Missing Women and the Price of Tea in China:

The Effect of Sex-Specific Earnings on Sex Imbalance

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Abstract

Economists have long argued that the severe sex imbalance which exists in many developing countries is caused by underlying economic conditions. This paper uses plausibly exogenous increases in sex-specific agricultural income caused by post-Mao reforms in China to estimate the effects of total income and sex-specific incomes on sex ratios of surviving children. The results show that increasing income alone has no effect on sex ratios. In contrast, increasing female income while holding male income constant increases survival rates for girls and increasing male income while holding female income constant decreases survival rates for girls. Moreover, increasing the mother's income increases educational attainment for all children while increasing the father's income decreases education attainment for girls and has no effect on boys' education attainment. (*JEL* I12, J13, J16, J24, O13, O15)

1 Introduction

Many Asian populations are characterized by highly imbalanced sex ratios. For example, only 48.4% of the populations of Albania, India and China are female in comparison with 50.1% in western Europe. Amartya Sen (1990, 1992) coined the expression "missing women" to refer to the observed female "deficit" in comparing sex ratios of developing countries with sex ratios of rich countries. An estimated 30-70 million women are "missing" from India and China alone. This phenomenon is not isolated to

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poor countries. Sex ratios of South Korea and Taiwan are identical to those of India and China. And Figures 1A and 1B show that China's sex imbalance is *increasing* rather than decreasing with rapid economic growth. In the long run, male-biased sex ratios can affect marriage market and labor market outcomes (Angrist, 2002; Samuelson, 1985). A more immediate concern is that to select the sex of a child, parents must resort to methods such as selective abortion, neglect or infanticide. Furthermore, the increasing availability of technology that facilitates sex-selective abortion leads to the reasonable concern that sex imbalance will continue to increase.

Previous research suggests that there are a number of factors associated with sex imbalance. Becker (1981) argued that sex imbalance responds to income. However, the empirical evidence is mixed (Burgess and Zhuang, 2001; Edlund, 1999; Grogan, mimeo; Gu and Roy, 1995; Li, 2002). An alternative hypothesis is that female survival rates, along with other outcomes for girls relative to boys, responds to the relative status of adult women (e.g. education or income). This has been supported with empirical evidence in studies by Ben Porath (1967, 1973, 1975), Burgess and Zhuang (2002), Clark (2000), Duflo (2002), Das Gupta (1987), Foster and Rosenzweig (2001), Rholf et. al. (2005), Rosenzweig and Schultz (1982) and Thomas et. al. (1991). Lastly, there are studies that argue that sex imbalance can be explained by biological factors completely unrelated to economic conditions (Norberg, 2004; Oster, 2005). The empirical challenge facing all of these studies is that the variable of interest may be correlated with omitted variables such as "culture".[1] For example, the observed correlation between sex ratios and socioeconomic status of adult females may reflect cultural attitudes towards women rather than the causal effect of relative female economic status on sex ratios. Foster and Rosenzweig's (2001) recent study of India exploits cross-sectional variation and time-variation in sex-specific returns to human capital to address this issue. They find that female survival rates are positively correlated with returns to having girls. [2]

This paper exploits variation in regional incomes and sex-specific incomes over time in China to capture the causal effect of economic conditions on sex ratios. I exploit first, variation in intensity of labor input across crops by sex and second, exogenous variation in agricultural income caused by two post-Mao reforms (1978-1980). This identification strategy is similar to Schultz's (1985) study of Swedish fertility rates in the late 19th century, which used changing world grain prices to instrument for changes in the female-to-male wage ratio. In China, women have a comparative advantage in picking tea, while men have a comparative advantage in orchard production. Hence, an increase in the relative value of tea increases both total income and *relative* female income in tea-producing households. Conversely,

[1] In this case, culture is defined to be slow-moving and endemic traits of society. While in the long run, culture can be affected by economic conditions, culturally based preferences do not quickly react to economic incentives.

[2] They exploit regional and time variation in sex-specific returns to human capital caused by the practice of patrilocal exogamy and productivity increases during the Green Revolution in India. (Patrilocal exogamy is the practice for married couples to reside with families of husbands). They test the hypotheses that parents may wish to avoid having female children when marriage requires a large dowry, or, that the demand for girls relative to boys may increase when female productivity increases.

an increase in the relative value of orchards increases total income but reduces relative female income.

A differences-in-differences framework is used to compare sex ratios for cohorts born before and after the reforms, between counties that plant and counties that do not plant sex-specific crops that experienced an increase in value due to the reform. First, I estimate the effect of an increase in adult female income on sex ratios holding adult male income constant, by estimating the effect on sex ratios of an increase in relative tea value. Second, I estimate the effect of an increase in adult male income on sex ratios while holding adult female income constant, by estimating the effect on sex ratios of an increase in relative value of orchards. Third, I investigate the effect of an increase in total household income without changing the relative female and male incomes by estimating the effect of an increase in the relative value of sex-neutral cash crops on sex ratios. These three estimates together allow me to distinguish the effects of increasing sex-specific (relative) incomes from the effects of increasing total household income. Finally, by using the same strategy for educational attainment, I am able to estimate the effects of increasing total and relative incomes on educational attainment of boys and girls.

The results show that an increase in relative adult female income has an immediate and positive effect on the survival rate of girls. In rural China during the early 1980s, increasing adult female income by US$7.70 (10% of average rural household income) while holding adult male income constant increased the fraction of surviving girls by 1 percentage-point and increased educational attainment for both boys and girls. Conversely, increasing male income while holding female income constant decreased both survival rates and educational attainment for girls, and had no effect on educational attainment for boys. Increasing total household income alone had no effect on either survival rates or educational attainment.

These findings imply that the increase in China's gender wage gap can partly explain the increase in sex imbalance as well as the decrease in rural education enrollment observed by Park and Hannum (mimeo). Furthermore, the findings add to the existing empirical evidence for the bargaining model of household decision making (Duflo, 2002; Park and Rukumnuaykit, 2004; Thomas, 1994). The effects on survival can be explained by either a model of intra-household bargaining or by a unitary model of the household where parents view children as a form of investment. The results on education, however, are not consistent with the latter model unless returns to education for girls are negatively correlated with male income and returns to education for boys and girls are positively correlated with female income. Therefore, the results for survival and education investment together suggest that at least part of the effect is due to changes in the bargaining power of the woman in the household. For policy makers, the results imply that factors that increase the economic value of women are also likely to increase the survival rates of girls and increase education investment in all children.

This study has several advantages over previous studies. First, a number of potentially confounding factors were fixed in China during this period. Migration was strictly controlled, little technological change occurred in tea production, sex-revealing technologies were unavailable to the vast majority of

China's rural population (Diao et. al., 2000; Zeng, 1993), and stringent family planning policies largely control family size.[3] Second, by estimating the effects of sex-specific wages on female survival rates and educational attainment, this study can speak to concerns regarding the impact of increasing gender wage gaps.[4] Finally, the availability of three censuses avoids the confounding of age and "cohort" effects. For example, Figures 1A and 1B show that in any census, age is negatively correlated with sex ratios. If only one census was available, the data would not be able to distinguish between the two hypotheses: 1) variation in the cross section is driven by differences across age groups – e.g. there are sex-differential mortality rates during childhood such that more boys are born and higher mortality rates for boys cause sex ratios to be negatively correlated with age (*age effect*); and 2) variation in the cross section is driven by differences across birth cohorts – e.g. the fraction of boys born is increasing each year (*cohort effect*). By plotting multiple censuses by birth year, Figure 1A shows that for any given birth year, sex ratios are similar between 1982, 1990 and 2000. In other words, sex ratios for a given birth cohort does not change as the cohort ages. This is inconsistent with the hypothesis that cross sectional variation in sex ratios is driven by differential mortality or age effects. Alternatively, Figure 1B plots sex ratios by age from the 1982 and 1990 censuses. It shows that there are more males for every age in 1990. Like the previous figure, this shows that cross sectional variation in sex ratios in China should be interpreted as cohort variation and not as age variation in sex ratios.[5] Interestingly, establishing that there is a positive cohort trend in sex ratios allows me to reject the possibility that the empirical findings of this paper are due to the recently posited biological explanations such as cohabitation patterns or hepatitis B.[6]

The following sections describe the policy background, conceptual framework, data, the empirical strategy and results, the interpretation of the results and offers the conclusion.

[3] See interpretation section for detailed discussion of family planning policies.

[4] Many studies estimate China's gender wage gap to have increased by over 100% since 1976. Before the reform, compensation for workers were set according to education, experience and skill. There was no official differentiation between sexes (Cai et. al., 2004, Rozelle et. al. 2002).

[5] Figure 1B also shows that the age structure of sex ratios in China in 1982 is very similar to that of the U.S.

[6] In a study of the U.S., Norberg (2004) finds that women living with an opposite-sex partner were 14% more likely to have a male child. However, there is no evidence of increased cohabitation during this period in China and divorce rates were *rising*. Oster (2005) hypothesizes that hepatitis B infection rates of pregnant mothers result in higher sex ratios at birth. She argues that this can explain 75-85% of China's total observed sex imbalance in the 1982 cross-section. However, in the context of this study, China's introduction of the vaccine in 1981 would imply that the prevalence of the disease (and sex ratios in Figures 1A and 1B) should be *decreasing*. Moreover, both cohabitation and hepatitis B infection rates are likely to be correlated with socioeconomic variables such as relative status of women which may affect sex ratios directly.

2 Background

2.1 Agricultural Reforms

Pre-1978 Chinese agriculture was characterized by an intense focus on grain production, allocative inefficiency, lack of incentives for farmers and low rural incomes (Sicular, 1988a; Lin, 1988). Agricultural policies aimed at subsidizing urban industrial populations with cheap food centered around production planning. After agriculture was unified in 1953 (*tong gou tong xiao*), planning included mandatory targets for crop cultivation, areas sown, levels of input applications and planting techniques by crop. Amongst these targets, sown area was the most important, in part, because it was easier to enforce (Sicular, 1988a).

Central planning divided crops into three categories. Category 1 included crops necessary for national welfare: grains, all oil crops and cotton. Procurement prices for grain during this period were generally 20%-30% lower than market prices (Perkins, 1966) and market trade of these products was strictly prohibited (Sicular, 1988a). Category 2 included up to 39 products, including: livestock, eggs, fish, hemp, silkworm cocoons, sugar crops, medicinal herbs and tea (Sicular, 1988b).[7] Category 3 included all other agricultural items (mostly minor local items); these were not under quota or procurement price regulation.

Under the unified system, the central government set procurement quotas for crops of categories 1 and 2 that filtered down to the farm or collective levels. Quota production was purchased by the state at very low prices. These quotas were set so that farmers were supposed to retain enough food to meet their own needs. But in reality, farmers were left with little remaining surplus (Perkins, 1966). Non-grain producers produced grain and staples for their own consumption and sold all cash crop output to the state at suppressed prices. Farmers had very little incentive to produce more than their quota.

After the Great Famine (1959-1961), the government re-emphasized grain production by increasing procurement prices for grain relative to other crops. The state resorted to commercial and production planning to carry out the objectives of grain production (*yi liang wei gang*) and self-sufficiency (*zi li geng sheng*). The government increased production by enforcing mandatory sown area targets for crops and promoted self-sufficiency by purchasing but not selling grain and oils in rural areas. Mandatory sown area targets often required cultivation on land unsuitable for grain. Grain production grew at substantial cost of other production. Production declined for crops which competed with grain for land. Living standards declined significantly in areas suitable for commercial crops (Lardy, 1983).

Post-Mao era reforms focused on increasing rural income, increasing deliveries of farm products to the state, and diversifying the composition of agricultural production by adjusting relative prices and profitability. Two sets of policies addressed this aims. The first set of policies gradually reduced plan-

[7] The number of crops in each category changed over time. And the number of crops reported in for each category for a given year may vary across sources.

ning targets and reverted to earlier policies of using procurement price as an instrument for controlling production (Sicular, 1988a). In 1978 and 1979, quota and above quota prices were increased by approximately 20%-30% for grain and certain cash crops. By 1980, prices had increased for all crops. Although category 1 crops benefited from the price increases, emphasis was placed on cash crops from category 2. The second set of policies, named the *Household Production Responsibility System* (HPRS), devolved responsibility from the collective, work brigade, or work team to households (Johnson, 1996; Lin, 1988). The HPRS was first enacted in 1980 and spread through rural China during the early 1980s, devolving all production decisions and quota responsibilities to individual households. The HPRS allowed households to take full advantage of the increase in procurement prices by partially shifting production away from grain to cash crops when profitable.

Together, the two reforms contributed to diversification of agricultural production, greater regional specialization, and less extensive grain cultivation (Sicular, 1988a). There was an immediate and significant increase in the output of cash crops (Johnson, 1996; Sicular 1988a). However, although the value of all crops increased, continued emphasis on rural-urban subsidization of grain and other category 1 products caused the *relative* value of category 1 products to decrease.[8] I will compute the income from each crop directly in the next section, but the increase in the relative value of category 2 crops is also reflected in the disproportionate growth in output of category 2 crops in comparison with category 1 crops. Figures 2A and 2B show that although output for category 1 crops increased, there is no change in the rate of increase. Figures 2C and 2D show that the rate of increase for suburban vegetables and orchard fruits, both category 2 crops, accelerated after the reform. Similar increases can be observed for tea, another category 2 crop, in Figure 3.

In a second round of reforms designed to reduce the fiscal burden of grain subsidies, the state increased urban grain retail prices and stopped guarantees of unlimited procurement of category 1 products at favorable prices. On average, contract procurement prices for grain were 35% lower than market prices (Sicular, 1988a). This change, combined with the de-regulation of other crops, further decreased the relative-profitability of category 1 products.

Complete substitution away from producing grains was prevented by the state's continued enforcement of household level grain production quotas and its suppression of intra-rural grain trade. As late as 1997, virtually every agricultural household planted staple crops (Eckaus, 1999). Using the 1997 Agricultural Census, Diao et. al. (2000) show that on average, 80% of sown area is devoted to grain and that self-sufficiency in grain was still an important part of Chinese agriculture.

One possible cause of the magnitude and speed of the response of the Chinese agricultural sector is the low labor productivity in the agricultural sector resulting from migration and other labor controls. Calculations for the marginal productivity of labor in Chinese agricultural production vary greatly.

[8]The central government complained that staple crop targets were under-fulfilled while production of economic crops greatly exceed plans (Sicular, 1988a).

However, most studies agree that the high population-to-land ratio and labor market and migration controls result in low marginal productivity in rural areas during this period. Households living in areas with the appropriate natural conditions can then easily expand into cash crop production in response of new economic opportunities. This is consistent with the fact that agricultural households very rarely hired labor from outside the family. In 1997, 1 per 10000 rural households hired a worker from outside of the immediate family (Diao et. al., 2000). Since migration and labor market controls were more strict in the 1980s, it is most likely that the households studied in this paper hired even fewer non-family members. Plentiful cheap adult labor would also reduce demand for child labor.

2.2 Tea and Orchard Production

This section discusses male and female labor intensities in tea and orchard production and how the production of each reacted to post-Mao reforms. I will also directly estimate the income from each crop and show that: the reforms increased income from category 2 cash crops (including tea and orchards) relative to income from category 1 staple crops; and income from tea did not exceed income from other category 2 cash crops. The latter fact addresses the possibility that the effect of income on sex ratio is not linear. An increase in income from tea (orchards) translates into an increase in total household income as well as an increase in relative female (male) income. On the other hand, sex neutral cash crops only affect total household income. To discern whether sex ratios are responding total income or relative female (male) income, I estimate the effect of sex-neutral cash crops on sex ratios. However, if the income effect on sex ratio is non-linear such that there exists some threshold income which must be met before income will affect sex ratio, this strategy will only work if income from tea does not exceed income from sex neutral cash crops.

Across Asia, tea is mainly picked by women. Labor input data by sex and crop is not available to examine sex specialization directly; however, in a study of South Indian tea plantations, Luke and Munshi (2004) show that 95% of workers are female. The most commonly cited reasons for why adult women have an absolute advantage in picking tea over adult men and children is that tea picking favors small and agile fingers. In general, the value of the tea leaves increase with the tenderness (youth) of the leaf. Adult women have a particular advantage over children, who are considered more careless, in picking green tea leaves, which is worthless if broken.[9] In addition, tea bushes are on average 2.5 feet (0.76 meters) tall, which disadvantages taller adult males. For China, the specialization caused by women's physical advantage might have been increased by strictly enforced household grain quotas that forced every household to plant grain. In households that wished to produce tea after the reform, men continued to produce grain while women switched to tea production. It follows that for tea planting households, an increase in tea value increased both the total household income and the *relative* value of adult female labor. Moreover, monitoring of tea picking is made difficult by the fact that tea picking

[9] Breakage causes tea leaves to oxidize and blacken.

is a very delicate task and that the quality and value of tea leaves vary greatly with the tenderness of the leaf. This resulted in almost no hired labor. Hence, the relative value of female labor increased in households that could produce tea despite the availability of cheap outside labor.

In contrast, height and strength yields a comparative advantage for men in orchard producing areas.[10] For orchard producing households, an increase in the value of orchard fruits increased both total household income and the *relative* value of adult male labor.

The presence of child labor cannot be ruled out in any agricultural production. However, adult labor surplus resulting from land shortages and labor market controls leaves little demand for child labor. In section 4 of this paper, I will establish that the identification strategy is robust to the possibility that children and adult males (females) contribute to tea (orchard) production.

The main effect of post-Mao reforms for tea production was to increase picking. Considered a priority crop, tea production was collectivized in the 1950s. Procurement and retail were completely nationalized by 1958. During the Cultural Revolution, the government pursued an aggressive expansion of tea fields. However, since farmers had little incentive to produce and tea picking is more difficult to enforce than sowing, most of the sown fields were left wild and untended until the post-Mao era, when the HPRS disaggregated 500 state tea farms into over 90,000 household level tea production units. Tea bushes were restored by extensive tending and pruning (Forster and Etherington, 1992). The procurement price for tea, which was largely unchanged between 1958-1978, doubled between 1979 and 1984. Figure 3A shows the increase in procurement price and yield for tea. Since there was no change in sown area during this period, the yield increase reflects an increase in picking, which, in turn, reflects an increase in the value of female labor.

Data for agricultural income by crop is not available during this period. Crop composition for the average household in tea planting counties from the 1997 Agricultural Census and data on net income by crop from tea planting households in 1982 (Etherington and Forster, 1994) suggest that in tea producing counties, tea comprises of 1-4% of total household net income. To examine the change in value of crops over time, I calculate the approximate gross income by crop using data on output per standard labor day by year by crop and procurement price by year by crop.[11] Figure 4A shows the national annual gross income from category 1 crops and tea. After 1979, income from tea increased at a faster rate than income from grains. I will exploit this increase to estimate the effect of an increase in relative

[10] Adult men have a comparative advantage in orchard production during both sowing and picking periods. Sowing orchard trees is strength intensive as it requires digging holes approximately 3 feet (0.91 meters) deep. The strength requirement is re-enforced by the fact that Chinese soil is composed of 85% rock. The height of apple trees and orange trees range between 16-40 feet (4.9-12.2 meters) and 20-30 feet (6.1-9.1 meters). The height of the trees mean that adult males have advantages both in pruning and picking over adult females and children. Orchard trees that are most commonly observed in orchards today are either genetically modified (stunted) to be short or kept short by constant pruning.

[11] Data on output per standard labor day by year by crop is reported by the National Bureau of Statistics of China. To the best of my knowledge, labor supply does not vary across years in their calculations.

adult female income on sex ratios. Figure 4B shows that the calculated income from orchard production increased at a faster rate than income from category 1 crops. I will exploit this increase to estimate the effect of an increase in relative male income on sex ratios.

Amongst category 2 crops, the government maintained more control on tea than other crops. Tea was viewed as a political symbol by the central government from the early 1950s. In 1984, tea was one of the nine crops to remain under designated procurement price. The central government continued to maintain a retail monopoly on tea up to the early 1990s. Until the late 1980s, China exported tea at subsidized prices. Part of the subsidy was achieved by suppressing procurement prices of tea (Etherington and Forster, 1994). Consequently, although price for tea grew significantly after 1979, tea was not as profitable as many other cash crops. Figure 4C shows that the gross income from tea experienced similar increases to other category 2 cash crops immediately after the reform. By 1983, the rate of increase was less than income from other category 2 crops although the income from tea continued to increase.

3 Conceptual Framework

This section presents a simple model of sex imbalance. I use this framework to show that adult income affects the desirability of daughters relative to sons through two mechanisms: first by changing the consumption value of having a girl relative to having a boy; and second by changing the investment value of having a girl relative to having a boy. Moreover, it shows that if households are not unitary (e.g. parents do not have identical preferences), a change in adult income can also affect the relative desirability of girls by changing the bargaining power of each parent within the household (Bourguignon et. al., 1993; Browning and Chiappori, 1998). The model generates empirically testable predictions for the unitary case.

3.1 Decision Rule

For most cohorts in this study, family size was constrained by China's family planning policies. Thus, I make the simplifying assumption that all households have exactly one child. The only decision which faces parents is the sex of their child. Because parents do not have access to prenatal sex revealing technology, parents select the sex of their child by deciding to keep or neglect a child once she is born. Conditional on having a girl, parents for each household i compare the maximum utility that they can derive from a girl and the maximum utility they can derive from a boy, and will choose to keep a girl if $V_g^H - V_b^H > \varepsilon_i$, where V_s^H is the household's indirect utility in the state of the world where it has a child of sex s, $s \in \{g, b\}$, and ε_i is the cost of sex selection for household i.

The probability of having a girl can be written as:

$$\Pr(S = g) = \Pr\left(\varepsilon_i < V_g^H - V_b^H\right) = F(V_g^H - V_b^H) \tag{1}$$

An increase in the probability of keeping a girl will be reflected in the population as an increase in the fraction of girls.

Let y_ρ, $\rho \in \{m, f\}$ denote parents' (mother's and father's) incomes. Given that $F'(\cdot) > 0$, if $\frac{\partial(V_g^H - V_b^H)}{\partial y_\rho} > 0$, then the probability of keeping a girl is increasing in parental income.

Henceforth, denote $\Gamma_{y_p} = \frac{\partial(V_g^H - V_b^H)}{\partial y_\rho}$.

3.2 Household Utility

The utility of parent ρ is $u_s^\rho(c)$, where $\rho \in \{m, f\}$ and s, $s \in \{g, b\}$, indicates the state of the world (sex of the child). c is each parent's consumption bundle. I normalize the price of consumption to equal 1. In each state s, parents pool their income and maximize the weighted sum of the mother's and father's utilities, $u_s^m(c)$, $u_s^f(c)$, subject to a household budget constraint comprised of the incomes of the father, mother and a child of sex s, y_f, y_m and y_s. Credit markets are assumed to be perfect such that parents can borrow against the child's adult income. For convenience, I represent parents' consumption and investment decisions in a one period model. The indirect utility function in state s, $V_s(y)$, is the maximand of the following household utility function.

$$\begin{aligned} V_s^H &= \max_c \mu u_s^m(c) + (1-\mu) u_s^f(c) \\ \text{s.t. } c &= y_f + y_m + y_s \end{aligned}$$

The investment value of a child is characterized by the inclusion of his/her income in the budget constraint. The weight, μ, which characterizes bargaining power, is a function of the mother's and father's income ratio. Hence, the mother's bargaining power is increasing in her income and decreasing in the father's income. Note that the unitary model is simply the special case of the bargaining model where parents have identical utility functions, $u_s^m = u_s^f$.

Assume that the productivity of a child is positively correlated with the productivity of parents such that a child's income is a function of his/her parents' incomes, $y_s = y_s(y_f, y_m)$. Furthermore, assume that the correlation is stronger between a child and a parent of the same sex such that

$$\frac{\partial y_g}{\partial y_m} > \frac{\partial y_g}{\partial y_f} \text{ and } \frac{\partial y_b}{\partial y_f} > \frac{\partial y_b}{\partial y_m}$$

When parents decide whether they wish to keep or neglect a girl, they solve for the maximum utilities they can achieve in the two states of the world where they have a girl or a boy. For each state s of the world, $s \in \{g, b\}$, parents solve the Lagrangian for household utility maximization

$$\mathcal{L}_s = \max_c \mu u_s^m(c) + (1-\mu) u_s^f(c) - \lambda_s \left[c - (y_f + y_m + y_s)\right]$$

The effect of a parent's income on the probability of having a girl is

$$\Gamma_{y_\rho} = \frac{\partial \mu}{\partial y_\rho} \left[\left(u_g^m - u_b^m\right) - \left(u_g^f - u_b^f\right)\right] + \left[\lambda_g \frac{\partial y_g}{\partial y_\rho} - \lambda_b \frac{\partial y_b}{\partial y_\rho}\right] + \lambda_g - \lambda_b \tag{2}$$

It follows from the first order conditions that λ_s is the bargaining weighted sum of the mother's and father's marginal utilities from income in the state of the world where the household has a child of sex s. $\lambda_g - \lambda_b$ is the *relative* "pure income effect" of having a girl as opposed to having a boy. Holding other variables constant, the effect of a parent's income on the probability of having a girl is increasing in the relative pure income effect. This means that if a daughter complements income more than a son, $\lambda_g > \lambda_b$, an increase in income will increase the desirability of daughters relative to the desirability of sons. In other words, an increase in parents' income will increase the probability of having a girl if girls are luxury goods relative to boys. Henceforth, I call this the relative "consumption value" from having girls.

The terms in the second brackets characterize the relative "investment value" from having a daughter. Holding other variables constant, the relative desirability of a girl will increase if a girl's income increases more with the parent's income than a boy's income , $\frac{\partial y_g}{\partial y_\rho} > \frac{\partial y_b}{\partial y_\rho}$.

The terms $u_g^m - u_b^m$ and $u_g^f - u_b^f$ are the mother's and father's utilities from having a girl relative to having a boy. As long as parents do not have the same relative "sex preferences", $u_g^m - u_b^m \neq u_g^f - u_b^f$, and bargaining power depends on income, $\frac{\partial \mu}{\partial y_\rho} \neq 0$, an increase in parental income will also affect the probability of having a girl by affecting the bargaining power of each parent. Otherwise, equation (2) reduces to the unitary case.

In the general case, if parents view children as only a form of consumption, children's income will not be included in the budget constraint and the terms, $\frac{\partial y_g}{\partial y_\rho}$, $\frac{\partial y_b}{\partial y_\rho}$ will drop out of equation (2). Similarly, if parents view children as only a form of consumption in the unitary case, equation (2) reduces to λ_g- λ_b, the pure income effect. Since the pure income effect is identical across all sources of income, the effects of mothers' and fathers' income on the relative desirability is also identical in this case, $\Gamma_{y_m} = \Gamma_{y_f}$. Therefore, the joint hypotheses that households are unitary and parents view children as only a form of consumption can, in principle, be tested by comparing the effect of an increase in adult female income and the effect of an increase in adult male income on population sex ratios.

The difference between the effects of the mother's income and the father's income for the general case can be written as

$$\begin{aligned} \Gamma_{y_m} - \Gamma_{y_f} &= \left(\frac{\partial \mu}{\partial y_m} - \frac{\partial \mu}{\partial y_f}\right)\left[\left(u_g^f - u_b^f\right) - \left(u_g^m - u_b^m\right)\right] \\ &\quad + \left[\lambda_g\left(\frac{\partial y_g}{\partial y_m} - \frac{\partial y_g}{\partial y_f}\right) - \lambda_b\left(\frac{\partial y_b}{\partial y_m} - \frac{\partial y_b}{\partial y_f}\right)\right] \\ &> 0, \text{ since } \frac{\partial \mu}{\partial y_m} > \frac{\partial \mu}{\partial y_f}, \frac{\partial y_g}{\partial y_m} > \frac{\partial y_g}{\partial y_f}, \frac{\partial y_b}{\partial y_m} < \frac{\partial y_b}{\partial y_f} \end{aligned} \tag{3}$$

Equation (3) shows that changes in the mother's income and the father's income will have different effects on the probability of having a girl because they affect each parent's bargaining power differently and because the correlation between each parent's income and a child's income is different for boys and girls.

If households are unitary and parents view children as a form of investment, equation (3) reduces to the bracketed terms. The difference in mothers' and fathers' income effect on the relative desirability of girls is the difference in the correlation of the mother's and father's incomes with the relative investment value of a daughter. It follows that mothers' and fathers' incomes will only have different effects on investments in education or other factors that affect child productivity if they have different effects on the returns to education (or other factors). Therefore, if returns to education can be controlled for, the joint hypotheses that households are unitary and parents view children as a form of investment can be rejected if the effect of increasing relative adult female income on educational attainment differ from the effect of increasing relative adult male income.

4 The Data

The analysis of sex ratios uses the 1% sample of the 1997 *Chinese Agricultural Census*, the 1% sample of the 1990 *China Population Census* and GIS geography data from the Michigan China Data Center matched at the county level.[12] The sample includes 1,621 counties in China's 15 southern provinces, south of the Yellow River (Huang He) where any tea is planted.[13] Map 1 show that these counties are dispersed throughout southern China. The 1990 census data contain 52 variables, amongst which are data on sex, year of birth, educational attainment, sector and type of occupation, and relationship to the head of household. Because of the different family planning policies and market reforms experienced by urban areas and rural areas, I limit the analysis to rural households. The individual and household level data are aggregated to the county level to match the agricultural census data. The number of individuals in each county-birth year cell is retained so that the regression analysis are all population weighted.[14].

Reliable data for procurement prices and output are not available for this period at the county level. For the sake of scope, accuracy and consistency between areas, this study uses county level agricultural data on the sown area from the 1% sample of the 1997 *China Agricultural Census*. Agricultural land is

[12] This section describes the 1% sample of the 1990 *Population Census*. Due to changes in geographic identifiers, I cannot link data from the 1990 Census with the 1982 and 2000 Censuses to form a panel of counties. Consequently, the analysis of sex ratios uses only the 1990 Census and the analysis of education uses only a 0.5% sample of the 2000 census (described in Appendix Table A3). The organization of the censuses are similar. Figure 1 supports the validity for interpreting variation in sex ratios in each census as cohort variation.

[13] Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hunan, Hubei, Guandong, Guangxi, Sichuan, Guizhou and Shanxi.

[14] Households are required to report to the census the number of children and the sex of each child born into each household in the past year. However, studies have shown that in the 1982 Census, there is up to 44% of underreporting of births in rural areas (Li and Feldman, 1996). Hence, in this study, I only use data for children one year of age and older. The density of China's rural population and the watchfulness of local authorities make hiding children increasingly harder as children become older. And past studies have shown that while there is under-reporting of female births, sex ratios for children of 2 or 3 years of age and older are reliable. This is consistent with Figure 1 which shows that sex ratios by birth year for children older than 2 are similar across census years.

allocated by the village to farmers based on the number of members per household and quality of land. Land is usually allocated for 15 year terms (Burgess, 2004). There is no market for buying or selling land.

Using 1997 agricultural data to proxy for agricultural conditions in the early 1980s introduces measurement error. It is also possible that the counties that which tea in 1997 are the counties which had stronger girl preference prior to the reform. In this case, comparing sex ratios in tea counties that plant tea in 1997 to tea counties that do not plant tea in 1997 will confound the effect of planting tea with the effect of underlying girl-preferences. However, as discussed earlier, the government emphasis on tea planting during the Cultural Revolution meant that the main determinant of whether a region had tea fields was geographic suitability rather than sex preferences preferences. Specifically, tea grows best on warm and humid hilltops. The population density of the Chinese countryside and even distribution of hills through out southern China means counties that plant some tea should not be very different from their neighboring counties that plant no tea (in other respects).

To assess whether counties that do not plant tea are good control groups for counties that plant tea, I look for systematic differences between the treatment and control groups. While I will exploit differences over time in both types of counties, any differential evolution is more likely to be due to the relative income effect if the counties are otherwise similar. The average demographic characteristics and educational attainment shown in Table 1 Panel A are very similar between counties that plant some tea and counties that plant no tea. The difference in ethnic composition will be controlled for in the regression analysis. The descriptive statistics for sector of employment in Panel B show that in both types of counties, 94% of the population is involved in agriculture. Panel C shows that households in tea counties farm less total land on average, devote more land to rice, garden production and less land to orchards. On average, agricultural households have very little farmable land, 4.06-4.85 mu (0.20-0.32 hectares) per household. Households in counties that plant tea have only 0.15 mu (0.02 hectares) of land for tea.

For a visual representation of the similarity in agricultural production between tea producing counties and non-tea producing counties, refer the Maps 1B-1E, which show agricultural density and production by crop. The black colored counties are counties which produce some tea. The gray shaded counties are counties which produce some garden vegetables (Map 2A), orchard fruits (Map 2B) and fish (Map 2C). Map 2D shows counties which produce some tea and counties where the average farmable land per household exceeds the median of 4 mu (0.27 hectares). These maps show that tea producing counties are not geographically distant from counties that produce other cash crops.

5 Empirical Strategy

5.1 Identification

The main problem in identifying the effect of increased relative female-to-male earnings on child outcomes is that both may be in part related to omitted household and community characteristics. For example, in communities with no male-bias, adult women will earn more and parents will view female and male children as equally desirable. In communities with strong male-bias, where adult women earn less and parents strongly prefer boys over girls, we will find a positive correlation between adult female income and girl survival rates. However, since female earnings and girls' survival rates are jointly determined by sex preference, the correlation would not reflect the effect of female income from the effect of sex preference on girls' survival rates. This problem is addressed by exploiting the increase in relative value of tea caused by post-Mao policies during 1978-1980. The exogenous variation in relative adult female earnings allows me to estimate the causal effect of an increase in relative adult female earnings on relative survival rates of girls.

First, I estimate the effect of the agricultural reforms on girl survival rates in tea planting regions. The identification strategy uses the fact that the rise in adult female income varied across region and time of birth. Substantial variation in amount of tea sown existed across regions. Therefore, the number of surviving female children should have increased in tea planting regions for cohorts born close to and/or after the reform, and the increase should have been larger for regions that planted more tea.[15] I use a differences-in-differences estimator to control for systematic differences both across regions and across cohorts. Only the combination of these two variations is treated as exogenous. In other words, I compare relative survival rates between counties which plant tea and counties which do not plant tea, for cohorts born before and after the reform. Comparing sex ratios within counties for cohorts born before and after the reform differences out time-invariant community characteristics. Comparing tea planting communities to non-tea planting communities differences out changes that are not due to planting tea. Thus, the causal effect of planting tea can be identified as long as tea planting areas did not experience changes which were systematically different from non-tea planting areas.

Figure 5A plots the fraction of males of each birth year cohort for tea planting counties and counties which do not plant tea. It shows that prior to the reform, tea counties had higher fractions of males and after the reform, tea counties had lower fractions of males. The fact that the change in relative sex ratios between tea and non-tea counties occurred for cohorts born immediately after the reform suggests lends credibility to the identification strategy.

The date of birth and whether an individual is born in a tea planting region jointly determine

[15] The exact timing of the response in sex ratios to the reform depends on the nature of sex selection. If sex selection is conducted by infanticide, the reform should only affect sex ratios of cohorts who were born after the reform. However, if sex selection is conducted by neglecting young girls, the reform can also affect sex ratios of children who were born a few years before the reform.

whether he/she was exposed to the relative adult female income shock. In other words, tea is a proxy for female earnings. The validity of the identification strategy does not rely on the assumption that only women pick tea. If men or children picked tea, the proxy for relative female income will exceed actual relative female income. Hence, the strategy will underestimate the true effect of relative female income on sex ratio. If there are any unobserved time-invariant cultural reasons that both cause women to pick tea and affect the relative desirability of female children, the effect will be differenced out by comparing cohorts born before and after the reform. The identification strategy is only in question if there is some time varying difference which coincides with the reform. For example, if the attitudes which drive sex preference changes in tea planting counties at the time of the reform, the estimate of the effect of planting tea will capture both the relative female income effect and the effect of the attitude change. Or, if the reason for women to pick tea was changed by the HPRS, the pre-reform cohort will be an inadequate control group. While I can not resolve the former problem, the latter concern is addressed by instrumenting for tea planting with time invariant geographic data.[16]

Second, I use the increase in value of orchard fruits relative to other crops to investigate the effect of an increase in relative male income on sex ratios. Third, I investigate whether the increase in tea value affects relative survival rates because of the increase in relative female income rather than an increase in total household income. I estimate the effect of the reform on girls' survival in regions that plant any cash crops (including tea and orchards) that experienced equal or more value increase than tea.

The identification strategy is based on the increase in the value of category 2 crops relative to category 1 crops, for which prices continued to be suppressed, and category 3 crops, which were never regulated. Therefore, the effect of category 1 and category 3 crops on sex ratios should not change after the reform. I estimate the effect of category 1 and category 3 crops on sex ratios. Figure 5B shows that indeed the effect of category 1 and 3 crops were identical before and after the reform.

5.2 Results for Survival Rates

5.2.1 Basic Results

To see that the effect of tea and orchards on sex ratios is due to the post-Mao agricultural reforms and not due to other changes in these regions, I check that the effect of tea and orchard on sex ratios increased in magnitude at the time of the reform. The unrestricted effect of tea planted for each birth cohort can be written as

$$sex_{ic} = \alpha + \sum_{l=1963}^{1990} (tea_i \times d_l)\beta_l + \gamma_i + \psi_c + \varepsilon_{ic} \qquad (4)$$

[16] I also address this problem more directly by comparing tea counties with only non-tea planting counties that are adjacent to a tea planting county. Tea is largely determined by geographic conditions such as hilliness. County boundaries are straight lines drawn across spatial areas. The OLS estimate for this restricted sample is very similar to the estimate for the whole sample. This adds to the plausibility of the identification strategy unless potentially endogenous factors change discretely across county boundaries.

The fraction of males in county i, cohort c is a function of: the interaction term between tea_i, the amount of tea planted for each county i, and d_l, a variable which indicates if a cohort is born in year l; γ_i, county fixed effects; and ψ_c, cohort fixed effects. The dummy variable for the 1962 cohort and all of its interactions are dropped.

β_l is the effect of planting tea on the fraction of males for cohort l. If the effect of tea on sex ratios was due to the reform, β_l should be zero until approximately the time of the reform, after which, it should become negative. The estimates for the coefficients in vector β_l, reported in Table 2 column (1), are statistically significant for cohorts born after 1979. Figure 6A, the plot of the estimates of β_l, clearly shows the link between the increase in tea value and the decrease in the fraction of males. The estimates oscillate around 0 until 1979, after which, they steadily decrease. To test the joint significance of the effect of planting tea for cohorts born before the reform and for cohorts born after the reform, I estimate the F-statistic for each cohort. They are 3.59 and 2.05, both statistically different from 0.

In a similar regression, I estimate the effect of orchard planted in each county i on the fraction of males in county i, cohort c.

$$sex_{ic} = \alpha + \sum_{l=1963}^{1990} (orchard_i \times d_l)\delta_l + \gamma_i + \psi_c + \varepsilon_{ic} \tag{5}$$

The coefficients in vector δ_l are plotted in Figure 6B. The plot shows that the effect of planting orchards on the fraction of males becomes positive after 1979. The estimates, reported in Table 2 column (2), are statistically insignificant. However, the F-statistics for the interactions for the pre-reform cohort and the post reform cohort are 0.82 and 1.75. This means that while being born in an orchard planting county before the reform has no effect on sex ratios, the effect of being born in an orchard planting county after the reform is jointly significantly different from 0.

Figure 6C plots the coefficients from a similar regression estimating the effect of all category 2 cash crops on fraction of males. The plot shows that the effect of cash crops on sex ratio experienced no change after the reform. Table 2 column (3) presents the estimates. The F-statistics for the pre-reform cohort and the post reform cohort are 1.32 and 1.37. Neither are statistically different from 0.

Because the relatively few counties produce tea or orchards while all counties produce grains, the reference group in equations (4) and (5) are counties that produce grains. Consequently, controlling for the amount of orchards planted should not affect the unrestricted estimates of the effect of tea from equation (4). To check that the unrestricted estimates are unchanged by including controls for orchards and cash crops, I estimate the following equation.

$$\begin{aligned} sex_{ic} \quad = \quad & \sum_{l=1963}^{1990} (tea_i \times d_l)\beta_l + \sum_{l=1963}^{1990} (orchard_i \times d_l)\delta_l + \\ & \sum_{l=1963}^{1990} (cashcrop_i \times d_l)\rho_l + Han_{ic}\zeta + \alpha + \psi_i + \gamma_c + \varepsilon_{ic} \end{aligned} \tag{6}$$

Tea_i is a continuous variable for the amount of tea planted in each county i. The dummy variable indicating that a cohort is born in 1962 and all its interactions are dropped. The estimated coefficients for the vectors β_l, δ_l and ρ_l are reported in Table 3. The similarity between these estimates and the unrestricted estimates from equation (4) and (5) can be seen in Figure 6D, which plots the coefficients for tea and orchards. The figure shows clearly that before the reform, sex ratios were very similar between tea and orchard regions, whereas after the reform, planting orchards increased the fraction of males while planting tea decreased the fraction of males. However, the estimates for tea are no longer statistically significant.

5.2.2 Differences-in-Differences

To summarize the effect on sex ratios, I estimate the following equation where the fraction of males in county i birth cohort c is a function of the interaction term of a dummy variable for whether a county plants tea and a dummy variable for whether a cohort is born after the reform, controlling for the amount of orchards and all category 2 cash crops planted, fraction of Han, county fixed effects, and a dummy variable for being born after the reform.

$$\begin{aligned} sex_{ic} &= \alpha + (tea_i \times post_c)\beta_1 + (orchard_i \times post_c)\beta_2 \\ &+ (cashcrop_i \times post_c)\beta_3 + Han_{ic}\zeta + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{7}$$

The differences-in-differences estimator, β_1, is the difference in the fraction of males between cohorts born before and after-reforms between tea planting counties and counties which do not plant tea. $orchard_i$ and $cashcrop_i$ are continuous variables for the amount of orchards planted in county i. All standard errors are clustered at the county level. The estimates in Table 4 columns (3) and (4) show that planting tea decreased the fraction of males by 0.7 percentage points, whereas planting orchards increased the fraction of males by 0.9 percentage points. Both estimates are statistically significant at the 1% levels. However the estimate for the effect of all cash crops, β_3, is not significantly different from zero. Because the absolute increase in income from tea does not exceed that of other cash crops (Figure 4C), I conclude that increase total household income has no effect on sex ratios.

5.2.3 Robustness

Family Planning Policies Family planning policies began in the early 1970s. The One Child Policy began in 1979/1980. However,the effective date of the One Child Policy does not coincide with the beginning of the agricultural reforms studied in this paper (1979-1982). Qian (2005) shows that the four-year birth spacing law initiated in the early 1970s meant that the unanticipated One Child Policy actually bound for cohorts born 1976 and after. The main concern is that the enforcement of these policies systematically varied between tea planting counties and counties that did not plant tea. First, I examine this possibility directly by matching local policy enforcement data from the *China Health and Nutritional Survey* to the data used in this paper. The data shows that local family planning policies are very similar between tea and non-tea counties. Unfortunately, the sample of counties that can be matched is too small for statistical analysis. Second, I use the fact that ethnic minorities (non-Han) were always exempt from family planning policies. I check that the effect of changes in income on sex ratios are not confounded with the effects of family planning policies by estimating equation (7) on a sample containing only ethnic minorities. The results are very similar.

Migration If migration patterns differed significantly between tea and non-tea areas, and between orchard and non-orchard areas, the OLS estimates could be capturing the effects of migration rather than of income changes. Cohorts born after the reform are 11 years of age or younger in the 1990 Census. Hence, migration would bias the estimates if households with boys are more likely to migrate out of tea areas and households with girls are more likely to migrate out of orchard areas. Migration controls, however, made migration of entire households impossible. Another possible cause for bias is if amongst pre-reform cohorts, females were more likely to migrate out of tea areas and males were more likely to migrate out of orchard areas. However, because strict migration controls suppressed long term migration from rural areas throughout the period of the study, migration is unlikely to be a serious issue.

To address this problem, I estimate the upper and lower bounds of the absolute value of the effect of planting tea and orchards on sex ratios by estimating equation (7) in a sample where migrants are assumed to be women in tea counties and men in orchard counties. To construct the *inferred* populations, the fraction of urban residents in each province that report they are not born in that city and the population of the province are used to calculate the maximum possible number of rural-urban migrants per province. The population of each county is then used to calculate the fraction of provincial population in each county. I then add the multiple of this fraction and the maximum number of migrants for that province back into each county. Since the post reform cohort is less than 10 years of age and migration of children is not likely, I assume that the new additions are all born prior to the reform. To estimate the lower bound of the effect of tea, the new additions to the pre-reform cohorts in tea counties are assumed to be female. To estimate the upper bound of the effect of tea, the new additions are assumed to be male. Similarly, for the lower bound of the effect of orchard, all the added inferred migrants in orchard counties are assumed to be male. To estimate the upper bound, all the inferred migrants are assumed to be female. The estimated bounds are very similar to the OLS estimates on the reported population, ruling out the possibility that the results are driven by migration.

Cohort Trends Cohort fixed effects control for variation across cohorts that do not also vary across counties. They cannot control for county-varying cohort trends which may have occurred over the 29 years of this study. I address this issue by including linear cohort trends at the county level. In order to make the estimates comparable to the 2SLS estimates in the next section, I restrict the sample to only counties for which there is geography data and estimate the same specification as the second stage of the 2SLS. This specification does not explicitly control for orchards because planting orchards can be endogenous for the same reasons as those discussed in the next section for tea. I estimate

$$\begin{aligned} sex_{ic} &= \alpha + (tea_i \times post_c)\beta_1 + (cashcrop_i \times post_c)\beta_2 \\ &\quad + Han_{ic}\zeta + \psi_i \times trend_c + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{8}$$

Tea_i is a dummy variable indicating whether a county plants any tea. $\psi_i \times trend_c$ is the interaction between county specific fixed effects with a linear time trend. Columns (1) and (2) of Table 5 shows estimates without and with the the county-level cohort trend. The point estimates are similar and both statistically significant at the 5% level. Thus, the OLS estimates are robust to changes across counties over cohorts.

5.2.4 Two Stage Least Squares

Two problems motivate the use of instrumental variables. First, using 1997 agricultural data to proxy for agricultural conditions in previous years will introduce measurement error which may bias the estimate downwards. Second, the OLS estimate will suffer from omitted variable bias if families which prefer girls relative to boys switched to planting tea after the reform. In this case, the OLS estimate will overestimate the true effect of an increase in the value female labor because it will confound the aforementioned effect with the sex-preferences of households which switched to planting tea after the reform. I address both problems by instrumenting for the tea planting with the average slope of each county.

Tea grows in very particular conditions: on warm and semi-humid hilltops, shielded from wind and heavy rain. Hilliness is a valid instrument for tea planting if it does not have any direct effects on differential investment decisions and is also not correlated with any other covariates in equation (10). Map 2 shows the slope variation in China, where darker areas are steeper. Map 3 overlays the map of counties which plant tea onto the slope map. The predictive power of slope for tea planting can be seen by comparing the tea planting counties with the steep regions in Map 2. I use the GIS data pictured in Map 2 to calculate the average slope for each county and estimate the following first stage equation, where both the amount of tea planted and slope is time-invariant. Note that since orchards is also an endogenous regressor, the 2SLS specification does not separately control it. The first stage equation is

$$\begin{aligned} tea_i \times post_c &= (slope_i \times post_c)\lambda + (cashcrop \times post_c)\varphi \\ &\quad + Han_{ic}\zeta + \alpha + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{9}$$

The predicted residuals are used to estimate the following second stage regression.

$$\begin{aligned} sex_{ic} &= (tea_i \times post_c)\beta + (cashcrop \times post_c)\varphi \\ &\quad + Han_{ic}\zeta + \alpha + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{10}$$

Column (3) of Table 5 shows the first stage estimate from equation (9). The estimate for the correlation between hilliness and planting tea, λ, is statistically significant at the 5% level. Column (4) shows the two stage least square estimate from equation (10). The estimate is larger than the OLS estimate and statistically significant. Column (5) shows the two stage least squares estimate controlling for county-level cohort trends. The estimate is similar in magnitude to the OLS estimate but no longer statistically significant. The estimates with and without trends are not statistically different from each other. The estimate without trends is larger in magnitude but also less precisely estimated. The 2SLS estimate in column (5) shows that conditional on county-level cohort time trends, the OLS estimate is not biased. Furthermore the OLS and 2SLS estimates in columns (2) and (5) are almost numerically identical to the initial OLS estimate in column (1). These results give confidence to the robustness of the initial OLS estimates of the effect of tea and orchards.

5.3 Results on educational attainment

The main results of the effect of relative adult earnings on sex ratios rejected the hypothesis that households are unitary and parents view children only as a form consumption. However, since increasing adult agricultural earnings also increase the earnings potential of children, these results do not distinguish the hypothesis that households are unitary and increasing mothers income increases the survival rates of girls by increasing the relative investment value of girls from the alternative hypothesis that increasing female income may increase the survival rates of girls through increasing female bargaining power. To gain further insight in the household decision making process, I investigate the effect of adult income changes on educational attainment.

Recall that in the unitary model where parents view children as a form of investment, the decision to invest in a child's education depends solely on the returns to education. Hence, increasing mother's income and increasing father's income will only have different effects on education investment for children if they have different effects on returns to education. Similarly, increasing mother's income and increasing father's income will only have different effects on the relative education investment for girls if they have different effects on the relative returns to education for girls. Because there is no income data from this period, I cannot explicitly control for returns to education. However, returns to education are presumably low for manual agricultural labor. Under the assumption that returns to education are the same for planting tea and for planting orchards, I can test the hypothesis that households are unitary and parents view children as a form of investment by estimating the effect of relative female income and relative male income on educational attainment.

This analysis uses county-birth-cohort level data from a 0.05% sample of the 2000 *Population Census*.[17] In order to isolate the sample to children who had completed their education, I restrict the sample to cohorts born between 1962 and 1982. Individuals in the sample should not be affected by the

[17] Descriptive statistics are in Appendix Table A3.

Cultural Revolution since disruptions to schools were generally isolated to urban areas.[18] I use cohorts which had not yet reached public preschool age at the beginning of the reforms (born before 1976) as the pre-reform control.[19]

The empirical strategy is the same as before. I estimate the following equation to examine the effect of planting tea, orchards and all category 2 cash crops on educational attainment for the all individuals. I then repeat the estimation for the sample of girls, the sample of boys and the difference in education between boys and girls.

$$\begin{aligned} eduyrs_{ic} &= (tea_i * post_c)\beta_1 + (orchard_i * post_c)\beta_2 + \\ &\quad (cashcrop_i * post_c)\beta_3 + Han_{ic}\zeta + \alpha + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{11}$$

$eduyrs_{ic}$ is the average years of educational attainment for individuals born in county i, birth year c. The estimates in column (1) of Table 6 show that planting tea increased overall, female and male educational attainment by 0.2, 0.25 and 0.15 years. On the other hand, planting orchards decreased female educational attainment by 0.23 years and has no effect on male educational attainment. These estimates are statistically significant at the 1% level. Planting orchards had no effect on male educational attainment. The estimates in Column (4) show that planting tea decreased the male-female difference in educational attainment whereas planting orchards increased the difference. The latter is statistically significant at the 1% level. The estimates for all category 2 cash crops are close to zero and statistically insignificant.

I re-estimate equation (11) with continuous variables for the amount of tea and orchards planted in each county i. Columns (5)-(8) of Table 6 show that the estimates have the same signs as the estimates with the dummy variables in columns (1)-(4). The estimates show that one additional mu of tea planted increases female educational attainment by 0.38 years and male educational attainment by 0.5 years, whereas one additional mu of orchards decreases female educational attainment by 0.12 years and has no effect on male educational attainment. Note that the effect of income from tea increases male educational attainment more than for female educational attainment and that cash crops in general have no effect on female educational attainment but decreases male educational attainment.

To observe the timing of the effect of tea on educational attainment, I estimate the effect of planting tea by birth year.

$$\begin{aligned} eduyrs_{ic} &= \sum_{l=1963}^{1982}(tea_i \times d_l)\beta_l + \sum_{l=1963}^{1982}(orchard_i \times d_l)\delta_l + \\ &\quad \sum_{l=1963}^{1982}(cashcrop_i \times d_l)\rho_l + \zeta Han_{ic} + \alpha + \psi_i + \gamma_c + \varepsilon_{ic} \end{aligned} \tag{12}$$

[18] I repeat the experiment on the sample of cohorts born after 1967, who did not begin primary school until after 1974, when schools were re-opened. The results are similar and statistically significant.

[19] Children enter public preschools at age 4 or 5 in China. Public nursery schools, targeted at children age 1-4, are not available to most rural populations.

The dummy for the 1962 cohort and all its interactions are dropped. The estimated coefficients for each cohort l in vectors β_l, δ_l and ρ_l are shown in Appendix Table A4. I plot the three year moving averages of the estimates for female educational attainment in Figure 7. It shows that female educational attainment was similar between tea and orchard areas until 1976, after which it increased in the former and decreased in the latter.

6 Interpretation

This section discusses the empirical results and their theoretical implications. The results for survival rates show that planting tea increased the fraction of girls by 0.7 percentage points. Data on agricultural income by crop is not widely available for the time period of this study. If the data on agricultural income used by Etherington and Forster's (1994) anthropological study of Chinese tea plantations are representative of the average tea planting household, the findings imply that increasing household income by 10% and giving it all to women increases the fraction of girls by 0.7 percentage points. This would increase educational attainment for boys and girls by approximately 0.2 years. Roughly speaking, this suggests that increasing female wages by 20% of household income without changing male income would have brought China's sex ratios in the early 1980s to be the same as that of Western Europe. Of course, this calculation should not be taken too literally since the elasticity of demand for girls relative to boys with respect to relative female earnings is unlikely to be constant across relative income levels.

Another caveat to consider when interpreting the results is China's stringent enforcement of family planning policies, namely the One Child Policy which began in 1980 and its subsequent relaxations. The main concern is that the enforcement of these policies systematically varied between tea planting and non-tea planting regions. This could affect the interpretation of the results in two ways. First, the identification assumption that there were no other changes in tea planting counties at the time of the reform would have been violated. In other words, the effect of an increase in relative value of tea would be confounded with the effect of family planning policies. To check if this is the case, I repeat the study on a sample containing only ethnic minorities (non-Han) who have never been subjected to family planning policies. The results are similar to those using the whole sample, suggesting that the main results are not driven by family planning policies. Variation in the policies can also be examined directly. By matching local policy enforcement data from the *China Health and Nutritional Survey* to the data used in this paper at the county level, it can be seen that local family planning policy does not systematically vary between tea and non-tea counties. Unfortunately, the number of matched counties are too few to be useful for statistical analysis. Furthermore, Qian (2005) shows that the four-year birth spacing law initiated in the early 1970s meant that the unanticipated One Child Policy was in reality binding for cohorts born 1976 and after. Hence, the effective date of the One Child Policy does not coincide with the increase in the price of tea in 1979.

Second, any effects of family planning policies will affect the proportion of the total observed sex imbalance that can be attributed to economic factors. This will in turn affect the interpretation of the underlying elasticity of demand for girls relative to boys with respect to relative female earnings. The results of this paper estimate the marginal effects of an additional dollar earned by adult females while holding adult male income constant on sex imbalance and education investment. This together with an estimate of the total amount of sex imbalance that can be attributed to economic factors implies an underlying elasticity. Qian (2005) shows that in some regions, the One Child Policy increased the fraction of males by 10 percentage-points. In these regions, the maximum sex imbalance that can be attributed to economic factors is 10 percentage-points less than the observed sex imbalance. Hence, the true elasticity is greater than the elasticity implied by the main results together with the observed sex imbalance. More research on the effect of family planning policies and other factors unrelated to economic conditions on sex imbalance is needed before this elasticity can be accurately estimated.

The results of this paper cannot distinguish different modes of sex selection. However, they should not be confounded with changes in sex-selection technology since it was generally unavailable for the time period of this study.[20] For the recent ten to fifteen years, studies have found that the rapid rise in use of pre-natal sex-revealing technologies has significantly increased sex imbalance (Chu, 2001; Coale and Banister, 1994). An interesting avenue of future research would be to examine how the decrease in cost of sex selection interacts with changes in sex-specific incomes.

The empirical results have several theoretical implications. The findings for both sex ratios and education reject the joint hypothesis that households are unitary and parents view children as a form of consumption only. An alternative explanation for the results within the unitary framework is that parents view children as a form of investment. This is consistent with the results for sex ratios. However, this explanation is only consistent with the results for educational attainment in unlikely circumstances. It would require that an increase in tea value increases returns to education of both boys and girls while an increase in orchard value decreases returns to education of girls and has no effect on boys. The lack of income data prevents a direct analysis of the returns to education. However, there are reasons to think that returns to education are not differentially affected by the reforms. Evidence from India shows that returns to education for tea workers is close to zero (Luke and Munshi, 2004). Evidence from China suggests that the returns to education for all manual agricultural labor is low (Cai et. al., 2004). Moreover, there was no technological change in tea or orchard production that would have changed the relative productivity of girls. In light of these other findings, a third, more natural explanation for the empirical findings is a model where mothers value education more than fathers and increasing the mother's income increases investment in education for all children because it increases her bargaining

[20] Manufacturing and import data show that pre-natal sex-revealing technology such as ultrasound B or sonograms were not available in rural population studied in this paper until the mid to late 1980s. Futhermore, there is no reason to believe that the diffusion of this technology varied systematically between tea planting and non-tea planting areas.

power within the household. This explanation does not distinguish between children viewed as a form of consumption and children viewed as a form of investment.[21]

The policy recommendation is the same for all the models discussed above. One way to reduce excess female mortality and/or to increase overall education investment is to increase the relative earnings of adult women.

7 Conclusion

This paper addresses the long standing question of whether economic conditions affect parents' demand for girls relative to boys. Methodologically, it resolves the problem of joint determination in estimating the effect of changes in adult income on the survival rate of girls by exploiting changes in total household income and sex-specific incomes caused by post-Mao reforms in rural China during the early 1980s. The empirical findings give a clear affirmative answer that sex imbalance and education investment respond to changes in sex-specific incomes in the short run. In addition, increasing total household income without changing the relative shares of female and male income has no effect on either survival rates or education investment. In association with the increased gender wage gap, these results can help explain the increased sex imbalance and the observed decrease in rural education enrollment in post-reform China.

[21] I also consider two mechanisms unrelated to household bargaining. First, the increase in the value of adult female labor may lead to an increase in adult female labor supply. This will increase the desirability of girls relative to boys only if girls are better substitutes for adult female labor inside the household relative to boys (and if parents take this into account when children are very young). However, this also predicts that an increase in the value of female labor should increase girls' opportunity cost of schooling relative to boys and therefore decrease girls' education attainment relative to boys which is inconsistent with the results.

Second, the opportunity cost of sex selection should be considered when explaining the results for survival rates. Since pre-natal sex revealing technology was not available, sex selection requires nine months of pregnancy. Hence, an increase in the value of women's physical labor will increase the cost of sex selection. Since boy-biased sex imbalance already existed before the reform, this will decrease the observed sex imbalance. In other words, parents are more likely to keep the child regardless of sex. However, in this case, parents may also time the pregnancy to correspond to crop seasons (Pitt and Sigle, 1999). I found no such correlation between month of birth and tea production seasons. Moreover, this mechanism cannot explain the results for educational attainment.

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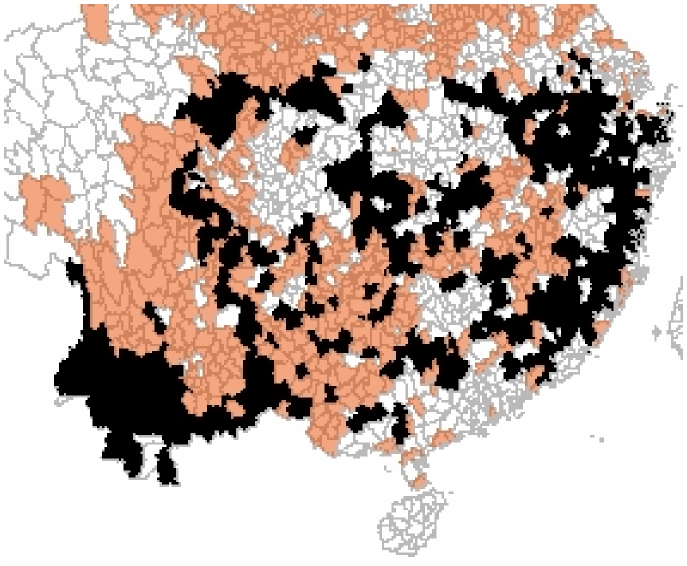
8 Appendix - Robustness of Linear Specification

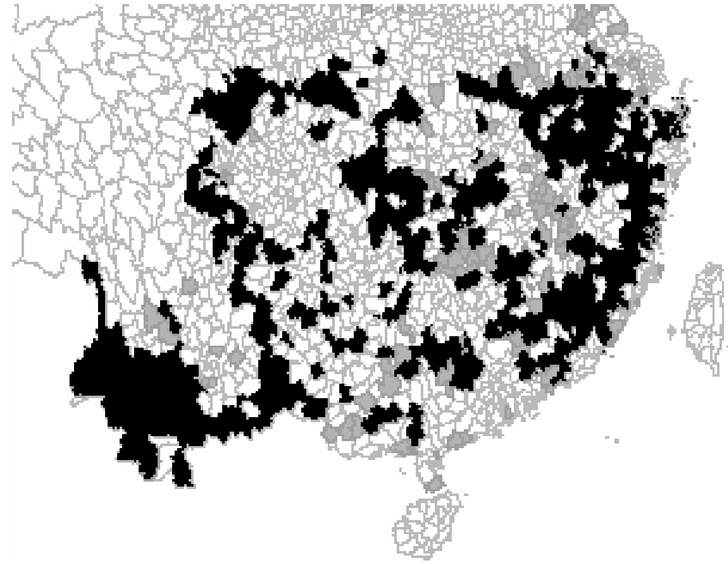
The empirical analysis of sex imbalance uses the fraction of males in the existing population as the dependent variable. To check the robustness of the additivity implied by the linear specification, I repeat the estimation in the paper using the log of male-to-female ratios as the dependent variable. Using log odds restricts the sample to county-birth year cells where there are both males and females. I estimate equations (4), (5) and (6) using the new dependent variable. The estimates are shown in Table A1 and plotted in Figures (A1)-(A4). The effects of tea, orchards and category 2 cash crops are statistically significant and very similar to the linear estimates. I estimate the differences-in-differences effect using equation (7) with the new dependent variable. The estimates are shown in Table (A2). They are statistically significant at the 5% level. The estimates in column (2) show that planting tea decreases the relative proportion of boys by 2.9% and planting orchards increase the relative proportion of boys by 2.7%. This translates to a 0.6 percentage-point decrease in the fraction of boys from planting tea and a 0.5 percentage-point increase in the fraction of boys from planting orchards. These estimates are very similar to the linear specification estimates reported in Table 3.

Map 1 – Tea Planting Counties in China
Darker shades correspond to more tea planted per household.

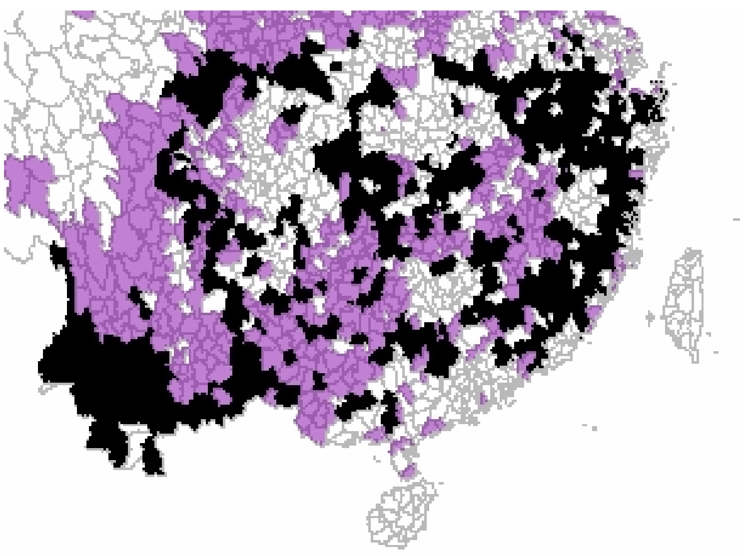
Map 2A – Garden and Tea Producing Counties
Tea counties are colored black



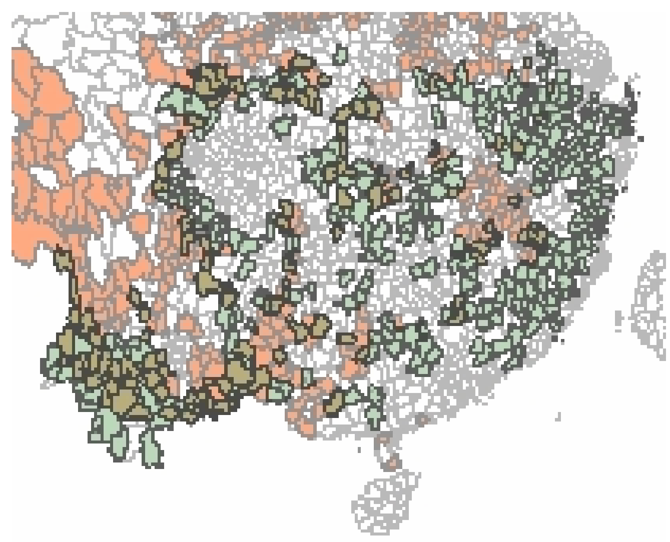
Map 2C – Fish and Tea Producing Counties
Tea counties are colored black.



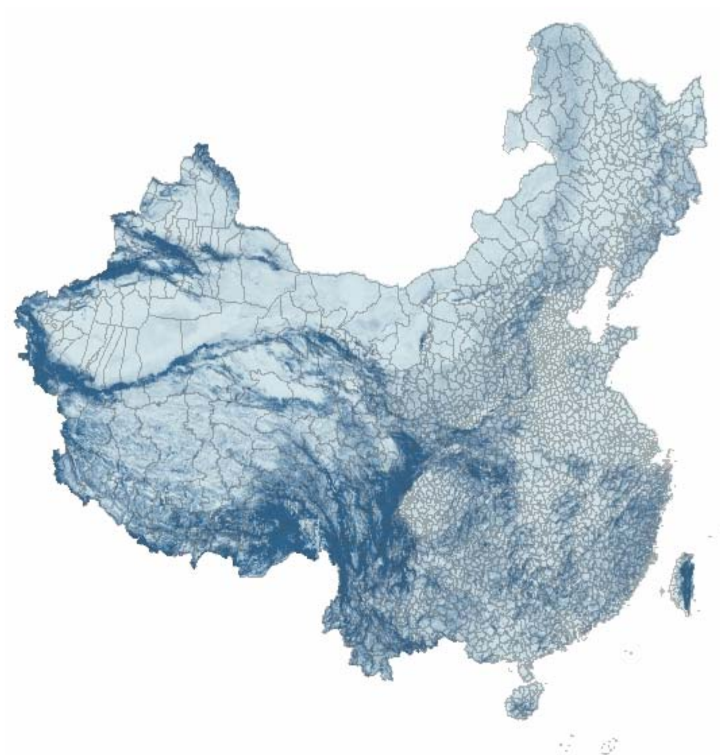
Map 2B – Orchard and Tea Producing Counties
Tea counties are colored black.



Map 2D – Agricultural Density and Tea Producing Counties
Tea producing counties are outlined.
Shaded counties indicate where the average land per household exceeds 4 mu.



Map 2: Hilliness
Darker shades correspond to steeper regions.



Map 3: Correlation between Tea and Slope
Tea counties are colored black.

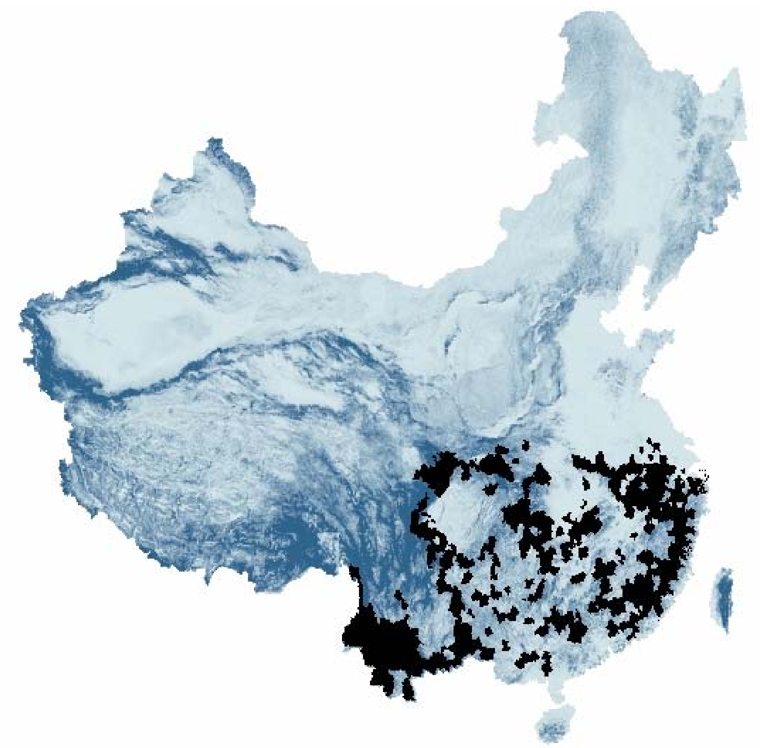
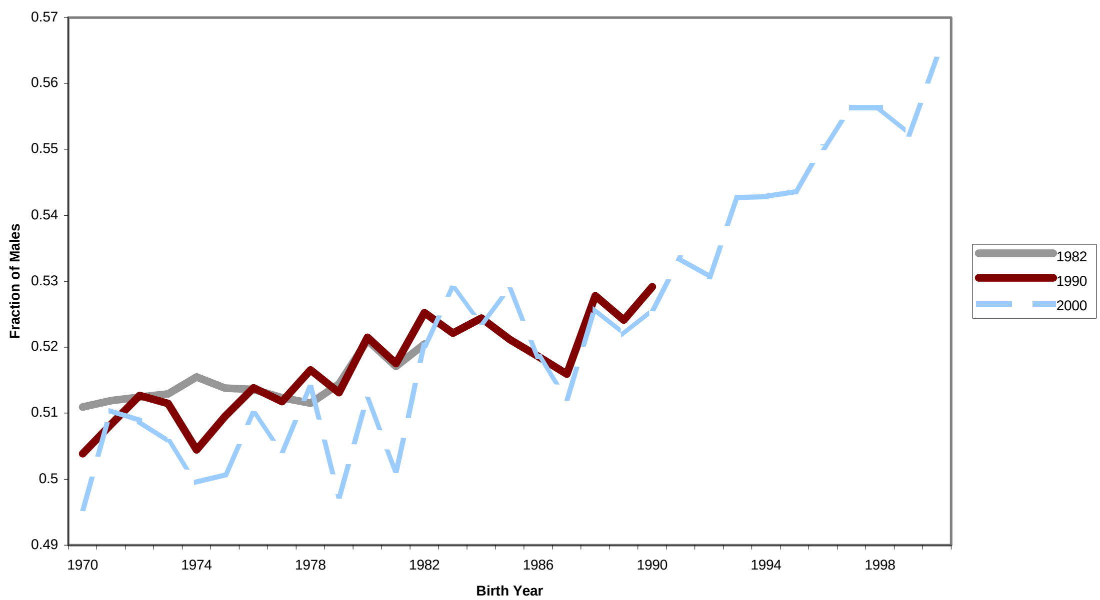
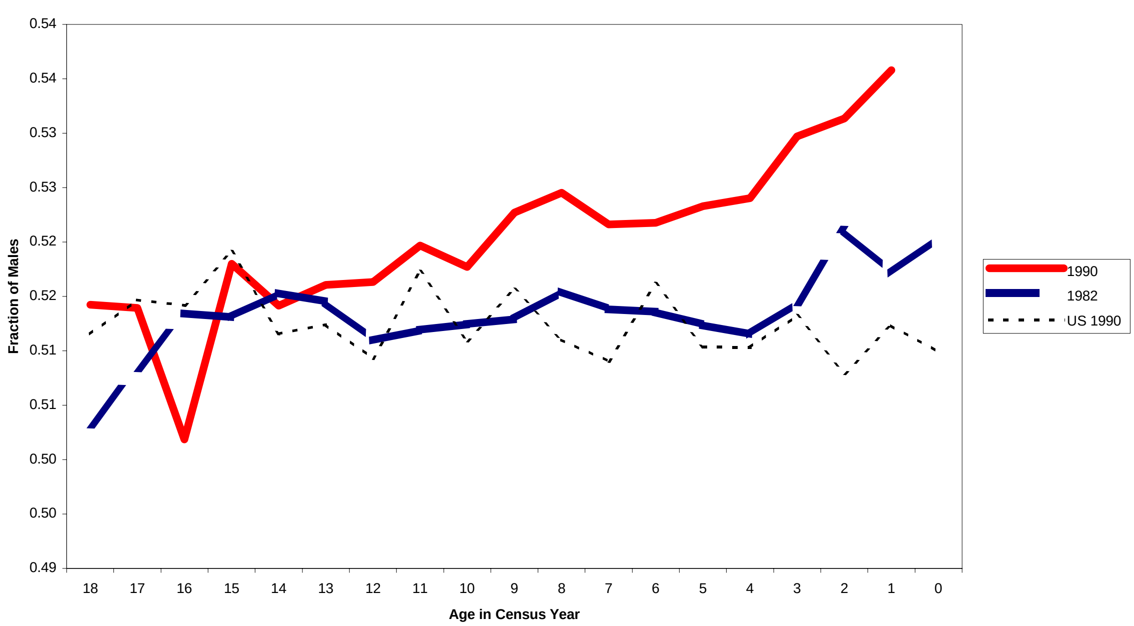


Figure 1A – Sex Ratios by Birth Year in Rural China



Source: 1982, 1990 and 2000 *China Population Censuses*; and 1990 *U.S. Population Census.* Notes: 1) the One Child Policy was implemented during 1978-1980; 2) The gender wage gap due to market reforms reportedly began increasing in the late 1970s; 3) The sample from the 2000 Census is half the size of the sample from the 1990 and 1982 Census, and will therefore be noisier.

Figure 1B – Sex Ratios by Age in Rural China



Source: 1982 and 1990 *China Population Censuses*; and 1990 *U.S. Population Census.*

Figure 2A – Category 1 Production: Grains
(Measured in Units of 1000 Kilo Tons)

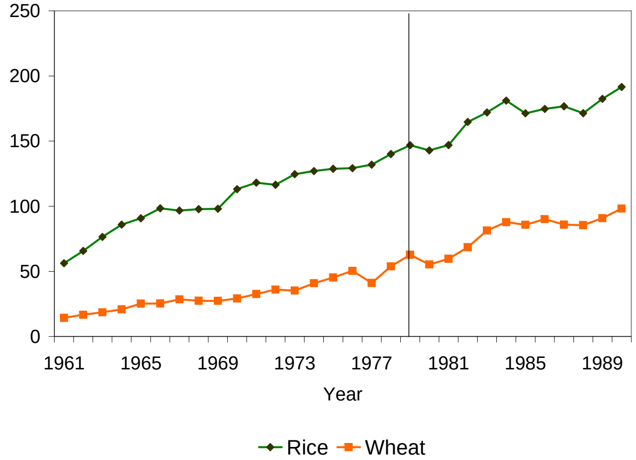


Figure 2C – Category 2 Production: Vegetables
(Measured in Units of 100 Kilo Tons)

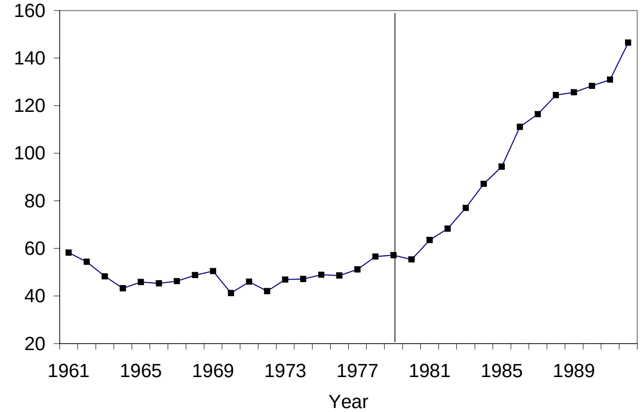


Figure 2B –Category 1 Production: Non-grains
(Soy and Oil Measured in Units of 100 Kilo Tons, Roots and Tubers Measured in 1000 Kilo Tons)

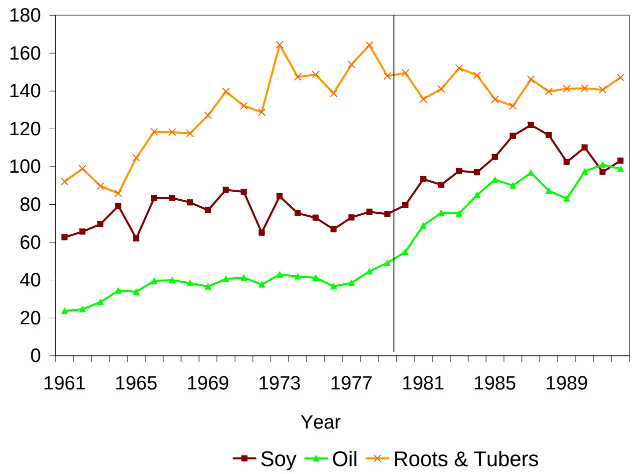
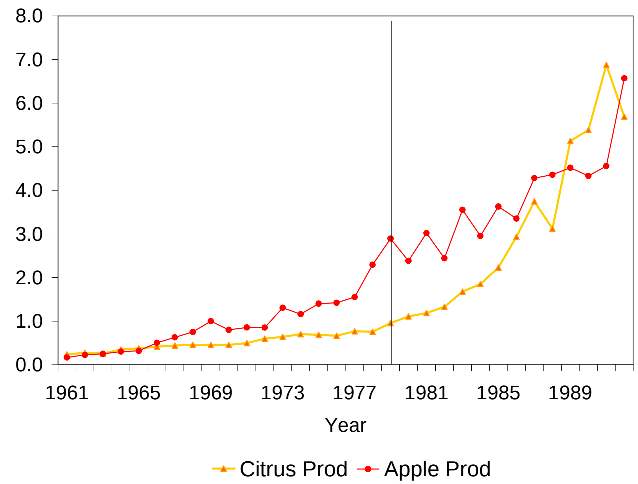


Figure 2D – Category 2 Production: Orchards
(Measured in Units of 1 Million Metric Tons)

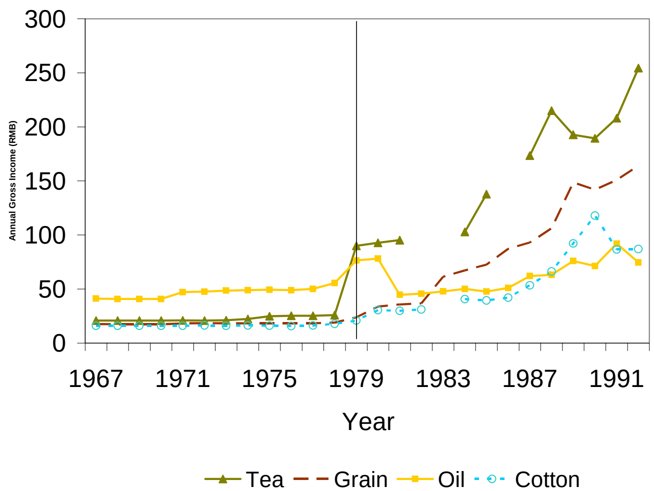


Note: The lag observed between the reform and the increase in output can be attributed to the time required for orchards to be sown and mature.

Figure 3 – Tea Yield and Tea Procurement Price

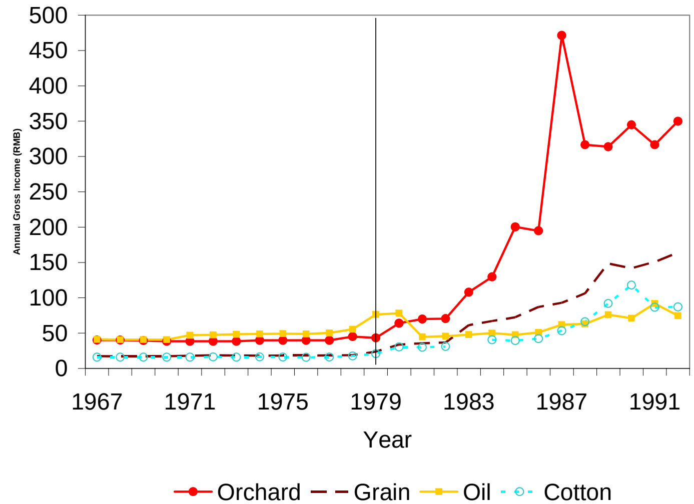
Notes: 1) in 1979, government set procurement price for tea increased by 50%; 2) 95% of tea fields were sown in a campaign during the Cultural Revolution (1966-1976); hence, the increase in yield entirely reflects an increase in picking.

Figure 4A – Gross Agricultural Incomes from Producing Tea and Category 1 Crops



Note: the missing data points reflect years for labor output data is missing.

Figure 4B – Gross Agricultural Income from Producing Orchards and Category 1 Crops



Notes: 1) income from producing orchards increased by 50% in 1979 (from 50 to 75RMB).; 2) the gradual increase in orchard income through the mid 1980s reflect the slow maturing process of the orchards.

Figure 4C – Gross Agricultural Income from Producing Tea and Other Category 2 Crops

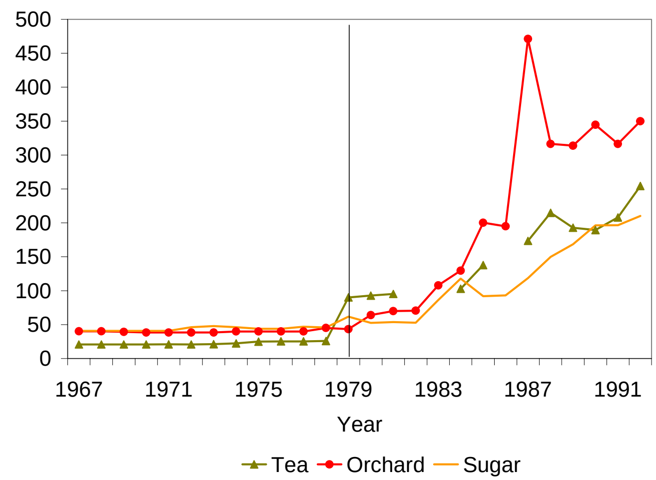


Figure 5A – Fraction of Males in Counties which Plant Some Tea and Counties which Plant No Tea

Figure 5B – The Effect of Category 1 and 3 Crops on Sex Ratios

Coefficients of the Interactions Birth Year * Amount of Category 1 Crops Planted and Birth Year * Amount of Category 2 Crops Planted in Unrestricted Sex Ratios Equation

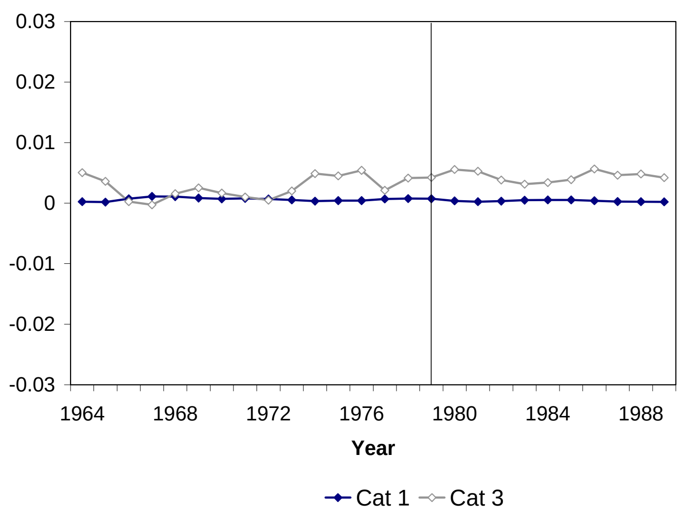


Figure 6A – The Effect of Planting Tea on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Tea Planted in Unrestricted Sex Ratios Equation

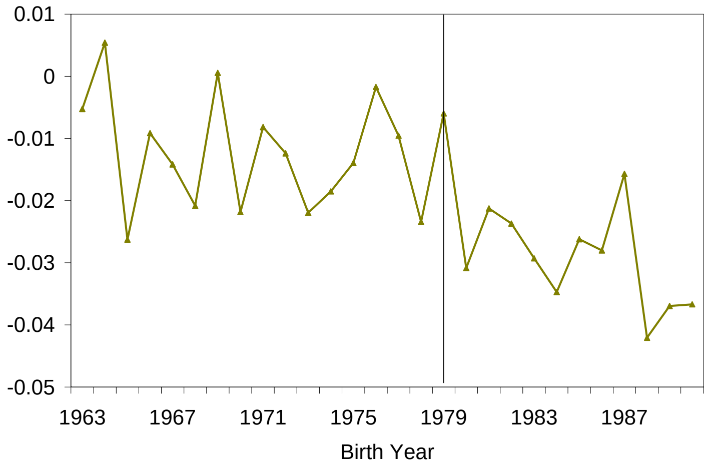


Figure 6C– The Effect of Planting All Category 2 Cash Crops on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Category 2 Cash Crops Planted in Unrestricted Sex Ratios Equation

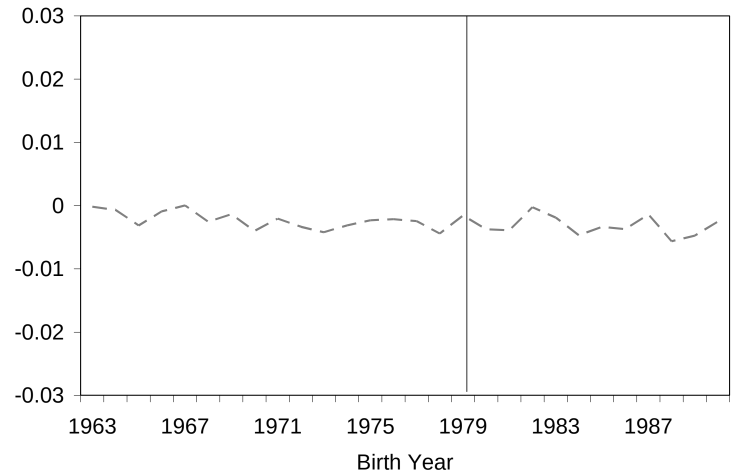


Figure 6B – The Effect of Planting Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Orchards Planted in Unrestricted Sex Ratios Equation

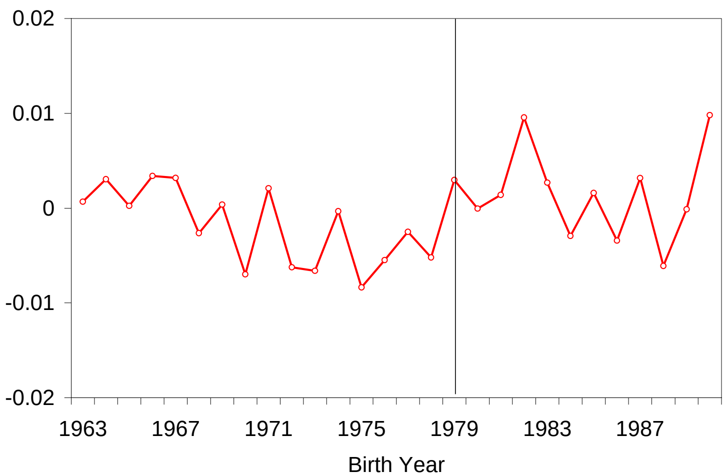


Figure 6D – The Effect of Planting Tea and Orchards on Sex Ratios
Coefficients of the Interactions
Birth Year * Amount of Tea Planted & Birth Year * Amount of Orchards Planted in Pooled Sex Ratios Equation

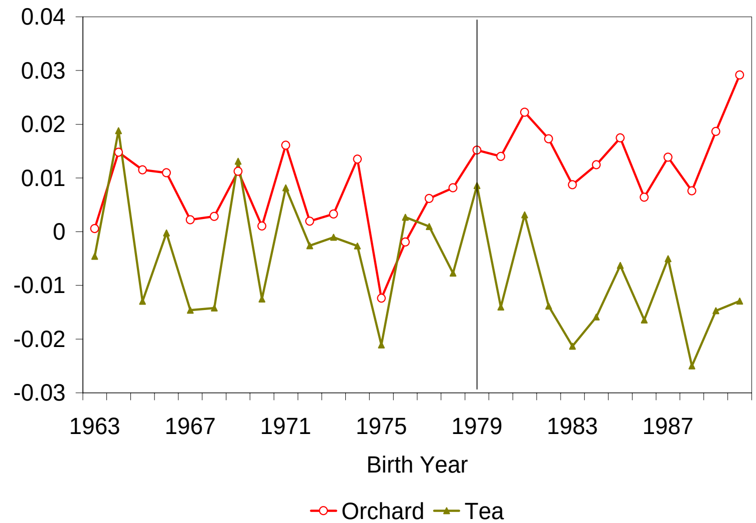


Figure 7 – The Effect of Planting Tea and Orchards on Girls' Education Attainment

Coefficients of the Interactions Birth Year * Amount of Tea Planted and Birth Year * Amount of Orchards Planted in Pooled Education Equation

Table 1 – Descriptive Statistics:
The Matched Dataset of the 0.1% Sample of the 1990 Population Census and the 1% Sample of the 1997 Agricultural Census

	Counties that Plant No Tea			**Counties that Plant Some Tea**		
	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.
A. Demographic Variables						
Fraction male	41665	0.51	(0.0003)	10101	0.52	(0.0007)
Age	41665	14.00	(0.0410)	10101	14.00	(0.0833)
Han	41665	0.95	(0.0009)	10101	0.88	(0.0027)
De-collectivized	41665	0.99	(0.0002)	10101	0.99	(0.0004)
Household size	41665	5.22	(0.0132)	10101	5.16	(0.0261)
Married	23641	0.62	(0.0002)	7164	0.62	(0.0004)
Years of Education	32785	6.63	(0.0095)	7996	6.38	(0.0205)
(Female)	37653	4.70	(0.0082)	9465	4.39	(0.0148)
(Male)	37618	6.01	(0.0072)	9465	5.69	(0.0130)
Father's Education	40647	6.17	(0.0067)	10043	5.82	(0.0127)
Mother's Education	40655	4.53	(0.0082)	10054	4.33	(0.0146)
School Enrollment (Female)	40781	0.24	(0.0018)	10009	0.22	(0.0036)
School Enrollment (Male)	40636	0.27	(0.0019)	9977	0.25	(0.0038)
B. Industry of Occupation of Household Head						
Agricultural	41665	0.94	(0.0006)	10101	0.94	(0.0013)
Industrial	41665	0.04	(0.0005)	10101	0.04	(0.0009)
Construction	41665	0.01	(0.0001)	10101	0.00	(0.0002)
Commerce, etc.	41665	0.01	(0.0001)	10101	0.01	(0.0002)
C. Agricultural production and Land Use (Mu)						
Farmable land per household	23018	4.87	(0.0150)	10101	4.06	(0.0211)
Rice Sown Area	23018	1.66	(0.0106)	10101	2.55	(0.0106)
Garden Sown Area	23018	0.23	(0.0029)	10101	0.34	(0.0047)
Tea Sown Area	41665	0.00	(0.0000)	10101	0.15	(0.0034)
Orchard Sown Area	23018	0.20	(0.0029)	10101	0.16	(0.0034)

Sample of those born in during 1962-1990.
Observations are birth year x county cells.
Cell size: Mean=89, Median=68.

Table 2 – The Effects of Tea, Orchards and Cash Crops on Fraction of Males (Unrestricted):
Coefficients of the Interactions between Dummies Indicating Birth Year and the Amount of Tea, Orchards or Category 2 Cash Crops Planted in the County of Birth

	Dependent Variable: Fraction of Males					
	Tea (1)		Orchards (2)		Cat 2 Cash Crops (3)	
Birth Year	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
1963	-0.005	(0.013)	0.001	(0.005)	0.000	(0.002)
1964	0.005	(0.023)	0.003	(0.006)	-0.001	(0.002)
1965	-0.026	(0.013)	0.000	(0.005)	-0.003	(0.002)
1966	-0.009	(0.014)	0.003	(0.005)	-0.001	(0.002)
1967	-0.014	(0.015)	0.003	(0.005)	0.000	(0.002)
1968	-0.021	(0.014)	-0.003	(0.005)	-0.003	(0.002)
1969	0.001	(0.015)	0.000	(0.005)	-0.001	(0.002)
1970	-0.022	(0.016)	-0.007	(0.007)	-0.004	(0.002)
1971	-0.008	(0.011)	0.002	(0.006)	-0.002	(0.002)
1972	-0.012	(0.010)	-0.006	(0.005)	-0.003	(0.002)
1973	-0.022	(0.011)	-0.007	(0.006)	-0.004	(0.002)
1974	-0.019	(0.014)	0.000	(0.005)	-0.003	(0.002)
1975	-0.014	(0.012)	-0.008	(0.007)	-0.002	(0.002)
1976	-0.002	(0.019)	-0.005	(0.006)	-0.002	(0.002)
1977	-0.010	(0.018)	-0.003	(0.005)	-0.002	(0.002)
1978	-0.023	(0.014)	-0.005	(0.006)	-0.004	(0.002)
1979	-0.006	(0.011)	0.003	(0.006)	-0.002	(0.002)
1980	-0.031	(0.015)	0.000	(0.005)	-0.004	(0.002)
1981	-0.021	(0.015)	0.001	(0.006)	-0.004	(0.002)
1982	-0.024	(0.011)	0.010	(0.005)	0.000	(0.002)
1983	-0.029	(0.015)	0.003	(0.005)	-0.002	(0.002)
1984	-0.035	(0.018)	-0.003	(0.005)	-0.005	(0.002)
1985	-0.026	(0.016)	0.002	(0.005)	-0.003	(0.002)
1986	-0.028	(0.014)	-0.003	(0.005)	-0.004	(0.002)
1987	-0.016	(0.016)	0.003	(0.005)	-0.001	(0.002)
1988	-0.042	(0.012)	-0.006	(0.006)	-0.006	(0.002)
1989	-0.037	(0.019)	0.000	(0.005)	-0.005	(0.002)
1990	-0.037	(0.018)	0.010	(0.006)	-0.003	(0.002)
Observations	49082		49082		49082	
R-Squared	0.14		0.14		0.14	

All regressions include county and birth year fixed effects.

Standard errors clustered at county level.

Table 3 – The Effects of Tea, Orchards and Cash Crops on Fraction of Males (Pooled):

Coefficients of the Interactions Between Dummies Indicating Birth Year and the Amount of Tea, Orchards and Category 2 Cash Crops Planted in the County of Birth

Dependent Variable: Fraction of Males						
	Tea (1)		Orchards (2)		Cat 2 Cash Crops (3)	
Birth Year	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
1963	-0.005	(0.016)	0.001	(0.009)	0.000	(0.002)
1964	0.019	(0.026)	0.015	(0.010)	-0.001	(0.002)
1965	-0.013	(0.016)	0.012	(0.009)	-0.003	(0.002)
1966	0.000	(0.016)	0.011	(0.009)	-0.001	(0.002)
1967	-0.015	(0.018)	0.002	(0.009)	0.000	(0.002)
1968	-0.014	(0.017)	0.003	(0.009)	-0.003	(0.002)
1969	0.013	(0.018)	0.011	(0.009)	-0.001	(0.002)
1970	-0.013	(0.019)	0.001	(0.010)	-0.004	(0.002)
1971	0.008	(0.014)	0.016	(0.011)	-0.002	(0.002)
1972	-0.003	(0.014)	0.002	(0.010)	-0.003	(0.002)
1973	-0.001	(0.013)	0.003	(0.010)	-0.004	(0.002)
1974	-0.003	(0.017)	0.014	(0.010)	-0.003	(0.002)
1975	-0.021	(0.016)	-0.012	(0.011)	-0.002	(0.002)
1976	0.003	(0.023)	-0.002	(0.012)	-0.002	(0.002)
1977	0.001	(0.021)	0.006	(0.009)	-0.002	(0.002)
1978	-0.008	(0.016)	0.008	(0.009)	-0.004	(0.002)
1979	0.009	(0.014)	0.015	(0.010)	-0.001	(0.002)
1980	-0.014	(0.017)	0.014	(0.009)	-0.004	(0.002)
1981	0.003	(0.018)	0.022	(0.010)	-0.004	(0.002)
1982	-0.014	(0.014)	0.017	(0.010)	0.000	(0.002)
1983	-0.021	(0.018)	0.009	(0.008)	-0.002	(0.002)
1984	-0.016	(0.021)	0.012	(0.009)	-0.005	(0.002)
1985	-0.006	(0.019)	0.017	(0.009)	-0.003	(0.002)
1986	-0.016	(0.017)	0.006	(0.009)	-0.004	(0.002)
1987	-0.005	(0.018)	0.014	(0.009)	-0.001	(0.002)
1988	-0.025	(0.015)	0.008	(0.009)	-0.005	(0.002)
1989	-0.015	(0.022)	0.019	(0.009)	-0.005	(0.002)
1990	-0.013	(0.023)	0.029	(0.011)	-0.002	(0.002)
Observations			49082			
R-Squared			0.14			

All regressions include county and birth year fixed effects.

Standard errors clustered at county level.

Table 4 – Differences-in-Differences Estimates
of the Effect of Planting Tea and Orchards on Sex Ratios:
Coefficients of the Interactions between Dummies Indicating Whether a Cohort was Born Post Reform
and Dummies Indicating Whether Any Tea Was Planted in the County of Birth

	Dependent Variable : Fraction of Male			
	(1)	(2)	(3)	(4)
Tea * Post	-0.0081	-0.0086	-0.0074	-0.0074
	(0.0024)	(0.0026)	(0.0026)	(0.0026)
Orchard * Post			0.0096	0.0093
			(0.0033)	(0.0033)
Cashcrop * Post		0.0007	-0.0016	-0.0016
		(0.0007)	(0.0011)	(0.0011)
Han	N	N	N	Y
Observations	49082	49082	49082	49082
R-squared	0.09	0.09	0.09	0.09

All regressions include county fixed effect and controls for post and cash crops *post.

Orchard and cashcrop are dummy variables for the amount of orchards and cashcrop planted in each county.

Post = 1 for cohorts born 1979-1990.

Standard errors clustered at county level.

Table 5 –OLS and 2SLS Estimates of
The Effect of Planting Tea and Orchards on Sex Ratios Controlling for County Level Linear Cohort Trends:
Coefficients of the Interactions between Dummies Indicating Whether a Cohort was Born Post Reform and Dummies Indicating Whether Any Tea Was Planted in the County of Birth

	Dependent Variables				
	Fraction of Males		**Tea**	**Fraction of Males**	
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	1st	IV	IV
Tea * Post	-0.013	-0.012		-0.072	-0.011
	(0.006)	(0.005)		(0.031)	(0.007)
Slope * Post			0.26		
			(0.057)		
Linear Trend	No	Yes	Yes	No	Yes
Observations	37756	37756	37756	37756	37756
R-squared	0.13	0.20	0.82	0.05	0.16

All regressions include county fixed effects and controls for Han, orchards, cash crop, and birth cohort.
Post = 1 for cohorts born 1979-1990.
Standard errors are clustered at the county level.

Table 6 – Differences-in-Differences Estimates of
The Effect of Planting Tea, Orchards and Category 2 Cash Crops on Education Attainment:
Panel A: Coefficients of the Interactions between Dummies Indicating Whether a Cohort was Born Post Reform and Dummies Indicating Whether Any Tea was Planted in the County of Birth; Panel B: Coefficients of the Interactions between Whether a Cohort was Born Post Reform and a Continuous Variable for the Amount of Tea Planted in the County of Birth

	Dependent Variable: Years of Education							
	A. Dummy for Tea and Orchards				B. Continuous Variables for Tea and Orchards			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All	Female	Male	Diff	All	Female	Male	Diff
Tea * Post	0.199	0.247	0.149	-0.069	0.449	0.383	0.501	-0.097
	(0.043)	(0.057)	(0.049)	(0.063)	(0.107)	(0.133)	(0.146)	(0.218)
Orchard * Post	-0.124	-0.226	-0.029	0.174	-0.021	-0.119	0.054	0.118
	(0.037)	(0.050)	(0.040)	(0.056)	(0.056)	(0.071)	(0.064)	(0.086)
Cat. 2 * Post	-0.036	-0.024	-0.037	-0.020	-0.065	-0.040	-0.074	-0.012
	(0.026)	(0.032)	(0.028)	(0.040)	(0.032)	(0.041)	(0.035)	(0.050)
Observations	68522	33538	34984	58314	68522	33538	34984	58314
R-squared	0.37	0.48	0.34	0.14	0.37	0.48	0.34	0.14

All regressions include controls for Han ethnicity, county fixed effects and birth year fixed effects.

All standard errors clustered at the county level.

Post = 1 for cohorts born after 1976.

Figure A1 – The Effect of Planting Tea on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Tea Planted In Unrestricted Log(Sex Ratios) Equation

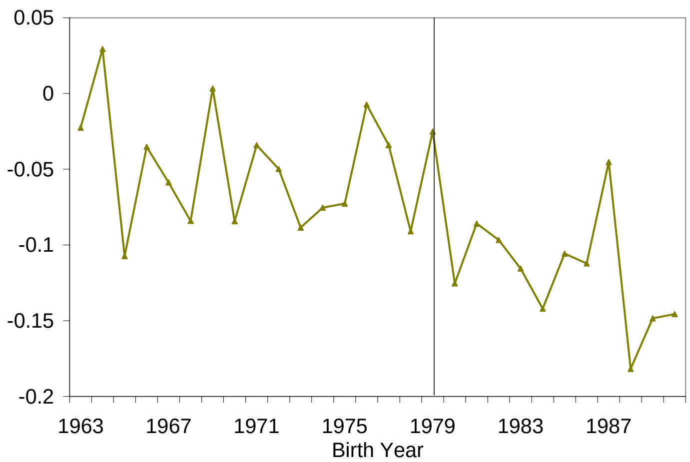


Figure A2 – The Effect of Planting Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Orchards Planted In Unrestricted Log(Sex Ratios) Equation

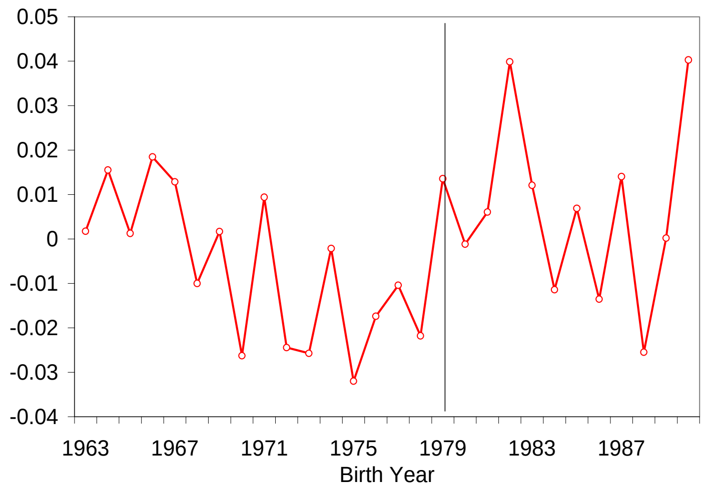


Figure A3 – The Effect of Planting Category 2 Cash Crops on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Category 2 Cash Crops Planted In Unrestricted Log(Sex Ratios) Equation

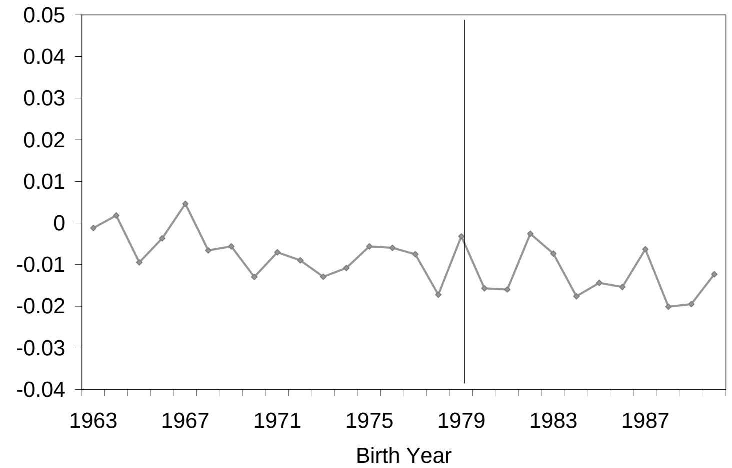


Figure A4 – The Effect of Planting Tea and Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Tea Planted and Birth Year * Amount of Orchards Planted in Pooled Log(Sex Ratios) Equation

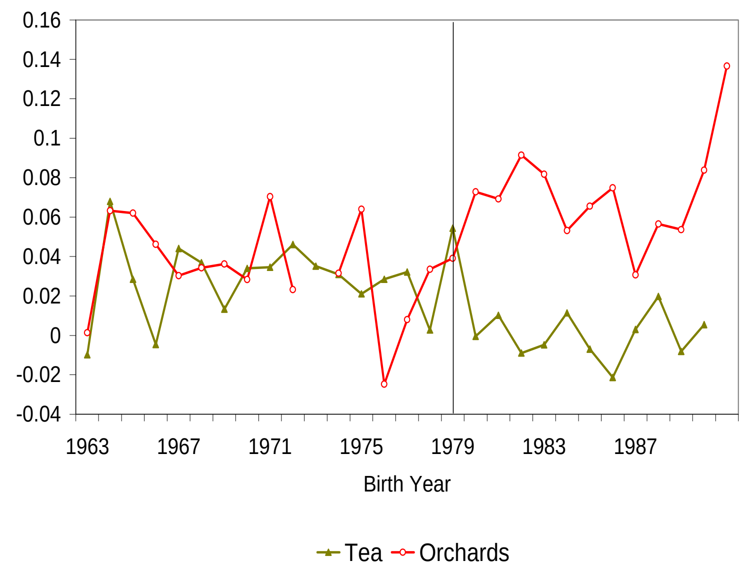


Table A1 – The Effect of Tea, Orchards and Cash Crops on Sex Ratios:
Coefficients of the Interactions between Birth Years and the Amount of Tea, Orchards and/or Category 2 Cash Crops Planted in the County of Birth

Dependent Variable: Log Sex Ratio

	A. Unrestricted						B. Pooled					
	Tea		Orchards		Cash Crops		Tea		Orchards		Cash Crops	
	(1)		(2)		(3)		(4)		(5)		(6)	
Birth Year	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
1963	-0.023	(0.055)	0.002	(0.038)	-0.001	(0.006)	-0.010	(0.030)	0.001	(0.037)	0.000	(0.013)
1964	0.029	(0.098)	0.015	(0.036)	0.002	(0.007)	0.068	(0.028)	0.063	(0.042)	-0.022	(0.013)
1965	-0.107	(0.054)	0.001	(0.038)	-0.009	(0.007)	0.028	(0.029)	0.062	(0.036)	-0.026	(0.013)
1966	-0.035	(0.057)	0.018	(0.023)	-0.004	(0.007)	-0.005	(0.027)	0.046	(0.036)	-0.011	(0.013)
1967	-0.059	(0.062)	0.013	(0.025)	0.005	(0.007)	0.044	(0.030)	0.030	(0.035)	-0.009	(0.014)
1968	-0.084	(0.059)	-0.010	(0.052)	-0.007	(0.007)	0.037	(0.030)	0.034	(0.037)	-0.019	(0.013)
1969	0.003	(0.062)	0.002	(0.038)	-0.006	(0.007)	0.013	(0.033)	0.036	(0.037)	-0.015	(0.014)
1970	-0.084	(0.066)	-0.026	(0.080)	-0.013	(0.008)	0.034	(0.031)	0.028	(0.041)	-0.024	(0.013)
1971	-0.034	(0.046)	0.009	(0.038)	-0.007	(0.008)	0.035	(0.035)	0.070	(0.042)	-0.026	(0.015)
1972	-0.050	(0.042)	-0.024	(0.069)	-0.009	(0.007)	0.046	(0.036)	0.023	(0.040)	-0.021	(0.015)
1973	-0.088	(0.044)	-0.026	(0.073)	-0.013	(0.007)	0.035	(0.034)	0.032	(0.038)	-0.025	(0.013)
1974	-0.075	(0.059)	-0.002	(0.046)	-0.011	(0.007)	0.031	(0.031)	0.064	(0.038)	-0.028	(0.014)
1975	-0.073	(0.052)	-0.032	(0.090)	-0.006	(0.008)	0.021	(0.037)	-0.025	(0.046)	-0.003	(0.015)
1976	-0.007	(0.082)	-0.017	(0.070)	-0.006	(0.008)	0.028	(0.037)	0.008	(0.046)	-0.011	(0.016)
1977	-0.034	(0.078)	-0.010	(0.054)	-0.007	(0.007)	0.032	(0.030)	0.034	(0.037)	-0.019	(0.013)
1978	-0.091	(0.058)	-0.022	(0.068)	-0.017	(0.007)	0.003	(0.029)	0.039	(0.037)	-0.025	(0.012)
1979	-0.025	(0.046)	0.014	(0.032)	-0.003	(0.007)	0.054	(0.032)	0.073	(0.038)	-0.026	(0.013)
1980	-0.125	(0.060)	-0.001	(0.041)	-0.016	(0.007)	0.000	(0.030)	0.069	(0.037)	-0.029	(0.013)
1981	-0.086	(0.065)	0.006	(0.042)	-0.016	(0.007)	0.010	(0.031)	0.091	(0.038)	-0.035	(0.012)
1982	-0.097	(0.047)	0.040	(0.004)	-0.003	(0.007)	-0.009	(0.032)	0.082	(0.039)	-0.017	(0.014)
1983	-0.116	(0.062)	0.012	(0.030)	-0.007	(0.007)	-0.005	(0.029)	0.053	(0.034)	-0.017	(0.011)
1984	-0.142	(0.075)	-0.011	(0.055)	-0.018	(0.007)	0.011	(0.032)	0.066	(0.036)	-0.032	(0.013)
1985	-0.106	(0.065)	0.007	(0.037)	-0.014	(0.007)	-0.007	(0.031)	0.075	(0.034)	-0.028	(0.012)
1986	-0.112	(0.057)	-0.014	(0.054)	-0.015	(0.007)	-0.021	(0.032)	0.031	(0.037)	-0.018	(0.013)
1987	-0.045	(0.066)	0.014	(0.028)	-0.006	(0.006)	0.003	(0.030)	0.057	(0.034)	-0.018	(0.012)
1988	-0.182	(0.050)	-0.025	(0.070)	-0.020	(0.007)	0.020	(0.033)	0.054	(0.038)	-0.034	(0.013)
1989	-0.148	(0.079)	0.000	(0.041)	-0.019	(0.007)	-0.008	(0.032)	0.084	(0.037)	-0.035	(0.013)
1990	-0.146	(0.076)	0.040	(0.012)	-0.012	(0.009)	0.005	(0.041)	0.137	(0.045)	-0.041	(0.016)
Observations	47214		47215		47216				47214			
R-squared	0.15		0.16		0.17				0.15			

All regressions includes county and birth year fixed effects.

Standard errors clustered at county level.

Table A2 – Differences-in-Differences Estimates of the Effect of Planting Tea and Orchards on Sex Ratios:

Coefficients of the Interactions between Dummies Indicating Whether a Cohort was Born Post Reform and Dummies Indicating Whether Any Tea was Planted in the County of Birth

	Dependent Variable: Log Sex Ratio	
	(1)	(2)
Tea * Post	-0.039	-0.029
	(0.010)	(0.011)
Orchards * post		0.027
		(0.013)
Observations	30355	30355
R-Square	0.13	0.13

All regressions includes controls for category 2 cash crop*post, post and county fixed effects.
Standard errors clustered at county level.

Table A3 – Descriptive Statistics of 0.1% Sample of the 2000 Population Census

	Counties that Plant no Tea			Counties that Some Tea		
	Obs	Mean	Std. Err.	Obs	Mean	Std. Err.
Fraction of Male	81774	53.31%	0.0017	25290	53.56%	0.0031
Fraction of Han	81774	93.47%	0.0008	25290	86.05%	0.0019
Years of Education	81774	7.14	0.0110	25290	6.89	0.0198
Male-Female Education	58590	0.55	0.0071	18034	0.55	0.0141
Fraction with Tap Water	81441	31.39%	0.0012	25182	37.60%	0.0021

Cohorts born 1962-1986

Birth Year x County Cells

Table A4 – The Effect of Tea, Orchard and Cash Crops on Education Attainment for Boys and Girl :

Coefficients of Interactions between Birth Year and the Amounts of Tea, Orchards and Category 2 Cash Crops in the County of Birth

	Dependent Variable: Years of Education											
	A. Sample of Girls						B. Sample of Boys					
	Tea (1)		Orchards (2)		Cat. 2 Cash Crops (3)		Tea (4)		Orchards (5)		Cat. 2 Cash Crops (6)	
Birth Year	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
1963	-0.806	(0.695)	-0.148	(0.269)	0.104	(0.185)	0.627	(0.386)	0.399	(0.182)	-0.169	(0.122)
1964	-0.107	(0.542)	-0.013	(0.223)	-0.006	(0.149)	0.721	(0.393)	0.492	(0.178)	-0.214	(0.091)
1965	-0.397	(0.576)	0.130	(0.250)	0.109	(0.171)	0.410	(0.324)	0.590	(0.186)	-0.302	(0.116)
1966	-0.713	(0.604)	-0.147	(0.248)	0.160	(0.172)	0.423	(0.438)	0.310	(0.192)	-0.131	(0.105)
1967	-0.527	(0.659)	0.145	(0.254)	0.016	(0.154)	0.221	(0.293)	0.716	(0.181)	-0.241	(0.106)
1968	-1.014	(0.512)	-0.134	(0.226)	0.085	(0.148)	0.476	(0.492)	0.423	(0.187)	-0.246	(0.102)
1969	-0.525	(0.611)	-0.010	(0.225)	0.101	(0.144)	0.137	(0.439)	0.565	(0.226)	-0.155	(0.117)
1970	-0.676	(0.456)	-0.047	(0.230)	0.038	(0.147)	0.795	(0.437)	0.431	(0.166)	-0.213	(0.093)
1971	-0.582	(0.645)	0.145	(0.237)	0.081	(0.155)	0.744	(0.412)	0.500	(0.203)	-0.261	(0.129)
1972	-0.673	(0.552)	-0.092	(0.248)	0.044	(0.161)	0.784	(0.352)	0.641	(0.209)	-0.219	(0.118)
1973	-0.675	(1.048)	0.103	(0.313)	-0.087	(0.219)	0.668	(0.629)	0.620	(0.211)	-0.181	(0.134)
1974	-0.547	(0.623)	-0.325	(0.255)	0.124	(0.170)	0.218	(0.531)	0.447	(0.204)	-0.169	(0.109)
1975	-1.354	(0.648)	-0.005	(0.267)	0.078	(0.156)	0.413	(0.398)	0.626	(0.200)	-0.121	(0.103)
1976	-0.387	(0.715)	-0.047	(0.257)	0.090	(0.149)	0.762	(0.619)	0.501	(0.189)	-0.245	(0.116)
1977	-1.051	(0.786)	0.048	(0.297)	0.085	(0.163)	0.400	(0.447)	0.567	(0.212)	-0.144	(0.103)
1978	0.528	(0.509)	-0.128	(0.300)	-0.068	(0.138)	0.638	(0.417)	0.535	(0.216)	-0.368	(0.112)
1979	-0.469	(0.548)	-0.348	(0.275)	0.049	(0.158)	1.226	(0.391)	0.471	(0.215)	-0.262	(0.109)
1980	-0.442	(0.661)	-0.436	(0.340)	-0.183	(0.229)	0.162	(0.568)	0.787	(0.255)	-0.304	(0.143)
1981	-0.395	(0.655)	-0.031	(0.291)	-0.044	(0.197)	1.175	(0.481)	0.730	(0.201)	-0.296	(0.126)
1982	0.063	(0.615)	-0.040	(0.247)	0.113	(0.151)	1.461	(0.573)	0.864	(0.225)	-0.359	(0.107)
Obs.			28065						29273			
R-Squared			0.51						0.38			

All regressions include controls for Han and county and birth year fixed effects.

Standard errors are clustered at the county level.

Table A5 – The Effect of Tea, Orchard and Cash Crops on Education Attainment for All Individuals and the Male-Female Difference in Education Attainment:
Coefficients of Interactions between Birth Year and the Amounts of Tea, Orchards and Category 2 Cash Crops in the County of Birth

	Dependent Variables:											
	Years of Education						Boy-Girl Difference in Years of Education					
	Tea (1)		Orchards (2)		Cat. 2 Cash Crops (3)		Tea (4)		Orchards (5)		Cat. 2 Cash Crops (6)	
Birth Year	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
1963	-0.168	(0.402)	0.150	(0.167)	-0.043	(0.110)	0.926	(0.744)	0.293	(0.303)	-0.128	(0.218)
1964	0.308	(0.329)	0.237	(0.144)	-0.108	(0.085)	0.960	(0.657)	0.454	(0.319)	-0.257	(0.223)
1965	0.019	(0.321)	0.388	(0.156)	-0.125	(0.103)	0.231	(0.522)	0.339	(0.278)	-0.378	(0.180)
1966	-0.230	(0.362)	0.086	(0.153)	0.030	(0.099)	0.547	(0.679)	0.312	(0.327)	-0.251	(0.209)
1967	-0.152	(0.315)	0.472	(0.171)	-0.136	(0.096)	0.371	(0.644)	0.372	(0.316)	-0.249	(0.195)
1968	-0.312	(0.380)	0.199	(0.159)	-0.088	(0.099)	1.002	(0.542)	0.308	(0.279)	-0.263	(0.173)
1969	-0.212	(0.402)	0.297	(0.159)	-0.023	(0.089)	0.254	(0.588)	0.499	(0.352)	-0.229	(0.213)
1970	0.055	(0.297)	0.209	(0.144)	-0.099	(0.089)	1.200	(0.520)	0.426	(0.285)	-0.283	(0.192)
1971	0.051	(0.385)	0.400	(0.163)	-0.134	(0.114)	1.147	(0.638)	0.117	(0.321)	-0.249	(0.202)
1972	0.030	(0.312)	0.308	(0.172)	-0.102	(0.102)	1.036	(0.514)	0.673	(0.311)	-0.302	(0.199)
1973	0.033	(0.499)	0.381	(0.184)	-0.144	(0.130)	1.711	(1.146)	0.461	(0.362)	-0.034	(0.227)
1974	-0.203	(0.446)	0.114	(0.162)	-0.036	(0.105)	0.108	(0.599)	0.470	(0.341)	-0.098	(0.179)
1975	-0.448	(0.420)	0.362	(0.168)	-0.027	(0.098)	1.430	(0.543)	0.523	(0.351)	-0.279	(0.192)
1976	0.141	(0.563)	0.250	(0.165)	-0.095	(0.095)	0.839	(0.784)	0.482	(0.318)	-0.326	(0.204)
1977	-0.356	(0.452)	0.301	(0.200)	-0.042	(0.108)	1.415	(1.350)	0.418	(0.374)	-0.198	(0.217)
1978	0.640	(0.295)	0.247	(0.201)	-0.238	(0.094)	-0.521	(0.751)	0.452	(0.351)	-0.164	(0.184)
1979	0.226	(0.318)	0.064	(0.168)	-0.110	(0.103)	0.744	(0.527)	0.633	(0.408)	-0.189	(0.188)
1980	-0.121	(0.392)	0.453	(0.219)	-0.245	(0.129)	0.188	(1.018)	0.481	(0.441)	-0.016	(0.314)
1981	0.408	(0.401)	0.366	(0.184)	-0.174	(0.121)	1.124	(0.578)	0.825	(0.356)	-0.335	(0.220)
1982	0.729	(0.357)	0.353	(0.172)	-0.148	(0.102)	0.135	(0.931)	0.507	(0.347)	-0.312	(0.171)
Observations			57338						48758			
R-Squared			0.39						0.16			

All regressions include controls for Han and county and birth year fixed effects.
Standard errors are clustered at the county level.