Three Essays on Applied Microeconomics

by

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Abstract

This thesis consists of three essays that study three different economic phenomena.

The first essay is inspired by the strikingly large number of children left behind by migrant parents in rural China. I study the effect of parental migration on the school enrolment of their left-behind children. I used a probit regression for my empirical analysis. I find evidence of a negative effect of parental migration on children's school enrolment, and this negative effect is larger on the school enrolment of boys than on girls'. The effect of parental migration is robust to the use of instrumental variable analysis by instrumenting for parental migration status using "the number of other migrant household members".

In the second essay, I set up a theoretical model trying to investigate why villagers redistribute farmland periodically though it is against the central government's policy, and I study the implication of this redistribution on long-run investment. I propose a limited liability model of land tenancy in an overlapping generations setting. The model implies that without soundly established insurance institutions and farmland rental market and stable off-farm job opportunities, farmland rental market and stable off-farm job opportunities, households with more children are better off under a land redistribution regime and thus favor it. In terms of long-run investment in farmland, redistribution according to demographic changes discourages long-term investment, yet redistribution based on farming failure may mitigate this negative effect.

The third essay tries to analyze three aspects of organizational hierarchy: (1) generalists or specialists: which should get to the top? (2) How many agents should get to the top? (3) Can the agents who should be at the top in the optimal hierarchy really get to the top? Using a T-period model with promotion, I finds that the optimal hierarchy form depends on the size of the externality of coordinating multiple assets by generalists. The number of agents at the top depends on the elasticity of the externality of coordinating multiple assets. Finally, promotion opportunity gives agents who should at the top more incentive to exert effort, and thus are more likely to get promoted.

Keywords: rural-urban migration; school enrolment; rural China; land tenure; land redistribution; organizational hierarchy

Dedication

To my parents: for your understanding and support.

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Chapter 1. The Effect of Parental Migration on the Educational Attainment of Their Left-behind Children in Rural China

1.1. Introduction

The economic development of China has been uneven and the urban-rural income gap has been widening since the economic reform and opening up in 1978. Statistics released by Chinese Ministry of Agriculture show that the urban-rural income gap was 1.71 in 1984, and increased to 2.79 in 2000 (China Statistical Yearbooks).[1] China has been one of a few countries in the world with urban-rural income gap above 2 (Lin, 2011). In 2008, the gap further widened to 3.36 with an absolute urban-rural income gap of over 11,000 *yuan* (China Statistical Yearbook). The expectation of higher income in cities lures tens of millions of farmers. Some bring their children with them, but the majority leave their children behind in the care of the other parent or relatives. This paper studies the effect of the absence of migrant parents on the educational attainment of their left-behind children.

According to a study by the All-China Women's Federation (ACWF) based on the 2005 By-Census of one percent of the national population, it is estimated that about 58 million children under 18 years old are left behind by their parents in the countryside, accounting for 21.72% of all children in China, and 28.29% of all rural children (China Network, February 2008). Among these left-behind children, about 48 million are aged between 6 and 17, and more than 30 million are aged between 6 and 14. The most recent published statistics show that there are more than 58 million rural left-behind

[1] That is, in 1984, urban residents earned 1.71 times as much as rural residents.

children in 2010; among them 57.2% have one parent absent, and 42.8% has both parents absent (China Daily, 2011). [2]

How does parents' absence affect children's educational enrollment? Does it affect in the same way and with the same magnitude children with one migrant parent versus children with two migrant parents? Does the duration of parental absence matter? This paper is trying to answer these questions.

A probit model with educational enrolment as the dependent variable is used on a survey sample of rural children collected in 2000. I find evidence of a negative effect of parental migration on school enrolment. Parental migration can possibly have three effects on school enrolment: a disruptive effect, a wealth effect, and an aspirational effect. The family disruptive effect will negatively affect children's well-being and schooling, while the wealth effect is positive as migrant parents in general earn higher income in the city. The sign of the migratory aspirational effect is positive as the rates of return on education in cities are higher than these in the countryside, and therefore, children who expect to migrate in the future would desire more schooling. The empirical results show that the latter two effects affect school enrolment positively; more specifically, for boys, it is the aspirational effect that matters, but for girls both wealth and aspirational effects matter. However, these positive effects are not strong enough to cancel out the disruptive effect, and thus, the total effect of migration is negative. I also find that the negative effect of migration is larger on the school enrolment of boys than on girls', and that the longer the duration of father's absence is, the bigger the negative effect on boys' enrolment. The overall effect of parental migration decreases the probability of school enrolment of boys by 7.9%, and the negative family disruptive effect of parental migration decreases the probability of school enrolment of boys by 15.9%. In addition, one year increase in father's migration decreases the probability of school enrolment of boys in households with migrant father and non-migrant mother by 1.2%. For girls, the overall effect of parental migration is negative but smaller and only significant at the 10% level of significance, since the positive wealth and aspirational

[2] The younger the child, the higher the likelihood of absence of both parents is.

effects partially neutralize the negative disruptive effect. The result suggests that left-behind mothers or relatives cannot fulfill fathers' role successfully in disciplining and motivating boys and help with their educational needs, and thus, father's involvement in son's education is important. As a robustness check, I instrument for parental migration status using "the number of other migrant household members". The results of the endogenous probit regression are consistent with those of the probit regression.

The remaining paper is organized as follows: Section 1.2 presents a theoretical model; Section 1.3 presents empirical findings on the relationship of parental migration and the education of left-behind children; Section 1.4 provides an overview of China's education system and internal migration; Section 1.5 contains the empirical analysis and robustness checks; lastly, Section 1.6 is discussion and conclusion.

1.2. Model

I present a simple model of optimal schooling decision based on Björklund and Salvanes (2011) and Collins and Margo (2006). A household consists of a parent and a child. The parent is altruistic toward her child, and her utility is defined over the household's current consumption (C) and the child's future consumption measured by the child's future income, Y.

$$U^p = u^p(C) + \delta^p v^p(Y) \quad (1)$$

where terms with superscript p refer to variables of the parent, and δ^p is a preference parameter measuring the degree of parental altruism toward the child.

After attaining adulthood, the child has two income sources: earnings, E, and transfers from her parent, X.[3]

$$Y = E + X \quad (2)$$

[3] E is the earnings net out of migration cost in the case of migration.

The child's adulthood earnings, E, are a function of human capital (H) and job opportunity (O).

$$\mathrm{E} = \mathrm{E}(\mathrm{H}, \mathrm{O}) \tag{3}$$

where $\mathrm{E}_{\mathrm{i}}'(\cdot) > 0,\ \ \mathrm{E}_{\mathrm{i}}''(\cdot) \leq 0, \text{and } \mathrm{E}_{\mathrm{ij}}''(\cdot) > 0,\ \forall\ i, j = H, O, i \neq j$

Job opportunity, O, depends on locations, and thus is affected by migration, O = O (M). Assume M is a continuous variable between zero and one; it measures the degree (or length) of absence. Given the big urban-rural income gap in China, it makes sense to assume that O is increasing in M. Assume that each adult makes her migration decision solely based on her income difference at the migrant origin and at the migrant destination and her idiosyncratic cost of migration. That is, she will migrate if her income difference is larger than her cost of migration.

Human capital is produced through a function of the effectiveness of parental involvement (PI), own ability (A), and schooling (S), and the function has the property of diminishing marginal returns.

$$\mathrm{H} = \mathrm{H}(\mathrm{PI}, \mathrm{A}, \mathrm{S}) \tag{4}$$

where $\mathrm{H}_{\mathrm{i}}'(\cdot) > 0,\ \ \mathrm{H}_{\mathrm{i}}''(\cdot) < 0, \text{and } \mathrm{H}_{\mathrm{ij}}''(\cdot) > 0,\ \forall\ i, j = PI, A, S, \mathrm{i} \neq \mathrm{j}$

The effectiveness of parental involvement is a function of the parent's human capital, socioeconomic status (income), and migration status.

$$\mathrm{PI} = \mathrm{PI}\left(\mathrm{H}^{\mathrm{p}},\ \mathrm{E}^{\mathrm{p}}\left(\mathrm{H}^{\mathrm{p}}, \mathrm{O}^{\mathrm{p}}(\mathrm{M}^{\mathrm{p}})\right) + \mathrm{X}^{\mathrm{p}}\right)(1 - \mathrm{M}^{\mathrm{p}}) \tag{5}$$

As suggested by previous literature, parental involvement is mainly manifested in discussion of the child's school performance and schooling choices and encouraging the child to work hard; thus, it cannot be separated from parental physical presence.

The child has total time, T, and it is divided between working at a given wage of w and schooling S. Thus, w can be interpreted as the opportunity cost of schooling.

Thus, parent's maximization problem is

$$\max_{\mathrm{C,S,X}}\ \mathrm{U}^{\mathrm{p}} =\ \mathrm{u}^{\mathrm{p}}\,(\mathrm{C}) +\ \delta^{\mathrm{p}}\mathrm{v}^{\mathrm{p}}(\mathrm{E} + \mathrm{X}) \tag{6}$$

subject to the household's budget constraint,

$$C + \gamma^{p}X = Y^{p} + w(T - S) \tag{7}$$

where Y^{p} is the income of the parent, w is the opportunity cost of the child's time spent on schooling (S), and γ^{p} is the parent's discount factor. The parent maximizes her utility by choosing the optimal C, S and X.

The optimal schooling of the child is determined by the equation below which is generated from three first order condition equations.

$$w = \gamma^{p} H'_{S}(PI, A, S) E'_{H}[H(PI, A, S), O(M)] \tag{8}$$

where $PI = PI\left(H^{p},\ E^{p}\left(H^{p}, O^{p}(M^{p})\right) + X^{p}\right)(1 - M^{p})$, $H'_{S}(\cdot)$ is the first-order derivative of human capital with respect to schooling (S), and $E'_{H}(\cdot)$ is the first-order derivative of earnings with respect to human capital (H).

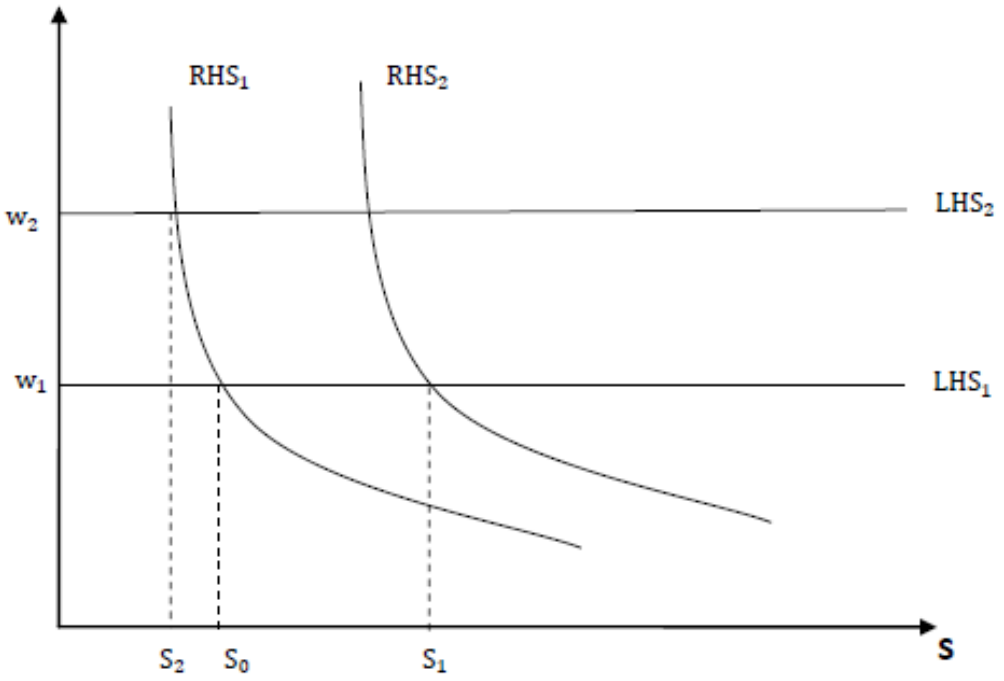

Figure 1. Optimal Schooling

The LHS of equation (8) can be interpreted as the marginal cost of schooling which is the constant opportunity cost, and the RHS of equation (8) can be interpreted

as the marginal benefit of schooling which is decreasing in schooling because of diminishing marginal return of human capital production. The LHS and RHS of equation (8) are graphed in Figure 1.

The predictions of the model are as follows: the key factors which affect schooling S are parental human capital H^p, the child's ability A, parental migration status M^p, family wealth X^p, the child's migratory aspiration M, the parent's discount factor γ^p, and the opportunity cost of schooling w. Schooling increases in H^p , X^p , A, M and γ^p as an increase in each of them shifts RHS curve up. In figure 1, shifting RHS from RHS_1 to RHS_2 increases schooling from S_0 to S_1. Schooling decreases in w as an increase in w shifts LHS curve up. In figure 1, increase w from w_1 to w_2 decreases schooling from S_0 to S_2. Lastly, the effect of M^p on schooling is ambiguous. On the one hand, an increase in M^p decreases parental involvement PI directly, which tends to shift RHS curve down and thus to decrease schooling. On the other hand, an increase in M^p increases the parent's earnings E^p and parental involvement PI indirectly, which tends to shift RHS curve up and thus to increase schooling. In addition, if a migrant parent can provide information and support in the migration destination, and potentially lower the child's migration cost, it may increase the child's aspiration to migrate (M), and thus may increase schooling. Overall, it is unclear from the model which effect dominates, and thus there is a role for empirical examination of the effect. In the empirical study section, I will examine the sign and the size of the overall effect of parental migration on children's school enrolment. I will also examine the existence and the size of the direct effect of parental migration and the indirect effect through income and migratory aspiration.

1.3. Literature Review

1.3.1. Migration and educational outcomes of left-behind children

There is an extensive literature on the impact of parental migration on left-behind children in the context of international migration. Consistent with the theoretical model, there are mainly three types of effects. First, migration may have a direct negative effect on educational outcome through family disruption. The disruptive effect is embodied in three aspects. On the one hand, the absence of a parent results in loss of parental

attention and supervision over the child, and leads to poorer school performance. On the other hand, the absence of a parent results in lack of adult labor in the home, and the left-behind child has to perform household duties, which may restrict him/her access to school. In addition, the absence of a parent may negatively affect the left-behind child's psychological wellbeing, and makes him/her feel being abandoned and thus perform poorly at school. Second, migration exerts positive income effect on educational attainment through remittances which eases the household budget constraint, increases household spending on education and reduces child labor. Third, parental migration may have an indirect effect on the left-behind child's educational outcome as it may increase the prospect of future migration for the child and change his/her educational aspiration. The sign of this effect depends on the rate of return on education at the migrant destination. If the rate of return on education at the migrant destination is higher than that at the migrant origin, the effect on schooling is positive; and vice versa. Because of the complex effects of migration, the empirical results on the effect of parental migration on the educational outcome of left-behind children are mixed.

Many studies find evidence of negative disruptive effect of migration on children's schooling. McKenzie and Rapoport (2006) examine the impact of migration on educational attainment in rural Mexico. They find evidence of a significant negative effect of migration on school attendance and attainment of 16–18 year-old girls; living in a migrant household lowers their probability of completing high school. Comparison of the marginal effects of migration on school attendance and on participation in other activities shows that the observed decrease in schooling of 16 to 18 year-old girls is accounted for by their increased housework. Lu and Treiman (2007) study the effect of migration on black children in South Africa. They find that while the probability of school enrolment is substantially higher for left-behind children in migrant households with remittances, the probability of school enrolment is lower for children in migrant household without remittances. Children with migrant parents and no remittances have lower probability of school enrolment than these from non-migrant households, though they have similar educational spending and child labor. Thus, the authors conclude that the lower enrolment is caused by the deleterious effect of parental out-migration. Mansuri (2006) studies the relationship between temporary economic migration and investment in child schooling in rural Pakistan. He finds evidence that that "male absence" increases the work burden of children in migrant households and that both boys and girls worked

substantially more in female headed households (24 days as compared to 16 days for children in male headed migrant households), as the author did not count housework, girls might work more than boys in such households. In addition, in terms of schooling, girls in such households did much worse than girls in male headed migrant households and did as well as girls in non-migrant households, with dropout rates increasing from 0.27 to 0.50. From a survey conducted by Save the Children (2006), researchers found that children of migrant mothers in Sri Lanka have poorer attendance and performance (lower grades) than those children with mothers working in Sri Lanka, and children of non–working mothers. Researchers related these outcomes with the impact of mothers' absence on children's psychological wellbeing; children with absent mother felt more lonely and sad. Gamburd (2005) also finds the educational performance of children left behind by mothers is lower than for those with mothers working in Sri Lanka and non–working mothers, as the children of migrant mothers tend to drop out of school to look for work or help with household chores.

A few studies fail to find disruptive effect of migration, and a positive effect of migration on educational outcomes can be found in Parreñas (2005) and Battistela and Conaco (1998). Both studies explore the relationship in the context of Philippines, and both emphasize the role of the other parent and relatives in fulfilling the role of the absent parent. In her book (Parreñas, 2005), Parreñas finds that children in migrant households had higher levels of enrolment and lower dropout rates, and girls with migrant parents were able to improve their school performance relative to other girls. Battistela and Conaco (1998) study left-behind children in elementary school in the Philippines, and find a positive relationship between migration and children's grades. They argue that migration is not necessarily disruptive for the development of the children left behind, particularly if it is the mother who remains in the home, as relatives can fulfill the role of parents relatively successfully.

On the other hand, the literature focusing on remittances often finds a positive effect of migration on left-behind children. Yang (2006) examines Philippine households' responses to overseas members' economic shocks, and finds that migration and remittances lead to increased child schooling and reduced child labor. In his study, a 25% improvement in the exchange rate increases the remittances share of household income by 6% which increases the probability of school attendance of girls and boys aged 10–17 by 3.3% and 1.7% respectively. The increase in remittances also reduces

child labor measured by average hours worked per week, by 0.54 hours for girls and 0.81 hours for boys. Other studies which find positive effect of migration and remittances include Bryant (2005) and a 2004 Children and Families Survey conducted in the Philippines by the Scalabrini Migration Center. Both studies find that remittances were used to send children to private schools which were considered better than public school, and left-behind children had a higher probability of attending private school and on average got better grades than children from non-migrant households.

Mansuri (2006) studies the relationship between temporary economic migration and investment in child schooling in rural Pakistan. She finds that children in migrant households were not only more likely to attend school, but they were also more likely to stay in school and accumulate more years of schooling in comparison to their counterparts in non-migrant households in the same village. Children in migrant households were also less likely to be involved in economic work and reported working for substantially fewer hours. The educational gain from migration was larger for girls than for boys which lead to a substantial net reduction in gender inequality in access to education. Positive effect of remittances on educational spending and thus schooling or enrolment can also be found in Kuhn (2006) studying children in Matlab area in Bangladesh, Cox and Ureta (2003) studying children in El Salvador, Hanson and Woodruff (2003) studying children in Mexico, and Lu and Treiman (2007) studying children in South Africa. Positive effect of remittances on educational spending and grades can be found in Kandel and Kao (2001) using data on children in Mexico.

Some studies attribute the negative effect of migration on educational outcome to the aspirational effect as parental migration eases future migration of left-behind children themselves. McKenzie and Rapoport (2006) examine the impact of migration on educational attainment in rural Mexico. They find evidence of a significant negative effect of migration on schooling attendance and attainment of 12–18 year-old boys; living in a migrant household lowers the probability of younger boys completing junior middle school and the probability of older boys completing high school. The authors argue that the lower schooling of boys is caused by the prospect of future illegal migration into the US where the return to human capital for an illegal immigrant is very low. Similar findings can be found in Kandel and Kao (2001) which investigates how temporary US labor migration by family members affects students' educational aspirations and performance in Mexico. They find that though there is a positive relationship between

parental migration to the US and children's grades, high levels of US migration are associated with lower aspirations to attend a university for students in migrant households at all academic levels. They conclude that while US migration allowed Mexican parents to overcome economic obstacles to schooling their children, it delivered a harmful message about the value of educational investment to children growing up in migrant households. Children in migrant households have lower educational aspirations and higher migratory aspirations as a result of the sizable wage differential between the US and Mexico and low return to schooling acquired in Mexico in the US labor market. Chiquiar and Hansen (2005) studying children in Mexico and Jampaklay (2006) studying children in Thailand also attribute the negative effect of migration to the change in children's prospects of future migration as well as a change in expected rates of return to education, while Mansuri (2006) studying children in rural Pakistan does not detect any effect of future migration prospects on schooling decisions for either boys and girls.

Few studies investigate the effect of different duration of parental migration on the educational outcome of left-behind children. Jampaklay (2006) studies the effect of parental absence on left-behind children's school enrolment in Kanchanaburi province in Thailand. She reports that the absence of parents has negative impacts on the school enrolment of left-behind children. She further elaborates that while long–term absence (2 years or more) of fathers did not have any impact on children's school enrolment, the opposite is true of mothers as their long–term absence significantly lowers the school enrolment of left-behind children. Nonetheless, the short–term absence (less than 2 years) of fathers also appeared to reduce children's chances of school enrolment.

1.3.2. Parental involvement

A large literature in sociology and educational psychology suggests that parental involvement has sizable positive effect on children's educational achievement, and recent economic studies confirm this (Fan, 2001; Fehrmann *et al*, 1987; Feinstein and Symons, 1999; Garg *et al*, 2002; George and Kaplan, 1998; Gonzalez–Pienda *et al*, 2002; Haveman, Wolfe, 1995; Izzo *et al*, 1999; Ma, 2001; Marchant *et al*, 2001; Mau, 1997; McNeal, 2001; Sacker *et al*, 2002; Sui–Chu and Willms, 1996). Studies on siblings estimate that at least 40% of the variation in years of schooling can be attributed to family background (Björklund *et al*, 2009; Conley and Glauber, 2008; Isacsson, 1999;

Lindahl, 2010; Mazumder, 2008; Miller *et al*, 1995; Raaum *et al*, 2006; Sieben *et al*, 2001; Solon *et al*, 2000).

There are two channels through which family background can affect children's educational achievement. The first is inherited ability coded in genes ("nature" factors), and the other one is the "nurturing" effect through parental involvement and interaction with children. Parental involvement takes many forms, including the provision of a secure and stable environment, intellectual stimulation, parent–child discussion, good models of constructive social and educational values, high aspirations relating to personal fulfillment, and so on (Desforges and Abouchaar, 2003). Among these forms of parental involvement, parental interest in and aspirations for the child's education has the strongest positive effect on children's educational achievement and behavior (Catsambis, 2001; Feinstein and Symons, 1999; George and Kaplan, 1998; Gonzalez–Pienda *et al*, 2002; McNeal, 1999; McNeal, 2001; Sacker *et al*, 2002; Singh *et al*, 1995; Sui–Chu and Willms, 1996). Parental interest and aspirations are manifested in discussion of their children's school performance and schooling choices and encouraging or urging them to work hard. Parental involvement is positively affected by parental socio–economic status measured by education, occupation or income, and negatively associated with maternal psycho–social problems and single parent status. It diminishes as the child gets older. (Sacker *et al*, 2002;) For those left-behind children nurturing factors may be lacking as parents migrate for work.

1.4. Background and Overview

1.4.1. Basic Education System and Compulsory Education Law in China

China operates a 6–3–3 system of primary and secondary schools with some variations; that is six years of primary school, three years of junior middle school and another three years of senior high school. According to the 1986 Compulsory Education Law, children should attend school when they reach age of six, and they are entitled to nine years of free education; these nine years of education, from primary to junior middle school, are compulsory. Thus, children aged 6 to 12 should be in primary school, children aged 12 to 15 should be in junior middle school, and children aged 15 to 18 should be in senior high school or vocational school.

Basic education is mainly provided by public schools in China, and the central government has decentralized educational finance for basic education to local governments and communities since the 1980s (World Bank, 1988, 1989). As a result of the reform, the central government is only responsible for paying teachers on the government payroll, and other expenditures have to be covered by a variety of locally generated income (Cheng, 1994). As the reform tightened the link between school resources and local economic conditions, local governments and communities in poor areas have to finance education by charging fees. In 2000, the State Development Planning Commission made an inspection of primary and secondary school fees in rural areas (the State Development Planning Commission, 2001). They discovered that 260 million *yuan* school fees were charged unlawfully as they inspected about 20,000 schools. High costs of education remain a major reason for drop–outs in rural areas (China Labor Bulletin 2009 report). The problem of low ability to afford costs of schooling is more prominent in poorer interior regions and remote areas as a result of the concurrency of household poverty and low level of regional development.

1.4.2. The Hukou System and Temporary Migrants

China's *Hukou* system (household registration system) was formally set up in 1958 for the purpose of controlling internal migration and managing certain classes of "targeted people" to ensure social stability (Wang, 2005). It classifies people as rural or urban residents. Registered urban residents have preferential treatment such as social security and public services in contrast to rural residents. Rural residents seeking to move from the country to urban areas to take up non–agricultural work would have to apply through the relevant bureaucracies. The number of people allowed to make such moves was tightly controlled. After the economic reforms in 1978, it became possible for a rural resident to unofficially migrate and get a job, but a job in the city does not entitle him/her to permanent residency right and the associated social benefits such as subsidized public housing, public education, public medical insurance and government welfare payments (Richburg, 2010). Also, such people must travel to their home towns to get a marriage license, apply for a passport or take the national university entrance exam (Richburg, 2010). Since the mid‐1990s, the *Hukou* system has undergone relaxation. For example, since 1995, 21 cities have allowed migrant workers to buy a temporary urban residency permit which allows the holder to work legally in the city

(Wang, 2005). [4] The reforms make the systems of distribution and control over migration more flexible but they have not fundamentally changed the *Hukou* system.

The number of rural-urban migrants has being soaring since 1990s. According to the Statistics Bureau of China, in 1995, there were 55 million people living out of their registered place for at least half a year which accounted for less than 5% of the population. In 2000, the number tripled to more than 144 million half of which are rural migrant workers. The 2005 By-Census of one percent of the national population data shows that there were more than 147 million of migrants accounting for 11.28% of total population, and more than two thirds of them are rural migrant workers (104.7 million). The latest census in 2010 shows that the number of migrants is more than 260 million, an increase of 81.03% comparing to the number in 2000. And the number of rural migrant workers in 2009 was 145.33 million (Statistics Bureau of China, 2009).

1.4.3. Left-behind Children

Typically, left-behind children in China are defined as children with one or both parents who migrated to find work (China National Institute for Educational Research). According to the 2000 Census, the All-China Women's Federation research team estimated that there exist about 20 million children under the age of 18 left behind by parents in the countryside (People's Daily Online, 2007). This number has almost tripled in 2005. According to another study by the All-China Women's Federation research team based on the 2005 By-Census of one percent of the national population, it is estimated that about 58 million children under 18 years of age left behind by parents in the countryside, accounting for 21.72% of all children in China, and 28.29% of all rural children. Among these left-behind children, about 48 million are aged between 6 and 17, and more than 30 million are aged between 6 and 14. Many factors contribute to the decision of leaving children behind, and they are all related to *Hukou* system which deprives migrant workers and their accompanying family from equal access to education, social and medical welfare in the cities. Since the local government allocates funding for education based on the number of school-age children of locally registered

[4] Price of a temporary urban residency permit is normally 5 – 10 *yuan* (about USD $1).

residents, there is an extra fee for migrant children to enroll. The fee waiving procedure is complicated. In addition, the university entrance examination can only be taken in the place of permanent residence, and different provinces may have different curricula.

Left-behind children in rural areas also have rare opportunities to contact their migrant parents. A survey based on 2000 census by the All-China Women's Federation research team shows that 88.2% of all left-behind children report that they can only communicate with their migrant parents by phone; among them 53.5% cannot talk longer than three minutes (People's Daily Online, 2007). Furthermore, 8.7% of left-behind children never have contact with their migrant parents. 24.2% of children with both migrant parents never or seldom talk with their adult guardians. Similar finding in a 2004 survey by the China National Institute for Educational Research found that over 30% of the children of migrants are left with grandparents or with other relatives with little or no supervision.

1.4.4. Son Preference and the "One Child" Policy

Son preference is prevalent in China, especially in rural areas. Cultural norms value male children over female children (Goodkind, 1999). A son is often preferred as an "asset" since he can earn income and support the family; a daughter is a "liability" since she will be married off to another family, and so will not contribute financially to her parents. Son preference has resulted in inferior treatment to daughters before and after birth. Sex-selective abortion and sex-selective infanticide as a result of son preference make the problem of gender imbalance more prominent. According to the 2005 census, the sex ratio at birth is 121 boys for every 100 girls (Statistics Bureau of China). There is also evidence of lower prenatal investment in girls after prenatal sex determination. Almond, Li and Meng (2010) find that early neonatal mortality of girls increased relative to boys with ultrasound access. As neonatal mortality tends to reflect pregnancy conditions, they infer that prenatal investment for girls carried to term is lower relative to boys once fetal sex was revealed. Song and Burgard (2008) compare children's growth trajectories in height between China where the level of son preference is relatively high and the Philippines where it is relatively low. They find evidence of preferential treatment of sons over girls. They find that male children in China show an additional height advantage relative to their female counterparts, when compared to the sex difference in growth trajectories in the Philippines, and the additional advantage of males in China is

stronger in rural areas. Because parents treat boys and girls differently, it is necessary to control for this gender effect in the empirical analysis.

China's "One-child" policy was introduced in 1978. It officially restricts married urban couples to having only one child, while allowing exemptions for rural couples and ethnic minorities and couples with a physically or mentally disabled first child. Married rural couples are allowed to apply to have a second child if the first born is a girl (Hu, 2002). The policy is enforced at the provincial level through fines that are imposed based on the income of the family and other factors. Despite this policy, there are still many families that continue to have more children than that are allowed. Therefore, the number of children in the household needs to be controlled for in the empirical analysis.

1.5. Data and Empirical Approach

1.5.1. The Data

The data was collected in the course of a poverty and rural development project carried out jointly between the CCAP (the Center for Chinese Agricultural Policy), University of California at Davis and the University of Toronto. The survey used self–enumerated questionnaires and multi–stage stratified sampling method, and was conducted in November and December 2000 in six provinces across rural China. The six provinces are representatives of different regions in China, with Gansu and Shaanxi in Northwest region, Hebei in the North China region, Jilin in the Northeast region, Jiangsu in the East China region, and Sichuan in the Southwest region. In terms of three major economic zones, three provinces (Gansu, Shaanxi and Sichuan) are in the least developed Western zone, one province (Jilin) is in the Central zone, and two provinces (Hebei and Jiangsu) are in the most developed Eastern Coastal zone. The data provide information on household demographics, education and employment, farming and consumption, and especially employment history of household individuals. For each year between 1981 and 2000, the questionnaire tracks each individual's participation in off–farm employment, the main type of off–farm work performed, the place of residence while working (within or outside the village), the location of off–farm employment, and whether or not each individual was self–employed or wage earner. Thus, the data allow

me to identify individuals' migration status. The data contain 4388 individuals in 181 villages.

According to international standards, children are defined as "individuals under the age of 18" (the Convention on the Rights of the Child, Article1); according to the Compulsory Education Law in China, children should attend school when they reach age of six; thus "a school-age child" is defined as an individual aged between 6 and 17. The data contain 1004 school-age children. Because of the low proportion of unmarried parents and children with non–agricultural *Hukou* (household registration), I further exclude children from these families. Thus, there are totally 963 rural school-age children in the sample. The Statistic Bureau of China defines a "migrant" as a person whose residency is different from the location of his household registration (*Hukou*) for at least half a year. I further restrict the definition of a migrant as a person who lives outside of his/her village while working for at least half a year. "A left-behind child" is a child aged 17 or under who has at least one migrant parent. In this paper, only school-age children are considered. "A migrant household" is a household with at least one migrant parent.

I categorize parent's occupation into three types. Occupation 1 is agricultural employment; occupation 2 includes blue collar and low-paying service sector jobs, such as construction worker, waiter/waitress, and maid; and occupation 3 includes white collar, professionals, government employees, and entrepreneurs. "An adult at home" is defined as an individual aged 18 or above who lives in the house and is not a migrant. I use the age of 55 as the cut-off point for "young" vs. "old", as age of parents range from 24 to 69 with 11 cases above age of 54 and nine cases under age of 27. "Other migrant household member" is defined as an individual who is a migrant aged 25 or above and is viewed as a relative by the household head but not a parent of the sample child. I define this age range so that other migrant household members are more likely to be of the parent's generation or older rather than of the sample child's generation. This variable will be used as an instrument variable in the endogenous probit regression and endogenous linear regression which will be discussed in Section 1.5.3.4. "First born child" is the first child of parents; if they only have one child, then the first born child is also the only child. "Total years of parent's migration" are the maximum of the accumulated years of migration between 1981 and 2000 and the claimed years of migration, regardless whether the parent was absent before or after the birth of the sample child, while "years of parent's migration" only count years of absence after the

birth of the sample child. Household wealth is defined as the sum of housing value and value of durable consumption goods in *yuan*. Farmland size is measured in *mu* which is equivalent to 666.67 square meters.

1.5.2. Descriptive Result

The descriptive results are summarized in Tables 1 – 8. Tables 1 – 4 are summary of variables of sample children's characteristics, household composition, and parents' migration and socioeconomic status. The results in Table 1 and Table 2 are summarized by gender of the sample child, thus they are not adjusted by household clustering effect. [5] The results in Table 3 and Table 4 are summarized by household migration status, thus they are adjusted by household clustering effect. The sample has an even proportion of boys and girls with 482 boys and 481 girls. The age of sampled boys and that of sampled girls both average at 12. Consistent with the one child policy and preference for sons, girls have more siblings than boys, and a t–test rejects the equality of number of siblings of girls and that of boys (Table 1). On average, girls have 1.12 siblings, while boys only have 0.74 siblings. Also, boys are twice likely to be the only child in a household than girls. In addition, boys are more likely to have at least one migrant parent, and Wilcoxon-Mann-Whitney test rejects the equality between girls and boys (Table 2). Migrant households have significantly[6] fewer adults in the house, especially male young adults; on average, there are 2.5 adults in non-migrant households and one of them is a young male, while there are 1.5 adults in migrant households and 0.5 of them are young males (Table 3).

Table 1. Summary of Continuous Variables by Gender

	Full Sample		Boys		Girls	
	Mean	St.d.	Mean	St.d.	Mean	St.d.
Age	11.83	3.34	11.75	3.34	11.91	3.34
# children	1.93	0.78	1.74	0.74	2.12	0.78

[5] The samples include children from the same household.

[6] "Significant" means significant at 5% level unless otherwise stated.

# girls (6-17)	0.97	0.85	0.45	0.67	1.49	0.66
# boys (6-17)	0.85	0.64	1.24	0.47	0.46	0.54
# children (<6)	0.11	0.32	0.05	0.22	0.17	0.38
# female siblings (6-17)	0.47	0.67	0.45	0.67	0.49	0.66
# male siblings (6-17)	0.35	0.52	0.24	0.47	0.46	0.54
# people in house	4.05	1.19	3.82	1.20	4.27	1.13
# adults in house (18+)	2.11	0.96	2.08	0.96	2.15	0.97
# female adults in house (18+)	1.18	0.56	1.16	0.53	1.20	0.58
# male adults in house (18+)	0.93	0.63	0.92	0.64	0.95	0.61
# young adults in house (18-54)	1.79	0.78	1.73	0.80	1.84	0.75
# young female adults in house (18-54)	1.00	0.42	0.98	0.42	1.02	0.42
# young male adults in house (18-54)	0.79	0.55	0.75	0.57	0.82	0.53
# old female adults in house (55+)	0.33	0.63	0.34	0.63	0.31	0.63
# old male adults in house (55+)	0.18	0.41	0.18	0.39	0.19	0.42
# male old adults in house (55+)	0.14	0.35	0.16	0.37	0.12	0.33
# other migrant household members (25+)	0.06	0.34	0.05	0.33	0.06	0.35
Total years of father migrated	6.76	5.81	7.23	6.18	6.18	5.28
Total years of mother migrated	3.02	2.67	3.20	2.80	2.79	2.50
Years of father migrated (since the child's birth)	4.52	4.61	4.58	4.78	4.45	4.41
Years of mother migrated (since the child's birth)	1.80	2.34	2.07	2.55	1.46	2.02
Father's Education (years)	7.61	2.99	7.65	2.99	7.58	2.99
Mother's Education (years)	5.54	3.58	5.62	3.55	5.47	3.62
Household wealth (yuan)	28624.10	64266.48	33386.94	80786.07	23841.13	41070.83
Farmland size (mu)	8.27	9.08	8.05	9.39	8.49	8.77

Table 2. Summary of Discrete Variables by Gender

	Percentage of Children (6-17) who answered yes		
Variable	Full Sample	Boys	Girls
Enrolment	0.827	0.844	0.809
Ethnic minority	0.119	0.102	0.137

First born child	0.487	0.448	0.526
Only child	0.185	0.251	0.119
At least one migrant parent	0.336	0.369	0.304
Only migrant father	0.228	0.247	0.210
Only migrant mother	0.032	0.033	0.031
Both migrant parents	0.076	0.089	0.062
Father's occupation 1	0.314	0.293	0.335
Father's occupation 2	0.505	0.519	0.492
Father's occupation 3	0.181	0.189	0.173
Mother's occupation 1	0.764	0.742	0.785
Mother's occupation 2	0.156	0.185	0.127
Mother's occupation 3	0.080	0.073	0.087
Gansu	0.162	0.151	0.173
Hebei	0.214	0.199	0.229
Jiangsu	0.114	0.114	0.114
Jilin	0.130	0.147	0.112
Shannxi	0.162	0.166	0.158
Sichuan	0.218	0.222	0.214

Table 3. Summary of Continuous Variables by Household Migration Status

	Full Sample		Non-migrant household		Migrant household	
	Mean	St.d.	Mean	St.d.	Mean	St.d.
# children	1.66	0.71	1.63	0.69	1.73	0.73
# girls (6-17)	0.76	0.75	0.78	0.75	0.70	0.75
# boys (6-17)	0.76	0.61	0.71	0.60	0.85	0.62
# children (<6)	0.15	0.36	0.13	0.35	0.18	0.38
# other migrant household members (25+)	0.07	0.35	0.04	0.24	0.12	0.50
# people in house	3.83	1.20	4.14	1.03	3.21	1.26
# adults in house (18+)	2.17	1.01	2.51	0.82	1.48	1.00
# female adults in house (18+)	1.20	0.57	1.28	0.50	1.05	0.65
# male adults in house (18+)	0.97	0.65	1.23	0.50	0.44	0.61

# young adults in house (18-54)	1.82	0.82	2.19	0.55	1.08	0.76
# old adults in house (55+)	0.35	0.65	0.32	0.61	0.40	0.73
# young female adults in house (18-54)	1.01	0.44	1.10	0.33	0.83	0.56
# young male adults in house (18-54)	0.81	0.57	1.08	0.36	0.25	0.49
# old female adults in house (55+)	0.19	0.41	0.17	0.39	0.21	0.45
# old male adults in house (55+)	0.16	0.37	0.15	0.36	0.19	0.39
Total years of father migrated	6.47	5.69	0.00	0.00	6.47	5.69
Total years of mother migrated	3.05	2.85	0.00	0.00	3.05	2.85
Father's Education (years)	7.52	2.97	7.19	3.01	8.17	2.80
Mother's Education (years)	5.68	3.56	5.60	3.63	5.84	3.42
Household wealth (yuan)	30132.42	66305.52	29143.71	63687.77	32147.68	71461.72
Farmland size (mu)	8.52	10.10	8.83	11.22	7.91	7.33

As indicated in Table 3, parents' levels of education are low; on average, fathers do not finish junior middle school, and mothers barely finish elementary school. The difference between the education levels of migrant parents and non-migrant parents is small. On average, migrant parents have less-than-one-year more education than non-migrant ones. Table 4 shows that parents in migrant households are more likely to have a job in occupation category 2 – blue collar and low-paying service sector jobs. Fathers in migrant households are 20% more likely to have a job in occupation category 2, while mothers in migrant households are 9% more likely to have a job in occupation category 2. [7] The durations of fathers' migration are longer than the duration of mothers'; on average, fathers have migrated for 6 years and mothers have migrated for 3 years (Table 3). Households of boys are on average wealthier than households of girls, and the difference is sizeable and significant. On average, households of sample boys are

[7] This comparison is conditional on being in a migrant household not conditional on being a migrant. Actually, a migrant father is 27.3% more likely to have a job in occupation 2 and 23.6% less likely to have a job in occupation 1; a migrant mother is 34% more likely to have a job in occupation 2 and 32.4% less likely to have a job in occupation 1. These numbers are calculated with consideration of household cluster.

9,500 *yuan* wealthier than households of sample girls (Table 1). [8] While migrant households are wealthier than non-migrant households on average, the difference is not significant (Table 3). Lastly, the proportions of migrant households are different across provinces; the Kruskal Wallis test rejects the hypothesis that the proportions are all equal. Hebei and Sichuan have higher proportions of migrant households than four other provinces (Table 4).

Table 4 . Summary of Discrete Variables by Household Migration Status

	Full Sample	Non-migrant Household	Migrant household
At least one migrant parent	0.333	0.000	1.000
Only migrant father	0.219	0.000	0.656
Only migrant mother	0.033	0.000	0.098
Both migrant parents	0.082	0.000	0.247
Father's occupation 1	0.326	0.384	0.210
Father's occupation 2	0.503	0.430	0.650
Father's occupation 3	0.171	0.186	0.140
Mother's occupation 1	0.753	0.779	0.701
Mother's occupation 2	0.165	0.135	0.224
Mother's occupation 3	0.082	0.086	0.075
Gansu	0.147	0.167	0.107
Hebei	0.197	0.158	0.274
Jiangsu	0.143	0.137	0.153
Jilin	0.141	0.149	0.126
Shannxi	0.171	0.179	0.153
Sichuan	0.202	0.209	0.186

Table 5. Enrolment by age groups

	Full Sample	Boys	Girls

[8] This number is calculated without considering household clustering effect.

Age	Mean	St.d.	Obs	Mean	St.d.	Obs	Mean	St.d.	Obs
6	0.738	0.444	61	0.813	0.397	32	0.655	0.484	29
7	0.971	0.170	68	0.972	0.167	36	0.969	0.177	32
8	0.975	0.156	81	0.957	0.206	46	1.000	0.000	35
9	0.984	0.128	61	0.955	0.213	22	1.000	0.000	39
10	0.976	0.154	83	0.976	0.156	41	0.976	0.154	42
11	0.986	0.120	70	0.972	0.167	36	1.000	0.000	34
12	0.989	0.103	94	0.981	0.139	52	1.000	0.000	42
13	0.882	0.324	102	0.922	0.272	51	0.843	0.367	51
14	0.835	0.373	91	0.886	0.321	44	0.787	0.414	47
15	0.800	0.402	90	0.864	0.347	44	0.739	0.444	46
16	0.481	0.503	79	0.400	0.496	40	0.564	0.502	39
17	0.325	0.471	83	0.395	0.495	38	0.267	0.447	45
Total Observations			963			482			481

Table 6. Percentage of children (6-17) enrolled in school by discrete variables

	Percentage of Children (6-17) who enrolled		
Variable	Full Sample	Boys	Girls
	0.827	0.844	0.809
Ethnic Han	0.838	0.859	0.817
Ethnic minority	0.739	0.714	0.758
Not first born child	0.800	0.816	0.781
First born child	0.855	0.880	0.834
Not only child	0.805	0.820	0.792
Only child	0.921	0.917	0.930
At least one migrant parent	0.821	0.831	0.808
No migrant parent	0.829	0.852	0.809
Only migrant father	0.795	0.807	0.782
Only migrant mother	0.839	0.813	0.867
Both migrant parents	0.890	0.907	0.867
Father's occupation 1	0.735	0.723	0.745
Father's occupation 2	0.858	0.900	0.814

Father's occupation 3	0.897	0.879	0.916
Mother's occupation 1	0.801	0.815	0.788
Mother's occupation 2	0.893	0.921	0.852
Mother's occupation 3	0.935	0.943	0.929
Gansu	0.865	0.849	0.880
Hebei	0.869	0.885	0.855
Jiangsu	0.891	0.945	0.836
Jilin	0.824	0.859	0.778
Shannxi	0.731	0.750	0.711
Sichuan	0.795	0.813	0.777

Tables 5 – 6 summarize variables that are related to the school enrolment rate. Table 6 shows that the school enrolment rates are different between boys and girls. Enrolment is lower for girls than for boys with 80.9% for girls and 84.4% for boys; however, the Wilcoxon-Mann-Whitney test fails to reject the equality of the enrolment of boys and girls. Enrolment shows a concave trend in age with a peak at the age of 12, and plummets sharply at age 16 (Table 5). With regard to migration status, enrolment is generally higher in non-migrant household than in migrant household, and the difference is larger for boys and larger among children aged 15 and above (Table 6). However, these are unconditional differences, and do not take account of other differences between migrant and non-migrant household which also affect enrolment. The enrolment of ethnic Han children is significantly higher than that of ethnic minority children, and the effect is larger for boys than for girls (Table 6). Enrolment is significantly positively correlated with the child's being the only child and first born child. In addition, enrolment rates are different among provinces with the highest of 89.1% in Jiangsu and lowest of 73.1% in Shannxi, and the Kruskal Wallis test rejects the hypothesis that enrolments from different provinces are from the same population (Table 6).

Table 7. Percentage of dropouts at each educational level

Education (years)	Total Dropouts	Boys	Girls	Left-behind Children
1	1.80	2.67	1.09	1.72
2	2.99	5.33	1.09	3.45
3	1.20	0	2.17	0
4	5.39	4.00	6.52	3.45

5	7.19	6.67	7.61	5.17
6	14.97	8.00	20.65	15.52
7	7.78	9.33	6.52	8.62
8	10.18	14.67	6.52	8.62
9	31.74	33.33	30.43	29.31
10	0	0	0	0
11	0	0	0	0
12	0.60	0	1.09	0
13	0.60	0	1.09	0
Not finish primary school	18.57	18.67	18.48	13.79
Not finish junior high school	51.50	50.67	52.17	46.55
Total Observations	141	63	78	44

Tables 7 – 9 show the timing and reasons of dropping out of school. Among the 141 dropouts, 55% are girls. Regarding their level of education, 19% of the dropouts dropped out before finishing primary school, and 52% dropped out before finishing junior middle school, thus they did not complete the mandatory 9-year basic education (Table 7). Judging from these unconditional figures, left-behind children seem to do better than children from non-migrant households.

Among all the dropouts, 40% chose “cannot afford the tuition” as the reason of not enrolling, and the second most chosen reason is “do not want to go to school” at 26%, followed by “not accepted” at 24% (Table 8). The reasons for dropping out of school are different between boys and girls. Among rural boys, “cannot afford the tuition” and “do not want to go to school” tie for the top reason at 33% each, while for rural girls, the number one reason is “cannot afford the tuition” at 45% followed by “not accepted” at 27%. Comparing to children from non-migrant households, children from migrant households are more likely to drop out because they “cannot afford the tuition”; this is especially true for girls (Table 9). The reasons for not enrolling in school are also different between students at different schooling stage. For children who have not finished primary school and children who do not enter junior middle school, “cannot afford the tuition” is the major reason at 55% and 56% respectively. At junior middle school level, “do not want to go to school” surpasses “cannot afford the tuition” by a little become the number one reason. For junior middle school graduates, “not accepted” is the major reason for dropping out. Moreover, once a student enters senior high school or

vocational school, he or she rarely drops out before graduation. Lastly, “lack of labor at home” and “has job opportunity” included in “other” reason are never the main reason for dropping out. Table 14 in the Appendix provides employment information for children the above 15. The data show no evidence that left-behind children work more in house or out which further proves that child labor is not a major reason for dropping out, though it can decrease educational attainment in theory.

Table 8. Reasons for Not Being Enrolled in School

	Percentage of Unenrolled Children (6-17) who chose this reason (%)							
Reason	Full Sample	Boys	Girls	No elementary school graduation	Elementary school graduate	Junior high school level	Junior high school graduate	Senior high school or vocational school
Cannot afford cost of schooling	39.72	33.33	44.87	54.84	56	40.63	21.57	50
Donot want to go to school	25.53	33.33	19.23	29.03	20	43.75	15.69	0
Not accepted	24.11	20.63	26.92	0	20	0	54.72	0
Other	10.64	12.7	8.97	16.13	4	9.38	9.8	50
Total observations	141	63	78	31	25	30	53	2

Table 9. Reasons of Left-behind Children for Not Enrolling in School

	Percentage of Unenrolled Left-behind Children (6-17) who chose this reason (%)						
Reason	Full Sample	Boys	Girls	No elementary school graduation	Elementary school graduate	Junior high school level	Junior high school graduate
Cannot afford cost of schooling	50	33.33	65.22	62.5	66.67	50	35.29
Donot want to go to school	27.27	38.1	17.39	25	33.33	50	11.76
Not accepted	20.45	23.81	17.39	0	0	0	52.94
Other	2.27	4.76	0	12.5	0	0	0
Total observations	44	21	23	8	9	10	17

1.5.3. Empirical Analysis

I use a binary probit model with educational enrolment as the dependent variable. The main variable of interest is a dummy for migrant household defined as in Section 1.5.1. The control variables include the sample child's characteristics and parents' education. In this baseline specification, because all control variables are predetermined and independent of migration, I can evaluate the overall effect of migration on enrolment. Next, I add controls for wealth and land holding, as well as parental occupations, to examine the existence of wealth effects and aspirational effect of migration. Parental occupations are significantly and highly correlated with parental migration status, especially a migrant parent is more likely to have a job in occupation 2, less likely to have a job in occupation 1, and as likely to have a job in occupation 3.[9] Such an occupational shift from occupation 1 to occupation 2 is a by-product of migration which cannot be detached from migration itself. Without migration, there may not exist an opportunity for the occupational shift to occur in the village. As the parent is a role model for the child, I can use parent's occupation 2 as a proxy for child's migratory (and occupational) aspiration and examine its effect on enrolment. With these controls, the estimated effect of migration can be interpreted as the disruptive effect of having absent parent(s). Lastly, to test whether any persons left at home can fulfill the role of the absent parent, household composition controls are added. Provincial dummies are also included in all cases, since the probabilities and opportunities of migration are different across provinces. Since the samples used in the probits for school enrolment include children from the same household, it is possible that unobservable household specific characteristics determining school enrolment are correlated among children of the same household. Thus, I adjusted the standard errors to allow for this by using the "cluster" option in STATA at the household level. Lastly, because the various factors could affect

[9] A migrant father is 27.3% more likely to have a job in occupation 2 and 23.6% less likely to have a job in occupation 1; a migrant mother is 34% more likely to have a job in occupation 2 and 32.4% less likely to have a job in occupation 1. These numbers are calculated with consideration of household cluster.

the school enrolment of boys and girls in different ways and with different magnitudes as seen in the descriptive result section, I run all regressions for boys and girls separately.

Control variables are chosen following the theoretical model in Section 1.2 and the descriptive results in Section 1.5.2. Both parents' schooling levels are included rather than only that of the household head for two reasons. First, the data do not provide information on cognitive ability, so both parents' education levels are included to better capture this inheritable ability. Second, the effects of father's education and mother's education may have different magnitudes on children's schooling, and affect daughters and sons differently. Previous research shows that mother's education has a stronger impact than father's education on child schooling (Schultz, 1993). With respect to sex–specific intergenerational effects, mother's education may have larger effect on daughters' schooling while father's education may have larger effect on sons' schooling (Thomas, 1994).

Included in the sample child's characteristic variables are sample child's age, quadratic term for age, dummy for ethnic minority, and dummy for being the first born child. To control for wealth effects, I use household wealth rather than income or consumption, because of potential endogeneity problems with the latter two measures. Income may increase because unenrolled children may work and earn income for the household, and enrollment may increase household consumption by their tuition, studying materials and other study related expenditures. In addition, agricultural incomes are volatile, making measured income sensitive to the timing of the survey. Third, household income is highly correlated with parental education and occupation, while wealth is more likely to be inherited from the older generation in rural China and thus has smaller correlation with education or occupation. In addition, remittances are not included in the regressions though the literature suggests that it may have positive effect on children's schooling. Because of the possible under-reporting of remittances, there are only 45 – 60 cases with non-zero remittances depending on how the remittance variable is defined, and the coefficient of remittance is never significant in the probit regression; thus, it is not included in the reported results. Lastly, food consumption was poorly recorded, and therefore total consumption calculated may be inaccurate. Farmland is separated from the wealth variable because ownership of farmland in rural China is the local village or community, and farmers only have user rights for the tenure

term of normally 30 years. Moreover, farmland may affect the school enrolment rate differently than wealth. Besides the wealth effect which tends to increase probability of school enrolment, farmland has a substitution effect on enrollment in the opposite direction as it increases the opportunity cost of going to school. Thus, it is appropriate to separate farmland from the wealth variable. Lastly, household composition variables include the number of children and the number of adults at home. In some specifications, a household is further broken down into the number of siblings aged under six, the number of female siblings aged 6 – 17, the number of male siblings aged 6 – 17, and the number of female adults and the number of male adults, or the number of young female adults, the number of old female adults, the number of young male adults, and the number of old male adults. Siblings aged under six are separated from the older school-age siblings, because day care centers and kindergartens are rare in rural China, and therefore the older school-age children may have to take care of the younger ones which will increase the opportunity cost of schooling and thus affect the school enrolment, according to the theoretical model in Section 1.2.

1.5.3.1. The Effect of Household Migration Status on Children's School Enrolment

Table 10 shows the average marginal effects from the probit regression; the coefficients of the probit regression are reported in Table 15 in the Appendix. [10] Columns 1 – 4 are for boys, and columns 5 – 8 are for girls. In columns 1 and 4, I include only the migration dummy, sample child's characteristic variables, parental education variables and province dummies. Then I added log of household wealth, log of land[11] and parental occupational dummies in columns 2 and 5. Columns 3 – 4 for boys and columns 7 – 8 for girls break down the household composition at different levels of detail. I will first

[10] The average marginal effect of age is not reported, as margeff in STATA is not suitable to calculate the marginal effect of a variable with polynomial terms. But tables reporting coefficients in the Appendix show enrolment is concave in age.

[11] There are two cases of zero land size; I substitute them with 0.01 when taking log. I tried substituting them with other small positive number, and it does not affect the regression results.

discuss the effect of the migration variable, and then report the results related to the control variables.

The most interesting finding is that having migrant parent(s) has negative effects on children's school enrolment, and the effect is stronger on the enrolment of boys than on girls'. For boys, the migration dummy is always significant. All else held equal, being in a migrant household decreases the probability of school enrolment by 7.9% for boys (column 1). Controlling for wealth and parental occupations amplifies the average marginal effect of migration. All else held equal, parental absence decreases the probability of enrolment by 12.6% for boys (column 2). With household composition controls, parental absence decreases the probability of school enrolment by 10.3% – 15.9%, depending on the specification (columns 3 – 4). The number of school-age brothers and numbers of young female adults both have significantly negative effect on boys' enrolment at 1% level of significance.

Column 5 shows that for girls, being in a migrant household has significant negative effect on the school enrolment, but it is significant only at 10%. When wealth, land and parental occupation controls are added, the average marginal effect of migration becomes larger – changes from –0.055 to –0.062. Thus, all else held equal, parental absence decreases the probability of enrolment by 6.2% for girls. However, the significance disappears after controlling for household composition. This implies that migration could be associated with variation of household composition – mostly likely with more children and few adults at home. On the one hand, the result suggests a quality–quantity tradeoff; more children, especially school-age sisters, competing for limited resources decreases probability of enrolment of the sample girl. On the other hand, when there are young female adults at home they are beneficial to girls' enrolment.

Table 10. Effect of being in a migrant household on children's enrolment (average marginal effect from probit regression)

	Boys				Girls			
	1 M.Eff./S.E.	2 M.Eff./S.E.	3 M.Eff./S.E.	4 M.Eff./S.E.	5 M.Eff./S.E.	6 M.Eff./S.E.	7 M.Eff./S.E.	8 M.Eff./S.E.
Any parent migrated	-0.079**	-0.126***	-0.159***	-0.103**	-0.055[1]	-0.062*	-0.025	-0.027
	(0.033)	(0.035)	(0.040)	(0.050)	(0.034)	(0.034)	(0.033)	(0.034)
Ethnic minority	-0.137**	-0.143**	-0.121**	-0.106*	-0.072	-0.078*	-0.060	-0.071
	(0.062)	(0.062)	(0.058)	(0.055)	(0.046)	(0.046)	(0.043)	(0.044)
First born child	0.026	0.019	0.017	0.005	0.060**	0.045**	0.045**	0.043*
	(0.026)	(0.026)	(0.028)	(0.028)	(0.024)	(0.023)	(0.021)	(0.022)
Father's education	0.002	0.000	0.002	0.002	0.015***	0.010**	0.010**	0.010**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Mother's education	0.011***	0.010**	0.010**	0.011***	0.011***	0.009**	0.009***	0.009***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Log of wealth		-0.001	0.002	-0.003		0.027***	0.023**	0.022**
		(0.011)	(0.011)	(0.011)		(0.010)	(0.010)	(0.010)
Log of land		-0.027	-0.025	-0.022		0.017	0.011	0.010
		(0.019)	(0.019)	(0.019)		(0.012)	(0.014)	(0.014)
Father's occupation2		0.073***	0.073***	0.088***		0.044*	0.046**	0.049**
		(0.018)	(0.019)	(0.018)		(0.023)	(0.022)	(0.022)
Father's occupation3		0.073***	0.074***	0.088***		0.087***	0.091***	0.095***
		(0.027)	(0.028)	(0.024)		(0.028)	(0.026)	(0.026)
Mother's occupation2		0.053[2]	0.056[3]	0.046		0.043	0.035	0.045
		(0.032)	(0.030)	(0.031)		(0.032)	(0.032)	(0.032)
Mother's occupation3		0.060	0.066	0.050		0.079	0.075	0.078
		(0.044)	(0.044)	(0.048)		(0.050)	(0.049)	(0.050)
# children			-0.036*				-0.030**	
			(0.020)				(0.014)	
# adults in house			-0.035***				0.027	
			(0.013)				(0.018)	
# sisters aged 6-17				-0.028				-0.035**
				(0.021)				(0.017)
# brothers aged 6-17				-0.090***				-0.033
				(0.026)				(0.022)
# children aged <6				0.014				-0.001
				(0.043)				(0.041)
# young male adults in hh				0.029				0.015
				(0.033)				(0.031)
# young female adults in hh				-0.086***				0.064**
				(0.030)				(0.032)
# old male adults in hh				-0.058*				-0.008
				(0.030)				(0.048)
# old female adults in hh				-0.001				0.026
				(0.032)				(0.033)
Pseudo R-Square	0.375	0.412	0.432	0.461	0.404	0.452	0.467	0.472
Observations	481	470	470	470	479	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

The effect of young female adults at home on children's school enrolment is somewhat surprising. Comparing the result of boys and girls, it appears that young female adults at home have opposite effect on the school enrolment of girls and boys. There are three possible scenarios: young female adults favor girls over boys; or they do not intentionally favor girls, but they spend more time and communicate better with girls and have difficulty dealing with teen boys, and thus girls benefit more from being with young female adults; or young female adults "spoil" boys not girls. There is empirical evidence indicating that the higher altruism of female adults is often focused more on girls than boys. For example, in the United States, white mothers who headed their household after their marriages broke up paid more attention to daughters than to sons (Mott 1994). Mott also finds that girls are more likely to be helped with poor school performance if the father is not in the home. Duflo (2003) finds that grandmothers in South Africa give more of their pension to their grandchildren than grandfathers, and more to granddaughters than grandsons. However, given the traditional family roles – fathers as family disciplinarians and mothers as care–givers, and the notorious son preference in the Chinese culture, the latter two scenarios are more likely to be true in the context of rural China – boys are spoiled or disciplined less by the single mother while the father is away. This reasoning is also consistent with the descriptive results that high proportion of drop-out boys leaves school because they "do not want to go to school".

School enrolment is concave in age for both rural boys and rural girls (see Table 15 in Appendix for coefficients on age and quadratic term of age). Table 10 shows that ethnic minority boys and girls have lower probabilities of enrolment than majority ethnicity of Han, and the negative effect on the school enrolment is stronger for ethnic minority boys than girls. Being a first born child gives girls an advantage in terms of enrolment, but not boys; nevertheless, this advantage loses its significance after controlling for parental occupations and household composition. There is no evidence of sex-specific generational effect of education. Mother's education has significantly positive effect on the school enrolment of both boys and girls, while father's education only has significantly positive effect on girls'. The average marginal effects of both parents' education are similar for girls and boys, with the exception of the effect of father's education on boys. One year of father's education or mother's education

increases the probability of school enrolment by about 1% for girls, and one year of mother's education increases the probability of school enrolment by about 1% for boys. Family wealth has significant positive effects only on the school enrolment of girls, which suggests that schooling of a girl is a luxury good with higher income elasticity than schooling of boys in rural China. A 1% increase in wealth increases the school enrolment of girls by 2.2% – 3.4%. The coefficient of log of land is never significant for either boys or girls. It may be that wealth effect and substitution effect cancel each other out or that land holding is not an important determinant for school enrolment as children rarely work on the farm and the wealth effect is controlled well by the log of wealth variable.

Columns 2 – 4 and 6 – 8 show that father having a job in occupation 2 or 3 has significantly positive effect on the school enrolment of both boys and girls, while the mother's occupation has no significant effect on the school enrolment of either boys or girls. Having a father working as a blue collar worker or in the service sector rather than a farmer increases boys' enrolment by 7% – 8% and increase girls' enrolment by about 5%, while having father working as a professional or a government employee or an entrepreneur rather than a farmer increases boy's enrolment by 7% – 8% and increases girls' enrolment by 9%. Judging from the sign of the effect of parental occupation 2, it appears that the migratory aspiration effect makes a child more likely to be enrolled at school, at least at primary and secondary school levels. The coefficient on the number of children under six years old is never significant for boys or girls, which is consistent with the descriptive result that children in the data do not work much and lack of labor is not an important reason for not enrolling in school.

In summary, parental migration has negative effect on the school enrolment of their left-behind children. Both the overall effect and the family disruptive effect of parental migration are stronger on the enrolment of boys than on girls'. All else held equal, being in a migrant household decreases the probability of school enrolment by 7.9% for boys and by 5.5% for girls, but the latter is not always statistically significant.

1.5.3.2. The Effect of Types of Migrant Households on Children's School Enrolment

To further identify the effect of different migrant households on school enrolment, I divide all households into four types. Three types of migrant households are: only

migrant father; only migrant mother; and both migrant parents. The default household type is one with no migrant parent. Control variables are added in the same way as in Section 1.5.3.1. Table 11 displays the average marginal effects, and the coefficients are reported in Table 16 in the Appendix.

Since the effects of the control variables are similar to these in the last section, I focus my discussion on the effect of the type of migrant household. For boys, being in a household with only migrant father and being in a household with only migrant mother both significantly negatively affect children school enrolment, and the effect of mother's absence is twice as large as father's though it is less significant than that of father's. Being in a household with only migrant father decreases the probability of boys' enrolment by 8.5%, while being in a household with only migrant mother decreases the probability of boys' enrolment by 16.8% (column 1). [12] With control on wealth and parental occupations, the absence of father alone decreases a boy's enrolment by 13.1%, and the absence of mother alone decreases a boy's enrolment by 20.5% (column 2). With household composition controls, being in a household with both migrant parents becomes significantly negative; thus, all three types of migrant households have significant negative effects on the school enrolment of boys. [13] With household composition controls, the absence of both parents decreases a boy's enrolment probability by 13.1% – 15.6% (columns 3 and 4).

[12] The small sample size of households with only migrant mother may affect the reliability of these results on this dummy. There are only 31 cases of households with only migrant mother in the data.

[13] The only exception is households with only migrant father in column 4.

Table 11. Effect of being in different type of migrant household on children's enrolment (average marginal effect from probit regression)

	Boys				Girls			
	1 M.Eff./S.E.	2 M.Eff./S.E.	3 M.Eff./S.E.	4 M.Eff./S.E.	5 M.Eff./S.E.	6 M.Eff./S.E.	7 M.Eff./S.E.	8 M.Eff./S.E.
Only father migrated	-0.085**	-0.131***	-0.157***	-0.044	-0.044	-0.056	-0.025	-0.052
	(0.037)	(0.040)	(0.046)	(0.049)	(0.037)	(0.039)	(0.037)	(0.047)
Only mother migrated	-0.168*	-0.205*	-0.174*	-0.331**	-0.053	0.028	0.045	0.069
	(0.089)	(0.111)	(0.097)	(0.131)	(0.059)	(0.042)	(0.040)	(0.042)
Both parents migrated	-0.031	-0.082	-0.156**	-0.131*	-0.102	-0.119**	-0.083	-0.059
	(0.052)	(0.058)	(0.072)	(0.077)	(0.070)	(0.059)	(0.063)	(0.063)
Ethnic minority	-0.136**	-0.141**	-0.122**	-0.115**	-0.074	-0.077*	-0.060	-0.070
	(0.062)	(0.063)	(0.059)	(0.055)	(0.046)	(0.046)	(0.043)	(0.044)
First born child	0.025	0.017	0.017	0.004	0.063***	0.046**	0.045**	0.041*
	(0.026)	(0.026)	(0.027)	(0.027)	(0.024)	(0.023)	(0.022)	(0.022)
Father's education	0.003	0.000	0.002	0.002	0.015***	0.010**	0.009**	0.009**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Mother's education	0.010**	0.010**	0.010**	0.011***	0.011***	0.009**	0.009***	0.009***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Log of wealth		-0.000	0.002	-0.002		0.027***	0.023**	0.022**
		(0.011)	(0.011)	(0.011)		(0.010)	(0.009)	(0.009)
Log of land		-0.026	-0.026	-0.025		0.020	0.014	0.013
		(0.018)	(0.019)	(0.017)		(0.013)	(0.014)	(0.015)
Father's occupation2		0.071***	0.073***	0.079***		0.047*	0.048**	0.054**
		(0.019)	(0.020)	(0.020)		(0.024)	(0.024)	(0.022)
Father's occupation3		0.072***	0.074***	0.083***		0.089***	0.092***	0.098***
		(0.027)	(0.028)	(0.025)		(0.028)	(0.026)	(0.026)
Mother's occupation2		0.053	0.057*	0.057*		0.052*	0.044	0.044
		(0.036)	(0.034)	(0.031)		(0.030)	(0.030)	(0.029)
Mother's occupation3		0.058	0.066	0.054		0.082	0.077	0.074
		(0.045)	(0.045)	(0.045)		(0.050)	(0.050)	(0.048)
# children			-0.036*				-0.033**	
			(0.020)				(0.014)	
# adults in house			-0.034**				0.022	
			(0.014)				(0.019)	
# sisters aged 6-17				-0.031				-0.038**
				(0.020)				(0.017)
# brothers aged 6-17				-0.097***				-0.035
				(0.027)				(0.022)
# children aged <6				0.023				-0.007
				(0.045)				(0.041)
# young male adults in hh				0.065*				-0.005
				(0.037)				(0.037)
# young female adults in hh				-0.117***				0.071*
				(0.037)				(0.041)
# old male adults in hh				-0.045				-0.009
				(0.031)				(0.048)
# old female adults in hh				-0.002				0.022
				(0.032)				(0.034)
Pseudo R-Square	0.379	0.414	0.432	0.469	0.405	0.455	0.470	0.475
Observations	481	470	470	470	479	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

A perhaps surprising result is that when adding detailed household composition controls, the negative effect of absence of father alone loses significance. It seems that the negative effect of father's absence can be solely explained by variation in household composition. With young male migrating out, these households have fewer young males who have a positive effect on boys' enrolment and more young females in charge who have a negative effect on boys' enrolment. The opposite happens to the case of only mother migrated after adding detailed household composition controls; the average marginal effect increases by more than half from –0.205 to –0.331 as in this type of household it is more likely to be the young male – father "in charge of" the boy. This result is consistent with the result in Section 1.5.3.1.

As shown in columns 5 – 8 of Table 11, for girls, being in a household with only migrant father and being in a household with only migrant father never significantly affect the school enrolment with or without extra controls. The overall effect of being in a household with both migrant parents on the enrolment of girls is negative but not significant. When wealth, land and parental occupation controls are added, the negative effect of being in a household with both migrant parents becomes significant at 5% level of significance. The absence of both parents decreases girls' enrolment by 11.9% (column 6). However, after adding household composition controls, the effect of being in a household with two migrant parents becomes insignificant. Consistent with the result in Section 1.5.3.1, the beneficial effect of the number of young female adults in household on the school enrolment of girls may explain the disappearance of significance of parental migration effect.

In summary, consistent with the results in Section 1.5.3.1, being in a migrant household has negative effects on the school enrolment of left-behind children, and the negative effects are larger on enrolment of boys than on girls'. More specifically, for boys, being in a migrant household with only migrant father or with only migrant mother has significant negative effect on school enrolment, and being in a migrant household with both migrant parents has significant negative effect on school enrolment after controlling for household composition. The marginal effects of types of migrant households are large, ranging between –8.5% and –33.1%. For girls, only being in a

migrant household with both migrant parents has significant negative effect on school enrolment. Its marginal effect on girls' school enrolment is –11.5%.

Table 12. Effect of migratory duration of father on enrolment of children in household with only migrant father (average marginal effects from probit regression)

	Boys				Girls			
	1	2	3	4	5	6	7	8
	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.
Migratory duration	-0.006	-0.012***	-0.012**	-0.007*	0.010	0.010	0.016**	0.017**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)
Ethnic minority	-0.124	-0.124	-0.065	-0.077	-0.026	0.003	-0.094	-0.121
	(0.101)	(0.086)	(0.073)	(0.052)	(0.109)	(0.099)	(0.112)	(0.107)
First born child	0.054	0.065	0.063	0.030	0.195***	0.200***	0.217***	0.210***
	(0.048)	(0.042)	(0.042)	(0.036)	(0.044)	(0.044)	(0.047)	(0.049)
Father's education	0.006	0.014	0.013	0.011	0.006	0.005	0.019	0.021
	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.015)	(0.015)
Mother's education	0.010	0.014**	0.009	0.010*	0.018**	0.019**	-0.000	-0.004
	(0.007)	(0.007)	(0.007)	(0.005)	(0.008)	(0.008)	(0.009)	(0.009)
Log of wealth		0.012	0.012	-0.005		-0.027	-0.026	-0.019
		(0.019)	(0.021)	(0.018)		(0.027)	(0.036)	(0.039)
Log of land		-0.041	-0.049	-0.061*		0.044**	0.067***	0.058**
		(0.041)	(0.043)	(0.035)		(0.021)	(0.025)	(0.029)
Father's occupation2		0.012	0.061	0.049		-0.055	-0.002	-0.074
		(0.063)	(0.055)	(0.041)		(0.135)	(0.122)	(0.153)
Father's occupation3		0.016	0.108*	0.109**		0.007	0.067	0.002
		(0.091)	(0.065)	(0.045)		(0.140)	(0.142)	(0.182)
Mother's occupation2		-0.262**	-0.253***	-0.244***		0.049	0.103	0.136**
		(0.119)	(0.097)	(0.079)		(0.064)	(0.077)	(0.069)
# children			-0.100***				-0.156***	
			(0.029)				(0.057)	
# adults in house			-0.028	0.017			-0.027	-0.025
			(0.041)	(0.029)			(0.074)	(0.078)
# sisters aged 6-17				-0.064**				-0.175***
				(0.029)				(0.060)
# brothers aged 6-17				-0.149***				-0.140**
				(0.023)				(0.060)
# children aged <6				0.047				-0.083
				(0.050)				(0.178)
Pseudo R-Square	0.433	0.490	0.551	0.601	0.490	0.513	0.581	0.585
Observations	119	106	106	106	84	75	75	75

* p<0.10, ** p<0.05, *** p<0.01

1.5.3.3. The Effect of Duration of Parental Migration on Children's School Enrolment

In this section, I show another aspect in which a migrant parent may affect a child's school enrolment. Instead of using types of households by migration, I use the duration of parental migration in the probit regression of probability of enrolment. Because of the small sample size of households with only migrant mother and both migrant parents when divided into male and female subsamples, I will only analyze the effect of duration of migrant fathers in migrant household with only migrant father. After all, this is the most typical migrant household type with left-behind children. The average marginal effects are shown in Table 12, and the coefficients are shown in Table 19 in the Appendix. For result reported in this section, I define "duration of migration" as total years of migration after the birth of the sample child, since migration before the birth of the sample child is unlikely to have any effect on the school enrolment, or even if it had, the effect may be different. As a robustness check, the effects of "total duration of migration regardless timing" are reported in Table 20 in the Appendix, and I will discuss it in Section 1.5.3.4. Control variables are added in the same way as in Section 1.5.3.1. I first report the effect of duration of father's migration, and then report the effects of the control variables.

The probit results show strong evidence for a sex-specific intergenerational effect. With controls for wealth and parental occupations, father's migratory duration has significantly negative effect on boys' enrolment. It has positive effect on girls' enrolment though the effect is not significant without household composition controls. For boys, the effect of father's migratory duration is negative but not significant, without controlling for wealth and occupation. It implies that the negative effect of father's absence is canceled out by the positive wealth effect and the positive effect of occupational aspiration and migratory aspiration as suggested by the theoretical model in Section 1.2. With these controls, the effect of father's migratory duration becomes significant; one year increase in father's migratory duration decreases boys' enrolment by 1.2% (column 2). The effect remains significant with household composition controls, but its level of significance diminishes and its magnitude decreases too when adding detailed household composition controls (columns 3 and 4). These results reveal that the negative effect of father's migratory duration is exaggerated by the higher number of school-age children in

the household. This effect of school-age siblings will be explained in detail later in this section. For girls, the effect of father's migratory duration is positive and insignificant, and it remains insignificant even after controlling wealth and parental occupations (columns 6 and 7). Once controlling for household composition, father's absence becomes significantly positive. Again, the effect of father's migratory duration is exaggerated by the higher number of school-age children in the household.

School enrolment is once again concave in age in all specifications. Being a first born child (including being an only child) gives girls an advantage, as it increases the probability of girls' enrolment by about 20%; but it has no significant effect on boys' enrolment. Father's education has no significant effect on the enrolment of either boys or girls in all specifications, which confirms the theoretical model that the physical presence of a parent is indispensible for parental involvement. Mother's education has positive effect on both boys and girls, and the effect is stronger on girls than on boys without household composition controls. With wealth and occupation controls, all else held constant, one year increase in mother's schooling increases the enrolment of a boy with migrant father by 1.4%, and it increases the enrolment of a girl with migrant father by 1.9% (columns 2 and 6). With household composition control, the effect becomes smaller and less significant, which implies that more educated mothers in the sample tend to have fewer children; the tendency is especially strong in the households of girls in the sample.

Log of wealth has no significant effect on either boys or girls, but log of land size has significant positive effect on girls' enrolment. A 1% increase in land size increases girls' enrolment by 4.2% – 6.7% depends on whether controlling for household composition. The effects of parental occupation also show strong evidence of sex-specific intergenerational effect. In general, conditional on having a migrant father and non-migrant mother, father working as a blue collar worker or in the service sector rather than a farmer increases boy's enrolment and decrease girls' enrolment, but all these effects are insignificant. Conditional on having a migrant father and non-migrant mother, mother working as a blue collar worker or in the service sector rather than a farmer decreases boy's enrolment and the effect is always significant; the effect on girls' enrolment is always positive and it is significant when controlling for household composition. All else held equal, having a mother working as blue collar worker or in the

service sector instead of working on the farm lowers the enrolment of a boy with migrant father by 26%. Lastly, the result suggests a quality-quantity tradeoff; the number of school-age sisters and number of school-age brothers both have negative effect on the school enrolment of boys and of girls (columns 4 and 8). All else being equal, having one more school-age sister decreases the school enrolment of a boy with migrant father by 6.4% and decreases the school enrolment of a girl with migrant father by 17.5%. All else being equal, having one more school-age brother decreases the school enrolment of a boy with migrant father by 14.9% and decreases the school enrolment of a girl with migrant father by 14%.

In summary, conditional on being in a household with migrant father and non-migrant mother, the duration of father's migration has significantly negative effect on the school enrolment of boys, and it has no significant effect on the school enrolment of girls without controlling for household composition. With household composition controls, the duration of father's migration has significantly positive effect on the school enrolment of girls, as its effect is exaggerated by the higher number of school-age children in the household.

1.5.3.4. Robustness Check

The robustness check in this section is threefold. First, I check whether the probit results are subject to endogeneity problem by performing an endogenous probit regression. Second, I check children at what education stage are most affected by parental migration. Lastly, I check whether the effect of father's migration duration is robust by using a different definition of his migration duration. In addition, the probit results are also robust when the children sample is restricted to only including children aged 7 to 17, as some scholars may have the concern that rural children might enroll in school at an older age. [14]

[14]These results are available upon request.

The effects of parental migration on school enrolment from the probit regressions are consistent with the existing literature presented in Section 1.3 and the prediction of the theoretical model presented in Section 1.2. But because the probit models may subject to endogeneity problem due to possible correlated missing variables, I will perform a robustness check to ensure that the results are not driven by the bias caused by missing variables. One such correlated missing variable is unobserved parental interest in and aspirations for children's education, as suggested in the literature. The strategy is instrumenting for parental migration using "the number of other migrant household members". "Other migrant household member" is defined, in Section 1.5.1, as an individual who is a migrant aged 25 or above and is viewed as a relative by the household head but not a parent of the sample child. I define this age range so that other migrant household member is more likely to be of the parent's generation or older rather than of the sample child's generation, so that its effect on the sample child's school enrolment is solely through its effect on the parent's migration. The instrument is valid because it is likely unrelated with the missing variable – the parent's interest in and aspirations for children's education, while it is related with the parent's migration status since other migrants in the family may provide information about migrant destination and thus facilitate the parent's migration. I choose a specification with household composition controls as in column 3 in Table 10 to conduct endogeneity check. Because the endogenous variable is a dummy variable, ivprobit in STATA is not suitable, so I use biprobit to perform an endogenous probit regression. The results of the biprobit regression are reported in Table 13, and the results of an endogenous linear regression and the corresponding OLS linear regression are reported in Table 17 in the Appendix.

In Table 13, the first three columns are probit and biprobit results for boys and the next three columns are these for girls. The average marginal effect of parental absence is reported in the first row, and the remaining are coefficients. The results of the probit and biprobit regressions are consistent with each other. For boys, the effect of parental migration is significantly negative in both probit and biprobit regressions and the average marginal effects are similar too. The average marginal effect is slightly less negative than that from the probit regression, which suggests that parental migration is negatively correlated with the missing variable – the parent's interest in and aspirations for children's education. Parental migration decreases the probability of boys' enrolment

by 15.9% according to the probit regression and by 15.3% according to the biprobit regression. For girls, the effect of parental migration is negative but insignificant in both probit and biprobit regressions.

Table 13. Effect of being in a migrant household on children's enrolment (probit and biprobit regression)

	Boys			Girls		
	Probit	Biprobit1	Biprobit2	Probit	Biprobit1	Biprobit2
	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.
Any parent migrated	-0.159***	-0.153**		-0.025	-0.014	
	(0.040)	(0.124)		(0.033)	(0.058)	
	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.
Any parent migrated	-1.005***	-1.211**		-0.180	-0.950	
	(0.215)	(0.612)		(0.227)	(0.858)	
Age	1.269***	1.245***	-0.321**	1.569***	1.492***	-0.099
	(0.201)	(0.211)	(0.159)	(0.228)	(0.269)	(0.171)
Quadratic age term	-0.062***	-0.062***	0.012*	-0.076***	-0.073***	0.001
	(0.009)	(0.009)	(0.007)	(0.010)	(0.012)	(0.007)
Ethnic minority	-0.712**	-0.702**	-0.008	-0.400	-0.468*	-0.601**
	(0.289)	(0.287)	(0.270)	(0.268)	(0.274)	(0.270)
First born child	0.118	0.130	0.288**	0.325*	0.303*	0.073
	(0.207)	(0.212)	(0.138)	(0.174)	(0.168)	(0.131)
Father's education	0.014	0.018	0.055*	0.071**	0.084***	0.072**
	(0.036)	(0.036)	(0.029)	(0.033)	(0.032)	(0.034)
Mother's education	0.071**	0.071**	0.000	0.063**	0.047	-0.073***
	(0.029)	(0.029)	(0.025)	(0.025)	(0.030)	(0.026)
Log of wealth	0.010	0.009	-0.067	0.166**	0.191***	0.175**
	(0.081)	(0.080)	(0.067)	(0.071)	(0.071)	(0.085)
Log of land	-0.177	-0.171	0.045	0.076	0.087	-0.036
	(0.140)	(0.142)	(0.134)	(0.101)	(0.100)	(0.156)
Father's occupation2	0.623***	0.656***	0.699***	0.368*	0.428**	0.456*
	(0.207)	(0.224)	(0.201)	(0.215)	(0.213)	(0.243)
Father's occupation3	0.634**	0.627**	0.099	0.841**	0.734*	-0.201
	(0.313)	(0.315)	(0.270)	(0.343)	(0.377)	(0.326)
Mother's occupation2	0.439	0.463	0.314	0.269	0.277	-0.071
	(0.287)	(0.293)	(0.216)	(0.280)	(0.273)	(0.245)
Mother's occupation3	0.517	0.544	0.323	0.631	0.650	0.123
	(0.420)	(0.420)	(0.327)	(0.528)	(0.510)	(0.420)

# children	-0.252*	-0.244*	0.192	-0.219**	-0.201*	0.151
	(0.140)	(0.142)	(0.129)	(0.106)	(0.109)	(0.154)
# adults in house	-0.239**	-0.288*	-0.892***	0.194	0.012	-1.105***
	(0.093)	(0.160)	(0.157)	(0.138)	(0.260)	(0.224)
# other migrant household members			0.790***			1.012***
			(0.269)			(0.345)
Constant	-3.653***	-3.403**	2.471**	-8.930***	-8.209***	0.376
	(1.412)	(1.506)	(1.088)	(1.442)	(1.889)	(1.210)
rho		0.124			0.508	
		(0.334)			(0.492)	
p-value in Wald test of rho=0		0.713			0.399	
Pseudo R-Square	0.432			0.467		
Observations	470	470	470	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

The instrument is relevant, and it is positive and significant at 1% level in the first stage of the endogenous probit regression for boys and for girls, as shown in columns 3 and 6. This is consistent with the assumption that the number of other migrant household members significantly positively affects the probability of the parents' migration. However, parental migration is not really endogenous as suspected for both boys and girls. A Wald test of the coefficient correlation of the two biprobit equations (rho) does not reject the null hypothesis that the two equations are independent. The p-value of the Wald test for boys is 0.713 and for girls is 0.399. Thus, the results suggest that the results of the probit model presented in Section 1.5.3.1 are likely not subject to endogeneity problem.

The results of a linear endogenous regression are reported in Table 17 in the Appendix. The results are consistent with the biprobit results on relevance of the instrument and the endogeneity of parental migration. First, the instrument is relevant and not weak, as the instrument is significant at 1% level in the first stage for both boys and girls, and the F-statistic for the first stage is 30.87 in the IV regression for boys and 11.29 for girls. In addition, the small-sample bias of IV relative to OLS estimates based on the first-stage F-statistic is below an upper bound of 16.38 for both boys and girls (Stock and Yogo, 2005). So, the estimated IV coefficients may be polluted with about 16% as much bias as the OLS estimates. Second, the results of endogeneity test of parental migration suggest that the OLS estimates do not subject to bias caused by severe endogeneity problem. The p-value of the endogeneity test of endogenous regressor is 0.101 for boys, which suggests that the null hypothesis of the exogeneity of parental migration cannot be rejected. The p-value of the endogeneity test of endogenous regressor is 0.043 for girls, which suggests that parental migration marginally pass the endogeneity test.

To show how children at different school stage are affected by parental migration, I report the result from a multinomial logit regression in Table 18 in the Appendix.[15] The dependent variable takes value of 1 if the child was enrolled, 2 if the child dropped out of middle school, 3 if the child dropped out of primary school, and 4 if the child was never enrolled in school.[16] The results show that parental migration starts to affect boys' enrolment as early as the first enrolment in school. Boys in migrant households have significantly higher probability of never being enrolled in school, and significantly higher probability of dropping out of primary school. If controlling for parents' occupations and wealth factors, being in migrant households also significantly increases boys' chance of dropping out of middle school. For girls, the detrimental effect of parental migration is only significant at the middle school stage.

In terms of the three effects of parental migration, a significant disruptive effect is consistently observed on boys at all school stages; the same is not true for girls. It seems that girls at all school stages are more resistant to the disruptive effect of parental migration than boys. Consistent with the finding in the previous sections, a significant beneficial wealth effect is only observed for girls and only after they were enrolled in school. At the primary school stage, the wealth variable significantly decreases girls' probability of dropping out; while at the middle school stage, the land holding variable significantly decreases girls' probability of dropping out. Lastly, the migratory aspirational effect of parental migration is observed for boys who were enrolled in school and it decreases the boys' probability of dropping out. At the primary school stage, the aspirational effect through the dummy variable of mother having a job in occupation category 2 is more significant than that of fathers', while the reverse is true for boys at the middle school stage. The aspirational effect is only significant for girls at the primary school stage through the dummy variable of mother having a job in occupation category

[15] To avoid confusion, marginal effect is not reported, since the interpretation of the marginal effect from "margins" in STATA is not consistent with the interpretation of the coefficient of the mlogit.

[16] In the mlogit regression, the base category is being enrolled; that is, the dependent variable takes value of 1.

2. Overall, it appears that mothers' occupation matters more for children at the primary school stage, and fathers' occupation matters more later for children at the middle school stage.

Lastly, I check the robustness of the effect of father's migration duration on children's school enrolment by using another definition of migration duration. As stated in Section 1.5.1, the migration duration used in Section 1.5.3.3 is defined as the years of parental migration after the birth of the sample child. In this section, I will use the total years of parent's migration defined as the total years of parental migration regardless whether the absence is before or after the birth of the sample child to exam the robustness of the effect of father's migration duration on children's enrolment. The results are reported in Table 20 in the Appendix. The results show that the sign and the size of the effect of father's migration duration on children's enrolment is not affected by the slight change in its definition. Father's migration durations still have significantly negative effect on boys' enrolment, and one year increase in father's total migration duration decreases the probability of school enrolment by about 1% for boys in households with migrant father and non-migrant mother. Father's migration durations has positive and insignificant effect on girls' enrolment without household composition controls and significant positive effect on girls' enrolment with household composition controls.

1.6. Discussion and Conclusion

I use a probit model to analyze the effect of parental migration on the school enrolment of left-behind children in rural China. I find evidence of a negative effect of parental migration on school enrolment. Migration can possibly have three effects on school enrolment: disruptive effect, wealth effect, and aspirational effect. In my data, the results show that the latter two effects affects school enrolment positively, however, these positive effects are not strong enough to completely neutralize the disruptive effect, and thus, the total effect of migration is negative. I also find that the negative effect of migration is larger on the school enrolment of boys than on that of girls, and the longer the duration of father's absence is, the bigger the negative effect on boys' enrolment. As migrant households in the data are predominantly households with only

migrant father, it seems that migrant father has larger negative effect on the school enrolment of boys than on that of girls. But, since households with only migrant father are the most typical case in China, the result is representative. The result indicates that left-behind mothers or relatives cannot fulfill fathers' role successfully in disciplining boys and help with their educational needs, and father's involvement in son's education is important.

My finding that there is a larger effect of parental migration on boys' enrolments than on these of girls is consistent with the literature that boys appear to be more vulnerable to difficult circumstances in the household. For example, a recent empirical study by Bertrand and Pan (2012) discovers that relative to other children, boys raised outside of intact families with two biological parents, especially by single mothers, were more likely to display behavioural problems at a young age and were suspended more often in primary and secondary education, which increased their probability of dropping out of school. Moreover, they find that the relationship between family structure and behavioral problems appears to be much stronger for boys than for girls.

My findings are also consistent with previous studies on the effect of father's absence on children's schooling. For example, Alfaro, Umana–Taylor, and Bamaca (2006) find that a father's academic support was positively related to adolescent boys' academic motivation to try hard in school, feel that their grades were important, and to place a high value on education. Children of involved fathers are more likely to have higher test scores (Astone and McLanahan, 1991; Blanchard and Biller, 1971; Cooksey and Fondell, 1996; Feldman and Wentzel, 1990; Gadsden and Ray, 2003; Goldstein, 1982; Gottfried *et al.*, 1988; Howard *et al.*, 2006; McBride *et al.*, 2005; National Center for Education Statistics, 1997; Shinn, 1978; Snarey 1993; Wentzel and Feldman, 1993). Children of involved fathers are also more likely to enjoy school (National Center for Education Statistics, 1997), and have positive attitudes toward school (Flouri *et al.*, 2002; Flouri, 2005).

The results further show that girls benefit from more young female adults at home while boys do not. It seems that young female adults, such as a left-behind mother, favor girls over boys. But the reason is not clear. It may be the case that mothers favor girls over boys intentionally, or that mothers are better at dealing with girl than boy, or mother

does harm to boy by “spoiling” him. With consideration of son preference social norm in rural China, the former case is unlikely.

Overall, it seems that fathers’ migration has more detrimental effect on boys’ enrolment, while having a mother as guardian benefits girls more than boys. This finding is consistent with findings in the divorce literature. For example, Cardosa and Souza (2004) found that relative to being in two-parent families, being raised by a single mother has a significant negative effect on the school attendance of boys in Brazil, not girls, while being raised by a single father has a significant positive effect on the school attendance of boys, not girls. Camara and Resnick (1988) and Santrock and Warshak (1979) found similar evidence of gender difference in the US. They found that boys in mother-custody families were worse off than girls, whereas girls in father-custody families were worse off than boys, in terms of psychological and cognitive development. Earlier studies also found evidence in the US that relative to being in single-parent families, the presence of a stepfather improves the well-being of boys but either has no effect on or decreases the well-being of girls (Chapman, 1977; Hetherington et al, 1985; Peterson and Zill, 1986; Santrock, 1972; Santrock *et al*, 1982).

Lastly, my results reveal a quality–quantity tradeoff. More children in the household lower the school enrolment of both boys and girls. The result also implies that in households with migrant father and non-migrant mother more educated mothers have fewer children. Thus, education of a girl has profound intergenerational effect, and deserves more attention from society and the government. Wealth variables have significant positive effect only on girls’ enrolment, which suggests that girls’ schooling is a luxury good with large income elasticity. This result is consistent with the prevalence of boy preference in rural China. If any policy targets raising school enrolment through financial aid such as vouchers, policy makers should consider making the aid to be gender specific to gain effectiveness.

Policy such as conditional cash transfer to the left-behind mothers, conditional on children’s school attendance and mothers’ involvement and input in the children’s education, may help to motivate the mothers to monitor and persuade boys to attend school. In addition, given that the main reason that boys drop out of school is “do not want to go to school”, making basic education curricula more interesting and more

attractive to teenagers may help to keep boys in school. However, there may not be a simple remedy to remove the disadvantage of boys in migrant households in a short time. I document this fact, and quantify the effect of parental migration on the left-behind children's enrolment, in the hope that policy makers will consider these factors when they makes changes to the *Hukou* system and education system in China.

There are several limitations to the analysis. First, the sample size of households with only migrant mother and of both migrant parents is small, and thus result on the dummies of these types of households may not be accurate. There are 31 cases of households with only migrant mother and 73 cases of households with both migrant parents. Second, a limitation of the duration effect is that it does not consider the possible non-linearity of the effect at different stage of the child's growth and the timing of the parent's absence. Maybe the effect of parental absence is larger if the absence is at an early schooling stage, or maybe the effect is larger if father is absence at a critical schooling point such as the progression stage from elementary school to middle school.

1.7. References

Alfaro, E. C., Umana–Taylor, A J., Bámaca, M. Y, (2006). The Influence of Academic Support on Latino Adolescents' Academic Motivation. *Family Relations*, 55 (3), 279–291.

Almond, D., Li, H., Meng, L., (2010). Son Preference and Early Childhood Investments in China. 2010 AEA conference.

Astone, N. M., McLanahan, S. S., (1991). Family Structure, Parental Practices, and High School Completion. *American Sociological Review*, 56, 309–320.

Battistela, G. , Gastardo-Conaco. M. (1998) The Impact of Labor Migration on the Children Left Behind, *Sojourn* , 13, 220–241.

Bertrand, M., Pan, J., (2012). The Trouble with Boys: Social Influences and the Gender Gap in Disruptive Behavior. *Applied Economics Journal*, forthcoming.

Björklund, A., Jäntti, M., Lindquist, M., (2009). Family Background and Income during the Rise of the Welfare State: Brother Correlations in Income for Swedish Men Born 1932–1967. *Journal of Public Economics*, 93, 671–680.

Björklund, A., Salvanes, K.G., (2009). Education and Family Background: Mechanisms and Policies. *Handbook of the Economics of Education*, 3, 201–247.

Blanchard, R. W., Biller, H. B. (1971). Father Availability and Academic Performance among Third Grade Boys. *Developmental Psychology*, 4, 301–305.

Bryant, J. (2005) Children of International Migrants in Indonesia, Thailand, and the Philippines: A Review of Evidence and Policies, *UNICEF Innocenti Research Centre Working Paper* No. 2005_5, Florence, Italy.

Camara, K. A., Resnick, G. (1988). Interparental Conflict and Cooperation: Factors Moderating Children's Post-divorce Adjustment. In E. M. Hetherington & J. D. Arasteh (Eds), Impact of Divorce, Single Parenting, and Stepparenting on Children, Hillsdale, NJ: Erlbaum. 169-196.

Cardosa, E, Souza, A.P. (2004). The Impact of Cash Transfers on Child Labor and School Attendance in Brazil. Vanderbilt University, Working Papers 0407.

Catsambis, S., (2001). Expanding Knowledge of Parental Involvement in Children's Secondary Education: Connections with High Schools Seniors' Academic Success. *Social Psychology of Education*, 5, 149–177.

Chan and Buckingham's (2008). Is China Abolishing Its Hukou System. *The China Quarterly*, 195, 582–606

Chapman, M. (1977). Father Absence, Stepfathers, and the Cognitive Performance of College Students. *Child Development*, 48,I155-1158.

Cheng, K.M., (1994). Issues in Decentralizing Education: What the Reform in China Tells. *International Journal of Educational Research* 21, 799–808.

China Daily, (2002). Family Planning Law and China's Birth Control Situation. 18 October 2002.

China Daily, (2011). Account Book on Educational Expenses: How Much Does It Cost for Kindergarten to University Graduate? 05 May, 2011.

China Daily (2011). There Are More Than 58 Million of Left-behind Children in Rural China – Self-contempt and Cowardice Result from Lack of Parental Care. 18 August, 2011.

China Network, (2008). The Report Says that the Left-behind Children in Six Provinces Account for 52% of All Left-behind Children in China and There Are More Left-behind Boys Than Girls. 27 February, 2008.

China Statistical Yearbooks, 1987–2008. The National Bureau of Statistics of China.

Chiquiar, D. , Hanson, G. (2005). International Migration, Self-Selection and the distribution of wages: Evidence from Mexico and the United States. Working Paper 59, The Center for Comparative Immigration Studies, University of California: San Diego.

Collins, W. J. , Margo, R. A., (2006). Historical Perspectives on Racial Differences in Schooling in the United States, *Handbook of the Economics of Education*, 3, 107–154.

Conley, D., Glauber, R., (2008). All in the Family? Family Composition, Resources, and Similarity in Socio–Economic Status. *Research in Social Stratification and Mobility*, 26, 297–306.

Cooksey, E.C. , Fondell, M.M. , (1996). Spending Time with His Kids: Effects of Family Structure on Fathers' and Children's Lives. *Journal of Marriage and the Family* 58(3): 693–707.

Cox and Ureta (2003). International Migration, Remittances, and Schooling: Evidence from El Salvador. NBER Working Paper w9766.

Desforges, C., Abouchaar, A., (2003). The Impact of Parental Involvement, Parental Support and Family Education on Pupil Achievement and Adjustment: A Literature Review. British Department for Education and Skills Research Report No 433.

Duflo E., (2003). Grandmothers and Granddaughters: Old-age Pensions and Intrahousehold Allocation in South Africa. *World Bank Economic Review*, 17, 1–25.

Fan, X, (2001). Parental Involvement and Students' Academic Achievement: A Growth Modelling Analysis. *The Journal of Experimental Education*, 70 (1), 27–62.

Fehrmann, P.G., Keith, T.Z., Reimers, T.M., (1987). Home Influence on School Learning: Direct and Indirect Effects of Parental Involvement on High School Grades. *The Journal of Educational Research*, 80 (6), 330–337.

Feinstein, L., and Symons, J., (1999). Attainment in Secondary School. *Oxford Economic Papers*, 51, 300–321.

Feldman, S. S., & Wentzel, K. R. (1990). Relations among Family Interaction Patterns, Classroom Self-Restraint, and Academic Achievement in Preadolescent Boys. *Journal of Educational Psychology*, 82, 813–819.

Flouri, E. (2005). Fathering and Child Outcomes. Chichester: Wiley.

Flouri, E., Buchanan, A., & Bream, V. (2002). Adolescents' Perceptions of Their Fathers' Involvement: Significance to School Attitudes. *Psychology in the Schools*, 39, 575–582.

Gadsden, V. & Ray, A. (2003). Fathers' Role in Children's Academic Achievement and Early Literacy (ERIC Publication No. ED482051. ERIC Clearinghouse on Early Education and Parenting, ERIC Digest.

Gamburd, M.R. (2005). Lentils There, Lentils Here! Sri Lankan Domestic Workers in the Middle East. In Asian Women as Transnational Domestic Workers, eds. Shirlena Huang, Brenda S.A. Yeoh, and Noor Abdul Rahman. Singapore: Marshall Cavendish Academic.

Garg, R., Kauppi, C., Lewko, J., Urajnik, D., (2002). A Structural Model of Educational Aspirations. *Journal of Career Development*, 29(2), 87–108.

George, R., Kaplan, D. 1998. A Structural Model of Parent and Teacher Influences on Science Attitudes of Eighth Graders: Evidence from NELS: 88. *Science Education*, 82, 93–109.

Goldstein, H. S. (1982). Fathers Absence and Cognitive Development of 12-17 Year Olds. *Psychological Reports*, 51, 843–848.

Gonzalez–Pienda, J.A., Nunez, J.C., Gonzalez–Pumariega, S., Alvarez, L., Roces, C., Garcia, M., (2002). A Structural Equation Model of Parental Involvement, Motivational and Aptitudinal Characteristics, and Academic Achievement. *The Journal of Experimental Education*, 70(3), 257–287.

Goodkind, D, (1999). Should Prenatal Sex Selection be Restricted?: Ethical Questions and Their Implications for Research and Policy. *Population Studies* 53 (1), 49–61.

Gottfried, A. E., Gottfried, A. W., & Bathurst, K. (1988). Maternal employment, Family environment, and Children's Development: Infancy through the School Years. In A. E. Gottfried & A. W. Gottfried (Eds.), Maternal employment and Children's Development: Longitudinal research. 11–58.

Haveman, R., Wolfe, B., (1995). The Determinants of Children's Attainments: A Review of Methods and Findings. *Journal of Economic Literature*, 33(4), 1829–1878.

Hetherington, E. M., Cox, M, Cox, R. (1985). Long-term Effects of Divorce and Remarriage on the Adjustment of Children. *Journal of the American Academy of Child Psychiatry*, 24, 518-530.

Howard, K.S., Lefever, J.E., Borkowski, J.G. and Whitman, T.L. (2006). Fathers' Influence in the Lives of Children with Adolescent Mothers. *Journal of Family Psychology*, 20, 468–476.

Isacsson, G., (1999). Estimates of the Return to Schooling in Sweden from a Large Sample of Twins*. Labour Economics*, 6, 471–489.

Izzo, C.V., Weissberg, R.P., Kasprow, W. J., Fendrich, M., (1999). A Longitudinal Assessment of Teacher Perceptions of Parent Involvement in Children's Educationa and School Performance. *American Journal of Community Psychology*, 27(6), 817–839.

Jampaklay, A., (2006). Parental Absence and Children's School Enrolment: Evidence from a Longitudinal Study in Kanchanaburi, Thailand, *Asian Population Studies*, 2(1), 93–110.

K. B. Richburg (2010). China 'Hukou' System Deemed Outdated as Way of Controlling Access to Services. Washington Post, 15 August 2010. http://www.washingtonpost.com/wp–dyn/content/article/2010/08/14/AR2010081402009.html

Kandel, W., Kao, G. (2001). The Impact of Temporary Labor Migration on Mexican Children's Educational Aspirations and Performance. *International Migration Review*. 35(4), 1205–1231.

Kuhn, R. (2006). The Effects of Fathers' and Siblings' Migration on Children's Pace of Schooling in Rural Bangladesh. *Asian Population Studies*, 2(1), 69–92.

Lin, H., (2011). China has the Largest Urban-rural Income Gap in the World. World journal, 20 September, 2011. http://www.worldjournal.com/view/full_Anews/15593000

Lindahl, L., (2010). A Comparison of Family and Neighbourhood Effects on Grades, Test Scores, Educational Attainment and Income – Evidence from Sweden. *Journal of Inequality*.

Lu, Y. , Treiman, D.J. (2007) The Effect of Labor Migration and Remittances on Children's Education among Blacks in South Africa. *California Center for Population Research*, working paper CCPR-001-07.

Ma, X., (2001). Participation in Advanced Mathematics: Do Expectation and Influence of Students, Peers, Teachers, and Parents Mater? *Contemporary Educational Psychology*, 26, 132–146.

Mansuri, G. (2006). Migration, School Attainment and Child Labour: Evidence from Rural Pakistan. *World Bank Policy Research Working Paper* No. 3945, Washington.

Marchant, G.J., Paulson, S.E., Rothlisberg, B.A., (2001). Relations of Middle School Students' Perceptions of Family and School contexts with Academic Achievement. *Psychology in the Schools*, 38(6), 505–519.

Mau, W., (1997). Parental Influences on the High School Students' Academic Achievement: A Comparison of Asian Immigrants, Asian Americans, and White Americans. Psychology in the Schools, 34(3), 267–277.

Mazumder, B., (2008). Sibling Similarities and Economic Inequality in the US. *Journal of Population Economics*, 21, 685–701.

McBride, B. A., Schoppe-Sullivan, S. J., Ho, M. (2005). The Mediating Role of Fathers' School Involvement on Student Achievement. *Journal of Applied Developmental Psychology*, 26, 201–216.

McKenzie, D.J. , Rapoport, H. (2006). Can Migration Reduce Educational Attainment? Evidence from Mexico. *World Bank Policy Research Working Paper* No. 3952, Washington.

McNeal, R.B., 1999. Parental Involvement as Social Capital: Differential Effectiveness on Science Achievement, Truancy, and Dropping Out. *Social Forces*, 78(1), 117–144.

McNeal, R.B., (2001). Differential Effects of Parental Involvement on Cognitive and Behavioural Outcomes by Socioeconomic Status. *Journal of Socio–Economics*, 30, 171–179.

Miller, P., Mulwey, C., Martin, N., 1995. What Do Twins Studies Reveal about the Economic Returns to Education? A Comparison of Australian and US Findings. *American Economic Review*, 85(3), 586–599.

Mott, E L., 1994. Sons, Daughters and Fathers' Absence: Differentials in Father–Leaving Probabilities and in Home Environments. *Journal of Family*, 15, 97–128.

National Center for Education Statistics, 1997. Fathers' Involvement in Their Children's Schools. NCES 98-091, by Christine Winquist Nord, DeeAnn Brimhall, and Jerry West. , U.S. Department of Education, Washington, DC.

Parreñas, R.S. (2005). Children of Global Migration: Transnational Families and Gendered Woes. Stanford University Press.

Peterson, J. L., Zill, N. (1986). Marital Disruption, Parent-child Relationships, and Behavior Problems in Children. Journal of Marriage and the Family, 49, 295-307.

Raaum, O., Sørensen, E.Ø., Salvanes, K.G., (2006). The Neighbourhood is Not What It used to be. *Economic Journal*, 116(508), 200–322.

Sacker, A., Schoon, I., Bartley, M., (2002). Social Inequality in Educational Achievement and Psychological Adjustment throughout Childhood: Magnitude and Mechanisms. *Social Science and Medicine*, 55, 863–880.

Santrock, J. W(1972). Relation of Type and Onset of Father Absence to Cognitive Development. *Child Development*, 43, 455-469.

Santrock, J. W, Warshak, R. (1979). Father Custody and Social Development in Boys and Girls. *The Journal of Social Issues*, 35,112-125.

Santrock, J. W, Warshak, R, Lindbergh, C, Meadows, L. (1982). Children's and Parents' Observed Social Behavior in Stepfather Families. *Child Development*, 53, 472-480.

Save the Children (2006). Left Behind, Left Out: The Impact on Children and Families of Mothers Migrating for Work Abroad. Save the Children: Sri Lanka.

Scalabrini Migration Center (SMC), (2004). Hearts Apart: Migration in the Eyes of Filipino Children.

Shinn, M. (1978). Father Absence and Children's Cognitive Development. *Psychological Bulletin*, 85, 295–324.

Sieben, I., Huinink, J., de Graaf, P.M., (2001). Family Background and Sibling Resemblance in Educational Attainment: Trends in the Former FRG, the Former GDR and the Netherlands. *European Sociological Review*, 17(4), 401–430.

Singh, K., Bickley, P.G., Keith, T.Z., Keith, P.B., Trivette, P., Anderson, E., 1995. The Effects of Four Components of Parental Involvement on Eighth–Grade Student Achievement: Structural Analysis of NELS–88 data. *School Psychology Review*, 24(2), 299–317.

Snarey, J. (1993). How Fathers Care for the Next Generation: A Four-Decade Study. Cambridge, MA: Harvard University Press.

Solon, G., Page, M., Duncan, G., (2000). Correlations between Neighboring Children in Their Subsequent Educational Attainment. *Review of Economics and Statistics*, 82(3), 383–392.

Song, S., Burgard, S., (2008). Does Son Preference Influence Children's Growth in Height? A Comparative Study of Chinese and Filipino Children. *Population Studies,* 62(3), 2008, 305–320.

Sui–Chu, E.H., Willms, J.D., (1996). Effects of Parental Involvement on Eighth–Grade Achievement. *Sociology of Education*, 69(2), 126–141.

The All-China Women's Federation, (2007). Problems Faced by Children Left Behind. People's Daily Online, 27 September 2007. http://acwf.people.com.cn/GB/99061/102368/102532/6319884.html

The All-China Women's Federation, (2009). The Children of migrant workers in China. China Labor Bulletin, http://www.china–labour.org.hk/en/node/100459#7b

The State Development Planning Commission, (2001). Special Charges on Rural Primary and Secondary Educationa Inspection Reports. November, 27, 2000.

The Statistics Bureau of China (2005). The Quantity, Structure and Characteristics of Rural Migrant Workers in 2004. http://www.sannong.gov.cn/fxyc/ldlzy/200507110158.htm

Wentzel, K. R., & Feldman, S. S. (1993). Parental Predictors of Boys' Self-Restraint and Motivation to Achieve at School: A Longitudinal Study. *Journal of Early Adolescence*, 13, 183–203.

World Bank, 1988. China: Finance and Investment. Washington DC.

World Bank. 1989. China: Revenue Mobilization and Tax Policy: Issues and Options. Washington DC.

Yang (2006). International Migration Remittances and Household Investment: Evidence from Philippine Migrant Exchange Rate Shocks. NBER WP 12325

1.8. Appendix

Table 14. Percentage of Children (16-17) Who Worked

	work in and out of house			work out of house			housework		
Parental Migration Status	Full Sample	Boys	Girls	Full Sample	Boys	Girls	Full Sample	Boys	Girls
Non-migrant household	55.5	50.9	59.7	51.3	47.4	54.8	21.8	15.8	27.4
Migrant household	53.5	52.4	54.5	44.2	52.4	36.4	14.0	9.5	18.2
Total	54.9	51.3	58.3	49.4	48.7	50.0	19.8	14.1	25.0

Table 15. Effect of being in a migrant household on children's enrolment (coefficients of probit regression)

	Boys				Girls			
	1 Coef./S.E.	2 Coef./S.E.	3 Coef./S.E.	4 Coef./S.E.	5 Coef./S.E.	6 Coef./S.E.	7 Coef./S.E.	8 Coef./S.E.
Any parent migrated	-0.507*** (0.187)	-0.798*** (0.196)	-1.005*** (0.215)	-0.733** (0.313)	-0.344* (0.196)	-0.427* (0.218)	-0.180 (0.227)	-0.196 (0.238)
Age	1.243*** (0.195)	1.223*** (0.204)	1.269*** (0.201)	1.434*** (0.215)	1.340*** (0.203)	1.501*** (0.209)	1.569*** (0.228)	1.641*** (0.228)
Quadratic age term	-0.061*** (0.008)	-0.060*** (0.009)	-0.062*** (0.009)	-0.069*** (0.009)	-0.066*** (0.009)	-0.074*** (0.009)	-0.076*** (0.010)	-0.079*** (0.010)
Ethnic minority	-0.757*** (0.281)	-0.801*** (0.289)	-0.712** (0.289)	-0.680** (0.304)	-0.415* (0.238)	-0.492* (0.268)	-0.400 (0.268)	-0.471* (0.272)
First born child	0.177 (0.187)	0.128 (0.196)	0.118 (0.207)	0.038 (0.215)	0.383** (0.173)	0.317* (0.178)	0.325* (0.174)	0.319* (0.184)
Father's education	0.016 (0.033)	0.000 (0.036)	0.014 (0.036)	0.017 (0.039)	0.098*** (0.032)	0.071** (0.033)	0.071** (0.033)	0.071** (0.034)
Mother's education	0.071*** (0.027)	0.070** (0.029)	0.071** (0.029)	0.082*** (0.030)	0.068*** (0.024)	0.062** (0.026)	0.063** (0.025)	0.069*** (0.026)
Log of wealth		-0.007 (0.079)	0.010 (0.081)	-0.025 (0.086)		0.193*** (0.071)	0.166** (0.071)	0.159** (0.071)
Log of land		-0.182 (0.134)	-0.177 (0.140)	-0.167 (0.148)		0.119 (0.091)	0.076 (0.101)	0.070 (0.108)
Father's occupation2		0.616*** (0.205)	0.623*** (0.207)	0.847*** (0.233)		0.344 (0.210)	0.368* (0.215)	0.399* (0.214)
Father's occupation3		0.619** (0.305)	0.634** (0.313)	0.851*** (0.328)		0.764** (0.336)	0.841** (0.343)	0.899** (0.358)
Mother's occupation2		0.409 (0.301)	0.439 (0.287)	0.377 (0.294)		0.330 (0.278)	0.269 (0.280)	0.360 (0.290)
Mother's occupation3		0.460 (0.406)	0.517 (0.420)	0.406 (0.454)		0.655 (0.530)	0.631 (0.528)	0.657 (0.542)
# children			-0.252* (0.140)				-0.219** (0.106)	
# adults in house			-0.239** (0.093)				0.194 (0.138)	
# sisters aged 6-17				-0.206 (0.159)				-0.257** (0.129)
# brothers aged 6-17				-0.667*** (0.198)				-0.238 (0.166)
# children aged <6				0.107 (0.351)				-0.011 (0.310)
# young male adults in hh				0.217 (0.252)				0.111 (0.235)
# young female adults in hh				-0.638*** (0.228)				0.467* (0.240)
# old male adults in hh				-0.428* (0.235)				-0.061 (0.350)
# old female adults in hh				-0.009 (0.245)				0.190 (0.252)
Constant	-4.432*** (1.127)	-4.267*** (1.272)	-3.653*** (1.412)	-4.690*** (1.439)	-6.121*** (1.134)	-8.803*** (1.328)	-8.930*** (1.442)	-9.683*** (1.432)
Pseudo R-Square	0.375	0.412	0.432	0.461	0.404	0.452	0.467	0.472
Observations	481	470	470	470	479	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

Table 16. Effect of being in different type of migrant household on children's enrolment (coefficients of probit regression)

	Boys				Girls			
	1 Coef./S.E.	2 Coef./S.E.	3 Coef./S.E.	4 Coef./S.E.	5 Coef./S.E.	6 Coef./S.E.	7 Coef./S.E.	8 Coef./S.E.
Only father migrated	-0.536*** (0.205)	-0.819*** (0.217)	-0.995*** (0.246)	-0.348 (0.361)	-0.278 (0.221)	-0.390 (0.257)	-0.179 (0.260)	-0.368 (0.311)
Only mother migrated	-0.936** (0.403)	-1.160** (0.509)	-1.077** (0.490)	-1.833*** (0.589)	-0.334 (0.342)	0.229 (0.387)	0.389 (0.395)	0.654 (0.502)
Both parents migrated	-0.219 (0.341)	-0.560 (0.348)	-0.989*** (0.368)	-0.890** (0.444)	-0.593* (0.352)	-0.754** (0.327)	-0.547 (0.369)	-0.410 (0.408)
Age	1.294*** (0.197)	1.259*** (0.199)	1.270*** (0.198)	1.441*** (0.220)	1.351*** (0.206)	1.506*** (0.211)	1.577*** (0.230)	1.643*** (0.228)
Quadratic age term	-0.063*** (0.008)	-0.061*** (0.009)	-0.062*** (0.009)	-0.070*** (0.009)	-0.066*** (0.009)	-0.074*** (0.009)	-0.077*** (0.010)	-0.079*** (0.010)
Ethnic minority	-0.754*** (0.282)	-0.794*** (0.293)	-0.714** (0.293)	-0.743** (0.308)	-0.427* (0.241)	-0.492* (0.271)	-0.400 (0.271)	-0.471* (0.273)
First born child	0.167 (0.185)	0.118 (0.194)	0.119 (0.204)	0.028 (0.213)	0.402** (0.177)	0.329* (0.181)	0.328* (0.177)	0.301 (0.184)
Father's education	0.018 (0.033)	0.003 (0.036)	0.014 (0.036)	0.018 (0.040)	0.096*** (0.032)	0.069** (0.033)	0.069** (0.034)	0.069** (0.035)
Mother's education	0.068** (0.027)	0.068** (0.029)	0.071** (0.029)	0.082*** (0.030)	0.070*** (0.025)	0.063** (0.026)	0.063** (0.026)	0.068*** (0.026)
Log of wealth		-0.001 (0.078)	0.011 (0.080)	-0.012 (0.086)		0.190*** (0.070)	0.167** (0.070)	0.163** (0.071)
Log of land		-0.175 (0.129)	-0.177 (0.137)	-0.193 (0.133)		0.141 (0.093)	0.099 (0.105)	0.095 (0.112)
Father's occupation2		0.600*** (0.212)	0.614*** (0.223)	0.746*** (0.242)		0.367 (0.223)	0.391* (0.228)	0.454** (0.228)
Father's occupation3		0.607** (0.305)	0.627** (0.314)	0.790** (0.332)		0.784** (0.343)	0.851** (0.347)	0.945*** (0.364)
Mother's occupation2		0.405 (0.339)	0.445 (0.320)	0.499 (0.324)		0.408 (0.272)	0.349 (0.269)	0.354 (0.272)
Mother's occupation3		0.445 (0.407)	0.517 (0.425)	0.473 (0.457)		0.680 (0.536)	0.645 (0.533)	0.651 (0.541)
# children			-0.250* (0.138)				-0.240** (0.106)	
# adults in house			-0.235** (0.098)				0.160 (0.144)	
# sisters aged 6-17				-0.235 (0.157)				-0.277** (0.128)
# brothers aged 6-17				-0.728*** (0.202)				-0.260 (0.167)
# children aged <6				0.184 (0.390)				-0.049 (0.312)
# young male adults in hh				0.490* (0.291)				-0.034 (0.280)
# young female adults in hh				-0.880*** (0.282)				0.518* (0.311)
# old male adults in hh				-0.344 (0.245)				-0.064 (0.350)
# old female adults in hh				-0.014 (0.253)				0.158 (0.256)
Constant	-4.730*** (1.131)	-4.539*** (1.234)	-3.669*** (1.355)	-4.646*** (1.427)	-6.163*** (1.149)	-8.825*** (1.331)	-8.861*** (1.440)	-9.614*** (1.432)
Pseudo R-Square	0.379	0.414	0.432	0.469	0.405	0.455	0.470	0.475
Observations	481	470	470	470	479	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

Table 17. Effect of being in a migrant household on children's enrolment (OLS and linear endogenous regression)

	Boys			Girls		
	OLS M.Eff./S.E.	IVreg M.Eff./S.E.	First-stage M.Eff./S.E.	OLS M.Eff./S.E.	IVreg M.Eff./S.E.	First-stage M.Eff./S.E.
Any parent migrated	-0.130***	0.150		-0.034	-0.375*	
	(0.037)	(0.179)		(0.034)	(0.207)	
Age	0.250***	0.278***	-0.085**	0.308***	0.293***	-0.039
	(0.035)	(0.041)	(0.043)	(0.039)	(0.041)	(0.038)
Quadratic age term	-0.012***	-0.013***	0.003*	-0.015***	-0.015***	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Ethnic minority	-0.131**	-0.136*	0.009	-0.076	-0.114*	-0.124*
	(0.062)	(0.071)	(0.073)	(0.049)	(0.060)	(0.066)
First born child	0.019	-0.002	0.075**	0.032	0.031	-0.007
	(0.029)	(0.034)	(0.038)	(0.029)	(0.030)	(0.031)
Father's education	-0.001	-0.005	0.015*	0.014**	0.020***	0.019**
	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)	(0.008)
Mother's education	0.013**	0.014**	-0.001	0.011**	0.005	-0.016***
	(0.005)	(0.005)	(0.007)	(0.005)	(0.006)	(0.006)
Log of wealth	-0.007	-0.004	-0.016	0.026**	0.043**	0.046**
	(0.012)	(0.014)	(0.018)	(0.013)	(0.018)	(0.019)
Log of land	-0.032*	-0.040*	0.022	0.018	0.021	0.003
	(0.020)	(0.024)	(0.035)	(0.014)	(0.017)	(0.033)
Father's occupation2	0.104***	0.053	0.194***	0.057	0.094**	0.115**
	(0.036)	(0.050)	(0.047)	(0.036)	(0.044)	(0.053)
Father's occupation3	0.102**	0.104*	0.002	0.104**	0.081	-0.068
	(0.050)	(0.054)	(0.065)	(0.044)	(0.053)	(0.074)
Mother's occupation2	0.075**	0.049	0.081	0.015	0.021	0.013
	(0.035)	(0.044)	(0.063)	(0.041)	(0.046)	(0.064)
Mother's occupation3	0.061	0.031	0.100	0.033	0.033	-0.003
	(0.042)	(0.051)	(0.092)	(0.044)	(0.054)	(0.100)
# children	-0.031	-0.042	0.042	-0.051***	-0.047**	0.010
	(0.024)	(0.029)	(0.034)	(0.019)	(0.023)	(0.039)
# adults in house	-0.034**	0.029	-0.224***	0.025	-0.055	-0.245***
	(0.016)	(0.042)	(0.025)	(0.017)	(0.051)	(0.027)
# other migrant household members			0.194***			0.192***
			(0.035)			(0.057)

Constant	-0.138	-0.463	1.107***	-1.022***	-0.817***	0.625**
	(0.230)	(0.307)	(0.294)	(0.235)	(0.280)	(0.302)
F-statistic			30.87			11.29
P-value from endogeneity test of endogenous regressors		0.101			0.043	
R-Square	0.367	0.273	0.336	0.418	0.316	0.366
Observations	470	470	470	466	466	466

* p<0.10, ** p<0.05, *** p<0.01

Table 18. Effect of being in a migrant household on the timing of children's dropout (the base category: being enrolled)

	Boys				Girls			
	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.	Coef./S.E.
2 dropped out of middle school								
Any parent migrated	0.491	1.589**	1.950**	1.475	1.077**	0.595	0.043	-0.815
	(0.477)	(0.646)	(0.781)	(0.976)	(0.546)	(0.620)	(0.761)	(0.895)
Age	4.487	3.682	3.676	2.990	13.121*	11.892	12.704	12.681
	(4.253)	(4.296)	(4.335)	(4.757)	(6.921)	(7.642)	(8.845)	(8.901)
Quadratic age term	-0.107	-0.076	-0.076	-0.052	-0.378*	-0.331	-0.353	-0.349
	(0.137)	(0.140)	(0.140)	(0.155)	(0.220)	(0.244)	(0.280)	(0.282)
Ethnic minority	0.813	0.668	0.719	0.737	0.548	1.146	1.036	1.776
	(0.796)	(1.004)	(1.004)	(1.032)	(0.925)	(1.175)	(1.147)	(1.155)
First born child	-0.104	0.132	0.272	0.314	-0.161	0.009	-0.384	-0.699
	(0.445)	(0.538)	(0.640)	(0.668)	(0.457)	(0.495)	(0.555)	(0.638)
Father's education	0.001	0.065	0.063	0.061	-0.210***	-0.152*	-0.170*	-0.285***
	(0.072)	(0.098)	(0.096)	(0.102)	(0.080)	(0.092)	(0.088)	(0.102)
Mother's education	-0.081	-0.118	-0.132*	-0.149*	-0.048	-0.090	-0.082	-0.051
	(0.064)	(0.078)	(0.080)	(0.084)	(0.063)	(0.073)	(0.073)	(0.080)
Log of wealth		0.311	0.295	0.342		-0.176	-0.191	-0.039
		(0.214)	(0.218)	(0.229)		(0.234)	(0.235)	(0.280)
Log of land		0.326	0.346	0.238		-0.591**	-0.576*	-0.582*
		(0.315)	(0.327)	(0.352)		(0.289)	(0.304)	(0.336)
Father's occupation 2		-2.331***	-2.219***	-2.402***		-0.779	-0.848	-0.958
		(0.611)	(0.596)	(0.681)		(0.647)	(0.684)	(0.705)
Father's occupation 3		-2.578**	-2.557**	-2.762**		-2.606***	-2.781***	-3.580***
		(1.215)	(1.230)	(1.286)		(0.998)	(1.040)	(1.261)
Mother's occupation 2		-1.562*	-1.679*	-1.589		-0.604	-0.418	-0.974
		(0.866)	(0.957)	(1.001)		(0.651)	(0.619)	(0.730)
Mother's occupation 3		0.806	0.845	0.908		-0.275	-0.121	-0.139
		(1.377)	(1.365)	(1.465)		(1.151)	(1.150)	(1.326)
# children			-0.092				0.460	
			(0.472)				(0.322)	
# adults in house			0.369				-0.444	
			(0.281)				(0.324)	
# sisters aged 6-17				-0.045				0.400
				(0.535)				(0.425)
# brothers aged 6-17				0.252				1.139**
				(0.733)				(0.554)
# children aged <6				0.258				-1.942
				(1.120)				(1.262)
# young male adults in hh				-0.382				-1.003
				(0.773)				(0.651)

# young female adults in hh				0.490				-1.088
				(0.603)				(0.697)
# old male adults in hh				0.528				0.573
				(0.645)				(1.317)
# old female adults in hh				0.529				-0.158
				(0.701)				(0.801)
Constant	-44.170	-41.776	-42.350	-37.287	-110.834**	-100.269*	-106.877	-106.819
	(32.968)	(33.521)	(33.829)	(36.652)	(54.008)	(59.412)	(69.236)	(69.388)
3 dropped out of primary school								
Any parent migrated	1.160*	1.433**	2.008***	0.628	0.764	1.082	0.524	0.633
	(0.663)	(0.608)	(0.590)	(0.819)	(0.616)	(0.699)	(0.635)	(0.846)
Age	-0.867	-0.842	-0.849	-1.441	3.860**	4.011**	4.482**	5.326***
	(0.793)	(0.976)	(0.915)	(0.988)	(1.696)	(1.742)	(1.926)	(2.047)
Quadratic age term	0.055*	0.054	0.056*	0.079**	-0.106*	-0.105*	-0.120*	-0.143**
	(0.031)	(0.037)	(0.034)	(0.037)	(0.059)	(0.061)	(0.065)	(0.069)
Ethnic minority	1.852**	1.965***	1.570**	1.416	-0.538	-0.748	-0.846	-0.667
	(0.741)	(0.692)	(0.692)	(0.864)	(0.781)	(0.990)	(1.021)	(1.311)
First born child	-0.688	-0.576	-0.542	-0.078	-0.926	-1.304**	-1.395**	-1.796**
	(0.689)	(0.751)	(0.712)	(0.954)	(0.572)	(0.665)	(0.684)	(0.845)
Father's education	0.029	0.083	0.038	0.084	-0.227**	-0.112	-0.133	-0.085
	(0.097)	(0.124)	(0.120)	(0.132)	(0.087)	(0.101)	(0.115)	(0.114)
Mother's education	-0.190**	-0.179**	-0.177*	-0.294***	-0.199***	-0.167**	-0.165**	-0.217***
	(0.090)	(0.086)	(0.090)	(0.088)	(0.060)	(0.069)	(0.075)	(0.071)
Log of wealth		-0.508	-0.689*	-0.489		-1.000***	-0.979***	-1.106***
		(0.339)	(0.403)	(0.393)		(0.274)	(0.280)	(0.379)
Log of land		0.038	0.252	-0.206		-0.298	-0.194	-0.054
		(0.541)	(0.602)	(1.020)		(0.358)	(0.385)	(0.459)
Father's occupation 2		-0.954	-0.937	-1.867**		-0.995	-1.002	-0.798
		(0.719)	(0.667)	(0.881)		(0.699)	(0.738)	(0.827)
Father's occupation 3		-0.385	-0.535	-1.648		-1.387	-1.596	-2.209
		(0.952)	(0.869)	(1.170)		(1.215)	(1.308)	(1.703)
Mother's occupation 2		-17.845***	-17.600***	-18.651***		-17.230***	-16.781***	-17.402***
		(0.648)	(0.615)	(1.031)		(0.853)	(0.961)	(1.153)
Mother's occupation 3		-17.829***	-17.843***	-18.348***		-16.451***	-15.788***	-15.577***
		(1.364)	(1.195)	(1.556)		(1.190)	(1.326)	(1.735)
# children			0.659				0.309	
			(0.510)				(0.316)	
# adults in house			0.882**				-0.602	
			(0.376)				(0.497)	
# sisters aged 6-17				0.325				0.873**
				(0.961)				(0.444)
# brothers aged 6-17				2.437***				-0.495
				(0.892)				(0.758)
# children aged <6				-16.577***				1.380*
				(1.152)				(0.835)
# young male adults in hh				-0.093				-0.057
				(0.590)				(0.940)

# young female adults in hh				-0.138				-1.950**
				(0.930)				(0.848)
# old male adults in hh				2.926***				0.400
				(0.967)				(1.223)
# old female adults in hh				0.408				-0.442
				(1.404)				(0.657)
Constant	-1.838	2.836	0.802	5.381	-31.485***	-24.300**	-27.425**	-32.757**
	(5.307)	(7.565)	(8.165)	(8.118)	(12.041)	(12.338)	(13.515)	(14.711)
4 never being enrolled								
Any parent migrated	1.708**	1.788***	2.117***	4.287*	-0.113	0.199	-1.800	-2.229
	(0.670)	(0.623)	(0.639)	(2.401)	(0.919)	(1.061)	(1.280)	(1.705)
Age	-1.974***	-2.196***	-2.314***	-5.019**	-3.115***	-3.337***	-3.433***	-4.187***
	(0.689)	(0.765)	(0.764)	(2.058)	(1.003)	(1.100)	(0.955)	(1.397)
Quadratic age term	0.081***	0.089***	0.095***	0.204***	0.124***	0.135***	0.134***	0.160***
	(0.029)	(0.033)	(0.034)	(0.074)	(0.044)	(0.048)	(0.042)	(0.057)
Ethnic minority	1.268	1.731**	1.301	1.675	2.542**	2.712**	2.927*	4.198
	(0.796)	(0.859)	(1.015)	(2.131)	(1.218)	(1.275)	(1.633)	(3.391)
First born child	-0.707	-1.550*	-1.236	0.334	-0.562	-0.729	-0.212	0.252
	(0.645)	(0.828)	(0.928)	(2.168)	(0.633)	(0.685)	(0.849)	(0.918)
Father's education	-0.173	-0.191	-0.210	-0.638	-0.123	-0.158	-0.272*	-0.374*
	(0.161)	(0.191)	(0.199)	(0.462)	(0.145)	(0.144)	(0.147)	(0.225)
Mother's education	-0.116	-0.186*	-0.191*	-0.362	-0.195*	-0.169	-0.175	-0.206
	(0.113)	(0.107)	(0.102)	(0.287)	(0.111)	(0.108)	(0.128)	(0.128)
Log of wealth		0.069	-0.014	-0.320		-0.057	0.219	0.295
		(0.223)	(0.248)	(0.477)		(0.247)	(0.247)	(0.239)
Log of land		1.153***	0.955*	1.836**		0.226	0.920**	1.151**
		(0.425)	(0.516)	(0.766)		(0.454)	(0.410)	(0.568)
Father's occupation 2		0.728	0.581	-1.024		-0.776	-0.739	-0.887
		(0.648)	(0.714)	(1.139)		(0.914)	(1.023)	(1.100)
Father's occupation 3		-0.918	-0.830	-1.753		-0.080	-0.222	-0.353
		(1.097)	(1.057)	(1.337)		(0.985)	(0.941)	(1.266)
Mother's occupation 2		1.117	1.004	6.389**		0.925	0.710	0.609
		(0.750)	(0.910)	(2.731)		(1.077)	(1.169)	(1.254)
Mother's occupation 3		-17.575***	-17.106***	-15.146***		-15.664***	-16.546***	-18.329***
		(1.186)	(1.684)	(1.631)		(1.058)	(1.514)	(1.964)
# children			0.838				0.488	
			(0.715)				(0.681)	
# adults in house			0.431				-1.819*	
			(0.294)				(0.944)	
# sisters aged 6-17				4.830***				0.775
				(1.700)				(0.914)
# brothers aged 6-17				4.059**				1.523
				(1.906)				(0.989)
# children aged <6				-2.752				0.361
				(3.023)				(0.986)
# young male adults in hh				-1.720				-2.698
				(1.505)				(2.360)

# young female adults in hh				6.195***				-2.234*
				(2.200)				(1.275)
# old male adults in hh				-1.338				-4.195
				(1.404)				(2.893)
# old female adults in hh				0.372				0.527
				(1.390)				(1.317)
Constant	-7.749*	-10.304**	-11.093**	-3.220	13.710***	15.459***	16.020**	19.885***
	(4.049)	(4.196)	(4.383)	(12.145)	(4.330)	(5.745)	(6.281)	(6.900)
Pseudo R-Square	0.427	0.514	0.533	0.614	0.507	0.571	0.592	0.625
Observations	481	470	470	470	477	464	464	464

* p<0.10, ** p<0.05, *** p<0.01

Table 19. Effect of migratory duration of father on enrolment of children in household with only migrant father (coefficients of probit regression)

	Boys				Girls			
	1 Coef./S.E.	2 Coef./S.E.	3 Coef./S.E.	4 Coef./S.E.	5 Coef./S.E.	6 Coef./S.E.	7 Coef./S.E.	8 Coef./S.E.
Migratory duration	-0.041	-0.098**	-0.104**	-0.082	0.069	0.080	0.150**	0.161**
	(0.036)	(0.041)	(0.048)	(0.053)	(0.046)	(0.050)	(0.070)	(0.077)
Age	1.852***	2.555***	3.139***	4.276***	2.308***	2.545***	2.826***	3.260**
	(0.408)	(0.459)	(0.701)	(1.102)	(0.708)	(0.946)	(0.873)	(1.389)
Quadratic age term	-0.087***	-0.119***	-0.146***	-0.197***	-0.110***	-0.122***	-0.137***	-0.155***
	(0.018)	(0.020)	(0.031)	(0.050)	(0.031)	(0.043)	(0.040)	(0.059)
Ethnic minority	-0.738	-0.872	-0.530	-0.857	-0.172	0.021	-0.826	-1.104
	(0.515)	(0.531)	(0.544)	(0.558)	(0.691)	(0.840)	(0.931)	(0.975)
First born child	0.369	0.519	0.556	0.362	1.390***	1.697**	2.136***	2.163***
	(0.378)	(0.406)	(0.439)	(0.465)	(0.531)	(0.724)	(0.821)	(0.830)
Father's education	0.041	0.109	0.115	0.131	0.039	0.042	0.177	0.205
	(0.051)	(0.087)	(0.105)	(0.148)	(0.077)	(0.083)	(0.151)	(0.163)
Mother's education	0.067	0.115**	0.075	0.116*	0.123*	0.153*	-0.003	-0.041
	(0.053)	(0.055)	(0.059)	(0.069)	(0.064)	(0.091)	(0.085)	(0.091)
Log of wealth		0.094	0.109	-0.060		-0.220	-0.240	-0.179
		(0.156)	(0.191)	(0.226)		(0.238)	(0.343)	(0.382)
Log of land		-0.328	-0.436	-0.736		0.360	0.630**	0.555*
		(0.339)	(0.407)	(0.469)		(0.228)	(0.262)	(0.305)
Father's occupation2		0.094	0.595	0.645		-0.417	-0.021	-0.677
		(0.532)	(0.582)	(0.577)		(0.998)	(1.168)	(1.428)
Father's occupation3		0.133	1.179	1.655*		0.054	0.677	0.021
		(0.788)	(0.939)	(0.907)		(1.202)	(1.567)	(1.801)
Mother's occupation2		-1.625**	-1.782**	-2.321**		0.432	1.088	1.511
		(0.703)	(0.753)	(0.966)		(0.671)	(0.926)	(0.996)
# children			-0.877***				-1.483**	
			(0.309)				(0.587)	
# adults in house			-0.247	0.206			-0.254	-0.241
			(0.351)	(0.380)			(0.700)	(0.765)
# sisters aged 6-17				-0.778**				-1.747**
				(0.365)				(0.738)
# brothers aged 6-17				-1.798***				-1.378**
				(0.501)				(0.679)
# children aged <6				0.614				-0.758
				(0.748)				(1.587)
Constant	-7.952***	-12.026***	-12.795***	-17.672***	-11.750***	-11.018**	-9.795**	-13.737**
	(2.245)	(2.867)	(3.675)	(5.707)	(3.944)	(4.710)	(4.946)	(6.882)
Pseudo R-Square	0.433	0.490	0.551	0.601	0.490	0.513	0.581	0.585
Observations	119	106	106	106	84	75	75	75

* p<0.10, ** p<0.05, *** p<0.01

Table 20. Effect of total migratory duration of father on enrolment of boy in household with only migrant father (average marginal effects from probit regression)

	Boys				Girls			
	1	2	3	4	5	6	7	8
	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.	M.Eff./S.E.
Migratory duration	-0.007**	-0.011***	-0.009***	-0.005*	0.010	0.009	0.015***	0.015**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.007)	(0.006)	(0.005)	(0.006)
Ethnic minority	-0.111	-0.118	-0.064	-0.070	-0.026	0.000	-0.108	-0.125
	(0.092)	(0.076)	(0.062)	(0.051)	(0.107)	(0.100)	(0.100)	(0.096)
First born child	0.047	0.060	0.053	0.030	0.203***	0.196***	0.224***	0.219***
	(0.047)	(0.038)	(0.036)	(0.034)	(0.046)	(0.043)	(0.041)	(0.044)
Father's education	0.008	0.013	0.013	0.011	0.005	0.004	0.014	0.016
	(0.007)	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.012)	(0.013)
Mother's education	0.011	0.016***	0.010*	0.010**	0.018**	0.019**	0.000	-0.002
	(0.007)	(0.006)	(0.005)	(0.005)	(0.008)	(0.008)	(0.008)	(0.008)
Log of wealth		0.013	0.009	-0.004		-0.024	-0.027	-0.023
		(0.017)	(0.019)	(0.018)		(0.024)	(0.028)	(0.034)
Log of land		-0.044	-0.057	-0.063*		0.044**	0.071***	0.066**
		(0.035)	(0.036)	(0.033)		(0.022)	(0.023)	(0.028)
Father's occupation2		0.011	0.046	0.047		-0.053	0.010	-0.028
		(0.052)	(0.052)	(0.042)		(0.136)	(0.112)	(0.117)
Father's occupation3		0.042	0.122**	0.125***		0.013	0.103	0.066
		(0.069)	(0.056)	(0.044)		(0.125)	(0.125)	(0.144)
Mother's occupation2		-0.194**	-0.201***	-0.205***		0.056	0.200***	0.214***
		(0.084)	(0.076)	(0.069)		(0.064)	(0.063)	(0.061)
# children			-0.088***				-0.162***	
			(0.026)				(0.047)	
# adults in house			-0.009	0.020			-0.049	-0.051
			(0.037)	(0.028)			(0.064)	(0.067)
# sisters aged 6-17				-0.065**				-0.177***
				(0.027)				(0.047)
# brothers aged 6-17				-0.140***				-0.150**
				(0.029)				(0.060)
# children aged <6				0.037				-0.128
				(0.051)				(0.140)
Pseudo R-Square	0.449	0.508	0.561	0.599	0.493	0.511	0.576	0.578
Observations	119	106	106	106	84	75	75	75

* p<0.10, ** p<0.05, *** p<0.01

Chapter 2. Land Tenure Versus Land Redistribution in China

2.1. Introduction

After the complete establishment of the household responsibility system in China in 1984, farmland was distributed almost equally among villagers. Since then, the central government implemented land tenure policy, first for 15 years in 1984, then for 30 years in 1993, aiming to secure land use rights and enhance long-run investment in land and capital assets that maintain and improve farmland quality and agricultural productivity. However, at the village level, periodical farmland redistribution occurred in most regions, at different frequencies and in different scales.[1]

Policy makers in China consider long-term land tenure as a "semi-private property right" which will give farmers better investment and production incentives; therefore it is more efficient than the former collective farming system. It is also well documented that secure land rights facilitate long-run investment in China (Brandt et al., 2002; Carter, Yao, 1998; Deininger, Jin, 2003; Jacoby et al., 2002; Li et al., 1998, 2000; Wen, 1996; Yao, 1999). Nonetheless, why does redistribution of land exist and is sustained, even though it is against the central government policy? One plausible economic justification for the land redistribution is that it gives more economic security

[1] In some villages, farmland was redistributed once or twice a year; in some others, the redistributions occurred every six or seven years. If the village redistributed land frequently, it was done by readjusting plots of land only among households with demographic changes. If there had been a long time without redistributions, full land redistribution occurred. In this case, all the land in the village is recalled and plots are redistributed randomly to households by drawing lots from a box. (Unger, 2006)

than land tenure or land privatization; as a result, farmers are willing to sacrifice efficiency for security (Benjamin, Brandt, 2002; Dong, 1996; Kung, Liu, 1997; Yao, 1999). These authors indicate that land redistribution acts as an insurance against the uncertainty of off-farm income. In addition, if land redistribution is done according to demographic changes, it may be efficient for rural labor allocation.

The argument of lack of an insurance mechanism is not surprising, but the interaction between land redistribution and long-run investment is far less obvious. In this paper, I build a formal model to analyze the impact and choice of alternative land tenure schemes; specifically, I will unravel the interaction between land redistribution and demographic change and its consequences. My model predicts that in the presence of factor market imperfections, households with growing size favor and are better off with farmland redistribution, though redistribution may lower long-run investment in the land.

The structure of the paper is as follows. Institutional background is given in Section 2. Section 3 presents the baseline model. The results of three alternative land tenure scenarios are in Section 4. Some theoretical arguments will be pointed out about the impact of farmland tenure schemes on long-run investments (as represented by fertilizer usage) both at micro and macro levels[2] and farming households' welfare, as well as the factors determining the preference for certain farmland tenure schemes. Section 5 provides two extensions of the baseline model. Off-farm job opportunities and a farmland rental market will be added to the baseline model and their impact is analyzed. Section 6 provides empirical evidence related to the model. Finally, Section 7 presents conclusions and policy implications.

[2] Here "micro" refers to individual household fertilizer usage level, and "macro" refers to aggregate fertilizer usage level in the village.

2.2. Background and Overview

2.2.1. Household Responsibility System and Land Tenure in Rural China

Collectivization of production was adopted in China since the 1950s, and it turned out to be a disaster. In the end of the 1960s, China became a grain importer from a former exporter. The adoption of the household responsibility system (HRS) began in the late 1970s and completed in the mid-1980s. Under the HRS, land use rights were assigned to the farming households; however, the reform did not change the collective land ownership. Under collective land ownership, each villager is entitled to the right to have an equal share of the village land (Zhou, Liu, 1988), so there is demand for land redistribution as the village's demography changes. After the HRS reform, the central government stipulated that the land use contract term was 15 years, and no readjustment should happen till the mid-1990s. In 1993, as the initial land tenures were expiring, the central government extended land tenure to 30 years, and the 30-year tenure without adjustment was legitimized by the "Farmland Contract Law" in 2003. However, widespread evidence for periodical land redistribution can be found in most villages in rural China (Brandt et al., 2004; Krusekopf, 2002; Unger, 2006). A sample survey by the Ministry of Agriculture in 1997 reported that 80 percent of 271 surveyed villages had readjusted landholding, and 66 percent of villages readjusted more than once (Unger, 2006).

2.2.2. Factor Markets

In most of China's rural areas, factor markets, such as credit, labor and farmland markets, are underdeveloped and developed unevenly across the country. The rural credit market in China is weak. Formal credit is hardly available, and most available credit comes from informal institutions. Feder et al. (1990) found that institutional credit constraints limited the amount of investment to sub-optimal levels. Rozelle (1994) showed that 33 percent of farming households in Jiangsu province have no access to credit while the corresponding number for Hubei province is even higher (37 percent). The same survey showed that among the 223 surveyed farming households, only ten households in the sample in Jiangsu Province borrowed money from the state's rural

credit cooperative or the local agricultural bank, and only 18 households in Hubei Province received loans from government sources.

In many parts of China, the market for agricultural labor is absent. In most regions, there are formal or informal restrictions against hiring labor for farming; while in other regions, hiring is mainly restricted to local residents. In addition, ”hiring labor is treated as a signal that the household has too much land for its available labor, which invariably leads to a future downward adjustment in the amount of cultivated land to eliminate or reduce the need for hired labor” (Rozelle, 1994). In Rozelle (1994) survey, only 3 percent of farmers reported hiring agricultural labor for a wage (the corresponding numbers are 1 percent in Jiangsu Province and 4 percent in Hubei Province), and this accounted for less than 1 percent of the agricultural labor used in the villages. Brandt et al. (2004)’s survey in eight Chinese provinces also found that less than 1 percent of agricultural labor was hired in 1995.

In the absence of agricultural insurance and credit, off-farm employment acts as a means to smooth consumption. However, because of the household registration system (the *Hukou* system), migrant farmers without a local *Hukou* and good education can hardly establish a decent life in cities. Migrant farmers usually work in the informal urban subsistence sector where jobs are mostly unstable. In addition, households differ considerably in terms of their ability to access off-farm jobs (Brandt et al., 2002). As a result, households with unstable non-farm income need some economic security provided by access to land-use rights and fall into two extremes. They either favor periodic redistribution of farmland in the hope to regain farmland in the case of unemployment[3] (Dong, 1996; Kung, Liu, 1997; Li et al., 2000), or they are strongly against it as they want to keep their land in hand as a form of guarantee and a substitute

[3] People in this group also favor redistribution because they could have their landholdings adjusted down if their land quota became too burdensome when facing an agricultural tax (see Section 2.4). (Brandt et al., 2002)

for unemployment insurance in the event that family members were dismissed from or unable to find off-farm employment (Ho, 2001). [4]

The development of farmland rental market in China is uneven and sub-leases and transfers are rare in most areas, though sub-leasing is permitted by law provided that land is used for agricultural purpose. In some regions, renting of farmland is tightly controlled or not allowed at all at the village level, and most rental agreements are between individuals who have close familial ties and are short-term, usually for one season. Moreover, the situation here is similar to the rural labor market, "any request for a land transfer to another farmer may be interpreted as a signal of resource misallocation; farmers are afraid that any temporary transfer will become permanent" (Rozelle, 1994). In Rozelle (1994)'s survey, only two of the 116 surveyed households reported rental transactions in 1988 and 1989. Brandt et al. (2004) found that in 1995 less than 3 percent of land was rented in 215 surveyed villages. Ho (2001), Huang (1995), Krusekopf (2002) and Kung (1995) report similar findings.

2.2.3. Agricultural Inputs and Investments

Large agricultural equipment, such as tractors, irrigating pumps and threshers, were under collective ownership when the HRS was introduced. The access to these equipments acts as an incentive mechanism commonly used by village heads: if a farming household does not follow the village head's orders, it will be denied access to the collective agricultural equipment. The liberalization of agricultural input markets began in the late-1980s when agricultural machinery, pesticides, plastic film, fertilizer and seeds began to be sold at market prices (Park, 2008). Among all these inputs, fertilizer usage is one kind of long-term land-specific investment as optimal usage of fertilizer can enhance land fertility and improve land productivity in the long run. Though China ranks first worldwide by total fertilizer volume used, the utilization rate of fertilizer is only around 30 percent (Zhou, 2002).

[4] According to Ho (2001), in a 1997 survey, 17.1 percent of households opposing land redistribution had non-farming income as their major income source.

2.2.4. Agricultural Tax

An agricultural tax had been established in China since 1958. It was an in-kind tax calculated based on average annual output, and was part of local taxes. The tax was collected by the local government through buying grains at below-market prices according to the state grain purchasing system.[5] Failure to meet the minimum yield levels to pay the in-kind tax was treated as a serious infraction, and could lead to cash penalty, and even forfeiture of farmland in some regions (Rozelle, 1994). However, in 2003, the Chinese government started to abolish this agricultural tax, aiming to alleviate the financial burden on farmers. In 2006, collection of agricultural tax was formally forbidden by law.

2.3. Baseline Model

I propose a limited liability model of land tenancy in an overlapping generations setting. In the OLG setting, the adult generation starts in period 1 and lives for two periods, and the "young" generation is born in period 2 and lives only for one period before turning into adult. The farmland tenancy contract is a fixed rent contract between the government and household, in which the delivery quota (in-kind tax) to the government is the fixed rent. Assume there are I farming households in a village. Without loss of generality, assume that there is one adult in each household initially. Resembling the redistribution at the beginning of the HRS, assume that each member of a typical household gets 1 unit of farmland under the contract at the beginning of period 1. Since the only member in each household is the adult, each household gets 1 unit of farmland in period 1. In the baseline model, the farmer can only work on the farmland belonging to his household, there are no off-farm job opportunities, and there is no farmland rental market. Also assume there is no credit market, so the household cannot borrow, but can only save to smooth consumption. The amount saved is not contractible. I consider three cases which resemble the possible land tenure scenarios in China. In

[5] The government purchasing price is about half of the market price.

the first case (referred to as NR below), there is no land redistribution for any reason. This case corresponds to strict land tenure for a considerably long period or full privatization of land. The second case allows land redistribution according to demographic changes only (RDC). The third case allows land redistribution based on both demographic changes and farming failure (RDCFF).

2.3.1. Agricultural Output

There are two levels of output, $Y > 0$ and 0.[6] In each period, the output levels Y and 0 are realized with probability p and $1 - p$, respectively; $p \in (0, 1)$. Normalize the market price for agricultural output to 1. Assume p is different among households; that is, p includes an idiosyncratic shock. The output level is observable. Under agricultural tax system, if output level Y ($Y > t$) is realized, the farming household pays the government agricultural tax (quota cost) t ($t \geq 0$) for that unit of farmland,[7] and the remaining output can be sold at the market price 1; if the low output level is realized, the household pays 0, because of the limited liability constraint arising from the non-observability of savings. Call the zero output situation “farming failure”.

2.3.2. Use of Fertilizer

In period 1, the farming household makes decision on the application of fertilizer. Denote the level of fertilizer as k. The cost of purchasing and applying fertilizer is (k) ; $c(k)$ is assumed an increasing convex function of k. To characterize the long-run investment nature, I assume that k can increase the probability of Y realized in both periods. Assume p is an increasing and strictly concave function of k, and $p(k)$ in the

[6] One can think about output *0* as the case in which a farmer failed to produce enough output to satisfy the government quota *t* ($t \geq 0$) under agricultural tax system, and the case in which output is lower than some standard level, for example, average annual level in the version of the model without agricultural tax. Output level *Y* is the case in which the output produced is larger or equal to the government quota under agricultural tax system, and the case in which output is higher or equal to the standard level in no agricultural tax situation.

[7] If assume the government quota is a per unit of farmland, and the quota price is p_a, $p_a \leq 1$, then the quota cost $t = ap_a$. If there is no agricultural tax, $t = 0$.

first period is the same as $p(k)$ in the second period, given implementing k in the first period. Assume also the household treats each unit of farmland it has in the same way; and for simplicity, assume $p(k)$ is the same on each unit of farmland of a household. Thus, if household i implements k_i on a unit of its farmland, the probability of realizing output Y on this unit is $k_i = p(k_i)$.

2.3.3. Demographic Change and Redistribution

At the beginning of period 2, newborns are added to each farming household. The ratio of number of members in household i in period 2 to that in period 1 is $n_i \in [1, \infty)$. Call n_i the gross household population growth rate of household i. Each newborn lives for one period as a child when he does not make any decision and then becomes an adult in period 3. Assume that there exist some i and j such that $n_i \neq n_j$; that is, the household population growth rates are not all equal in the village. Therefore there will be different demographic changes among households in period 2.

In the no redistribution case, demographic change will not cause land redistribution, but as household size increases, each member gets less land. In contrast, demographic change is a cause of land redistribution in the other two cases. After redistribution caused by demographic changes, each villager is entitled to an equal share of land. Assume each member in household i can get α unit of farmland; $\alpha \in (0, 1]$. Assume the total land endowment in the village does not change, and thus the following equations hold:

$$I = \alpha \sum_{i=1}^{I} n_i$$

i.e.

$$\frac{1}{\alpha} = \frac{1}{I} \sum_{i=1}^{I} n_i \qquad (1)$$

Define the inverse of α, $g = 1/\alpha$, as the gross village population growth rate. Since a farming household cannot control the number of children other households will have, it cannot control α. Thus α is exogenous in each household's decision making, though it is endogenous in the model. Also, notice that, even though after redistribution each villager gets the same unit of farmland, since some households have higher household

population growth rates than the village population growth rate, these households will get more farmland than in period 1, while the others get less. This is the embodiment of farmland redistribution.

In the redistribution with demographic changes and farming failure case, besides demographic changes, farming failure is another cause of redistribution. In this case, if the realization of output is zero, then the household's farmland will be recalled and held by the village for one period with probability f, $f \in (0,1]$.[8] In sum, after redistribution, in the NR case, household i expects to retain 1 units of farmland; in the RDC case, household i expects to retain αn_i units of farmland; in the RDCFF case, household i expects to retain $\alpha n_i[p(k_i) + (1 - p(k_i))(1 - f)]$ units of farmland.

2.3.4. Timeline

The timeline is as follows. At the beginning of period 1, the household gets a unit of farmland. The household has an expectation of how many children it is going to have in period 2. Assume rational expectations, so that in period 2 the household will have the same number of children as it expected. Based on this expectation, the household decide how much fertilizer to implement. Then output is realized at the end of period 1. If output is Y, after paying the agricultural tax, the household can consume and save the remaining part for the next period. At the beginning of period 2, new babies are born; they are treated as children and do not make any decision. Farmland will be redistributed or not under the different regimes. Farmers continue to farm on their remaining farmland, and at the end of period 2, output is realized, and the household consumes all what is left after paying the agricultural tax. In period 3, the former adults die, and their children become adult, and repeat the process. Since adults only live for two periods, and only adults can make decisions, I will only consider period 1 and 2 in the rest of the paper.

[8] If the farmland is recalled, it becomes collective land whose output can be shared among villagers if needed. This assumption is innocuous unless all land is recalled because no one applies enough fertilizer.

2.3.5. Preference

The farming household is assumed to be risk neutral, and it maximizes expected utility which is linear in its two periods' consumptions. Assume that there is no discounting.

$$\mathrm{Eu_i} = \mathrm{Eu_i^1} + \mathrm{Eu_i^2} = \left[\mathrm{p(k_i)(Y-t)} - \mathrm{c(k_i)}\right] + \pi_i \mathrm{p(k_i)(Y-t)} \quad (2)$$

where π_i is the amount of units of land household i expects to get in period 2. In the no redistribution case, $\pi_i = 1$; in the redistribution with demographic changes case, $\pi_i = n_i\alpha$; in the redistribution with demographic changes and farming failure case, $\pi_i = n_i\alpha[p(k_i) + (1-p(k_i))(1-f)]$.

2.4. Results

2.4.1. First Best Case (FB)

In the first best scenario, a "benevolent social planner" who cares about every household chooses the optimal fertilizer usage level for the households to maximize the total welfare of all villagers that is total output of all farmland in the village in two periods less total fertilizer cost. The objective function of the social planner is

$$\max_{\mathrm{k_i}} EW = I\,[2\mathrm{p(k_i)(Y-t)} - \mathrm{c(k_i)}] \quad (3)$$

The first best fertilizer usage level k_i^{FB} is given by the first order condition below

$$2\mathrm{p'(k_i)(Y-t)} = \mathrm{c'(k_i)} \quad (4)$$

Notice that the optimal fertilizer usage level is affected by the agricultural tax t, but not by the population growth rates.

2.4.2. No Redistribution Case (NR)

Without redistribution, $\pi_i = 1$, and thus household i's expected utility is

$$Eu_i = 2\mathrm{p(k_i)(Y-t)} - \mathrm{c(k_i)} \quad (5)$$

The household maximizes Eu_i by choosing k_i. The first order condition gives

$$2\mathrm{p}'(\mathrm{k_i})(\mathrm{Y}-\mathrm{t}) = \mathrm{c}'(\mathrm{k_i}) \quad (6)$$

That is the marginal benefit of k equals to its marginal cost. The second order condition holds because of the strict concavity of $p(k)$ and convexity of $c(k)$. Eq. (6) determines the optimal level of fertilizer. Notice that $k_i^{NR} = k_i^{FB}$; i.e., under the NR regime, farming household can achieve the first best fertilizer usage level. Also, under the NR regime, the optimal fertilizer usage level is independent of population growth rates.

Lemma 1. Under the NR regime, the optimal fertilizer usage level achieves the first best, and it is independent of the household population growth rates.

Proof. See Appendix.

2.4.3. Redistribution caused by Demographic Changes Case (RDC)

With demography-based redistribution, $\pi_i = n_i\alpha$, and thus household i's expected utility is

$$\mathrm{Eu_i} = (1 + \alpha\mathrm{n_i})\mathrm{p}(\mathrm{k_i})(\mathrm{Y}-\mathrm{t}) - \mathrm{c}(\mathrm{k_i}) \quad (7)$$

The household maximizes Eu_i by choosing k_i. The optimal fertilizer level is defined by the first order condition.

$$(1 + \alpha n_i)\mathrm{p}'(\mathrm{k_i})(\mathrm{Y}-\mathrm{t}) = \mathrm{c}'(\mathrm{k_i}) \quad (8)$$

Lemma 2. Under the RDC regime, the agricultural tax t reduces fertilizer usage levels and makes farming households worse off, while the population growth rate ratio

n_i/g [9] increases fertilizer usage levels. These households with higher n_i/g ratio are better off relative to other households with lower n_i/g ratio.

Proof. See Appendix.

Notice that under the RDC (and RDCFF in the next section) both household population growth rate n_i and village population growth rate g matter. This is because of the nature of the redistribution scheme which is based on demographic change. The RDC regime favors household with proportionately more children by allocating them more land.

2.4.4. Redistribution caused by Demographic Changes and Farming Failure Case (RDCFF)

With redistribution, $\pi_i = \alpha n_i[p(k_i) + (1 - p(k_i))(1 - f)]$, and thus household i's expected utility is

$$\mathrm{Eu_i} = \left[1 + \alpha \mathrm{n_i}\left(\mathrm{p(k_i)} + \left(1 - \mathrm{p(k_i)}\right)(1 - \mathrm{f})\right)\right]\mathrm{p(k_i)(Y - t)} - \mathrm{c(k_i)} \qquad (9)$$

Household i maximizes Eu_i by choosing k_i. The optimal fertilizer usage level is determined by the first order condition below, assuming the second order condition holds.

$$\{1 + \alpha n_i[1 + f(2\mathrm{p(k_i)} - 1)]\}\mathrm{p'(k_i)(Y - t)} = \mathrm{c'(k_i)} \qquad (10)$$

Lemma 3. Under the RDCFF regime, agricultural tax t reduces fertilizer usage levels and makes the farming households worse off, while the population growth rate ratio n_i/g increases fertilizer usage levels. These households with higher n_i/g ratio are better off relative to other households with lower n_i/g ratio. The confiscation threat f may have a positive effect on fertilizer usage levels under certain condition but may have a negative effect on the households' expected utilities.

[9] $\frac{n_i}{g} = \alpha n_i$

Proof. See Appendix.

From Eq. (10), it can be seen that the confiscation threat, f, has two effect on the optimal fertilizer usage level, k_i^{RDCFF*}. First, like eviction threats (Banerjee, Ghatak, 2004), the threat to confiscate farmland gives the farming households incentive to implement higher level of fertilizer, since higher k generates lower probability of farming failure, and lower probability of losing farmland. Second, the uncertainty of land holding in period 2 decreases their incentive to implement fertilizer. Thus, the total effect of the confiscation threat on the optimal fertilizer usage level is ambiguous. So is the total effect of the confiscation threat on the farming households' expected utilities. With functional form of $p(k_i) = k_i^{\frac{1}{2}}$ and $c(k_i) = k_i$, Eq. (10) gives the optimal fertilizer usage level under the RDCFF regime as

$$k_i^{RDCFF*} = \frac{[1 + \alpha n_i(1-f)]^2(Y-t)^2}{4[1-\alpha n_i f(Y-t)]^2}$$

In this case, k_i^{RDCFF*} increases in f if $\alpha n_i > \frac{1}{Y-t} - 1$. That is, for households with large $(Y-t)$ and high population growth ratio n_i/g, higher confiscation threat increases their optimal fertilizer usage level under the RDCFF regime because the cost of losing the high yield farmland is too large, but for households with small $(Y-t)$ and low population growth ratio n_i/g, higher confiscation threat decreases their optimal fertilizer usage level.

Combining the three lemmas gives the following proposition.

Proposition 1.

Agricultural tax: under all the three land tenure regimes, agricultural tax reduces fertilizer usage levels and makes farming households worse off;

Population growth: under the NR regime, the household population growth rate, n_i, has no effect on the household's optimal fertilizer usage level; under the RDC and RDCFF regimes, the population growth rate ratio n_i/g increases fertilizer usage levels. These households with higher n_i/g ratio are better off relative to other households with lower n_i/g ratio under redistribution regimes.

Threat to confiscate farmland: under the RDCFF regimes, the confiscation threat caused by farming failure may increase fertilizer usage levels under certain condition but may make farming households worse off.

2.4.5. Comparisons of the Land Tenure Regimes

Two interesting questions arise. Which land tenure regime is most beneficial to the long-run productivity of the land? And which regime will be preferred by what type of farming households? This can be done by comparing the optimal fertilizer usage levels and households' expected utilities under different regimes.

2.4.5.1. The Optimal Fertilizer Usage at Household Level

Proposition 2. The optimal fertilizer usage levels in household i can be ranked as

$k_i^{NR*} > k_i^{RDC*}$ if $n_i < g$;

$k_i^{NR*} > k_i^{RDCFF*}$ if $n_i < \frac{g}{1+\beta}$; where $\beta = f\left(2p\left(k_i^{RDCFF*}\right) - 1\right)$;

$k_i^{RDCFF*} > k_i^{RDC*}$ if $\left(k_i^{RDCFF*}\right) > 0.5$;

vice versa.

Proof of Proposition 2.

The optimal fertilizer usage levels are determined by the first order condition equations. First we look at the NR regime and the RDC regime. Eq. (6) and Eq. (8) are identical if $2 = 1 + \alpha n_i$, or $n_i = \frac{1}{\alpha} = g.$ Therefore, if $n_i < g$, the marginal benefit of fertilizer is higher under the NR regime, and thus the optimal fertilizer level is higher under the NR regime; vice versa.

Now compare the NR regime and the RDCFF regime. Define

$$m = \frac{g}{1 + f\left(2p\left(k_i^{RDCFF*}\right) - 1\right)}$$

It is obvious to see that when $n_i = m$, Eq. (6) and Eq. (10) will give the same optimal fertilizer level, $k_i^{NR*} = k_i^{RDCFF*}(m)$. Furthermore, for $n_i < m$, at the margin,

$$MB^{RDCFF}(k_i^{NR*}, n_i) < MB^{NR}(k_i^{NR*}) = MC^{NR}(k_i^{NR*})$$

Therefore, the optimal fertilizer level must be

$$k_i^{RDCFF*}(n_i) < k_i^{RDCFF*}(m) = k_i^{NR*}$$

The other direction of inequality can be proved in the same way.

Lastly, we compare the RDC regime and the RDCFF regime. It is trivial to show that when $\alpha n_i = \alpha n_i\left[1 + f\left(2p\left(k_i^{RDCFF*}\right) - 1\right)\right]$, i.e., $p\left(k_i^{RDCFF*}\right) = 0.5$, Eq. (8) and Eq. (10) generate the same optimal fertilizer level, $k_i^{RDC*} = k_i^{RDCFF*}$. Define this optimal fertilizer level as k_0^* such that $p(k_0^*) = 0.5$ and Eq. (10) holds with k_0^*. If $k_i^{RDCFF*} > k_0^*$, at the margin,

$$MB^{RDC}(k_i^{RDCFF*}) < MB^{RDCFF}(k_i^{RDCFF*}) = MC^{RDCFF}(k_i^{RDCFF*}) = MC^{RDC}(k_i^{RDCFF*})$$

Therefore, the optimal fertilizer level under the RDC regime must be $k_i^{RDC*} < k_i^{RDCFF*}$. The other direction of inequality can be proved in the same way.

qed.

Proposition 2 summarizes the relationship among household's optimal fertilizer usage levels under different regimes, and the relationship can be represented as in Figure 1. Figure 1 is drawn based on the assumption that $p(k_i) = {k_i}^{\frac{1}{2}}$ and $c(k_i) = k_i$.[10] It shows that households with relatively fewer children (lower household population growth n_i relative to the village population growth, g) use more fertilizer under the no

[10] In this numerical example, $k_i^{NR*} = (Y - t)^2$, $k_i^{RDC*} = \frac{(1+\alpha n_i)^2(Y-t)^2}{4}$, and $k_i^{RDCFF*} = \frac{[1+\alpha n_i(1-f)]^2(Y-t)^2}{4[1-\alpha n_i f(Y-t)]^2}$.

redistribution regime. In other words, the no redistribution regime elicits the highest optimal fertilizer usage level from households with relatively fewer children, and the redistribution regimes can elicit the highest optimal fertilizer usage level from households with relatively more children. In addition, when $(Y - t)$ is large enough, the optimal fertilizer usage level is is higher under the RDCFF regime than under the RDC regime. Therefore, the removal of agricultural tax increases $(Y - t)$ and possibly makes the RDCFF regime more appropriate than the RDC regime from the aspect of providing farmers investment incentive.

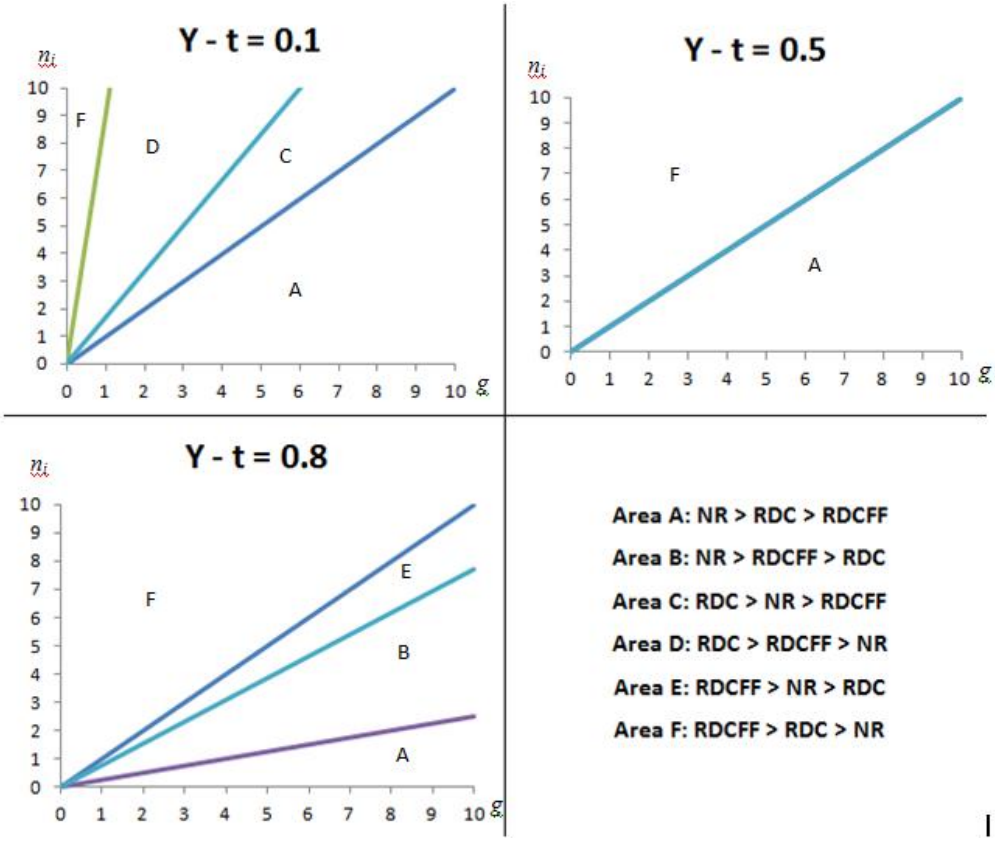

Figure 2. The optimal household fertilizer levels under different regimes

Overall, the comparison of optimal fertilizer usage levels under different regimes at the individual household level does not provide a clear picture of which regime promote higher long-run aggregate investment at the village level. To further examine the overall effect, I compare the village aggregate optimal fertilizer usage levels under different regimes.

2.4.5.2. The Optimal Fertilizer Usage at Village Level

Define the village aggregate fertilizer usage level as the summation of all the households' optimal fertilizer usage levels under a certain regime:

$$K^{j*} = \sum_{i=1}^{I} k_i^{j*}, \quad j = NR, RDC, RDCFF$$

Define

$$\overline{p(k_i^{RDCFF*})} = \frac{1}{I}\sum_{i=1}^{I} p\left(k_i^{RDCFF*}\right)$$

as the average probability of producing output Y at the optimal fertilizer level k_i^{RDCFF*} under the RDCFF regime. The following proposition compares the village aggregate fertilizer usage levels under different regimes.

Proposition 3. Given that $p(k_i)$ is strictly concave and $p'''(k_i) \leq 0$, and $c(k_i)$ is convex and $c'''(k_i) \geq 0$, $K^{NR*} > K^{RDC*}$ always holds; also, there exist some θ and γ such that $0 < \theta < \gamma < 1$, and the following inequalities hold:

$$K^{NR*} > K^{RDC*} > K^{RDCFF*} \; if \; \overline{p(k_i^{RDCFF*})} < \theta;$$

$$K^{NR*} > K^{RDCFF*} > K^{RDC*} \; if \; \theta < \overline{p(k_i^{RDCFF*})} < \gamma;$$

$$K^{RDCFF*} > K^{NR*} > K^{RDC*} \; if \; \overline{p(k_i^{RDCFF*})} > \gamma.$$

Proof. See Appendix.

Figure 2 illustrates the Proposition 3. The aggregate fertilizer usage level is always higher under the NR regime than under the RDC regime. When $\overline{p(k^{RDCFF*})}$ is small, no redistribution regime dominates redistribution regimes in terms of aggregate fertilizer usage level; only when $\overline{p(k^{RDCFF*})}$ is large enough, the RDCFF regime dominates the other two regimes. The intuition is that when $\overline{p(k^{RDCFF*})}$ is large enough, the confiscation threat gives all the farming households incentive to implement higher

level of fertilizer to lower probability of farming failure, while the threat is not too large to make them back away from investing and give up.

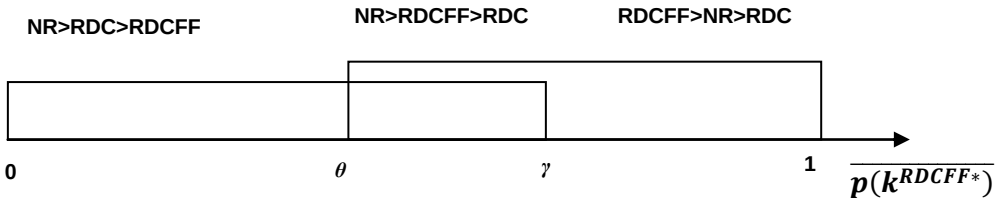

Figure 3. The optimal aggregate fertilizer levels under different regimes

Using the function forms in the numerical example in the previous section, one can conclude that $\overline{p(k^{RDCFF*})}$ increases in net output $(Y-t)$, and the mean-preserving spread of the distribution of n_i. Thus, with the removal of agricultural tax which increases $(Y-t)$, the RDCFF regime may be the best regime for a village with high variation in household population growth from the aspect of the aggregate fertilizer usage level. But for areas with low agricultural output and low variation in household population growth, the NR regime is the best regime from the aspect of the aggregate fertilizer usage level.

2.4.5.3. Households' Maximized Expected Utility Levels

The following proposition reveals the farming households' preference over different regimes by compares farming households' maximized expected utility levels under different regimes.

Proposition 4. There exists some n_0 such that when $n_i < n_0$, household i strictly prefers the no redistribution regime to the redistribution regimes, e.g., $Eu_i^{NR*} > Eu_i^{RDC*}(n_i)$ and $Eu_i^{NR*} > Eu_i^{RDCFF*}(n_i)$.

Proof. 1. NR versus RDC

The two expected utility functions, Eq. (5) and Eq. (7), are identical if $n_i\alpha = 1$. And Eu_i^{RDC*} increases in $n_i\alpha$, as stated in Lemma 2 and Proposition 1 while Eu_i^{NR*} is independent on $n_i\alpha$. Therefore, if $n_i\alpha < 1$, or $n_i < g$, $Eu_i^{NR*} > Eu_i^{RDC*}$; vice versa.

The intuition is that the households with relatively low population growth, $n_i < g$, invest more under the NR regime where unlike under the RDC regime they have secure

land tenure and have no worry about losing land holding in period 2. The higher investment levels combined with no loss of land holding results in higher utility levels in these households relative to under the RDC regime.

2. NR versus RDCFF

From the proof of Proposition 2, it is true that if $\mathrm{n_i} = \mathrm{m}$, the optimal fertilizer level $\mathrm{k_i^{NR*}} = \mathrm{k_i^{RDCFF*}(m)}$. Put $\mathrm{k_i^{RDCFF*}(m)} = \mathrm{k_i^{NR*}}$ into Eq. (9).

$$
\begin{aligned}
& Eu_i^{RDCFF*}\left(k_i^{RDCFF*}(m), n_i = m\right) = Eu_i^{RDCFF*}\left(k_i^{NR*}, n_i = m\right) \\
& = N\left\{\left\{1 + \alpha m\left[1 + f\left(p\left(k_i^{RDCFF*}(m)\right)\right) - 1\right]\right\} p\left(k_i^{NR*}\right)(Y - t) - c\left(k_i^{NR*}\right)\right\} \\
& = N\left\{\left\{1 + \alpha m\left[1 + f\left(2p\left(k_i^{RDCFF*}(m)\right) - 1\right)\right] - \alpha m f p\left(k_i^{RDCFF*}(m)\right)\right\} p\left(k_i^{NR*}\right)(Y - t)\right. \\
& \qquad \left. - c\left(k_i^{NR*}\right)\right\} \\
& = N\left\{2p\left(k_i^{NR*}\right)(Y - t) - c\left(k_i^{NR*}\right) - \alpha m f\left[p\left(k_i^{NR*}\right)\right]^2 (Y - t)\right\} \\
& = Eu_i^{NR*} - N\alpha m f\left[p\left(k_i^{NR*}\right)\right]^2 (Y - t) \\
& < Eu_i^{NR*}
\end{aligned}
$$

Since $\mathrm{Eu_i^{RDCFF*}}$ and $\mathrm{k_i^{RDCFF*}}$ increase in $\mathrm{n_i}$, there must exist some $\mathrm{n^*} > m$ such that $\mathrm{Eu_i^{NR*}} = \mathrm{Eu_i^{RDCFF*}}\left(\mathrm{k_i^{RDCFF*}(n^*), n^*}\right)$, and if $\mathrm{n_i} < \mathrm{n^*}$, $Eu_i^{NR*} > Eu_i^{RDCFF*}\left(k_i^{RDCFF*}(n_i), n_i\right)$;vice versa.

To sum up, there exist some $n_0 = \min\{1/\alpha, n^*\}$ such that when $n_i < n_0$, $Eu_i^{NR*} > Eu_i^{RDC*}(n_i)$, and $Eu_i^{NR*} > Eu_i^{RDCFF*}(n_i)$.

qed.

The intuition is that the households with relatively low population growth, $n_i < n_0$, invest more under the NR regime where they have secure land tenure and have no worry about losing land holding in period 2 and thus have more incentive to invest. The higher investment levels combined with no loss of land holding in period 2 results in higher utility levels in these households relative to under the redistribution regimes.

The implication of Proposition 4 is twofold. On the one hand, it implies that households with larger growing size prefer redistribution regimes to the no redistribution regime; vice versa. On the other hand, it helps to explain why different villages adopt different farmland redistribution regimes. Suppose in a village, the farmland redistribution regime is either determined by one of two mechanisms, a majority voting or dictatorship. In the first scenario, the median voter householder is pivotal to the village redistribution decision. If the median voter household has the property of $n_i < n_0$, then there will be no redistribution, and the villagers can enjoy secure rights to their farmland. Otherwise, there will be some kind of redistribution to accommodate the demographic change. In the second scenario, the preference of the dictator which is affected by its household population growth rate determines which farmland redistribution regime will be adopted. According to my model, it is always the households with higher household population growth rate who lobby the village head for land redistribution.

2.5. Extensions

The baseline model rules out the off-farm job opportunities and farmland rental market. In this section, I add these two features to the baseline model, to see how they affect the utility and choice of the farming households.

2.5.1. Off-Farm Job Opportunities

In this section, assume besides working on the farm, a farmer has a choice to search for a job on the off-farm job market. The choice is binary. If he decides to search for an off-farm job, he can ask someone to farm on his land for free and the yield of the land belongs to the one who work on his land. If the farmer finds a job, he earns the market prevalent wage w. At the beginning of each period, the farmer needs to decide

whether to work on the farm or off farm.[11] The probability of finding a job and retaining it for one period is $q_i \in (0,1]$ for the farmer in household i. Assume farmers have different probability of finding jobs; thus, there exist some i and j such that $q_i \neq q_j$. Farmers have rational expectation of q_i before they make the choice. Because of the heterogeneity in the ability to access off-farm job among farmers, the expected income from off-farm job, wq_i, may be higher or lower than the expected income from working on the farm.

2.5.1.1. No Redistribution Case (NR)

In the absence of farmland rental market, the farmer in household i can choose either to work on his farm or to search for an off-farm job. The farming household's expected utility is

$$Eu_i = max\{2p(k_i)(Y-t) - c(k_i), 2wq_i\} \quad (11)$$

If the former item of Eq. (11) is larger than the latter one, then it is the same as the no off-farm job case, and the optimal level of fertilizer will also be the same as the one in the no off-farm job case, and hence, the farming household is as well off. If the latter item is larger than the former one, then farming household is strictly better off with the off-farm job opportunity. To sum up, the farming household is weakly better off with off-farm job opportunity under NR regime.

2.5.1.2. Redistribution caused by Demographic Changes Case (RDC)

Household i's expected utility is

$$Eu_i = max\{(1+\alpha n_i)p(k_i)(Y-t) - c(k_i), 2wq_i\} \quad (12)$$

Like the NR case, the farming household is weakly better off with off-farm job opportunity under RDC regime. The effect of an off-farm job opportunity is purely a positive wealth effect; it may potentially increase the expected income and thus the

[11] This is consistent with the current "Rural Land Contract Law" and "Land Management Law" in China. According to these laws, if the farming household do not work on their land, then they have to find someone to work on the land for them; otherwise, they have to give up their land.

expected utility of a farming household without distorting the usage of fertilizer. The difference from the NR case is that under RDC regime, the village and household population growth rates affect farming household's decision. The optimal fertilizer usage level does not depend on population growth rates under the NR regime, while it increases in the population growth rate ratio, n_i/g, under the RDC regime. Under the RDC regime, the households with relatively high population growth rate tend to choose to work on the farm while the households with relatively low population growth rate tend to choose to work off farm. The intuition is that household with proportionately more children can take advantage of the farmland redistribution to get more land by sticking on the farm.

2.5.1.3. Redistribution caused by Demographic Changes and Farming Failure Case (RDCFF)

The major difference between RDCFF regime and RDC regime is that under the RDCFF regime, if the household's farmland is confiscated because of farming failure, then the adult in this household can look for off-farm job. Thus, household i's expected utility is

$$Eu_i = max\left\{\left\{1+\alpha n_i\left[p(k_i)+\left(1-p(k_i)\right)(1-f)\right]\right\}p(k_i)(Y-t)-c(k_i)+\right.$$
$$\left. 1-pkifwqi,\ 2wqi \right. \qquad (13)$$

The first order condition with respect to k_i gives

$$\left\{\{1+\alpha n_i[1+f(2\mathrm{p}(\mathrm{k_i})-1)]\}(\mathrm{Y}-\mathrm{t})-fwq_i\right\}\mathrm{p}'(\mathrm{k_i})=\mathrm{c}'(\mathrm{k_i}) \qquad (14)$$

Comparing to the situation without off-farm job, the off-farm job opportunity decreases the marginal benefit of fertilizer, and thus decreases the optimal fertilizer level under the RDCFF regime. Furthermore, the comparative statics analysis shows that $\partial k/\partial w < 0$ and $\partial k/\partial q_i < 0$. The intuition is that with off-farm job opportunity, farming income becomes less important, so the confiscation of land frees the farmer from farming and creates an opportunity for the farmer to looking for off-farm job and earning off-farm income. Therefore, the confiscation threat is not as effective as an incentive mechanism in the case without off-farm job opportunity. As a result, the usage of fertilizer is lower, and farmland will be underfertilized with off-farm job opportunity under

the RDCFF regime. Thus, investments in the land and off-farm jobs are somewhat substitutes. The underfertilization lowers the income from farming, but the availability of the off-farm job serve as a safety net in the case of confiscation and thus has a positive wealth effect. The positive effect dominates the former effect; thus the total effect of the availability of off-farm job opportunity on the expected utility is strictly positive under RDCFF regime. Intuitively, the off-farm job opportunity provides a safety net in the case of land confiscation, and provides the farmer an alternative income source; thus, it makes the farming household better off.

2.5.2. Farmland Rental Market

In this section, assume besides working on his own farm, a farmer has a choice to rent his farmland out earning the market prevalent rent R per unit of land. Assume that under the redistribution regimes, the farming household will not rent its farmland out, because it is "a signal of excess farmland", and it will be redistributed out for sure. Therefore, no one would like to take the risk to rent his farmland out, though policy allows it. Thus the behavior and utility level of farming household will be the same as under the redistribution regimes without farmland rental market. Only under the no redistribution regime, can a rental market function well.

2.5.2.1. No Redistribution Case (NR)

With a farmland rental market, the farmer in household i can choose either to work on his farm or to rent it out. The farming household's expected utility is

$$Eu_i = max\{2p(k_i)(Y - t) - c(k_i), 2R\} \quad (15)$$

Comparing to the no rental market case, rental has a potential pure wealth effect, and it will not distort fertilizer level. Thus, farmland rental market makes the farming household weakly better off.

The two extensions can be summarized by the following proposition.

Proposition 5. Under the NR regime, farming households are weakly better off with off-farm job opportunities and farmland rental market, without change in optimal fertilizer level;

under the RDC regime, farming households are weakly better off with off-farm job opportunities, without change in optimal fertilizer level;

under the RDCFF regime, farming households are strictly better off with off-farm job opportunities, but the optimal fertilizer level is lower.

2.5.3. A Summary

In the baseline model, I find that the agricultural tax is a burden to the farming household; it hampers long-run investment such as the usage of fertilizer, and lowers farming household's utility, in general. Therefore the abolition of the agricultural tax is compatible with the goal of enhancement of farming households' welfare and further development of the agricultural industry in China. Redistribution caused by demographic changes (RDC) discourages long-run investment; however, the confiscation threat in the case of farming failure can stimulate long-run investment. Hence, comparing to a long-term land tenure (or farmland privatization) regime, the RDC regime features lower long-run investment level, while the RDCFF regime may have higher long-run investment level if the net output is large enough. The household population growth rate affects the preference of the household regarding the land tenure regime, and its disparity among different households in a village leads to land redistribution. Households with relatively more children prefer the redistribution regimes to the no redistribution regime. Off-farm job opportunities makes farming households weakly better off under the NR regime and the RDC regime, without affecting long-run investment. Off-farm job opportunities make farming households implement less long-run investment under the RDCFF regime; nevertheless it makes farming households better off since it provides farming households a safety net in the case of land confiscation, and provides the farmer an alternative income source. Farmland rental market can only function well under the NR regime, and it makes farming households weakly better off.

2.6. Evidence

Many previous empirical studies on land tenure in China provide evidence that is consistent with the predictions of the model. Periodical land redistributions shorten farming households' investment horizon and dampen their incentives to invest in their

land to sustain and improve their land condition; and consequently, long-run agricultural productivity is lowered. Studies which document this fact include Brandt et al. (2002), Carter and Yao (1998), Deininger and Jin (2003), Jacoby et al. (2002), Li et al. (1998, 2000),Wen (1996) and Yao (1999). There is also evidence of the investment-enhancing impact of land tenure security. Li et al. (2000)'s empirical work on China showed that secure tenure rights positively affected the use of inputs, especially those with long-term effects on land fertility. As the length of tenure increased by one year, the amount of organic fertilizer use rose by 0.04 cubic meters per mu (15 mu equals 1 hectare or 2.47 acres). Deininger and Jin (2003) studied the same issue using data from the land-rights "experiment" (the so-called "two noes" policy) in Meitan County in Guizhou province in China, which adopted long-term land-use rights. The "two noes" policy stipulated no land increase for new population and no land decrease for reduced population. Their estimations indicated that more secure land rights increased producers' propensity to invest in agriculture. Regressions suggested a significant and positive impact of more secure land rights on investment; households in Guizhou province that adopted the "two noes" invested more in agriculture than those in the other provinces without this policy.

Brandt et al. (2004) regressed the number of land redistributions since the introduction of the HRS on other variables, and found positive correlation between the number of redistributions and village population growth. Deininger and Jin (2003) found that households with a large number of children who were born after the initial land redistribution were against the no redistribution policy and instead preferred a regime similar to the RDC regime in the model, since redistribution would provide them with additional land. Kung (2002a) also found that household's preference is affected by its demography. Households with proportionately more dependents were more likely to prefer land redistribution; while households with proportionately more members being assigned land desired more stable land tenure regime.

Deininger and Jin (2003) addressed on the impact of off-farm job opportunity on investment in land. Their empirical findings showed that households that had children migrating to off-farm jobs were less likely to invest in their land. It confirms the substitutability property of investment in land and off-farm jobs.

Kung (2002a)'s empirical results showed that households that had rented out land were "supporters of a more stable land tenure regime". Furthermore, Kung (2006), based on Meitan "two noes" experiment, found that freezing land redistributions facilitates the development of a land rental market and that the rental incomes help to subsidize the households with deficient labor. Deininger and Jin (2003) also provided empirical evidence that household can benefit more from more secure land rights if the households have farmland transfer rights. In addition, the transfer rights are important if the farming household members have access to off-farm jobs. They found a similar result as Carter and Yao (1999) that transfer rights together with off-farm job opportunity can play an important and beneficial role for farming households. Similar result can also be found in Brandt, *et al* (2002), and Unger (2006).

2.7. Concluding Remarks

This paper sets up a model trying to investigate the contradictory phenomenon that central government implements land tenure policies while farmland is redistributed periodically at the village level. To my best knowledge, this is the first paper which provides a formal model on land tenure regimes, long-run investment and fertility. It provides theoretical basis for the previous empirical works, a majority of which is descriptive or based on simple OLS regression.

The model indicates that in the absence of well-established factor markets, individual farming households could be better off under a redistribution regime; institutions matter. Although in the model household's utility does not depend directly upon the number of the children, children affect the household's utility in the sense that they sharing the household's resource and that their number affects the household's preferences in land redistribution or tenure regimes. The model predicts that households with proportionately more children tend to lobby for land redistribution which results in a lower level of long-run investment. A "straightforward" policy to promote long-run investment is prohibiting the land redistribution by introducing long-term land tenure. Nevertheless, without well-established factor markets, long-term land tenure may be against people's will and redistribution may hardly be prevented in practice. Moreover, once the factor markets are soundly established, land redistribution may no longer be

preferred. In addition, the paper also provides theoretical basis for the empirical finding that land redistribution discourages fertilizer usage, especially, redistribution without punishing for farming failure.

The land insecurity brought by the periodical redistribution caused by demographic changes inhibits long-run investment. One type of potential solution is a reform towards long-term tenure regime and better monitoring or outright land privatization. This type of policy eliminates redistribution, and thus gives farming households a longer horizon for planning and investing. Another type of solution is providing farming households direct incentives to invest. A possible incentive is a threat to redistribute land out in case of farming failure, given that long-run investment can decrease the probability of farming failure. But this threat needs to be used with great caution, since it may harm farming households by creating more risk for farmers in the absence of formal insurance markets and off-farm labor market.

A well-functioning farmland rental market can serve as a substitute for administrative land redistributions, by transferring land from the less needed to the more needed. But a rental market and administrative land redistribution cannot coexist. On the one hand, renting out land may be interpreted as a signal that the household has too much land than it needs. Being afraid to lose land, farming households are thus reluctant to rent land out and so the land rental market cannot function. On the other land, with well-functioning farmland rental market, administrative redistribution will be redundant. Therefore, a gradual transition from administrative redistribution to rental mechanism may not be possible, and a one-shot reform is needed for the transition. In addition, the incompatibility between rental market and land redistribution regime also implies that China is in great needs of formal institutions that provide protection of property rights and legal sanction, and foster enforcement. All of these are indispensable for the rental market to sustain and function efficiently.

It is the variation in household population growth rates that generates the desire for land redistribution in the model. If family planning policy can be followed more strictly in the rural area, the variation in household population growth rates will be smaller, and redistribution will be unnecessary. Thus, family planning policy not only has positive inter-generational implication through quality-quantity trade-off but also facilitates the

establishment of long-term land tenure system in the rural area. In addition, taking into account that rural couples are allowed to have up to two children under the current policy, the dependency ratios in the future will not be as serious a problem as for city dwellers.

2.8. References

Bandiera, O., 2007. Contract Duration and Investment Incentives: Evidence from Land tenancy Agreements, Journal of the European Economic Association 5(5), 953-986.

Banerjee, A., Gertler, P. J., Ghatak, M., 2002. Empowerment and Efficiency: Tenancy Reform in West Bengal, Journal of Political Economy 110(2), 239-280.

Banerjee, A., Ghatak, M., 2004. Eviction Threats and Investment Incentives, Journal of Development Economics 74, 469-488.

Benjamin, D., Brandt, L., 2002. Property Rights, Labour Markets, and Efficiency in a Transition Economy: The Case of Rural China, Canadian Journal of Economics 35(4), 689-716.

Besley, T., 1995. Property Rights and Investment Incentives: theory and Evidence from Ghana, Journal of Political Economy 103(5), 903-937.

Brandt, L., Huang, J., Li, G., Rozelle, S., 2002. Land Rights in Rural China: Facts, Fictions and Issues, The China Journal 47, 67-97.

Brandt, L., Rozelle, S., Turner, M. A., 2004. Local Government Behavior and Property Right Formation in Rural China, Journal of Institutional and Theoretical Economics 160(4), 627-662.

Carter, M., Yao, Y., 1998. Property Rights, Rental Markets, and. Land in China, Department of Agricultural and Applied Economics working paper Series No. FC20050071.

Carter, M., Yao, Y., 1999. Specialization without Regret: Transfer Rights, Agricultural Productivity, and Investment in an Industrializing Economy, World Bank Policy Research Working Paper No. 2202.

Chan, N., 1999. Land-Use Rights in Mainland China: Problems and Recommendations for Improvement, Journal of Real Estate Literature 7(1), 53-63.

Deininger, K., Jin, S., 2003. The Impact of Property Rights on Households' Investment, Risk Coping, and Policy Preferences: Evidence from China, Economic Development and Cultural Change 51(4), 851-82.

Ding, C., 2003. Land Policy Reform in China: Assessment and prospects, Land Use Policy 20, 109-120.

Dong, X., 1996. Two-Tier Land System and Sustained Economic Growth in Post-1978 Rural China, World Development 24(5), 915-928.

Feder, G., Lau, L. J., Lin, J., Luo, X., 1990. The Relationship between Credit and Productivity in Chinese Agriculture: A Microeconomic Model of Disequilibrium, American Journal of Agricultural Economics 72(5), 1151-1157.

Ho, P., 2001, Who Owns China's Land? Policies, Property Rights and Deliberate Institutional Ambiguity, China Quarterly 0(166), 394-421.

Jacoby, H. G., Li, G., Rozelle, S., 2002. Hazards of Expropriation: Tenure Insecurity and Investment in Rural China, American Economic Review 92(5), 1420-47.

Jacoby, H. G., Mansuri, G., 2002. Incomplete Contracts and Investment: A Study of Land Tenancy in Pakistan, the World Bank's Policy Research Working Paper Series, no. 3826.

Krusekopf, C. C., 2002. Diversity in Land tenure Arrangements under the Household responsibility System in China, China Economic Review 13(23), 297-312.

Kung, J., 2000. Common Property Rights and Land Reallocations in Rural China: Evidence from a Village Survey, World Development 28(4), 701-19.

Kung, J., 2002a. The Role of Property Rights in China's Rural Reforms and Development: A Review of Facts and Issues, Chinese Economy 35(3), 52-70.

Kung, J., 2002b, Choice of Land Tenure in China: The Case of a Country with Quasi-Private Property Rights, Economic Development and Cultural Change 50(4), 793-817.

Kung, J., 2003. Common Property Rights and Land Reallocations in Rural China: Evidence from a Village Survey, Property Rights and Environmental Problems 2, 195-213.

Kung, J., 2006. Do Secure Land Use Rights Reduce Fertility? The case of Meitan County in China, Land Economics, 82(1), 36-55.

Kung, J., Liu, S., 1997. Farmers' Preferences Regarding Ownership and Land Tenure in Post-Mao China: Unexpected Evidence from Eight Counties, The China Journal 38, 33-63.

Li, G., Rozelle, S., Brandt, L., 1998. Tenure, land rights, and farmer investment incentives in China, Agricultural Economics 19(1-2), 63-71.

Li, G., Rozelle, S., Huang, J., 2000. Land Rights, Farmer Investment Incentives, and Agricultural Production in China, Department of Agricultural and Resource Economics, UC Davis, Working Paper Series no. 1033.

Lin, J., 1988. The Household Responsibility System in China's Agricultural Reform: A Theoretical and Empirical Study, Economic Development and cultural Change 36, 199-224.

McMillan, J., Whalley, J., Zhu, L., 1989. The Impact of China's Economic Reforms on Agricultural Productivity Growth, Journal of political Economy 97(4), 781-808.

Park, A., 2008. Agricultural Development in China: Lessons for Ethiopia. Briefing note prepared for the DFID funded study "Understanding the constraints to continued rapid growth in Ethiopia: the role of agriculture".

Rozelle, S., 1994. Decision-Making in China's Rural Economy: The Linkages between Village Leaders and Farm Households, China Quarterly 137, 99-124.

Rozelle, S., Brandt, L., Li, G., Huang, J., 2005. Land tenure in China: Facts, fictions and issues. In Developmental dilemmas: Land reform and institutional change in China. New York: Routledge.

Rozelle, S., Li, G. 1998. Village Leaders and Land-Rights Formation in China, American Economic Review, 88(2), 433-438.

Unger, J., 2006. Family Customs and Farmland Reallocations in Contemporary Chinese Villages, Social Transformations in Chinese Societies 1, 113-130.

Wen, G., 1996. The Land Tenure System and its Saving and Investment Mechanism: The Case of Modern China, Asian Economic Journal 10(3), 233-260.

Yao, Y., 1999. Induced Institutional Change under Collective Decision-The Case of Land Tenure Evolution in Rural China, CCER Working Paper, no. E1999001.

Yao, Y., 2004. Land Tenure Choice in Chinese Villages: The Rational versus the Political Model, Land Economics 80(4), 477-89.

Zhou, Q., Liu, S., 1988. Meitan: Changes in the Land Tenure System of a Traditional Agrarian Community, Report on Development Research 7, the State Council Development Research Center of China.

Zhou, Y., 2002. Report on China's development and investment in land and water, Investment in Land and Water, Food and Agriculture Organization of the United Nations.

2.9. Appendix

Proof of Lemma 1. The proof is straightforward. Eq. (5) is a strictly decreasing function of t and n_i; thus increase in t (or n_i) will decrease farming household's expected utility. The left hand side of Eq. (6), marginal benefit of k_i, is strictly decreasing in t and n_i. Thus, as t (or n_i) increases, $MB(k_i)$ decreases, which leads to a decrease in k_i^*. This will

further decrease farming household's expected utility.

qed.

Proof of Lemma 2. The proof of the negative effect of the agricultural tax t is similar to that of the Lemma 1, and it will be skipped here. To see the effect of g, notice that Eq. (7) and the left hand side of Eq. (8) are strictly increasing in α (strictly decreasing in g). Therefore, increase in g will lower α, which not only decreases Eu_i directly, but also decreases k_i^* and reduce Eu_i indirectly.

qed.

Proof of Lemma 3. Because the agricultural tax t and village population growth g affect the fertilizer usage level and farming household's expected utility in the same way as in the RDC regime, the proof will be skipped. To prove the effect of f, notice that the left hand side of Eq. (10) is a strictly increasing function of f for $p(k_i^*) > 0.5$. Therefore, if f satisfies the condition of $p(k_i^*(f)) > 0.5$, at the margin, increasing f will increase $MB(k_i)$ and increase k_i^* which indirectly increase Eu_i. However, because Eq. (9) is strictly decreasing in f, increasing f will decrease Eu_i directly. As a result, the total effect of f on Eu_i is ambiguous.

qed.

Proof of Proposition 3. Dividing the three first order condition equations, Eq. (6), Eq. (8), Eq. (10) by $p'(k_i)$ gives the following three equations:

$$2(Y-t) = \frac{c\prime(k_i)}{p\prime(k_i)} \tag{16}$$

$$(1+\alpha n_i)(Y-t) = \frac{c\prime(k_i)}{p\prime(k_i)} \tag{17}$$

$$\{1+\alpha n_i[1+f(2p(k_i)-1)]\}(Y-t) = \frac{c\prime(k_i)}{p\prime(k_i)} \tag{18}$$

The three equations have the same right-hand side function, $\frac{c\prime(k_i)}{p\prime(k_i)}$. The strict concavity of $p(k_i)$, convexity of $c(k_i)$, $p'''(k_i) \leq 0$, and $c'''(k_i) \geq 0$ are sufficient but not

necessary conditions for $\frac{c\prime(k_i)}{p\prime(k_i)}$ to be strictly increasing and strictly convex in k_i.[12] Given these conditions hold, the inverse function of $\frac{c\prime(k_i)}{p\prime(k_i)}$ is strictly increasing and strictly concave. Denote this inverse function as $F^{-1}\left(\frac{c\prime(k_i)}{p\prime(k_i)}\right)$.

1. Start from comparing the NR and RDC regimes. Notice that give n_i the left-hand side of Eq. (16) and Eq. (17) are all constants, and the summation of the two LHS functions are equal.

$$\begin{aligned}\sum_{i=1}^{I}[(1+\alpha n_i)(Y-t)] &= (Y-t)\sum_{i=1}^{I}(1+\alpha n_i)\\ &= (Y-t)\left(I+\alpha\sum_{i=1}^{I}n_i\right)\\ &= (Y-t)(I+\alpha Ig)\\ &= 2I(Y-t)\\ &= \sum_{i=1}^{I}[2(Y-t)]\end{aligned}$$

Given that the inverse function of the right-hand side function $\frac{c\prime(k_i)}{p\prime(k_i)}$ is strictly increasing and strictly concave. Jensen's inequality implies

$$\frac{1}{I}K^{RDC*} = \sum_{i=1}^{I}\left[\frac{1}{I}F^{-1}\big((1+\alpha n_i)(Y-t)\big)\right]$$

[12] The strict concavity of $p(k_i)$ and convexity of $c(k_i)$ are the sufficient conditions for $\frac{c\prime(k_i)}{p\prime(k_i)}$ to be strictly increasing in k_i. The strict convexity of $\frac{c\prime(k_i)}{p\prime(k_i)}$ requires $c'''(k_i)(p'(k_i))^2 - p'''(k_i)c'(k_i)p'(k_i) - 2c''(k_i)p'(k_i)p''(k_i) + 2c'(k_i)(p''(k_i))^2$ to be positive, and the strict concavity of $p(k_i)$, convexity of $c(k_i)$, $p'''(k_i) \leq 0$, and $c'''(k_i) \geq 0$ are sufficient for that.

$$< F^{-1}\left(\sum_{i=1}^{I}\left\{\frac{1}{I}[(1+\alpha n_i)(Y-t)]\right\}\right)$$

$$= F^{-1}\left(\frac{1}{I}\sum_{i=1}^{I}[2(Y-t)]\right)$$

$$= F^{-1}\big(2(Y-t)\big)$$

$$= \frac{1}{I}K^{NR*}$$

Thus,

$$\mathrm{K}^{\mathrm{RDC}*} < \mathrm{K}^{\mathrm{NR}*}$$

always holds as long as there exist some $i \neq j$ such that $n_i \neq n_j$ which always holds by assumption.

2. NR versus RDCFF

Jensen's inequality implies $\mathrm{K}^{\mathrm{RDCFF}*} < \mathrm{K}^{\mathrm{NR}*}$ if

$$\sum_{i=1}^{I}\left\{\frac{1}{I}F^{-1}\left(\{1+\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\}(Y-t)\right)\right\}$$

$$< F^{-1}\left(\sum_{i=1}^{I}\left\{\frac{1}{I}\{1+\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\}(Y-t)\right\}\right)$$

$$\leq F^{-1}\left(\sum_{i=1}^{I}\left[\frac{1}{I}2(Y-t)\right]\right)$$

$$= \sum_{i=1}^{I}\left[\frac{1}{I}F^{-1}\big(2(Y-t)\big)\right]$$

(19)

Since $F^{-1}\left(\frac{c'(k_i)}{p'(k_i)}\right)$ is an increasing function, Eq. (17) implies

$$\sum_{i=1}^{I}\left\{\frac{1}{I}\{1+\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\}(Y-t)\right\} \leq \sum_{i=1}^{I}\left[\frac{1}{I}2(Y-t)\right]$$

or

$$\sum_{i=1}^{I}\{1+\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\} \le \sum_{i=1}^{I}2 = 2I$$

$$\sum_{i=1}^{I}\{\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\} \le I$$

$$\sum_{i=1}^{I} n_i + \sum_{i=1}^{I}[n_i f(2p(k_i^{RDCFF*})-1)] \le Ig$$

$$Ig + f\sum_{i=1}^{I}[n_i(2p(k_i^{RDCFF*})-1)] \le Ig$$

$$f\sum_{i=1}^{I}[2n_i p(k_i^{RDCFF*})-n_i] \le 0$$

$$2\sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})] - Ig \le 0$$

$$\sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})] \le 0.5Ig$$

Because p(k_i^{RDCFF*}) is increasing in n_i,

$$Ig\overline{p(k^{RDCFF*})} \le \sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})] \le 0.5Ig$$

or

$$\overline{p(k^{RDCFF*})} < 0.5$$

Then there must exist some γ such that if $\overline{\mathrm{p(k^{RDCFF*})}} \le \gamma$ holds, $K^{RDCFF*} \le K^{NR*}$; and if $\overline{\mathrm{p(k^{RDCFF*})}} > \gamma$ holds, $K^{RDCFF*} > K^{NR*}$.

3. RDC versus RDCFF

From the proof in the previous part, we know that when $\sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})] = 0.5Ig$, the summation of the LHSs of Eq. (8) and Eq. (10) are equal.

$$\sum_{i=1}^{I}\{1+\alpha n_i[1+f(2p(k_i^{RDCFF*})-1)]\}(Y-t) = 2I(Y-t) = \sum_{i=1}^{I}(1+\alpha n_i)2(Y-t)$$

(20)

Because $p(k_i^{RDCFF*})$ is increasing in n_i, the LHS function of Eq. (10) is a mean-preserving spread of the LHS function of Eq. (20). Thus, When $\sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})] \leq 0.5Ig$, $K^{RDCFF*} < K^{RDC*}$. Because $Ig\overline{p(k^{RDCFF*})} \leq \sum_{i=1}^{I}[n_i p(k_i^{RDCFF*})]$, there must exist some θ such that if $\overline{p(k^{RDCFF*})} \leq \theta$ holds, $K^{RDCFF*} \leq K^{RDC*}$; and if $\overline{p(k^{RDCFF*})} > \theta$ holds, $K^{RDCFF*} > K^{RDC*}$.

qed.

Chapter 3. Generalists, Specialists: Who Gets to the Top

3.1. Introduction

This paper aims to identify which organizational hierarchy form should be employed by a certain firm. In this paper, I will study three aspects of organizational hierarchy forms: (1) generalists or specialists, which type should get to the top? (2) How many agents should get to the top? (3) Can the agents who should be at the top really get to the top? The first two aspects deal with the design of optimal hierarchy form, and the third aspect verifies the feasibility of the optimal hierarchy form. The model is suitable for large corporations rather than small owner-managed firms.

The paper defines hierarchy form in terms of authority as in Aghion and Tirole (1997) and Hart and Moore (2005); i.e., the upper-level agent has authority over his subordinates, the lower-level agents. The special feature of this paper is involving incentives in the hierarchy design. Thus, the paper considers not only the ex ante incentive, but also the ex post efficiency. With a T-period model, using backward induction, the paper tries to analyze all the three aspects of hierarchy mentioned above.

The paper is motivated by the broadly observed phenomenon that fresh graduates first work at entry levels, and within several years, some of them are promoted while others are not. Generalists and specialists differ in potential productivity, which is unobservable and non-contractible at the time of hiring. Specialists can learn the specialties from experience and have a higher productivity in working with single asset than a generalist after the initial period. Generalist cannot accumulate specialty experience, but he will have a higher productivity in coordinating multiple assets than a specialist after familiar with the working environment in the initial period. Only two hierarchy forms are considered, pyramid form (generalists at the top) and inverted pyramid form (specialists at the top). Who should be at the top depends on the size of

the externality of coordinating multiple assets. If the size of the externality is large, generalist at the top is desirable; if it is small, specialist at the top may be desirable. The optimal number of the agents at the top depends on the optimal span of control that depends on the elasticity of the externality of coordinating multiple assets. In the pyramid form, if the size of the externality is very sensitive to the number of the assets, i.e., if the elasticity of the externality is large, the span of control should be large, and optimally there should be fewer generalists at the top; otherwise, more agents should be at the top. Finally, the T-period model with promotion can give agents who should at the top more incentive to work harder and thus are more likely to be promoted to the top.

The paper is organized as follows. In Section 2, I will review the recent literature on hierarchy. Section 3 introduces the model and assumptions. Section 4 analyzes who should get to the top. Section 5 analyzes how many agents should get to the top. Section 6 analyzes the initial period and discusses the incentive of getting to the top. Section 7 is conclusion.

3.2. Literature Review

Hierarchy has become a hot issue since the internal organization of the firm has attracted more attention of not only the scholars in management science but also economists. Many scholars argue that hierarchy is indispensable in large organizations. The authority system provided by hierarchical structure makes it possible that unambiguous accountability is preserved in organizations with large numbers of people (Jacques, 1990). In addition, hierarchical structure plays an important role in processing information by decomposing large organizations into small information processing units (Williamson, 1985).

Generally, hierarchy has been modeled in two ways. In one way, a firm is defined as the owner of a set of assets, and it authorizes agents the right to use these assets. Each asset represents a decision on the use of the asset. Thus, in this framework, hierarchy can be interpreted as a sequence of commands over assets. For a subset of the assets k, the most senior agent exercises authority, unless he delegates the authority to the next agent(s) in the sequence. Aghion and Tirole (1997) study delegation

in a setting where two agents, a boss and his subordinate, have incongruent objectives. They argue that delegation involves a tradeoff between increase in subordinate's incentive and cost of loss of control. Hart and Moore (2005) study the optimal hierarchical structure given that coordinators and specialists have different tasks. Based on certain assumptions, they conclude that coordinators should be senior to specialists, "crisscross" hierarchies are never optimal, and the optimal hierarchy is a pyramid form under certain condition.

Another way of modeling hierarchy treats the firm as an information processor, and it solves tasks by collecting, communicating and confirming information. In this framework, hierarchy can be interpreted as the locus of the communication of the information. New information is acquired and processed at the lower level and then transferred upstream to the boss, while the command of the boss is passed downstream to the lower-level agents. However, communication is imperfect and costly, not only because communicating and absorbing new information cost time, but because information may be contaminated or lost in the communication process. The cost of communication depends on the nature of the information. "Specific knowledge" is more costly to transfer than "general knowledge" (Jensen and Meckling, 1992). Thus, there is a tradeoff between specialization and communication. Bolton and Dewatripont (1994) argue that if the returns to specialization outweigh costs of communication, it is efficient for several agents to collaborate within a firm. Jensen and Meckling (1992) also argue that it is desirable for groups of individuals to exercise decision rights jointly because of bounded rationality (an individual has limited mental capability) and the inalienability of rights within an organization.

3.3. The Model

The model is a T-period internal labor market model. The organization form is a "hierarchy over assets", which is contractible ex ante at the beginning of period 1. The hierarchy modeling is in spirit of Hart and Moore (2005): there is a chain of commands over each asset, and the most senior person with 'an idea' exercises authority over the asset. In more detail, in the hierarchy, if the most senior agent who is senior to others on all of his working assets has an idea, then he can exercise his idea and generates value,

while any agents who work with any of these assets and junior to him cannot exercise their idea even though they have one. On the other hand, if the most senior agent does not have an idea on the assets, he will pass the authority to his subordinates, the lower-level agents.

Assume there are n assets in a firm. The size of n depends on the size of the firm that is assumed exogenous. Assets are identical; each single asset can produce the same value (1) , and any combination of $k > 1$ assets can produce the same value $V(k)$. In period 1, the firm hires N agents, both generalists and specialists, in the competitive external labor market. By signing contract, the firm commits ex ante to promoting Q_0 percentage of agents in period 2.

Generalists and specialists differ in potential productivity, but among the same type, agents are identical. Assume asymmetric information at hiring, so that the firm does not know agents' types in period 1, while each agent knows his own type. Because of the lack of information about agents' types, the firm has to treat all the agents in the same way in period 1. Assume in period 1, all newly hired agents are treated as lower-level agents. Each agent will work on a set of assets consisting of $k = n/N$ assets, and will be paid the same wage, W_0. With effort level, e_1, an agent can generate value $V(k)$ with probability $P(e_1, k)$. This is referred as "an agent has an idea" (Hart, Moore, 2005). Effort is unobservable, but the value generated is observable.

At the beginning of period 2, Q_0 percentage of agents with the highest value generated will be promoted to the upper level in the hierarchy and they will have authority over a different set of assets consisting of *j* assets. The others who do not get promoted will stay at the lower level and still have authority over *k* working assets. In period 2, the upper-level agents are paid W^u, and lower-level agents are paid W^l; both W^u and W^l depend on the performance of the agents. An agent can choose to quit or stay at the beginning of period 2. The time line is shown in Figure 4. By repeating this hire-promotion process for H periods, the optimal hierarchy form will be achieved and stable.

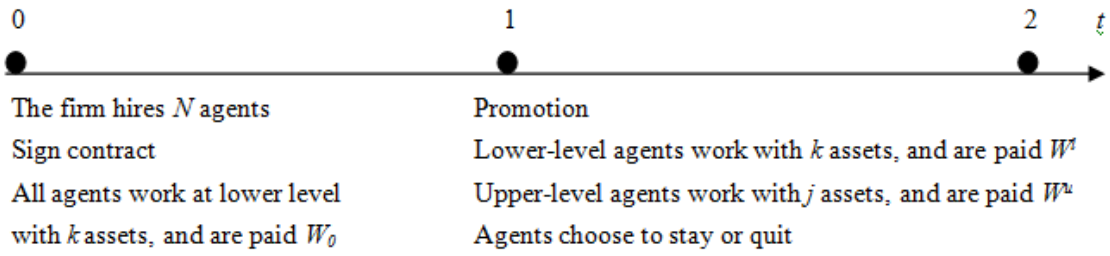

Figure 4. Time Line

The advantages of the proposed contract are as follows. In period 1, since the firm does not know agents' types, there is a hidden information problem. By providing a promotion opportunity, the principal can give agents incentive to reveal their types. In period $t \geq 2$, since effort level is unobservable and non-contractible, there is a hidden action problem (moral hazard). However, since the hierarchy is formed, and each agent has been allocated to the proper position, payment based on performance could be an effective and fair way to give agents incentive.

Types and Productivities

Specialists and generalists differ in term of their potential productivities. In period 1, all agents have the same productivity. With effort level, e_1, an agent can generate value $V(k)$from k assets with probability $P(e_1, k)$. Since period 2, a specialist has accumulated the specialties from period 1 and has a higher productivity in working with a single asset than a generalist. Therefore, in period $t \geq 2$, with effort level, e_t, $P^s(e_t, 1) > P^g(e_t, 1)$ (the superscripts s and g stand for specialist and generalist respectively, and the subscripts t stands for the time period). A generalist cannot accumulate specialty experience, but he will have a higher productivity in coordinating multiple assets than a specialist after familiar with the working environment in period 1. Therefore, in period $t \geq 2$, with effort level e_t, $P^g(e_t, k) > P^s(e_t, k)$, for any $k > 1$. Assume that there is no more productivity improvement after period 2.

Preferences

Assume that all agents are risk neutral and live for T periods, $T \geq H$. Each agent has reservation utility $\bar{u}$, and he maximizes his expected utility, which is a linear function of the total expected income net of the cost of effort. For simplicity, assume no

discounting (relaxing this simplification will not affect the results). Assume that the probability of being promoted for an agent is Q. Then, the total expected wage income of an agent i is

$$E(W^i) = W_0 + \sum_t [\, QW^u + (1 - Q)\, W^l] \,, i = g, s \qquad (1)$$

And the expected utility of an agent i is

$$E(U^i) = E(W^i) - C(e_1^i) - \sum_t [\, QC(e_t^{ij}) + (1 - Q)\, C(e_t^{ik})], i = g, s \qquad (2)$$

where k and j are the number of assets a lower-level agent and an upper-level agent have authority over, respectively.

The firm is risk neutral. The firm's object is twofold. First, firm wants to choose the optimal hierarchy form that can maximize the expected profit. Second, firm wants to hire and promote the proper agents to realize such a hierarchy.

Other Assumptions

Assumption (1) Probability of generating value is a function of type i, effort level e, and number of working assets k; $P^i(e\,, k) \in [0, 1]$ is increasing and concave in e, and decreasing and convex in k.

$$P_e^{i\prime}(e, k) > 0, P_{ee}^{i}{}''(e, k) < 0, P_k^{i\prime}(e, k) < 0, P_{kk}^{i}{}''(e, k) < 0, P_{ek}^{i}{}''(e, k) > 0$$

The intuition is that each agent has bounded rationality. Given that each agent has limited time and energy, working with more assets requires the agents process more information, and thus lower the probability of generating idea at each effort level. Effort increases the probability of generating idea, but has diminishing returns.

Assumption (2) Cost of effort $C(e)$ is increasing and convex in e.

$$C'(e) > 0, C''(e) > 0$$

Assumption (3) The value of k assets, $V(k)$, is an increasing and convex function of k.

$$V'(k) > 0, V''(k) > 0$$

It can be interpreted as a positive externality of working with multiple assets; that is, there is increasing returns to scale of assets worked together by one agent.

Assumption (4) The expected value function $P(e_t, k)V(k)$ $(t \geq 2)$ is concave in k for generalists and decreasing in k for specialists.

From the assumption (4) and the assumption on the types and productivities, one can conclude that in the optimal hierarchy, generalists who have higher probabilities of having ideas on multiple assets and can generate higher expected values from multiple assets should actually work on multiple assets. In contrast, specialists who have higher probabilities in having ideas on individual assets and can generate higher expected values from individual assets should work on individual assets.

Assumption (5) Assume there are only two hierarchy levels, an upper level and a lower level.

Optimal Wages and Incentive of Delegation

Before proceeding to the hierarchy form, let us look at the optimal wage payments for the agents in hierarchy in period $t \geq 2$. Effort level is unobservable, but since agents are risk-neutral, the wage payment schedule that makes agents the residual claimants can elicit the first best effort level as if there were no moral hazard problem. If the agent is at the upper level, he is in charge with the hierarchy composed of himself and his subordinates, and then he should be the residual claimant of the value generated by the hierarchy, so he gets

$$W^u = P(e,j)V(j) + \frac{j}{k}\left[1 - P(e,j)\right]P(e,k)V(k) - a \qquad (3)$$

where $\frac{j}{k} > 0$, and a is a constant.

If the agent is at lower level, then he is the residual claimant of the value generated by himself, and he gets

$$W^l = [1 - P(e,j)]P(e,k)V(k) - b \qquad (4)$$

where b is a constant.

Furthermore, if a and b are chosen such that it gives the agent an expected utility same as the reservation utility $\bar{u}$, then the principal will get the same expected profit as if there were no moral hazard problem. It is worth to note that this wage payment schedule implies that the upper-level agents have incentive to monitor his subordinates, though I do not model monitoring explicitly.

In addition, this wage payment schedule makes sense of the incentive of delegation. If the upper-level agent does not "have an idea", then delegating the authority right to his subordinates can increase the potential value generated by the hierarchy, and this potentially increases his own wage payment. Thus, in this model, unlike Hart and Moore (2005), the delegation decision is endogenized in the model. The upper-level agent will always delegate authority to his subordinates if he does not have an idea.

3.4. Who Should Get to the Top

I will focus on two kinds of hierarchy forms, pyramid form (generalists at the top) and inverted pyramid form (specialists at the top). Crisscross form such as matrix form is not considered here. As Hart and Moore (2005) argued, "crisscross form is never optimal" under the assumption that generalist is not a multifaceted specialist who have ideas about small subsets of the assigned working assets. This is also true here, because of the assumption of positive externality of coordinating assets. In this section, I will assume that the number of assets is two, $k = 2$.

Using backward induction, solve the model starting from period $t \geq 2$. The optimal hierarchy form is the one that maximizes the firm's expected profit. Since agents are identical among the same type, the optimal hierarchy is symmetric. For simplicity, we look at the following two hierarchy forms.

Definition: *Hierarchy form gss* is a pyramid form of hierarchy with two assets where a generalist is at the upper level and two specialists are at the lower level (the left one in Figure 5).

Definition: *Hierarchy form ssg* is an inverted pyramid form of hierarchy with two assets where two specialists are at the upper level and a generalist is at the lower level (the right one in Figure 5).

Figure 5. Hierarchy Forms

In the optimal contract, the firm sets two pairs of effort-wage in period $t \geq 2$, to maximize his expected profit subject to the agents' participation constraints and incentive compatibility constraints. Under the hierarchy form *gss*, the firm's problem is:

$$max_{a,b} E\pi_{gss} = P^{g2}(e^{g2}, 2)V(2) - W^u + 2\left[1 - P^{g2}(e^{g2}, 2)\right]P^{s1}(e^{s1}, 1)V(1) - 2W^l \quad (5)$$

subject to

$$E(U^g) = W^u - C(e^{g2}) = P^{g2}(e^{g2}, 2)V(2) + [1 - P^{g2}(e^{g2}, 2)]P^{s1}(e^{s1}, 1)V(1) - a - C(e^{g2}) \geq \bar{u} \quad (6)$$

$$E(U^s) = W^l - C(e^{s1}) = [1 - P^{g2}(e^{g2}, 2)]P^{s1}(e^{s1}, 1)V(1) - b - C(e^{s1}) \geq \bar{u} \quad (7)$$

$$max_e\, E(U^g) = P^{g2}(e^{g2}, 2)V(2) + [1 - P^{g2}(e^{g2}, 2)]P^{s1}(e^{s1}, 1)V(1) - a - C(e^{g2}) \quad (8)$$

$$max_e\, E(U^s) = [1 - P^{g2}(e^{g2}, 2)]P^{s1}(e^{s1}, 1)V(1) - b - C(e^{s1}) \quad (9)$$

In this section, the subscript t is ignored because we are considering a single period $t \geq 2$ in this section, and the superscript stands for the type of the agent and the number of assets he works with. Eq. (6) and (7) are the agents' participation constraints, and eq. (8) and (9) are the agents' incentive compatibility constraints. Since the monotone likelihood ratio property holds under the assumptions, one can replace eq. (8) and (9) with their corresponding first-order conditions.

$$P^{g2\prime}(e^{g2}, 2)[V(2) - 2\,P^{s1}(e^{s1}, 1)V(1)] = C'(e^{g2}) \quad (10)$$

$$P^{s1\prime}(e^{s1}, 1)[1 - P^{g2}(e^{g2}, 2)]V(1) = C'(e^{s1}) \quad (11)$$

Eq. (10) and (11) give the optimal effort levels, $e^{g2*}$and e^{s1*}. The comparative statics of eq. (10) suggest that the reaction function of the generalist is downward sloping; that is, the generalist's effort is decreasing in the specialist's effort. The same is true for the specialists; the specialist's effort is decreasing in the generalist's effort.

An agent will accept the contract as long as it gives him an expected utility of at least ū. At the optimal, eq. (8) and (9) are binding. Substitute the optimal efforts in eq. (8) and (9), one will get the optimal a^* and b^*.

$$a^* = P^{g2}(e^{g2*}, 2)V(2) + [1 - P^{g2}(e^{g2*}, 2)]P^{s1}(e^{s1*}, 1)V(1) - C(e^{g2*}) - \bar{u} \quad (12)$$

$$b^* = [1 - P^{g2}(e^{g2*}, 2)]P^{s1}(e^{s1*}, 1)V(1) - C(e^{s1*}) - \bar{u} \quad (13)$$

Substitute e^{g2*}, e^{s1*}, a^* and b^* in eq. (5), the optimal expected profit of the firm becomes

$$E\pi^*_{gss} = P^{g2}(e^{g2*}, 2)V(2) + 2\big[1 - P^{g2}(e^{g2*}, 2)\big]P^{s1}(e^{s1*}, 1)V(1) - C(e^{g2*}) - 2C(e^{s1*}) - 3\bar{u} \quad (14)$$

Under the hierarchy form *ssg*, firm's problem is:

$$max_{a,b} E\pi_{ssg} = 2\,[P^{s1}(e^{s1}, 1)V(1) - W^u] + [1 - P^{s1}(e^{s1}, 1)]^2 P^{g2}(e^{g2}, 2)V(2) - W^l \quad (15)$$

subject to

$$E(U^g) = W^l - C(e^{g2}) = [1 - P^{s1}(e^{s1}, 1)]^2 P^{g2}(e^{g2}, 2)V(2) - b - C(e^{g2}) \geq \bar{u} \quad (16)$$

$$E(U^s) = W^u - C(e^{s1}) = P^{s1}(e^{s1}, 1)V(1) + \left(\frac{1}{2}\right)[1 - P^{s1}(e^{s1}, 1)]^2 P^{g2}(e^{g2}, 2)V(2) - a - C(e^{s1}) \geq \bar{u} \quad (17)$$

$$max_e\, E(U^g) = [1 - P^{s1}(e^{s1}, 1)]^2 P^{g2}(e^{g2}, 2)V(2) - b - C(e^{g2}) \quad (18)$$

$$max_e\, E(U^s) = P^{s1}(e^{s1}, 1)V(1) + \left(\frac{1}{2}\right)[1 - P^{s1}(e^{s1}, 1)]^2 P^{g2}(e^{g2}, 2)V(2) - a - C(e^{s1}) \quad (19)$$

Eq. (16) and (17) are the agents' participation constraints, and eq. (18) and (19) are the agents' incentive compatibility constraints. The first-order conditions of eq. (18) and (19), eq. (20) and (21), give the optimal effort levels, $e^{g2*}$and e^{s1*}.

$$P^{s1\prime}(e^{s1}, 1)\{V(1) - [1 - P^{s1}(e^{s1}, 1)]P^{g2}(e^{g2}, 2)V(2)\} = C'(e^{s1}) \quad (20)$$

$$P^{g2\prime}(e^{g2}, 2)[1 - P^{s1}(e^{s1}, 1)]^2 V(2) = C'(e^{g2}) \quad (21)$$

Similar to the *gss* form, the comparative statics of eq. (20) suggest that the reaction function of a specialist is downward sloping; that is, the specialist's effort is decreasing in the generalist's effort. The same is true for the generalist; the generalist's effort is decreasing in the specialist's effort.

At the optimal, eq. (16) and (17) are binding. Substitute the optimal efforts into the binding eq. (16) and (17), one will get the optimal a^* and b^*.

$$a^* = P^{s1}(e^{s1*}, 1)V(1) + \left(\frac{1}{2}\right)[1 - P^{s1}(e^{s1*}, 1)]^2 P^{g2}(e^{g2*}, 2)V(2) - C(e^{s1*}) - \bar{u} \quad (22)$$

$$b^* = [1 - P^{s1}(e^{s1*}, 1)]^2 P^{g2}(e^{g2*}(e^{s1*}), 2)V(2) - C\left(e^{g2*}(e^{s1*})\right) - \bar{u} \quad (23)$$

Substitute e^{g2*}, e^{s1*}, a^* and b^* in eq. (15), the optimal expected profit of the firm becomes

$$E\pi^{*}_{ssg} = 2P^{s1}(e^{s1*},1)V(1) + [1 - P^{s1}(e^{s1*},1)]^2 P^{g2}(e^{g2*}(e^{s1*}),2)V(2) - 2C(e^{s1*}) - C\left(e^{g2*}(e^{s1*})\right) - 3\bar{u} \quad (24)$$

Lemma 1. Under both hierarchy forms, the reaction curves of the upper-level agents and the lower-level agents are downward sloping. That is, under both hierarchy forms, increase in generalist's effort will reduce the specialist's effort, and vice versa.

Proof. See the argument above.

qed.

The finding in Lemma 1 is consistent with Aghion and Tirole (1997): centralization harms the incentive of the agents at lower level; that is, the effort of the upper-level agents will crowd out the effort of lower-level agents. Thus, there is a tradeoff between incentive at lower level and loss of control, since the lower-level agents and the upper-level agents have different decision on the use of the assets. However, as discussed before, in the case of having no idea, upper-level agents will always want to delegate. In addition, the model here is different from the model in Aghion and Tirole (1997) in two senses. First of all, in the model here, both upper-level and lower-level agents are treated as "agent" in an agent-principal problem, and the "principal" is the firm, the one who constructs the hierarchy. Nevertheless, in Aghion and Tirole (1997), the upper-level agent acts as the "principal", and the lower-level agent acts as the "agent". Secondly, in the model here, the expected income of a lower-level agent only depends on the expected value he generated by his own, but in Aghion and Tirole (1997), the expected income of a lower-level agent not only depends on the expected value he generated by himself, but also depends on the principal's expected value generated.

Lemma 2. Given the optimal effort-wage pairs, a generalist will choose (e^{g2*}, a^{*}) and a specialist will choose (e^{s1*}, b^{*}) under the *gss* form, and a generalist choose (e^{g2*}, b^{*}) and a specialist will choose (e^{s1*}, a^{*}) under the *ssg* form.

Proof. Because the participation constraints are binding, (e^{g2*}, a^{*}) for a generalist and (e^{s1*}, b^{*}) for a specialist satisfy equality of eq. (4) and equality of (5) under the *gss* form. Under the assumption of types and productivities and Assumption (4), $P^{s2}(e^{g2*},2) < P^{g2}(e^{g2*},2)$, $P^{g1}(e^{s1*},1) < P^{s1}(e^{s1*},1)$. Thus, (e^{g2*}, a^{*}) will give a

specialist negative expected utility; and (e^{s1*}, b^*) will give a generalist negative expected utility; and therefore a generalist will never choose (e^{s1*}, b^*) and a specialist will never choose (e^{g2*}, a^*) under the *gss* form. Similarly, one can prove that under the *ssg* form, a generalist will always choose (e^{g2*}, b^*) and a specialist will choose (e^{s1*}, a^*).

qed.

Proposition 1. If the gain of coordinating assets by the generalist is large, the hierarchy form *gss* is optimal; otherwise, the hierarchy form *ssg* is optimal.

Proof. Subtract eq. (14) by eq. (24), one gets:

$$E\pi^*_{gss} - E\pi^*_{ssg} = \{P^{g2}\left(e^{g2*}_{gss}, 2\right) - [1 - P^{s1}(e^{s1*}_{ssg}, 1)]^2 P^{g2}(e^{g2*}_{ssg}(e^{s1*}_{ssg}), 2)\}V(2) - [C\left(e^{g2*}_{gss}\right) - C(e^{g2*}_{ssg}(e^{s1*}_{ssg}))] - 2\{P^{s1}\left(e^{s1*}_{ssg}, 1\right) - [1 - P^{g2}(e^{g2*}_{gss}), 2)]P^{s1}(e^{s1*}_{gss}, 1)\}V(1) + 2[C\left(e^{s1*}_{ssg}\right) - C(e^{s1*}_{gss})] \quad (25)$$

It is trivial to show that the first part (first two items) of the right-hand side of eq. (25) is positive, and the second part (last two items) is negative. Therefore, if the first part is larger than the second part, i.e., the gain of coordinating multiple assets by the generalist is large, then the generalist should be at the top, and the *gss* form is optimal; otherwise, the specialists should be at the top, and the *ssg* form is optimal.

qed.

The intuition of Proposition 1 is that since the effort of an upper-level agent will crowd out the effort of the lower-level agents as shown in Lemma 1, if the potential net output (net of wage payment) produced by a generalist is large, then the principal should not assign him at lower level where his effort will be inhibited. Otherwise, if the coordination is not important, then the specialist should be assigned to the upper level where he will exert a higher effort. Proposition 1 is consistent with the claim in Hart and Moore (2005). Involving incentive in hierarchy makes the necessary and sufficient condition of optimal hierarchy form much more complicated; however, unlike Hart and Moore's model, the agent at the top does not necessarily have lower probability of generating value.

3.5. How Many Agents at the Top

This section still deals with a single period $t \geq 2$ (the subscript t is ignored in this section). Assume the optimal hierarchy is a pyramid form (like the *gss* form), and the assumption below applies.

Assumption (6) There are n assets in the firm, and the span of control of an upper-level agent is m; i.e., an upper-level agent is senior to m lower-level agents.

The size of n depends on the size of the firm, which is assumed exogenous. The size of n may be affected by technology, market structure, and industry, but not by the hierarchy structure. Under assumptions (6), there need n/m upper-level agents and n lower-level agents in the optimal hierarchy. Firm's problem becomes

$$max_{a,b} E\pi = \frac{n}{m}[P^{gm}(e^{gm}, m)V(m) - W^u] + n\{[1 - P^{gm}(e^{gm}, m)]P^{s1}(e^{s1}, 1)V(1) - W^l\} \quad (26)$$

subject to

$$E(U^g) = W^u - C(e^{gm}) = P^{gm}(e^{gm}, m)V(m) + m[1 - P^{gm}(e^{gm}, m)]P^{s1}(e^{s1}, 1)V(1) - a - C(e^{gm}) \geq \bar{u} \quad (27)$$

$$E(U^s) = W^l - C(e^{s1}) = [1 - P^{gm}(e^{gm}, m)]P^{s1}(e^{s1}, 1)V(1) - b - C(e^{s1}) \geq \bar{u} \quad (28)$$

$$max_e E(U^g) = P^{gm}(e^{gm}, m)V(m) + m[1 - P^{gm}(e^{gm}, m)]P^{s1}(e^{s1}, 1)V(1) - a - C(e^{gm}) \quad (29)$$

$$max_e E(U^s) = [1 - P^{gm}(e^{gm}, m)]P^{s1}(e^{s1}, 1)V(1) - b - C(e^{s1}) \quad (30)$$

The first-order conditions of eq. (29) and (30), i.e., eq. (31) and (32) give the optimal effort levels, $e^{gm*}(m)$ and $e^{s1*}(m)$.

$$p_e^{gm\prime}(e^{gm}, m)[V(m) - m\,P^{s1}(e^{s1}, 1)V(1)] = C'(e^{gm}) \quad (31)$$

$$p_e^{s1\prime}(e^{s1}, 1)[1 - P^{gm}(e^{gm}, m)]V(1) = C'(e^{s1}) \quad (32)$$

Substitute $e^{gm*}(m)$ and $e^{s1*}(m)$ into binding participation constraints (equation (27) and (28) with equal signs), one can get the optimal $a^*(m)$ and $b^*(m)$.

$$a^* = P^{gm}(e^{gm*}(m), m)V(m) + [1 - P^{gm}(e^{gm*}(m), m)]P^{s1}(e^{s1*}(m), 1)V(1) - C(e^{gm*}(m)) - \bar{u} \quad (33)$$

$$b^* = [1 - P^{gm}(e^{gm*}(m), m)]P^{s1}(e^{s1*}(m), 1)V(1) - C(e^{s1*}(m)) - \bar{u} \quad (34)$$

Thus, the expected profit of the firm with the optimal effort-wage pairs is

$$E\pi^* = \frac{n}{m}\left[P^{gm}(e^{gm*}(m), m)V(m) - C\left(e^{gm*}(m)\right)\right] + n\left\{[1 - P^{gm}(e^{gm*}(m), m)]P^{s1}(e^{s1*}(m), 1)V(1) - C\left(e^{s1*}(m)\right)\right\} - (m+1)\frac{n}{m}\bar{u} \quad (35)$$

The first-order condition of eq. (35) with respect to *m* gives the optimal span of control *m**.

Lemma 3. The optimal span of control is independent of the size of the firm.

Proof. The proof is trivial, as all n's are cancelled out in the first-order condition of eq. (35).

qed.

From assumption (3), there is a positive externality of coordinating multiple assets. Define the *elasticity of externality of cooperating multiple assets* as the sensitivity of potential value increased when an agent working with more assets.

$$\textit{Elasticity (externality of cooperating } m \textit{ assets)} = \frac{V'(m)}{\frac{V(m)}{m}} \quad (36)$$

Proposition 2. The more elastic the externality of cooperating is, the larger the span of control should be; otherwise, the span of control should be small.

The proof is tedious and is skipped here, but the intuition is simple. Here, the upper-level agents are generalists, and they work with multiple assets. If their

cooperating effect is significant and has large impact on the value, then they should work with more assets, and the hierarchy should have larger span of control; therefore, steeper hierarchy is favorable. Otherwise, there should be small span of control, and therefore flatter hierarchy is favorable.

3.6. Who Wants to Get to the Top

Now go back to solve the period 1's problem. Like the previous section, this section also assumes the optimal hierarchy is a pyramid form (like the *gss* form), and there are n assets and the span of control of upper-level agent is m. In addition, as committed ex ante, Q_0 percentage of agents with the highest value generated will be promoted to the upper level at the beginning of period 2. Assume in period 1, all agents work with one asset, so that Q_0 percentage of agents with the higher value generated will be the same as the Q_0 percentage of agents with the higher probability of generating value.

Assume the distribution of the agents' probability of generating value in period 1 is $f_0(P)$, and the cumulative density function is $F_0(P)$. Let *P** be such that $Q_0 = 1 - F_0(P^*)$. That is, if an agent's probability of generating value greater than P^*, he will be promoted to the upper level. P^* is endogenous, but a single agent treats P^* as a parameter. Define the distribution of $(P^* - P)$ as $f(P^* - P)$, and the cumulative density function is $F(P^* - P)$. Then for an agent who has probability P of generating value, the probability of being promoted is

$$Q = [1 - F(P^* - P)] \tag{37}$$

The firm's problem is

$$max\ E(\pi) = \pi_1 + \pi_2 + \pi_3 + \cdots + \pi_H + \pi_{H+1} + \cdots \tag{38}$$

subject to

$$W_0 - C(e_1^g) + F\left(P^* - P_1^{g1}\left(\left(e_1^g, 1\right)\right)\right)\sum_{1<t\leq T}[W_t^l - C(e_t^{g1})]$$

$$+\left[1-F\left(P^{*}-P_{1}^{g1}\left(\left(e_{1}^{g},1\right)\right)\right)\right]\sum_{1<t\leq T}[W_{t}^{u}-C(e_{t}^{gm})]\geq\ \sum_{t\leq T}\bar{u} \quad (39)$$

$$W_{0}-C(e_{1}^{s})+F\left(P^{*}-P_{1}^{s1}\left((e_{1}^{s},1)\right)\right)\sum_{1<t\leq T}[W_{t}^{l}-C(e_{t}^{s1})]$$

$$+\left[1-F\left(P^{*}-P_{1}^{s1}\left((e_{1}^{s},1)\right)\right)\right]\sum_{1<t\leq T}[W_{t}^{u}-C(e_{t}^{sm})]\geq\ \sum_{t\leq T}\bar{u} \quad (40)$$

$$maxe\ E((U^{g})=W_{0}-C(e_{1}^{g})+F\left(P^{*}-P_{1}^{g1}\left(\left(e_{1}^{g},1\right)\right)\right)\sum_{1<t\leq T}[W_{t}^{l}-C(e_{t}^{g1})]$$

$$+\left[1-F\left(P^{*}-P_{1}^{g1}\left(\left(e_{1}^{g},1\right)\right)\right)\right]\sum_{1<t\leq T}[W_{t}^{u}-C(e_{t}^{gm})] \quad (41)$$

$$maxe\ E(U^{s})=W_{0}-C(e_{1}^{s})+F\left(P^{*}-P_{1}^{s1}\left((e_{1}^{s},1)\right)\right)\sum_{1<t\leq T}[W_{t}^{l}-C(e_{t}^{s1})]$$

$$+\left[1-F\left(P^{*}-P_{1}^{s1}\left((e_{1}^{s},1)\right)\right)\right]\sum_{1<t\leq T}[W_{t}^{u}-C(e_{t}^{sm})] \quad (42)$$

Eq. (39) and (40) are the agents' participation constraints, and eq. (41) and (42) are the agents' incentive compatibility constraints. Since the monotone likelihood ratio property holds under the assumptions, one can replace eq. (41) and (42) with their corresponding first-order conditions.

$$-C'(e_{1}^{g})+F'(\bullet)P_{1}^{g1\prime}(e_{1}^{g},1)\ \sum_{1<t\leq T}\{\left[W_{t}^{u}-C\left(e_{t}^{gm}\right)\right]-[W_{t}^{l}-C(e_{t}^{g1})]\}=0 \quad (43)$$

$$-C'(e_{1}^{s})+F'(\bullet)P_{1}^{s1\prime}(e_{1}^{s},1)\ \sum_{1<t\leq T}\{[W_{t}^{u}-C(e_{t}^{sm})]-[W_{t}^{l}-C(e_{t}^{s1})]\}=0 \quad (44)$$

Proposition 3. Under the assumption of types and productivities, given the contract under the *gss* form, the generalist has more incentive to exert higher effort in period 1 and thus is more likely to be promoted.

Proof. Because of the assumption of types and productivities, in period $t \geq 2$, being at the upper level and working with m assets is more favorable for a generalist. That is, in eq. (43) and (44) (the first-order conditions of incentive compatibility constraints), $\{\left[W_{t}^{u}-C\left(e_{t}^{gm}\right)\right]-[W_{t}^{l}-C(e_{t}^{g1})]\}$ for a generalist is relatively larger than $\{[W_{t}^{u}-C(e_{t}^{sm})]-[W_{t}^{l}-C(e_{t}^{s1})]\}$ for a specialist. Therefore, because of the higher

marginal benefit of effort, a generalist has more incentive to exert effort and thus can have higher probability of generating value in period 1, and thus, he is more likely to be promoted in period 2.

qed.

3.7. Conclusion

This paper analyzes optimal hierarchy using a T-period model. Agents' types are unobservable at hiring, and their effort levels are unobservable, so there are hidden information problem and hidden action problem. Firm wants to choose the optimal hierarchy form to maximize profit and assign proper types of agents to realize the optimal hierarchy. Because the specialist can accumulate specialty of working with individual asset after period 1 and the generalist is more productive on coordinating multiple asset after period 1, in the optimal hierarchy the specialist should work with individual asset and the generalist should work with multiple assets. The optimal hierarchy form depends on the externality of working with multiple assets. If the externality is large, the generalist at the top is desirable; if it is small, the specialist at the top may be desirable. How many agents should be at the top depends on the elasticity of the externality of working with multiple assets. Given the pyramid form, if the externality of working with multiple assets is very sensitive to the number of the assets, the span of control should be large, and there are fewer generalists at the top; otherwise, more agents should be at the top. Finally, the T-period model with promotion can give the agents who should be at the top more incentive to get promoted.

The model has exogenous levels of hierarchy, and I only analyze the case where there are two hierarchy levels. Future work can extend the model to endogenize the layers of the hierarchy. If there are many hierarchy levels, then the lowest-level agents can get incentive from promotion opportunity; the highest-level agents get incentive from evaluation of performance; and any intermediate agents get incentive from both promotion opportunity and evaluation of performance.

3.8. References

Aghion and Tirole (1997) “Formal and Real Authority in Organizations”, *Journal of Political Economy*, vol. 105(1), p. 1-28

Athey and Roberts (2001) “Organizational Design: Decision Rights and Incentive Contracts”, *Organizational Economics*, vol. 91(2), p. 200-205

Bolton and Dewatripont (1994) “The Firm as a Communication Network”, *Quarterly Journal of Economics*, vol. 109(4), p. 809-839

Gibbs (1995) “Incentive Compensation in a Corporate Hierarchy”, *Journal of Accounting and Economics*, vol. 19, p. 247-277

Harris and Raviv (2002) “Organization Design”, *Management Science*, vol. 48(7), p. 852-865

Hart and Moore (2005) “On the Design of Hierarchies: Coordination versus Specialization”, *Journal of Political Economy*, vol. 113(4), p. 675-702

Jacques (1990) “In Praise of Hierarchy”, *Harvard Business Review*, vol. 68, p. 127-133

Jensen and Meckling (1992), “Specific and General Knowledge, and Organizational Structure”, *Contract Economics*, Blackwell, Oxford, p. 251-274

Malcomson (1984) “Work Incentives, Hierarchy, and Internal Labor Markets”, *Journal of Political Economy*, vol. 92(3), p. 486-507