,\theta_i\right)}{\partial\theta_i}&=\left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}}\left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu-1}}\left[\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)}\left(\theta_i-\overline{\theta}\right)\left(\frac{1-\beta}{\rho_\mu\kappa_\mu w}\right)^{\frac{1}{\rho_\mu-1}}\\&\quad\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\sigma_i}{\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}}\right]+\left(\frac{1}{\theta_i-\overline{\theta}}\right)\right\}\\&=\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\sigma_i}{\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}}\right]+\left(\frac{1}{\theta_i-\overline{\theta}}\right)\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}\\&=\left(\frac{\sigma_i}{\theta_i-\overline{\theta}}\right)\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+\left(1-\sigma_i\right)\overline{\theta}}\right]+\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}\\&>0\end{aligned}$$

The FOC w.r.t σ_i as in Equation 3.8:

$$
\begin{aligned}
\frac{\partial F\left(\sigma_i, \theta_i\right)}{\partial \sigma_i} &= \left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu-1}} \left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right] \\
&\quad \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)-1} \left(\theta_i - \overline{\theta}\right)^2 \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)^{\frac{1}{\rho_\mu-1}} - \rho_\sigma\left(\rho_\sigma - 1\right)\kappa_\sigma \sigma_i^{\rho_\sigma-2} \\
&= \left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i - \overline{\theta}}{\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}}\right] \\
&\quad \left[\left(\frac{w}{\beta}\right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta}\right)^{\frac{1}{1-\beta}}\right]^{\frac{\rho_\mu}{\rho_\mu-1}} \left[\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}\right]^{\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)} \left(\theta_i - \overline{\theta}\right)\left(\frac{1-\beta}{\rho_\mu \kappa_\mu w}\right)^{\frac{1}{\rho_\mu-1}} \\
&\quad - \rho_\sigma\left(\rho_\sigma - 1\right)\kappa_\sigma \sigma_i^{\rho_\sigma-2} \\
&= \left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i - \overline{\theta}}{\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}}\right]\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1} - \rho_\sigma\left(\rho_\sigma - 1\right)\kappa_\sigma \sigma_i^{\rho_\sigma-2} \\
&= \left\{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i - \overline{\theta}}{\sigma_i\theta_i + (1-\sigma_i)\,\overline{\theta}}\right] - \left(\rho_\sigma - 1\right)\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}
\end{aligned}
$$

The proof for Equation 3.9:

$$
\begin{aligned}
\frac{d\sigma_i}{d\theta_i} &= -\frac{\frac{\partial F(\sigma_i,\theta_i)}{\partial \theta_i}}{\frac{\partial F(\sigma_i,\theta_i)}{\partial \sigma_i}} \\
&= -\frac{\left(\frac{\sigma_i}{\theta_i-\overline{\theta}}\right)\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+(1-\sigma_i)\overline{\theta}}\right]+\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}}{\left\{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+(1-\sigma_i)\overline{\theta}}\right]-(\rho_\sigma-1)\frac{1}{\sigma_i}\right\}\rho_\sigma\kappa_\sigma\sigma_i^{\rho_\sigma-1}} \\
&= -\left(\frac{\sigma_i}{\theta_i-\overline{\theta}}\right)\left\{\frac{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+(1-\sigma_i)\overline{\theta}}\right]+\frac{1}{\sigma_i}}{\left[\frac{\beta}{1-\beta}+\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu-1}\right)\right]\left[\frac{\theta_i-\overline{\theta}}{\sigma_i\theta_i+(1-\sigma_i)\overline{\theta}}\right]-(\rho_\sigma-1)\frac{1}{\sigma_i}}\right\} > 0
\end{aligned}
$$

The proof for Equation 3.10:

$$\frac{d\mu_i}{d\theta_i} = \left\{ \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w} \right) \left(\frac{w}{\beta} \right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta} \right)^{\frac{1}{1-\beta}} \right\}^{\frac{1}{\rho_\mu - 1}} \frac{1}{1-\beta} \left(\frac{1}{\rho_\mu - 1} \right) \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta} \right]^{\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)-1} \left[\sigma_i + \left(\theta_i - \overline{\theta} \right) \frac{d\sigma_i}{d\theta_i} \right]$$

$$= \left\{ \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w} \right) \left(\frac{w}{\beta} \right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta} \right)^{\frac{1}{1-\beta}} \right\}^{\frac{1}{\rho_\mu - 1}} \frac{1}{1-\beta} \left(\frac{1}{\rho_\mu - 1} \right) \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta} \right]^{\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)-1}$$

$$\left[\sigma_i - \left(\theta_i - \overline{\theta} \right) \left(\frac{\sigma_i}{\theta_i - \overline{\theta}} \right) \left\{ \frac{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1} \right) \right] \left[\frac{\theta_i - \overline{\theta}}{\sigma_i \theta_i + (1-\sigma_i)\overline{\theta}} \right] + \frac{1}{\sigma_i}}{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1} \right) \right] \left[\frac{\theta_i - \overline{\theta}}{\sigma_i \theta_i + (1-\sigma_i)\overline{\theta}} \right] - (\rho_\sigma - 1)\,\frac{1}{\sigma_i}} \right\} \right]$$

$$= \left\{ \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w} \right) \left(\frac{w}{\beta} \right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta} \right)^{\frac{1}{1-\beta}} \right\}^{\frac{1}{\rho_\mu - 1}} \frac{1}{1-\beta} \left(\frac{1}{\rho_\mu - 1} \right) \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta} \right]^{\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)-1}$$

$$\sigma_i \left\{ 1 - \frac{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1} \right) \right] \left[\frac{\theta_i - \overline{\theta}}{\sigma_i \theta_i + (1-\sigma_i)\overline{\theta}} \right] + \frac{1}{\sigma_i}}{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1} \right) \right] \left[\frac{\theta_i - \overline{\theta}}{\sigma_i \theta_i + (1-\sigma_i)\overline{\theta}} \right] - (\rho_\sigma - 1)\,\frac{1}{\sigma_i}} \right\}$$

$$= -\left\{ \left(\frac{1-\beta}{\rho_\mu \kappa_\mu w} \right) \left(\frac{w}{\beta} \right)^{\frac{\beta}{\beta-1}} \left(PX^{1-\beta} \right)^{\frac{1}{1-\beta}} \right\}^{\frac{1}{\rho_\mu - 1}} \frac{1}{1-\beta} \left(\frac{1}{\rho_\mu - 1} \right) \left[\sigma_i \theta_i + (1-\sigma_i)\,\overline{\theta} \right]^{\frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1}\right)-1}$$

$$\left\{ \frac{\rho_\sigma}{\left[\frac{\beta}{1-\beta} + \frac{1}{1-\beta}\left(\frac{1}{\rho_\mu - 1} \right) \right] \left[\frac{\theta_i - \overline{\theta}}{\sigma_i \theta_i + (1-\sigma_i)\overline{\theta}} \right] - (\rho_\sigma - 1)\,\frac{1}{\sigma_i}} \right\}$$

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