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ABSTRACT

Missing Women and the Price of Tea in China: The Effect of Sex-Specific Earnings on Sex Imbalance*

Economists long have argued that the severe sex imbalance that 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 income on sex ratios of surviving children. The results show that increasing income alone has no effect on sex ratios. In contrast, increasing female income, holding male income constant, increases survival rates for girls; increasing male income, 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 educational attainment for girls and has no effect on boys' educational attainment.

JEL Classification: I12, J13, J16, J24, O13 and O15
Keywords: development, gender and household bargaining

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1 Introduction

Many Asian and Muslim 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.[1] 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.[2] This phenomenon is not isolated in poor countries. The ratios of South Korea and Taiwan are identical to those of India and China. 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, though, 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 on that 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, respond 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, 1976), 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). Finally, 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 the omitted variables, such as "culture".[3] 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.[4]

[1] Source: WDI indicators

[2] The approximate number of missing women is calculated using sex ratios reported in WDI indicators and using sex ratios in Western Europe as a benchmark.

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

[4] 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 of married couples residing 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. They find that female survival rates are positively correlated with returns to having girls.

This paper exploits the variation in regional incomes and sex-specific incomes over time in China to capture the causal effect of economic conditions on sex ratios. First, I exploit variation in intensity of labor input across crops by sex; second, I exploit 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, an increase in the relative value of orchards increases total income but reduces relative female income.

The empirical strategy of this paper is similar to a differences-in-differences framework in that it compares sex ratios for cohorts born before and after the reforms, between counties that plant and do not plant sex-specific crops where value increased because of the reform. Unlike differences-in-differences, it examines the impact of planting sex-specific crops on sex ratios for each birth year after the increase in relative crop value. This decreases the likelihood that the results are confounded with the effects of subsequent policies of the post-Mao reform era. I first 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. Then, 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 the relative value of orchards. Next, 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 incomes. Finally, by using the same strategy for educational attainment, I am able to estimate the effects of increasing total and relative incomes on the 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 Hannum and Park (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 a either model of intra-household bargaining or by a unitary model of the household in which parents view children as a form of investment. The results on education, however, are not consistent with the latter model unless the returns to education for girls are negatively correlated with male income and the 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 to 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 controlled family size.[5] Second, by estimating the effects of sex-specific wages on female survival rates and educational attainment, this study can speak to concerns about the impact of increasing gender wage gaps.[6] Finally, the availability of three censuses avoids the confounding of age and "cohort" effects. For example, Figures 1A and 1B show that, in the 1990 and 2000 censuses, age is negatively correlated with sex ratios (whereas there is little or no correlation in 1982). If only one census were available, then 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 relatively similar in 1982, 1990 and 2000. In other words, sex ratios for a given birth cohort does not change as the cohort ages. This is not consistent 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 using China's 1982 and 1990 censuses and the 1990 U.S. IPUMS. It shows that sex ratios by age in China in 1982 were similar to those of the U.S. However, in 1990, there is a higher fraction of males for all individuals over age 14 in the census year. Like the previous figure, Figure 1B shows that cross-sectional variation in sex ratios in China should be interpreted as cohort variation and not as

[5] To directly check that the main results are not confounded with the effects of family planning policies, I also repeat this study on a sample containing only ethnic minorities who have largely been exempt from these policies. The results are very similar. See the interpretation section for a further discussion of family planning policies.

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

age variation in sex ratios. 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 confounded with the recently posited biological explanations, such as cohabitation patterns or hepatitis B.[7]

The following sections describe the policy background, conceptual framework, data, the empirical strategy and results, the interpretation of the results, and offer concluding remarks.

2 Background

2.1 Agricultural Reforms

Before 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*), the 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% below market prices (Perkins, 1966) and market trade in 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).[8] 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 could 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.

[7] 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 by all accounts *rising*. Oster (2005) hypothesizes that hepatitis B infection rates of pregnant mothers result in higher sex ratios at birth. She interprets the observed negative correlation between age and sex ratios in the 1982 China Population Census as differential mortality effects (age effects) and argues that 75-85% of the observed sex imbalance is caused by hepatitis B. Cohabitation and hepatitis B infection rates may also be correlated with socioeconomic variables, such as relative status of women, that may affect sex ratios directly.

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

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 oil crops in rural areas. Mandatory sown-area targets often required cultivation on land unsuitable for grain. Grain production grew at a substantial cost for other production. Production declined for crops that competed with grain for land. Living standards declined significantly in areas suitable for commercial crops (Lardy, 1983).

Post-Mao era reforms focused on raising 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 gradually reduced planning targets and represented a return to earlier policies that used 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 been increased for all crops. Although category 1 crops benefited from the price increases, the emphasis was on cash crops from category 2. The second set of policies, commonly called the *Household Production Responsibility System* (HPRS), devolved responsibility from the collective, work brigade, or work team to households (Johnson, 1996; Lin, 1988). The HPRS first was enacted in 1980 and spread throughout 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 shifting production partially 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, a continued emphasis on rural-urban subsidization of grain and other category 1 products caused the *relative* value of category 1 products to decrease.[9] I directly compute the income from each crop in the next section. Clearly, the increase in the relative value of category 2 crops also is reflected in the disproportionate growth in their output relative to 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 in Figure 3 for tea, another category 2 crop.

Given China's turbulent political history during the 1960s and 70s, it may be surprising that households perceived the policy changes from 1978 and onwards as permanent shocks. However, Mao Zedong,

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

the countries's de-facto leader for three decades had passed in 1976. More importantly, this was the first time that the post 1949-regime had experimented with market-oriented reforms. Therefore, while agricultural households may not have viewed each specific reform as permanent, they most likely viewed the overall regime shift as permanent (i.e. shift from a regime where they were not supposed to make profits to a regime where they could make profits). Consequently, only this initial regime shift is plausibly exogenous and I will not use the variation in prices which occurred afterwards (see identification section).

In a second round of reforms designed to reduce the fiscal burden of grain subsidies, the state increased urban retail grain prices and ended 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 grain production 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; 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 its low labor productivity as a result of migration and other labor controls. Estimates of the marginal productivity of labor in Chinese agricultural production vary greatly. However, most studies agree that the high population-to-land ratio and controls on the labor market and migration result in low marginal productivity in rural areas during this period. Households living in areas with the appropriate natural conditions thus can easily expand into cash crop production in response to new economic opportunities. This is consistent with the fact that agricultural households very rarely hired labor from outside the family. In 1997, 1 per 1000 rural households hired a worker from outside of the immediate family (Diao et. al., 2000). Because 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 also would reduce the 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 each reacted to post-Mao reforms. I 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 to total income or to 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, then this strategy will only work if income from tea does not exceed income from sex neutral cash crops.

Tea is picked mainly by women in China (and other Asian countries).[10] Data on labor input by sex and crop are not available for examining sex specialization directly. However, using household level data from surveys conducted by the Ministry of Agriculture's Rural Center on the Rural Economy (RCRE), Table 1A columns (1)-(4) show that, in 1993, the amount of tea sown and the fraction of arable land that is devoted to tea are both negatively correlated with the fraction of male laborers within households.[11] In South India, Luke and Munshi (2004) find that 95% of workers on tea plantations are female. The most commonly cited reasons for adult women having an absolute advantage over adult men and children in picking tea is that it requires 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 are worthless if broken.[12] In addition, tea bushes are 2.5 feet (0.76 meters) tall on average, which disadvantages taller adult males.

For China, the specialization in tea caused by women's physical advantages 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 the women switched to tea production. It follows that, for tea planting households, an increase of the value of tea increased both total household income and the *relative* value of adult female labor. Moreover, the monitoring of tea picking is made difficult by the fact that it is a very delicate task and that the quality and value of tea leaves vary greatly with the tenderness of the leaf. This decreases the desirability of hired labor. Hence, the relative value of female labor has 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.[13] Columns (5)-(8) in Table 1A show that the amount of orchards sown and the fraction of a household's arable land devoted to orchards is positively correlated with the fraction of males labor-

[10] See Lu (2004) for a detailed anthropological analysis of the historical role of women in tea picking.

[11] The RCRE surveys did not record the amount of household land devoted to tea before 1993. See section on data for more detailed description of the RCRE data.

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

[13] 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 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 means that adult males have advantages, both in pruning and picking, over adult females and children. Orchard trees that are most commonly observed today are either genetically modified (stunted) to be short or kept short by constant pruning.

ers within a household. 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 analysis of agricultural production. However, adult labor surplus resulting from land shortages and labor market controls leaves little demand for child labor. In certain circumstances, men may also pick tea. The empirical strategy of this study does not require that only/mainly women pick tea. It only requires that women have a comparative advantage in picking tea relative to producing grains (see section on identification).

The main effect of post-Mao reforms for tea production was increased 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, because farmers had little incentive to produce, and, because tea picking is more difficult to enforce than sowing, most of the sown fields were left wild and untended until the post-Mao era; then 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, 1994). The procurement price for tea, which was largely unchanged between 1958-1978, doubled between 1979 and 1984. Figure 3 shows the increase in tea procurement price and yields. It shows that there is a sudden increase in tea procurement prices by approximately 50% in 1979. Since there was little change in sown area during this period, the increase in yield 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 approximately 4% of total household income. To examine the change in the value of crops over time, I calculate the approximate gross income by crop using data on output-per-standard-labor-day, by year and by crop, and procurement price by year and by crop.[14] 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 exploit this increase to estimate the effect of an increase in relative adult female income on sex ratios. Figure 4B shows that the calculated income from orchard production increased at a faster rate than the income from category 1 crops. I exploit this increase to estimate the effect of an increase in relative male income on sex ratios.

Among category 2 crops, the government maintained more control on tea than other crops. The central government viewed tea as a political symbol after 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 until the early 1990s. Until the late 1980s, China exported tea at subsidized

[14] 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.

prices. Part of the subsidy was achieved by suppressing procurement prices of tea (Etherington and Forster, 1994). Consequently, although the price of 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.

It is important to note that the empirical strategy of this study relies on the effect of planting tea immediately after the first wave of post-Mao reforms (1978/1980). There are several reasons for this. First, sex-specific comparative advantage caused by sex-specific physical attributes may diminish with technological change. This paper avoids these potentially confounding factors by focusing on the early 1980s, when agricultural technology was largely unchanged. Second, the nature of the policies affecting agricultural prices and the overall structure of the rural economy was likely to have changed after the 1980s. The validity of the empirical strategy only requires that the initial increase in relative prices of cashcrops and the HPRS were uncorrelated with characteristics specific to cashcrop producing regions. (See identification section for a more detailed discussion).

2.3 Family Planning Policies

China's stringent enforcement of family planning policies, namely the One Child Policy was introduced first in urban areas, beginning with Shanghai in 1979. Enforcement in rural areas were phased in during the early 1980s. Qian (2005) shows that for rural areas, 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 in 1976 and later. Hence, the effective date of the One Child Policy does not coincide with the increase in the price of tea in 1979. Using a matched dataset from the 1989 *China Health and Nutritional Survey* and the 1990 Census, I also directly investigate whether family planning policies vary between tea and non-tea planting regions. I find that local family planning policies do not systematically vary between tea and non-tea counties.[15]

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, if households are not unitary (e.g. parents do not have identical preferences), then a change in adult income also can affect the relative desirability of girls by changing the bargaining power of each parent within the household (Bourguignon et. al., 1993;

[15] There are too few matched counties to be useful for statistical analysis.

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 that parents face 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:

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

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 increases with her income and decreases with 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 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 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, then 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 differs 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.[16] The sample includes 1,621 counties where any tea is planted in China's

[16] This section describes the 1% sample of the 1990 *Population Census*. Because of 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.

15 southern provinces, south of or along the Yellow River.[17] Map 1 shows that these counties are dispersed throughout southern China. The 1990 census data contain 52 variables, including 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 versus 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 analyses are all population weighted.[18].

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*. There is no official market for buying or selling land. Agricultural land is allocated by the village to farmers based on characteristics such as the number of household members and land quality (Benjamin and Brandt, 2000; Burgess, 2004; Carter et. al., 1995; Jacoby et. al., 2002; Johnson, 1995; Kung and Liu, 1997; Kung, 1994; Li, 1999; and Rozelle and Li, 1998). There is no evidence that the land allocation systematically differed between tea and non-tea producing regions.[19]

Data on sex-specific labor input across crops is not available for the period of this study. To check the assumption about labor intensity by sex by crop, I use the household and village level surveys from the Research Center for Rural Economics (RCRE) which are available from 1986-2003. I use the data from 1993 to examine the correlation between tea production and fraction of female laborers (see section of background). The data is also helpful for examining migration patterns between tea and non-tea areas during 1986-1990. (The usefulness of the RCRE data is greatly limited by the fact that it reports household level tea production beginning only in 1993, when the rural economy was much changed since the period of this study; and that there is almost no individual level data).

Using 1997 agricultural data to proxy for agricultural conditions in the early 1980s introduces measurement error. It is also possible that the counties that produced tea in 1997 are the counties that had stronger girl preference prior to the reform. In this case, comparing sex ratios in counties that plant tea in 1997 to sex ratios in 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

[17]Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Sichuan, Yunnan, Shaanxi.

[18]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% 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.

[19]I also give evidence in the identification section to show that the results of this paper are not likely to be driven by other policies from this period.

emphasis on tea planting during the Cultural Revolution meant that the main determinant of whether a region had tea fields was geographic suitability, not sex preferences. Specifically, tea grows best on warm and humid hilltops. The population density of the Chinese countryside and the distribution of hills throughout southern China, means that counties that plant some tea should not be very different in other respects from their neighboring counties that plant no tea. (The difference between hilly and flat regions is addressed directly in the section on identification).

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 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 1B 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 and 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 to the Maps 1B-1E, which show agricultural density and production by crop. The black-colored counties 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 that 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 related in part 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 distinguish the effect of female income from the effect of sex preference on girls' survival rates. This problem is addressed by exploiting the increase in the 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 the relative survival rates of girls.

First, I estimate the effect of the agricultural reforms on girls' 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. There was substantial variation in the amount of tea sown across regions. Therefore, the number of surviving female children should have increased in the tea planting regions for cohorts born close to and/or after the reform, and that increase should have been larger for regions that planted more tea.[20] This strategy is similar to a differences-in-differences estimator except that it estimates the effect of planting tea on sex ratios for each birth year. The main advantage of this strategy relative to a differences-in-differences estimator is that it allows me to check that the effect of planting tea changes around the time of the increase in relative tea prices. Hence, the estimates are less likely to be confounded with the effects of subsequent post-Mao reforms. Differences-in-differences estimates capture the effects of all the changes that occur after the initial reforms (1978/1980). Like the differences-in-differences estimator, I compare relative survival rates between counties that do and 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 the time-invariant community characteristics. Comparing tea planting to non-tea planting communities differences out the 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 that were systematically different from those of non-tea planting areas. In other words, the strategy controls for systematic differences both across regions and across cohorts. Only the combination of these two variations is treated as exogenous.

Figure 5A plots the fraction of males in each birth year cohort for tea planting and non-tea planting counties. It shows that, prior to the reform, tea counties had higher fractions of males; 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 lends credibility to the identification strategy.

The date of birth, and whether an individual is born in a tea planting region, jointly determine whether he/she was exposed to the adult female relative 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 would exceed actual relative female income. Hence, the strategy would underestimate the true effect of relative female

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

income on sex ratio. If there are any unobserved time-invariant cultural reasons that cause women to pick tea *and* affect the relative desirability of female children, then 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 that coincides with the reform. For example, if the attitudes that drive sex preference changes in tea planting counties at the time of the reform, then 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 increase in procurement price and the HPRS changed the reason for women to pick tea, then the pre-reform cohort will not be an adequate control group. While I cannot resolve the former problem, the latter is addressed by instrumenting for tea planting with time invariant geographic data.[21]

Next, 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. Finally, I investigate whether the increase in the value of tea affects relative survival rates because of the increase in relative female income, rather than through 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 higher increases in value 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 Ordinary Least Squares

To see that the effect of tea and orchards on sex ratios is attributable to the post-Mao agricultural reforms and not 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

[21] I also perform two other checks on the identification strategy. First, to check that the estimates are not driven by systematic differences between hilly regions (that are more likely to produce tea) and flat regions, I estimate the impact of planting tea on sex ratios for a sample containing only tea counties and non-tea counties that share a boundary with tea counties. Hilliness varies gradually. County boundaries are straight lines drawn across spatial areas. The OLS estimate for this restricted sample is similar to the estimate for the whole sample although the precision is reduced due to the smaller sample size. This adds to the plausibility of the identification strategy unless potentially confounding factors change discretely across county boundaries. Second, I show that planting tea had no effect on sex ratios for non-agricultural households living in tea planting counties. This suggests that between-county comparison is unlikely to capture spillover effects between agricultural and non-agricultural households. Together, the two identification checks support the claim that the empirical strategy does not confound the effect of the reforms of interest with other policies from this period that targeted the overall rural population. Results are available upon request.

birth cohort can be written as

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

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, then 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 and after the reform, I estimate the F-statistic for each cohort. They are 3.59 and 2.05 respectively, 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 is positive for most years 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 respectively. 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 the fraction of males. The plot shows that the effect of cash crops on sex ratio did not change after the reform. Table 2 column (3) presents the estimates. The F-statistics for the pre-reform cohort and the post-reform are 1.32 and 1.37 respectively. Neither is statistically different from 0.

Because relatively few counties produce tea or orchards while all counties produce grains, the reference group in equations (4) and (5) is counties that produce grains. Consequently, controlling for the area of orchards planted should not affect the unrestricted estimates of the effect of tea taken 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; 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 Robustness

Migration If migration patterns differed significantly between tea and non-tea areas, and between orchard and non-orchard areas, then 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 were more likely to migrate out of tea areas and households with girls were more likely to migrate out of orchard areas. However, migration controls made migration of entire households difficult. Another possible cause for bias is if, among 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. Using the RCRE surveys, I find that the probability of having a household member work away from the home village is low and very similar between regions that produce tea and regions that do not produce tea during 1986-1990.[22] Since migration controls relaxed over time, the similarity in migration patterns during the late 1980s suggests that they were also similar for the preceding decade.

To address migration more directly, I estimate the upper and lower bounds of the absolute value of the effect of planting tea and orchards on sex ratios; I estimate equation (6) 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 entire province is 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 there. Next, I add back into each county the multiple of this fraction and the

[22] During the 1990s, the probability of migrating in tea producing regions increases relative to non-tea producing regions. This may reflect a divergence in the distribution of the benefits of economic reforms in the 1990s.

maximum number of migrants for that province. 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 were all born prior to the reform. To estimate the lower and upper bounds of the effect of tea, I assume that the new additions to the pre-reform cohorts in tea counties are female and male respectively. Similarly, for the lower and upper bound effects of orchard, all the added inferred migrants in orchard counties are assumed to be male and female, respectively. The estimated bounds are very similar to the OLS estimates on the reported population which suggests that the main results are not driven by migration.[23]

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 that 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 differences-in-differences specification does not explicitly control for orchards because planting orchards can be endogenous for the reasons discussed in the next section. I estimate

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

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. Column (1) Table 5 shows the basic fixed effects estimates. Column (2) shows the estimate for when county-level cohort trends are controlled for. The point estimates are similar. They show that planting tea decreased the fraction of males by 1.3 and 1.2 percentage-points. Estimates from both specifications are statistically significant at the 5% level. Thus, the OLS estimates are robust to linear changes across counties over cohorts.

5.2.3 Two Stage Least Squares

Two problems motivate the use of instrumental variables. First, using 1997 agricultural data to proxy for agricultural conditions in earlier years introduces measurement error that may bias the estimate downwards. Second, the OLS estimate will suffer from omitted variable bias if families that prefer girls switch to planting tea after the reform. In this case, the OLS estimate will overestimate the true effect of an increase in the value of female labor because it will confound the aforementioned effect with the sex-preferences of households that switched to planting tea. I address both problems by instrumenting for 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. Therefore, hilliness is a valid instrument for tea planting if it does not have any direct effect

[23] Results available upon request.

on differential investment decisions and is not correlated with any other covariates in equation (9).[24] Map 2 shows the slope variation in China, where the darker areas are steeper. Map 3 overlays the map of counties that 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 the slope is time-invariant. Note that since orchards also is an endogenous regressor, the 2SLS specification does not separately control for it. The first stage equation is

$$\begin{aligned} tea_i \times post_c &= (slope_i \times post_c)\lambda + (cashcrop \times post_c)\varphi \\ &\quad + Han_{ic}\zeta + \alpha + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{8}$$

The second-stage regression is

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

Column (3) of Table 4 shows the first-stage estimate from equation (8). The estimate for the correlation between hilliness and planting tea, λ, is statistically significant at the 5% level. Column (4) shows the 2SLS estimate from equation (9). The estimate is larger than the OLS estimate and statistically significant. Column (5) shows the 2SLS estimate after 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 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 that parents view children only as a form of consumption. However, because increasing adult agricultural earnings also increase the earnings potential of children, these results do not distinguish the hypothesis that households are unitary and that 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 by increasing female bargaining

[24] See footnote in section on identification for a discussion of hilly regions.

power. To gain further insight into 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 and father's income will only have different effects on education investment for children if they have different effects on the returns to education. Similarly, increasing mother's and 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 that 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*.[25] In order to confine the sample to children who had completed their education, I restrict it to cohorts born between 1962 and 1982. Individuals in the sample should not be affected by the Cultural Revolution because disruptions to schools generally were isolated to urban areas.[26] 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.[27]

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 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.

$$\begin{aligned} eduyrs_{ic} &= (tea_i * post_c)\beta_1 + (orchard_i * post_c)\beta_2 + \\ &\quad (cashcrop_i * post_c)\beta_3 + Han_{ic}\zeta + \alpha + \psi_i + post_c\gamma + \varepsilon_{ic} \end{aligned} \tag{10}$$

$eduyrs_{ic}$ is the average years of educational attainment for individuals born in county i, birth year c. The estimates in column (1) of Table 5 show that planting tea increased overall, female, and male educational attainment by 0.2, 0.25 and 0.15 years, respectively. On the other hand, planting orchards decreased female educational attainment by 0.23 years and had 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

[25] Descriptive statistics are in Appendix Table A3.

[26] 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.

[27] 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.

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 (10) 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 decrease 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.

$$\begin{aligned} eduyrs_{ic} \quad = \quad & \sum_{l=1963}^{1982}(tea_i \times d_l)\beta_l + \sum_{l=1963}^{1982}(orchard_i \times d_l)\delta_l + \\ & \sum_{l=1963}^{1982}(cashcrop_i \times d_l)\rho_l + \zeta Han_{ic} + \alpha + \psi_i + \gamma_c + \varepsilon_{ic} \end{aligned} \tag{11}$$

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. This 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 1.3 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, then the findings imply that increasing household income by 10%, and giving it all to women, increases the fraction of girls by 1.3 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 about the level of Western Europe. Of course, this calculation should not be taken too literally, because 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. The main concern is that the enforcement of these policies systematically varied between tea planting and non-tea planting regions. In this case, the identification assumption that there were no other changes in tea planting counties at the time of the reform would have been violated. This is unlikely for the reasons described in the background section. However, I am able to check that the results are robust to changes in family planning policies by repeating the study on a sample containing only ethnic minorities (non-Han) who have largely been exempt from them. The results are similar to those using the whole sample.

Family planning policies also affect the interpretation of the results of this paper in another way. Any effects of family planning policies on sex ratios will change the proportion of the total observed sex imbalance attributable 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 that implied by the main results together with the observed sex imbalance. More research is needed on the effect of family planning policies and other factors unrelated to economic conditions on sex imbalance 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. There is also little reason to believe that the diffusion of this technology varied systematically between tea planting and non-tea planting areas. More recently, for the past ten to fifteen years, studies have found that the rapid rise in the use of pre-natal sex-revealing technologies has significantly increased sex imbalance (Chu, 2001; Coale and Banister, 1994). One interesting avenue of future research would be to examine how the decrease in the 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 that 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 the 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 the returns to education are not differentially affected by the reforms. Evidence from India shows that the returns to education for tea workers are close to zero (Luke and Munshi, 2004). Evidence from China suggests that the returns to education for all manual agricultural labor are 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 in which mothers value education more than fathers and increasing the mother's income increases investment in education for all children because it increases her bargaining power within the household. Using this model, the empirical results cannot distinguish between children viewed as a form of consumption and children viewed as a form of investment.[28] Importantly, this explanation does not require mothers to prefer girls more than fathers. A likely scenario is that because mothers have more prolonged contact with an infant, they are less willing to neglect an infant regardless of sex. If there is boy-biased sex-selection before the reform, then the equalization in treatment of boys and girls will lead to an increase in female survival rates.

The policy recommendation is the same for all of the models discussed here. 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 addresses the problem of joint determination in estimating the effect of changes in adult income on the survival rate of girls; it does this 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 provide a clear affirmative answer: both sex imbalance and education investment respond to changes in sex-specific incomes in the short run. In addition, increasing total

[28] 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 that of boys and therefore decrease girls' educational attainment relative to boys. This 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 required 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 also may 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.

household income without changing the relative shares of female and male income has no effect on either survival rates or education investment. Combined with the increased gender wage gap, these results can help to explain the increased sex imbalance and the observed decrease in rural education enrollment in post-reform China.

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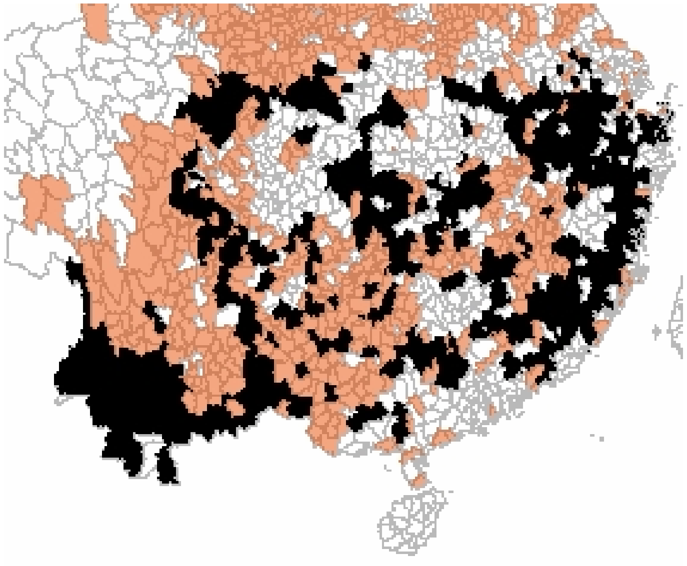
8 Appendix - Robustness of Linear Specification

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 (**??**) 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.

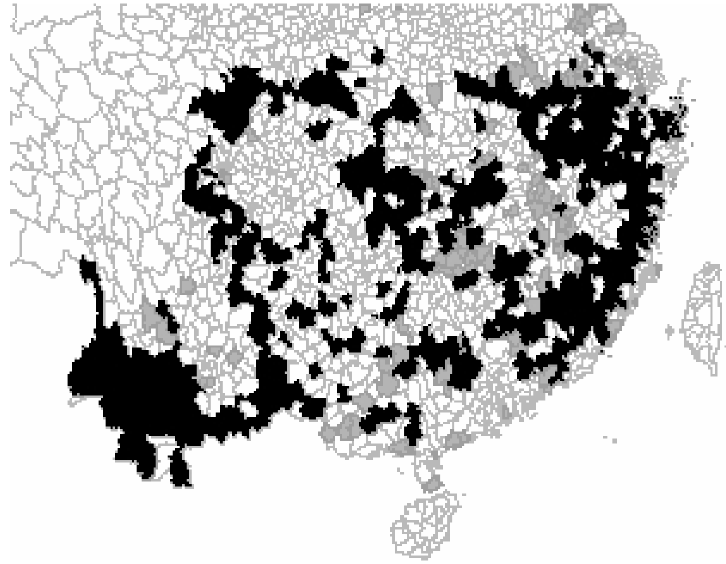
Map 1 – Tea Planting Counties in China

Darker shades correspond to more tea planted per household.

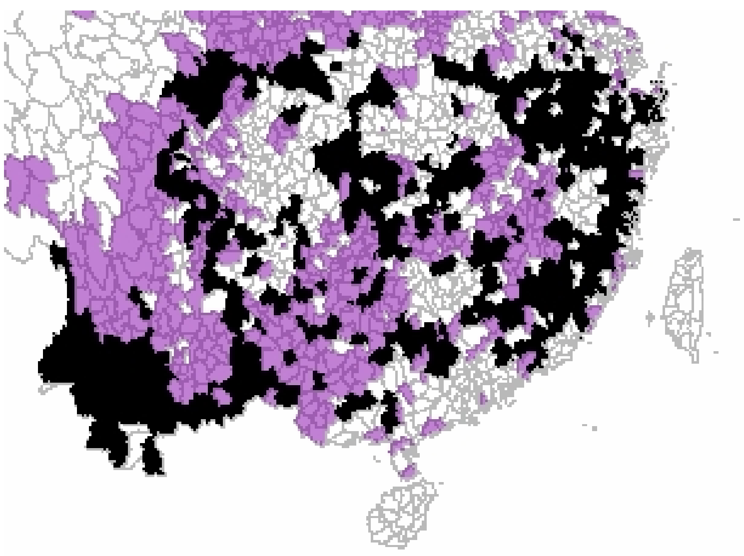
Map 2A – Garden and Tea Producing Counties
Tea counties are colored black



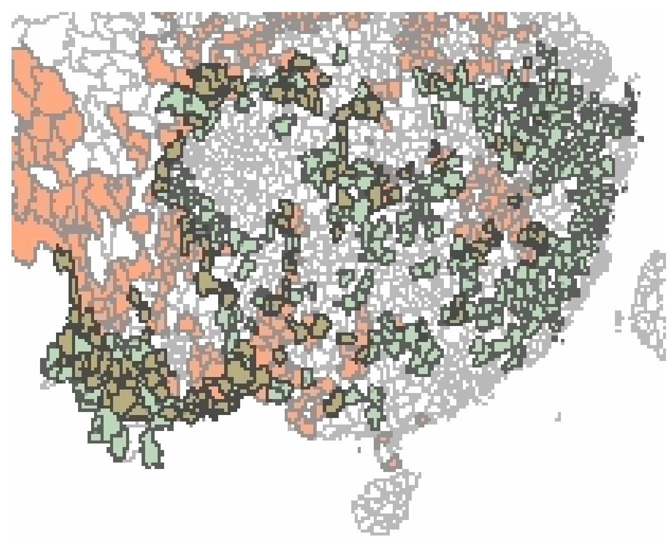
Map 2C – Fish and Tea Producing Counties
Tea counties are colored black.



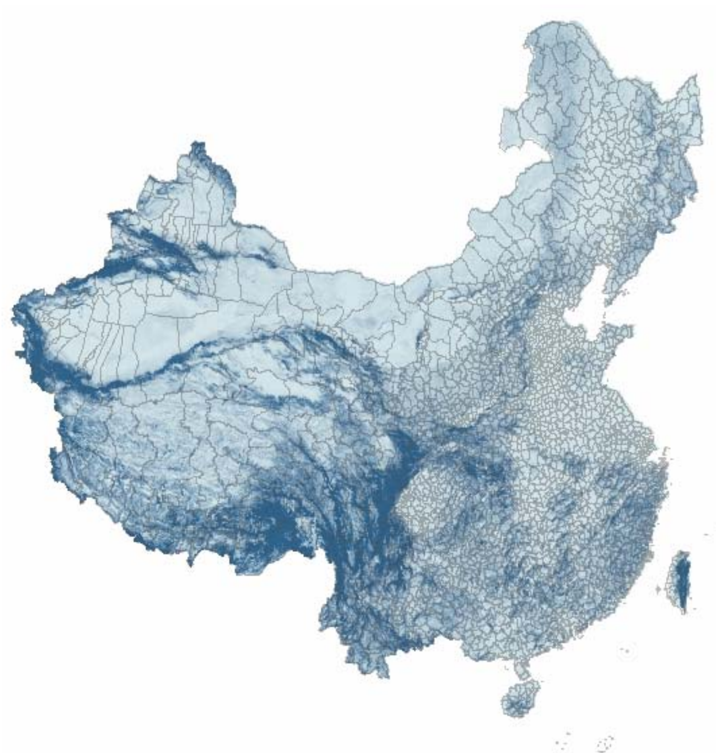
Map 2B – Orchard and Tea Producing Counties
Tea counties are colored black.



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.

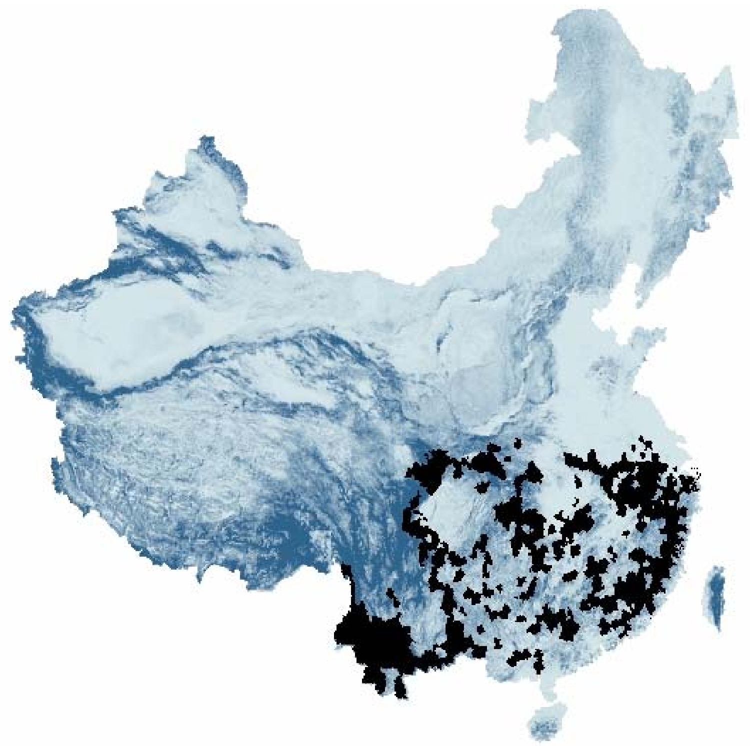
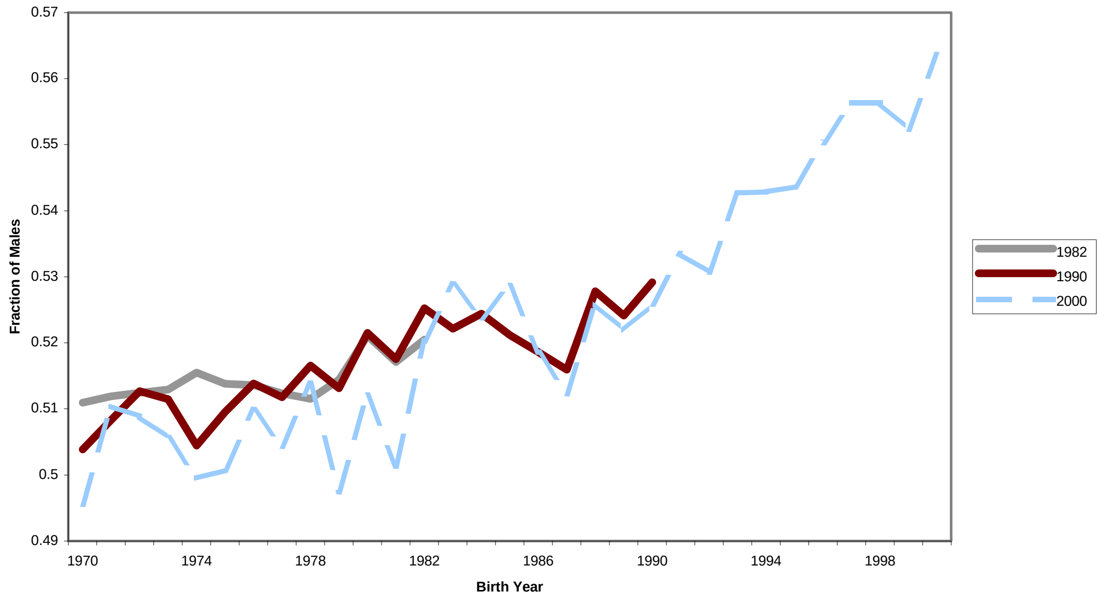
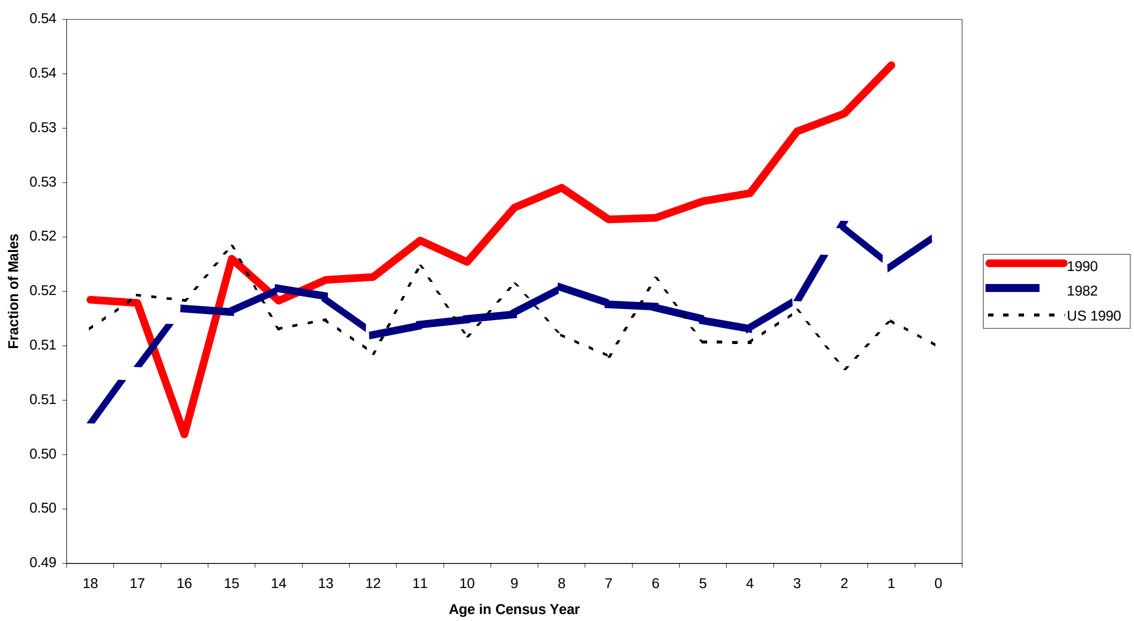


Figure 1A – Sex Ratios by Birth Year in Rural China



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)

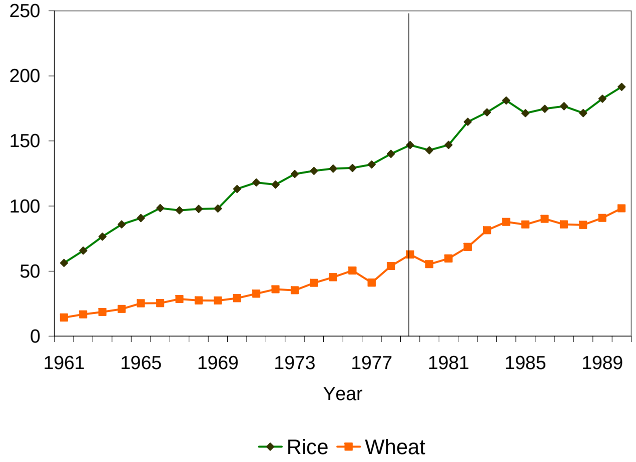


Figure 2C – Category 2 Production: Vegetables
(Measured in Units of 100 Kilo Tons)

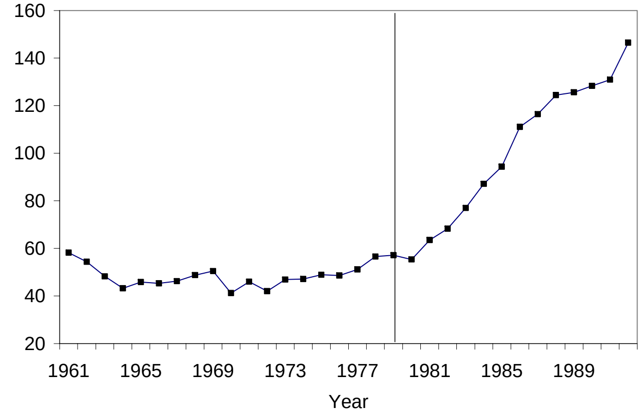


Figure 2B –Category 1 Production: Non-grains
(Soy and Oil Measured in Units of 100 Kilo Tons, Roots and Tubers Measured in 1000 Kilo Tons)

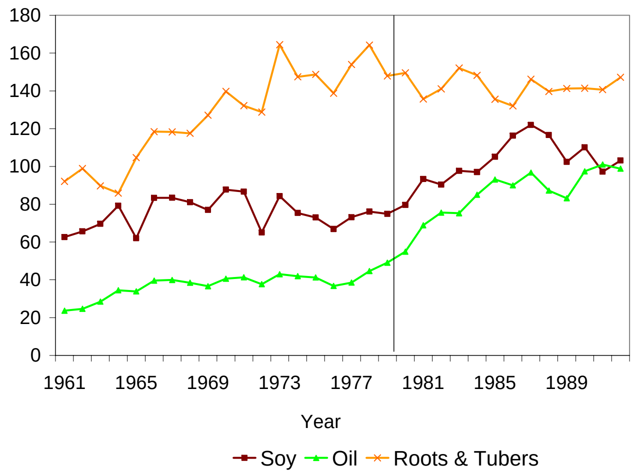
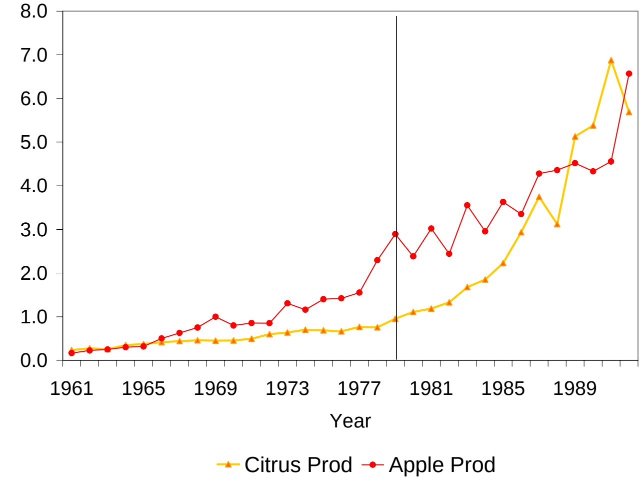


Figure 2D – Category 2 Production: Orchards
(Measured in Units of 1 Million Metric Tons)

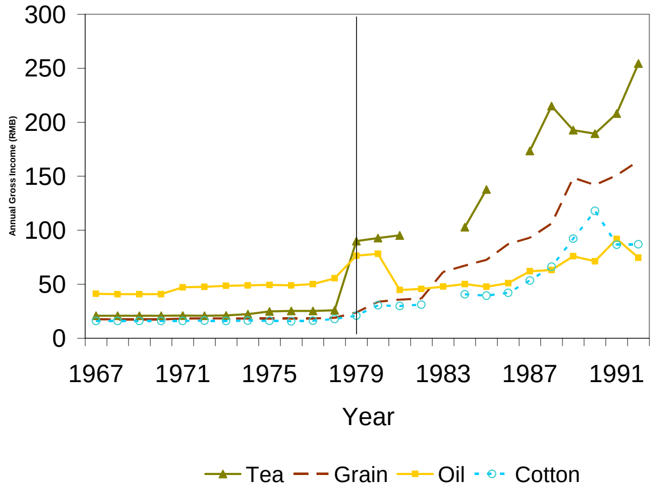


Note: The lag observed between the reform and the increase in output can be attributed to the time required for orchards to be sown and mature.

Figure 3 – Tea Yield and Tea Procurement Price

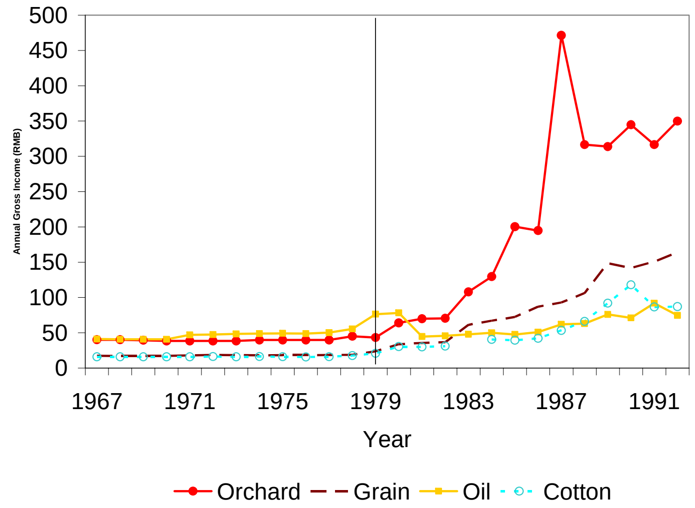
Notes: 1) in 1979, government set procurement price for tea increased by 50%; 2) 95% of tea fields were sown in a campaign during the Cultural Revolution (1966-1976); hence, the increase in yield entirely reflects an increase in picking.

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

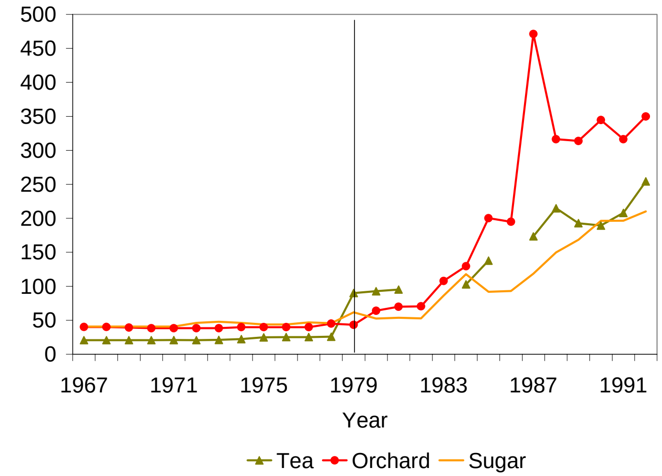


Figure 5A – Fraction of Males in Counties which Plant Some Tea and Counties which Plant No Tea

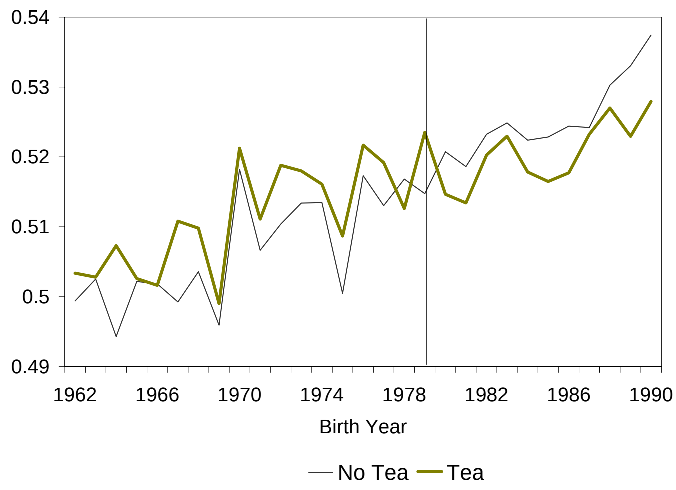


Figure 5B – The Effect of Category 1 and 3 Crops on Sex Ratios

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

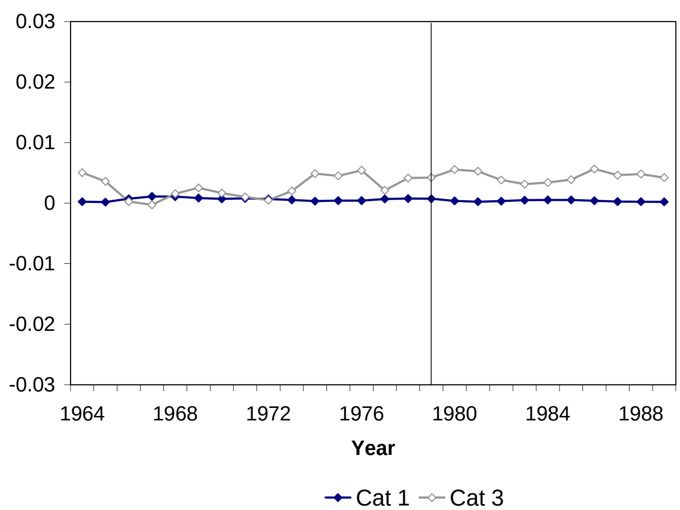


Figure 6A – The Effect of Planting Tea on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Tea Planted in Unrestricted Sex Ratios Equation

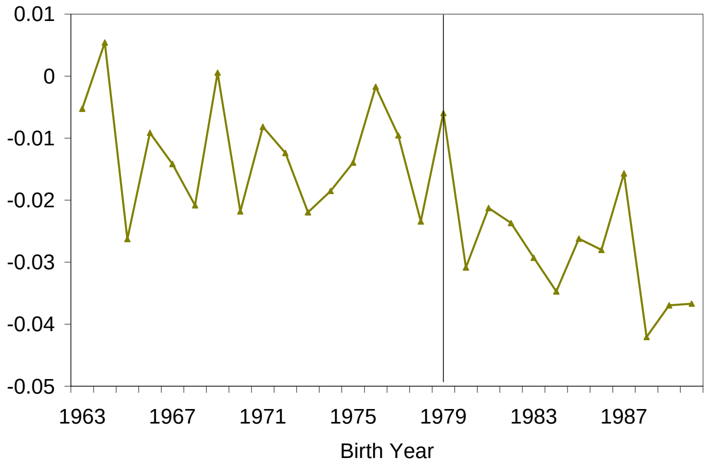


Figure 6C– The Effect of Planting All Category 2 Cash Crops on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Category 2 Cash Crops Planted in Unrestricted Sex Ratios Equation

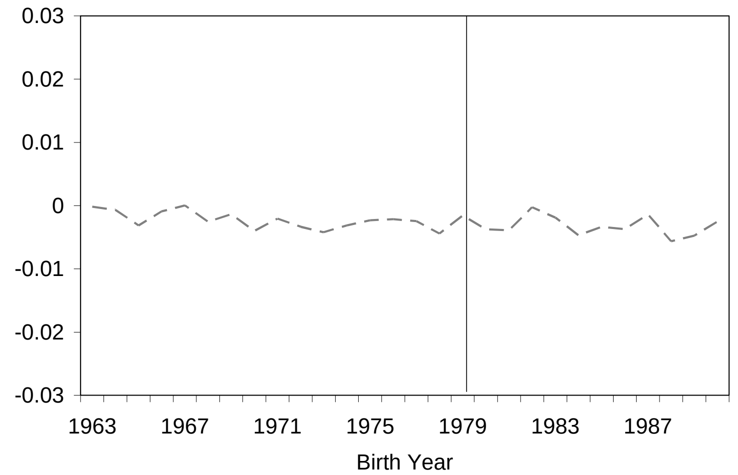


Figure 6B – The Effect of Planting Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Orchards Planted in Unrestricted Sex Ratios Equation

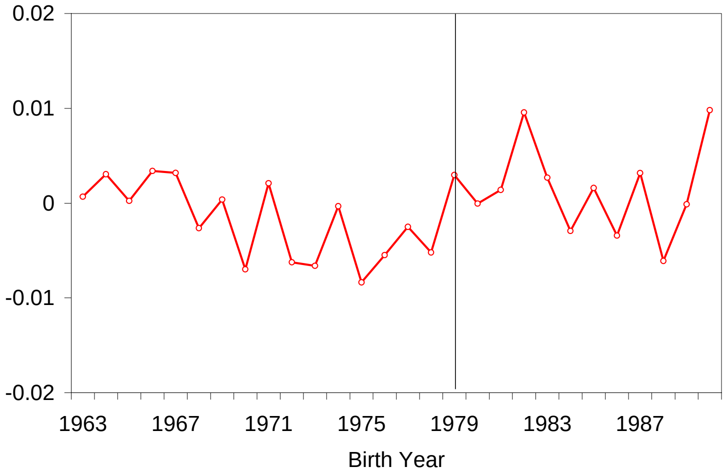


Figure 6D – The Effect of Planting Tea and Orchards on Sex Ratios
Coefficients of the Interactions
Birth Year * Amount of Tea Planted & Birth Year * Amount of Orchards Planted in Pooled Sex Ratios Equation

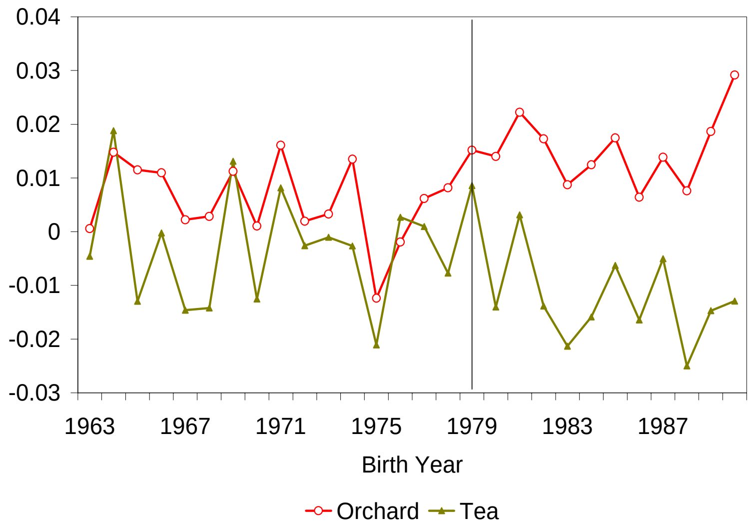


Figure 7 – The Effect of Planting Tea and Orchards on Girls' Education Attainment

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

Table 1A – The Correlation between Sex Ratios of Adult Laborers and Tea and Orchard Production
Coefficients of the fraction of males amongst adult laborers per household

	Dependent Variables							
	Tea Land Sown (Mu)		**Tea Land/Total Arable Land**		**Fruit Land Sown (Mu)**		**Fruit Land/Total Arable Land**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
# Male/# Total Labor in HH	-0.115	-0.086	-0.040	-0.010	0.0002	0.065	0.005	0.015
	(0.056)**	(0.055)	(0.021)*	(0.022)	(0.106)	(0.037)*	(0.016)	(0.004)***
Village Fixed Effects	N	Y	N	Y	N	Y	N	Y
Observations	3488	3488	3457	3457	3488	3488	3457	3457
R-squared	0.00	0.14	0.00	0.18	0.00	0.06	0.00	0.05

Standard errors are clustered at the village level.
Data source: RCRE 1993 Household Survey

Table 1B – 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		Orchards		Cat 2 Cash Crops	
	(1)		(2)		(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 – 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 5 – 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

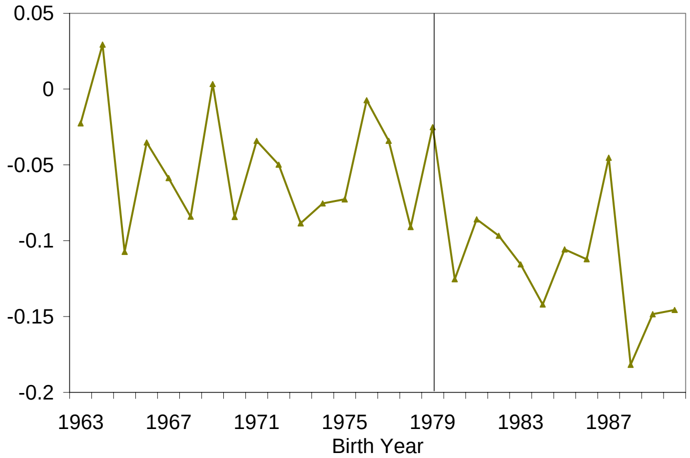


Figure A2 – The Effect of Planting Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Orchards Planted In Unrestricted Log(Sex Ratios) Equation

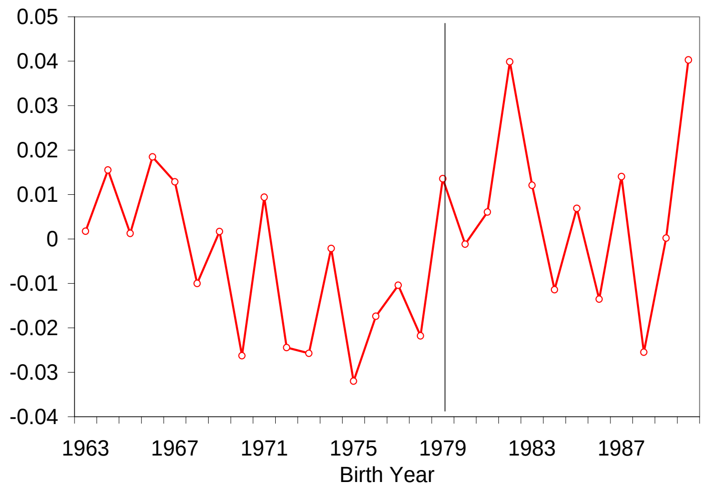


Figure A3 – The Effect of Planting Category 2 Cash Crops on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Category 2 Cash Crops Planted In Unrestricted Log(Sex Ratios) Equation

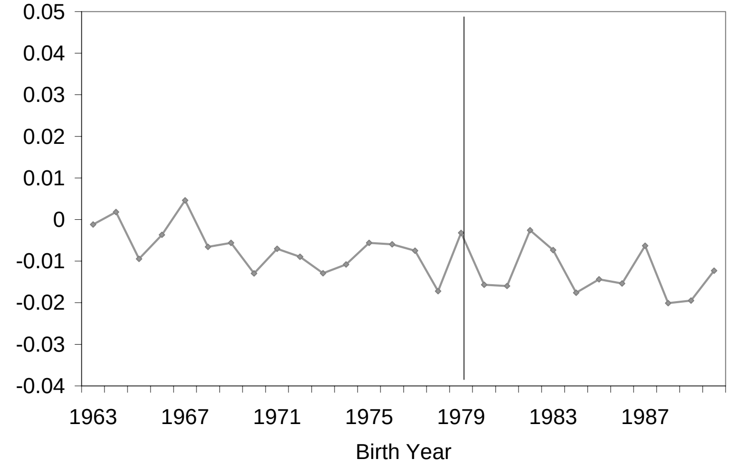


Figure A4 – The Effect of Planting Tea and Orchards on Sex Ratios
Coefficients of the Interactions Birth Year * Amount of Tea Planted and Birth Year * Amount of Orchards Planted in Pooled Log(Sex Ratios) Equation

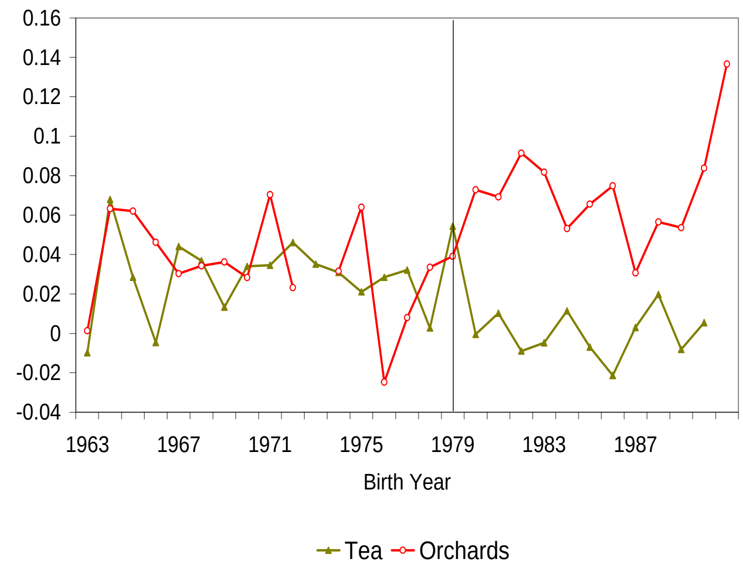


Table A1 – The Effect of Tea, Orchards and Cash Crops on Sex Ratios:
Coefficients of the Interactions between Birth Years and the Amount of Tea, Orchards and/or Category 2 Cash Crops Planted in the County of Birth

	Dependent Variable: Log Sex Ratio											
	A. Unrestricted						B. Pooled					
	Tea (1)		Orchards (2)		Cash Crops (3)		Tea (4)		Orchards (5)		Cash Crops (6)	
Birth Year	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
1963	-0.023	(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.