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Essays on Human Capital and Social Network Effects

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Abstract

The first chapter of this dissertation looks at the relationship between parental investment in daughters' human capital and marital transfers in India. I evaluate the existence, nature, and magnitude of a causal relationship between a daughter's education level and the price her family pays for a groom in India using nationally representative data and a two stage least squares instrumental variable estimation methodology. I construct a policy instrument using an Indian national school-latrine-construction initiative to estimate the effect of an exogenous increase in a woman's years of education on the groom price that her parents pay. My OLS estimates show that a woman with an additional year of education pays on average an extra Rs. 14,314 (USD 298) for her groom price, while my 2SLS results indicate that a woman with an additional year of education pays on average an extra Rs. 22,283 (USD 464) for her groom price, which is 6 percent of the average groom price in my sample. However, when I account for their groom's education, my estimates indicate that an increase in a woman's education results in her marrying a groom with an additional 0.5 years of education. These results suggest that while a woman's own education has a negative effect on her groom price, she pays an extra amount of groom price for each additional year of her groom's education with the total effect of a woman with more education paying more groom price on average.

The second chapter looks at whether farmers' irrigation decisions in the Southeastern United States are affected by social or peer behavior. This paper looks at whether the adoption of irrigation by a county is influenced by that of its' neighboring counties. I estimate a peer-effects model to investigate the effect that neighboring counties have on each other's likelihood to irrigate using three-year panel data from the US Department of Agriculture censuses of 2002, 2007, and 2012 for the 439 counties in Alabama, Florida, Georgia, North Carolina, and South Carolina. Two-stage least squares instrumental variable fixed effects estimations suggest that after controlling for farm operator and farm characteristics, the extent of irrigation among neighboring counties positively and significantly affects the percentage of farmers who irrigate in a county. This suggests that learning from others may be one of the mechanisms through which farmers in the Southeastern US make their irrigation decisions. The results also suggest that larger farms (in area) and farms with operators who are primarily farmers, are more likely to irrigate. My results also suggest having peers of the same race category may have an effect on irrigation when the category is a very small group as a percentage of all farm operators in a county on average.

Dedication

For my parents.

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Chapter 1

The Relationship between Groom Price and Parents' Investment in their Daughter's Human Capital

1.1 Introduction

The purpose of this paper is to evaluate whether an improvement in a woman's human capital affects the price that her family pays for her groom and if so, what the nature of this relationship is and purpose of this payment. Groom price is a complex socioeconomic issue that is unique to South Asia. One aspect of groom price in South Asia that makes it unique is its persistence and even suggested escalation. While South Asian economies modernize and experience economic growth, the groom price proportion of marriage transactions in South Asia have steadily increased (Anderson, 2003; Arunachalum and Logan, 2008; Botticini and Siow, 2003). Another aspect is that groom price exists despite the fact that groom price is acknowledged as a social evil and economic burden, banned by law in India, Pakistan, and Bangladesh for over two decades. Existing literature suggests the effects of groom price include female foeticide, domestic violence, household inequality as well as nutritional and health care inequality for girls and women (Bloch and Rao, 2002; Srinivasan, 2005).

In the economics literature, the price paid by a brides family for a groom is termed as groom price.[1] The term groom price distinguishes the fact that it is the groom who has legal rights over this monetary transfer even in the case where the marriage is dissolved. In defining groom price, an important aspect of the problem of groom price can be more clearly understood; groom price is related to the characteristics of the prospective grooms and brides, and the supply of available grooms and brides in the marriage market. Beckers theory on marriage states that groom price acts as a market clearing mechanism (Becker, 1981). An estimate by Neelakantan and Tertilt (2008) for the marriage sex ratio in India is 109 women per 100 men. The estimated marriage rate is 0.992 for women (UN, 2003) and 0.984 for men (UN, 1990) in India. This shows that marriage is still almost universal in India, and thus groom price can potentially affect the welfare of all girls and women in India.

One prominent hypothesis is that unequal economic development between urban and rural areas has created greater heterogeneity in the quality of grooms as well as greater economic inequality between men and women (Anderson, 2004; Botticini and Siow, 2003). This hypothesis has led to the suggestion that groom price is the result of price bidding for high quality grooms who are scarce relative to the brides who wish to marry them. However, whether this makes womens human capital and groom price substitutes or complements depends on the grooms preference for his brides human capital (Anderson and Bidner, 2015). In this aspect, the empirical evidence in the literature so far is inconclusive as to what the relationship is between womens

1. Note: groom price and dowry are not always distinguished in the literature and are still mostly synonymous in literature in other fields and colloquially.

human capital and groom price. This leads to another reason why it is important to investigate the relationship is between womens human capital and groom price. Despite the increasing number of women pursuing secondary and post-secondary education; since 2005, more than 25 million Indian women have left the labor force (World Bank). Countries often experience a dip in womens labor-force participation as incomes rises and women drop out of low-paying menial work, usually in agriculture. But typically as the economy develops further and education levels rise, more and more women enter the labor force. A better understanding of how other factors interact with womens education, such as marriage transactions like groom price may help researchers gain insight regarding this contradiction. For example, is it better for a woman to share the household resources of her husband and pay a higher groom price than to earn her own income by participating in the labor market? If policies targeting female foeticide, womens education, and labor-force participation are to work, it is imperative to know what affects womens education and how.

Previous literature has not been able to address the problem of endogeneity between womans education and her groom price when estimating the relationship between womens human capital and groom price. Peters and Siow (2002) states, by investing in their childrens wealth, parents increase the wealth of their children and the quality of the spouses that their children can marry. In the case of India, there are two mechanisms through which parents can investment in their daughters wealth, human capital investment and the quality of her groom by means of a groom price. Unless parents consumption decisions in different periods are uncorrelated, it would be remiss to assume parents do not take into consideration how the potential quality of groom will be affected by their investment in their daughters human capital. In this paper, I am using a new approach by a utilizing policy instrument that affects girls educational attainment but not their groom price in order to address the problem of endogeneity between groom price and womens human capital attainment. The policy I use has been implemented under the School Sanitation and Hygiene Education program by the Indian national government since 2003 to commit substantial financial resources to support widespread school latrine construction. Using this policy, I examine how improving the school environment through female-only latrine construction influences the educational decisions (Adukia, 2014) and as a result, groom price decisions of girls and their parents. My instrument is specific to females because my treatment is the availability of female-only toilets in schools that include middle school and beyond (grades 8 and above). The rational is that girls on average are in 8th grade at age 14 years or above and this is usually when they reach puberty. Adukia (2014) finds that pubescent-age girls benefit substantially from the construction of sex-specific latrines, but benefit little from a unisex latrine. I also find this effect using my data. I have set the age for puberty to 14 years based on a study by (Pathak, Tripathi, and Subramanian, 2014) which estimates the mean age at menarche among Indian women was 13.76 years (95 % CI: 13.75, 13.77) in 2005. I combine data from the 2011-12 wave of the Indian Development Survey (Desai and Vanneman, 2012) with data from the Unified District Information System for Education (U-DISE, n.d.) and compare education attainment of women who were pubescent girls and attending school in districts that experienced an increase in female-only latrines to the education attainment of pubescent girls in districts that did not experience such a change. For the empirical analysis, I employ a two stage least squares instrumental variable methodology.

I use an identification strategy that is similar to Ashraf et al. (2015), who following Duflo (2001) use massive school construction programs to examine the relationship between returns to education and bride price for women in Indonesia and Zambia. In my work, I use the latrine construction program as an instrumental variable that exploits both the variation between pre-treatment and post-treatment cohorts and the spatial variation in treatment.

Previous evidence on the existence and nature of the relationship between womens human capital and groom price is inconclusive if not contradictory (Anderson, 2004; Edlund, 2000; Rao, 1993). Assuming education and groom price are the only two forms of investment parents make for their daughters, and that parents face a budget constraint, when parents decide on the amount they will invest in their daughters education, they are also fixing their daughters groom price and as a result there arise the issues of simultaneity bias and reverse causality. Parental premarital investment in their childrens wealth affects the quality of the spouses that their children can marry (Peters and Siow, 2002). Parents are likely to be aware that their investment in daughters education will affect the quality of their spouse and therefore the groom price they are likely to pay in the future (Anderson and Bidner, 2015). Also, parents with the same household income may have different preferences in investing in their daughters. This creates the need for an instrument that affects womens education but not groom price. The literature has discussed the difficulty in addressing this endogeneity between groom price and daughters education due to the limits of survey data (Frijters and Sharma, 2002).

There is more than one aspect through which my paper makes a contribution to the literature. First, (as described above) OLS may give a biased estimate of the relationship between a daughters education level and her groom price. My OLS estimates show that a woman with an additional year of education pays on average an extra Rs. 16,472 for her groom price. To address the endogeneity problem, I estimate the relationship between groom price and womens education by instrumenting womens education with the national school sanitation policy using the two stage least squares method. My first stage regression estimates show that a woman who attended school in a district that experienced an increase in the percentage of girls toilets in middle and high schools completed an additional one year of education compared to a woman who attended school in a district that did not experience such an increase. This is consistent with the findings of Adukia (2014) who also uses female-only latrine construction from the national school sanitation policy and the U-DISE data source to investigate whether improving the school environment through female-only latrine construction affects the education decisions of pubescent-age girls. She finds a statistically significant 11 percent increase in female enrollment due to the construction of a female-only latrine. My 2SLS results indicate that a woman with an additional year of education pays on average an extra Rs. 22,283 for her groom price, which is 6 percent of the average groom price in my sample compared to the OLS estimate which is 4 percent of the average groom price.

Second, the data I am using is a sample with observations from 22 states across northern and southern India including both urban and rural areas as opposed to the data used in the existing literature where the studies have been restricted to a particular region within India or only rural areas due to unavailability of data. Both Rao (1993) and Edlund (2000) have a sample that is from six rural villages in South Central India and Frijters and Sharma (2002) have a sample that is for one city in India. A geographically wider sample allows me to estimate the average effect of a year of education on the groom price of the average daughter that is likely to be closer the national average, not just a specific subset of the Indian population. Finally, since my data includes married women with spousal information, I can control for groom education. This allows me to separate the effect the education of the groom (measure of groom quality) a woman marries from the direct effect of a womans education on her groom price. My estimates suggest that although a woman's own education has a negative effect on her groom price, for each additional year of education for her groom, she pays an extra amount of groom price, resulting in the total effect of a woman with more education paying more groom price on average. This result aligns with the literature on property rights, bargaining power and marriage payments which suggest that increase in property rights and bargaining power is related to an increase groom price (Anderson and Bidner, 2015; Ambrus, Field, and Torrero, 2010).

1.2 Literature Review

The literature on the existence and nature of the relationship between womens human capital and groom price is inconclusive if not contradictory. Rao (1993) finds the effect of bride's years of schooling on groom price to be negative and insignificant. Using the same data set, Edlund (2000) finds a positive effect of wives schooling on the net amount of groom price. Both Rao (1993) and Edlund (2000) use data restricted to rural areas of south-central India. Anderson (2004) finds both bride and groom education are important positive determinant of the value of groom price paid although, the positive effect of brides education becomes insignificant when the average level of female education in the area is included. However, I find that after controlling for groom education, groom education has positive and significant effect on groom price paid while brides education has a negative and significant effect on groom price. Also, Anderson (2004) estimates are for Pakistan using data from the Living Standards Measurement Study (LSMS) of Pakistan, collected in 1991.

One reason for this inconsistency in results may be due to the problem of identification. If education and groom price are the only two forms of investment parents make for their daughters, and that parents face a budget constraint, when parents decide on the amount they will invest in their daughters education, they are also fixing their daughters groom price. Thus the two variables are simultaneously determined even though the investment in education occurs much earlier to the groom price payment, giving rise to the problems of reverse causality and simultaneity bias. For example, parents with more income may spend more on both their daughters education and groom price so that a woman with parents who have enough income would have both a higher groom price and more years of education resulting in groom price and a daughters education being endogenous. While endogeneity due to household income can be resolved by controlling for household income, in this case there may be other factors which affect both groom price and a womans education. Parental premarital investment in their childrens wealth affects the quality of the spouses that their children can marry (Peters and Siow, 2002). Parents are likely to be aware that their investment in daughters education will affect the quality of their spouse and therefore the groom price they are likely to pay in the future (Anderson and Bidner, 2015) Also, parents with the same household income may have different preferences in investing in their daughters. Even with the same income level, some parents may value their daughters future consumption more than other parents and prefer to allocate more income for their daughters future consumption (by transferring more wealth to her through higher investments) than on their own present consumption. So, there is still likely to be a problem of endogeneity and thus the need for an instrument which affects womens education but not groom price. Previous literature either assumes that parents take their daughters education as given at the time of marriage or controlling for parental education and occupation can account for parental preferences in investing in their daughters. The literature has discussed the difficulty in addressing endogeneity between groom price and daughters education due to the limits of survey data.

Frijters and Sharma (2002) look at the same relationship as this paper and estimate that a one year increase in a womans education increases groom price by 21,200 rupees which is significant at the 5 percent level. They rely on a structural model to address the issue of endogeneity between groom price and womens education and acknowledge the difficulty of finding an instrument that is uncorrelated with the error term in their main estimating equation. Frijters and Sharma (2002) data are from the city of Patna in the state of Bihar compared to my data which include observations from 22 out of 34 states of India and from both urban and rural areas. Also, Frijters and Sharma (2002) explore the relationship between womens human capital and groom price but they only estimate the total effect that a womans education has on her groom price and do not account for the indirect effect of a womans education on her groom price through her groom quality. In this paper I use an instrumental variable that has not been previously used to control for parental income and preferences on groom price as well as the effect of other unobservables which may affect both groom price and a womans education. Ashraf et al. (2015) use a similar identification strategy to estimate the effect of bride price and returns to education for women in Indonesia and Zambia. They exploit the quasi-experimental variation in number of schools built by birth district in Indonesia and study the differentials effect of school construction policy on schooling by bride price custom. In 1973, the Indonesian government launched a large-scale school construction program called the Sekolah Dasar INPRES program. Over the course of the next five years, 61,800 primary schools were constructed, leading to an increase in enrollment rates of children aged 7 to 12from 69 percent in 1973 to 83 percent in 1978. Ashraf et al. (2015) estimate a positive and significant effect of bride price on returns to education for women by using the variation arising from the interaction between pre-treatment and post-treatment cohorts and the spatial variation in treatment intensity. By utilizing the spatial variation resulting from regional heterogeneity in the practice of bride price in Indonesia, they find a positive effect of the school construction policy on female education. My paper employs a similar strategy by using an instrumental variable that captures both the variation between pre-treatment and post-treatment cohorts and the spatial variation in treatment intensity.

Another distinction between this paper and the previous literature is that much of the literature does not directly address the relationship between womens human capital and groom price. To the best of my knowledge, only Frijters and Sharma (2002) attempt to explore the relationship between womens human capital and groom price. For example, Rao (1993) looks at the effect of the marriage cohort sex ratio (which he argues is the ratio of number of women aged 10-19 to men aged 20-29) on groom price using a hedonic pricing model. Brides years of schooling appears as a control variable in the estimation of the dowry[2] function and the paper finds the effect of bride's years of schooling on groom price to be negative and insignificant. Rao (1993) does not address the endogeneity between groom price and the bride's years of schooling. In Anderson (2004) the key variable of interest is relative groom and bride heterogeneity in education and wages and the analysis is for Pakistan.

There have been efforts to address the problems of endogeneity in the previous literature. Anderson (2004) uses a structural model to estimate education of brides and grooms as a function of the personal characteristics of their parents, and the proximity to schools in the individuals area of origin prior to the dowry estimations. The predicted values from these regressions are then used to obtain estimates for the effect education on groom price. Frijters and Sharma (2002) use the same approach with similar variables on family characteristics but do not control for possible any differences in access to education unlike Anderson (2004). This approach to addressing endogeneity requires the assumption that parental preferences for investing in their

2. See footnote: 1.

daughters can be controlled for using parents education and occupation. However, parents with the same household income may still have different preferences in investing in their daughters. Even with the same income level, some parents may value their daughters future consumption more than other parents. These parents may prefer to allocate more income for their daughters future consumption (by transferring more wealth to her through higher investments) than on their own present consumption. Using the increase in availability of female-only latrines due to the national policy for school latrine construction and its effect on female education, however only requires the assumption that the increase in availability of female-only latrines does not have any direct relationship with groom price.

1.3 Data

1.3.1 Data Source

I use data from two sources, the Indian Human Development Desai and Vanneman (2012) survey 2012 (IHDS-II) and Unified-District Information System for Education U-DISE (n.d.) database.

The India Human Development Survey 2012 (IHDS-II) is a nationally representative, multi-topic survey of 42,152 households in 384 districts, 1420 villages and 1042 urban neighborhoods across India. The data was collected through two one-hour interviews in each household which covered topics concerning health, education, employment, economic status, marriage, fertility, gender relations, and social capital[3]. Currently the IHDS is the only nationally representative data in India that includes household information on groom price. IHDS-II is the second round of the IHDS

3. See reference for detailed information.

where most of the households interviewed in the year 2004-2005 are reinterviewed in the year 2011-2012[4]. The reason for using IHDS-II instead of IHDS-I is because IHDS-II contains both women who were attending school in the years before and after 2003, which was the policy year. Using the IHDS-II data I get a sample of women who attended school and either completed their education or are married at the time of the IHDS-II survey in 2012. This gives me their total years of school education and avoids the problem of censored data, which would occur if I included women who were still attending school.

To control for endogeneity between a womans education and her groom price, I use a binary policy variable that captures whether a district has been affected by the national policy for school latrine construction. The data for the policy variable is from the Unified-District Information System for Education U-DISE (n.d.) , a database which collects annual data on schools in India since 2005[5] through a nationally-standardized survey-questionnaire answered by school principals. The U-DISE includes annual school-level data for school facilities. Also, the school latrine construction policy is for schools i. e., for grades up to 12th grade; colleges and universities do not receive funding from this policy or to the best of my knowledge, any other policy, for the construction of female toilets in their infrastructure, so using U-DISE data which are for schools only is not an issue for my estimations.

As stated by the National University of Educational Planning and Administration (NUEPA) which developed U-DISE, U-DISE is supposed to cover all the schools in India including the unrecognized schools[6]. But given the fluctuation in

4. 85 percent of 2004-05 households (households interviewed for IHDS-I).

5. DISE data collection was initiated as a pilot in 1995, but systematic data-collection mechanisms were not established until 2001 and the government had yet to expand DISE data coverage to all states before 2005. At present the government only makes data from academic year 2005-2006 publicly available.

6. Unrecognized schools are schools without a government license. Recognized schools include

when schools are included, it is likely that there are missing schools. Also, the DISE data is self-reported by school principals. However, the data is subject to a multi-stage review process. First, cluster officials verify responses for completeness and accuracy. Third, district officials aggregate the data and check it for computational and consistency errors. Fourth, state-level officials conduct further consistency checks. Finally, each state is responsible for hiring external agents to conduct post-enumeration audits and cross-check data with site visits.

1.3.2 Data Construction

Using the Desai and Vanneman (2012) and U-DISE (n.d.) data I construct my estimation dataset. I start by constructing an individual level dataset with the unit of observation being every female of the India Human Development Survey 2012 (IHDS-II) who attended school and either completed their education or are married at the time of the IHDS-II survey in 2012. The IHDS-II data contains socio-economic information for each female and her family. Only for the case of married women, I keep the married women whose childhood residence was in the same village or district as their current address. This is because I only have geographical data on the married womens current location and data on whether their childhood residence was in the same village or district as their current location. For my analysis, I need to match districts which were affected by the national school sanitation policy to the district where each married woman went to school in order to determine whether a married woman was affected by the policy or not. I use this method because it not possible to determine the married womens school district by tracing the married women in IHDS-II to their parental household in IHDS-I. The reason for this is, IHDSII only

schools managed by Department of Education, Local Body, Social/Tribal Welfare Department, Private-Aided, Private Un-aided and Other managements.

interviewed split households residing within the same village, so only women married into households located within their parental village can be traced back to their parents household in this way. Using this latter method would mean losing most of the married women in my sample because there are few women who married into a household that is in the exact same village as their parental household although many are married to households within the same district. Also, I cannot assume that there is no inherent difference between women who married within their parental village and women who migrated for marriage. This may not be as ideal as being able to actually link married women from IHDS-II to their parent household in IHDS-I but the married women in IHDS-II still have information on their childhood place of residence and family background such as education of their parents and siblings so I can still control for these factors. As my instrument addresses differences in parental income, and I can still control for the married womens family background I can use married women in my estimations which Frijters and Sharma (2002) are unable to do. Another concern with the estimation data may be that the households have moved during the time the women in my sample where attending school and so their parental addresses may not identify their school district correctly. I use the information on how many years a household has remained at the place they are surveyed using both my estimation sample and the complete IHDS sample. I find that average years a household has remained at the place they are surveyed is 78 years for both my estimation sample and the full Desai and Vanneman (2012) sample. Only 22 percent of the households from the full IHDS sample were originally from a place other than their current residence and only 10 percent of the households from the full IHDS sample that were originally from elsewhere had moved from another district. For the girls who are unmarried and so still live in their parental household, I drop the households that were originally from elsewhere and had moved from another district after the woman was 18 years or older because I cannot trace whether they came from a district which had been affected by the policy. So for the girls who are single and have never been married, the district of their household should accurately identify their school district because the average age of single women in my sample is 20 years and the district they have been residing in for at least 16 years would be their relevant school district for the policy treatment. Given the Desai and Vanneman (2012) is a nationally representative sample, if the households on average have remained at the place they are surveyed for 78 years then it is unlikely that the married womens household moved from the district of their childhood residence while they were attending school. After selecting women based on these criteria, I am left with a final sample of 11,187 women from 291 districts and 22 states. So, my estimation sample may no longer be representative of the Indian population. However, the variable means for all women who attended school and either completed their education or are married in the IHDS-II survey and my sample are not significantly different.

The socio-economic control variables are the individual womans years of schooling completed, the years of schooling completed by highest educated male in her parental household, the years of schooling completed by the highest educated female in her parental household, whether the individual herself is the highest educated female in her household, and religion of household, the average household income and school development funds for each district. I also include the womans age to control for the overall rise in average years of female education over time. The geographic control variables include state and district of the household and whether the household is in an urban or rural location. I control for the years of schooling completed by highest educated male in her parental household, and the years of schooling completed by the highest educated female in her parental household to proxy for household income as I do not have data for the parental household income for the married women in my sample. However, I do control for income differences across districts using average income of districts estimated using the total income of all households in the Desai and Vanneman (2012) data. I also control for differences in school quality across districts by including the average amount of school development funds received by schools and the percentage of schools that are in rural areas in a district. To control for any unobservable abilities of the woman, I include a binary variable for whether the individual herself is the highest educated female in her household.

1.3.2.1 Construction of Dependent Variable

In India both giving and receiving of any property or valuable security or agreement for such a transaction in connection with marriage is prohibited and punishable by law. Although the impact of this law in deterring payments is negligible due to a very low conviction rate, lack of independent or unbiased witnesses, and social attitudes, it does make it difficult to document groom price payments in the same way as underground economic activity such as smuggling, bribery, etc. This is because under the amended Indian Dowry Prohibition Act 1983, a complaint allows for immediate arrest of individuals accused and it is a non-bailable offense. As a result, I construct observations for the dependent variable, groom price, from the sum of estimates given by an ever-married woman in each household regarding the usual amount of money spent by a family like theirs, in their community (jati) at the time a daughter gets married. The corruption literature often uses indirect questions about corruption so managers can answer questions without incriminating themselves. The World Bank's Enterprise Surveys, for example, ask managers whether 'firms like this one' pay bribes rather than asking the manager directly if he or she pays bribes. I use marriage expenses because groom price is generally perceived as, and included in the cost of a daughters marriage in India. Also, the average amount of groom price in my sample is comparable in magnitude to that of Frijters and Sharma (2002)[7] who are able to get estimates of expected groom price from their interviewees (Table 1.2). However, their variable includes both ex-ante and ex-post responses which is also the case for my data which includes single women as well.

The data I use for my outcome variable is derived from the answers to the following IHDS-II survey questions a) At the time of girl's marriage, how much money is usually spent by the girl's family, in your community (jati[8]) for a family like yours? This question is an estimate of the money and value of the assets transferred and costs of the wedding celebrations. This means my measure of groom price will include estimates of all marriage expenses, not only the cost of the groom price but also the amount spent on the bequest to the bride from her family and the expense of the wedding celebrations. This is because groom price is a technical term defined in the economics of marriage literature as a pecuniary transfer from the bride to the groom to clear the marriage market (Becker, 1981; Botticini and Siow, 2003). However, the cultural practice that actually takes place is the transfer of dowry at the time of marriage, where dowry is the transfer of money and assets made by brides parents at the time of marriage. This transfer includes both a pre-mortem bequest to their daughter as her inheritance and a payment to the groom and his family to secure an agreement of marriage (groom price), as discussed in the economic literature on martial transfers(Anderson and Bidner, 2015; Rao, 2007). It is the motive and ownership of the transfer combined that actually distinguishes the between the different types of marital transfers. See Appendix Tables A1 and A2 for detailed definitions and examples of dowry, groom price, bequest, and wedding celebrations.

7. It is possible that Frijters and Sharma (2002) can explicitly ask about groom price payments because they conduct their own survey using a smaller sample from one city. In any case, this provides some evidence that both direct and indirect question techniques elicit comparable responses.

8. Jati means caste or subcaste in Hinduism. Jati defines fairly rigid socio-economic strata in India.

Ideally, I would have liked my outcome variable, groom price to measure the transfers and expenses that are demanded by the groom and his family from the bride's family in return for an agreement to marry but my outcome variable also includes estimates of the bequest that remains the daughter's property and the bride's family wedding celebration expenses for themselves, as detailed in Appendix Tables A3 and A4.

Given this, there is a concern that the positive coefficient for groom price due to a unit increase in a woman's education in my estimates could be overestimated due to an increase in other marriage expenses such wedding celebrations or an increase in the bequest over which a woman retains ownership. In my data there is also a separate measure which asked for household expenses for social functions such as marriage, funeral etc. the average expenditure for social functions is Rs. 6,756 compared to the average marriage expenses of Rs. 354,235. The average expenditure on social functions is statistically different from those of a daughters marriage expenses (Table 1.3). I also use a measure I have on the extent of wedding celebrations, the number of wedding guests, and estimate a 2SLS regression of wedding guests on woman's education and find no statistically significant effect of woman's education and the number of wedding guests (Table 1.4) which usually is representative of the scale of a wedding celebration in South Asia. I do find a significant relationship between family background, years of schooling of highest educated male in household has a positive and significant on the number of wedding guest. This suggests that the costs of wedding celebrations are more likely to be proportional to family background. Finally, even if my estimations are capturing movements in other costs of marrying a daughter than that of directly paying for her groom, these results are still relevant in the context of the costs and economic obligations that are associated with having a daughter in India and the general bias in attitude these costs create against female children.

Another source of measurement error due to the use of self-reported estimates of the amount of money spent at the time of daughter's marriage may of course be under or over reported. This type of measurement error in the dependent variable can cause biases in OLS if it is systematically related to one or more of the explanatory variables. If the measurement error is just a random reporting error that is independent of the explanatory variables, as is often assumed, then OLS is perfectly appropriate. First, as the event of a daughter's marriage is a very significant event in India, it is likely household have an estimate of the amount of money spent for this event in a similar way to that of US households knowledge regarding a child's cost of attending college. So, although the estimate of money spent at the time of a daughter's marriage may not be an exact estimate as it is self-reported and not from actual receipts, but it is an estimate household would able provide with ease. Second, as I am using an instrumental variable estimation approach, I am estimating the effect of an exogenous change in female human capital on the groom price and so measurement error due to imprecise reporting should not create a bias in my estimations.

1.3.2.2 Construction of Instrumental Variable

For the policy variable, I use data from the U-DISE database for the years 2005-2006 to 2010-2011 to construct a binary policy variable which is equal to one if the probability a woman having access to a female-only toilet increased while she was a pubescent-age girl attending school and zero otherwise. I assume this increase in probability of having access to a female-only toilet is due to the national policy for school latrine construction as there was no other government policy providing financial support for school latrine construction and 82 percent of schools in India are government operated or receive government funding. Annual school latrine construction data in figure 1 shows that school latrine construction approximately doubled in India between 2007 and 2009.

My instrument is specific to females because my treatment measure is the availability of female-only toilets in schools that include middle school and beyond (grades 8 and above). The rational for this is that girls on average are in 8th grade at age 14 years or above which is usually when they reach puberty and (Adukia, 2014) finds that pubescent-age girls benefit substantially from the construction of sex-specific latrines, but benefit little from a unisex latrine. I use 14 years as the age for puberty based on a study by (Pathak, Tripathi, and Subramanian, 2014) which estimates the mean age at menarche among Indian women was 13.76 years (95 % CI: 13.75, 13.77) in 2005. Using the IHDS-II data, I find the grade that a girl is most likely to be in at age 14 years is the 8th grade.

Since the girls in the IHDS data cannot be linked to a particular school in the U-DISE data, I collapse the data from school level to district level when constructing the instrument variable. The closest possible identification is matching a girl and a school to the same district. To construct a measure of whether or not a district was affected by the national policy for school latrine construction, I use 7 years of school-level data on whether a coeducational school has a separate functional toilet for girls or not, the presence of a functional toilet in girls-only schools, and the number of coeducational and girls-only schools in a district. Using this data, I estimate for each district available, the percentage of coeducational and girls-only schools that include middle school and beyond (grades 8 and above) that have a functional toilet for girls for each year. I assume that a district has been affected by the national school sanitation policy in a particular year, if the district has an increase in the percentage of co-ed and girls-only schools (grades 8 and above) with a functional female-only toilet for that year[9] . I assume a woman to be treated if there was an increase in the percentage of coeducational and girls-only schools that had 8th grade and above and a functional toilet for girls in her district while she was attending school (Table 1.1). I assume a woman was attending school in the year her school district is affected by the national school sanitation policy if her age that year was 18 years or less. Again, my assumption is based on the average age I see for girls currently attending 12th grade in the IHDS data.

Table 1.1: **Treated and control groups for female education policy instrument**

For same year, if	Women aged $\leq$ 18 years	Women aged > 18 years
School District affected by policy	Treated	Not Treated
School District not affected by policy	Not Treated	Not Treated

The summary statistics in Table 1.5 show that the average groom price in my sample is Rs. 354,309.93 which is roughly USD 7,381 where the average district mean household income in my sample is Rs. 139,764 or USD 2,912 and the minimum groom price is Rs.0 and maximum is Rs. 6.26 million or roughly USD 130,417[10]. The average education level of the women in my sample is 8.5 years while the highest level of education completed is 16 years. The average the years of schooling completed by highest educated male in the individuals parental household is 9 years, and the years of schooling completed by the highest educated female in individuals parental household is 6.9 years which higher is than the highest educated female as expected

9. Also see first-stage results for the 2SLS estimation Table 1.7.
10. Estimates using 2012 Indian Rupee to US Dollar exchange rate. Source: Reserve Bank of India `https://www.rbi.org.in` .

given the gender parity in India.

In Frijters and Sharma (2002) the average level of female education is 15.15 years which is much higher than average 8.5 years of schooling completed for women in my sample. Frijters and Sharma (2002) state that their data for daughters years of schooling contains both ex-ante and ex-post information; a greater proportion of the responses in their data are level(s) of education parents are planning to make available to their female children and not actual years of education completed where actual daughters years of education completed is unavailable, so their result may be biased by measurement error in their explanatory variable for daughter's human capital. My sample includes only women who have either completed their education or are married, to avoid this issue. Finally, Frijters and Sharma (2002) state that a limitation of their study is the smaller sample size that primarily captures the perceptions of middle class residents of one city, Patna, on dowry related issues. My data include households both above and below the poverty-line and are from 22 out 34 states and roughly half the districts of India allowing my analysis a more broader social-economic and geographical scope.

1.4 Estimation Results

1.4.1 OLS Regression Results

First I report the OLS results as a reference point under the following specifications:

$$GroomPrice_{hh} = \beta_0 + \beta_1 \textit{Years of education completed}_i + \beta_n \mathbf{X_i} + \theta State_i$$

$$+\gamma Religion_i + \alpha Urban_i + \epsilon_i \rightarrow [1]$$

where the dependent variable is the constructed groom price variable, i is individual ever-married woman, $\mathbf{X}_i$ represents all the independent variables outlined earlier in Table 1.5, state, religion, and whether an individual lives in an urban or rural location dummies.

Table 1.6 presents the standard OLS estimates for Eq. (1). Approximately 23.7 percent of the variation in the dependent variable Groom Price is explained by the explanatory variables. The explanatory variables are jointly significant at the 1% level (F 7, 290 = 33.75). My OLS estimates in Table 1.6, show the coefficient of the variable of interest woman's years of education completed is positive and statistically significant at the 1% level, implying that, controlling for the years of schooling completed by highest educated male and female in her parental household, and whether the individual herself is the highest educated female in her household, a woman with an additional year of education pays on average an extra Rs. 14,314 for her groom price. Here I have used the level of education attained by the highest educated male and female in the womans parental household as proxy variables for family background.

Compared to Frijters and Sharma (2002), my OLS results show that a year increase in a womans education increases her groom price by Rs. 14,314 while they estimate a year increase in a womans education increases her groom price by Rs. 18,610.

However, OLS may give an incorrect estimate of the relationship between groom price and womens education is due to the problem of endogeneity. If education and groom price are the only two forms of investment parents make for their daughters, and that parents face a budget constraint, when parents decide on the amount they will invest in their daughters education, they are also fixing their daughters groom price. Thus the two variables are simultaneously determined; even though the investment in education occurs much earlier to the groom price payment.

Given this issue of endogeneity, we need an instrument which affects womens education but not groom price and so I estimate the relationship between groom price and womens education by instrumenting womens education with the national school sanitation policy variable using the two stage least squares method.

1.4.2 2SLS Regression Results

In the first stage I run:

$$Woman's\ Years\ of\ education\ completed_i = \delta_0 + \rho[IV]_i + \beta_n\mathbf{X_i} + \theta[State]_i$$

$$+\gamma[Religion]_i + \alpha[Urban]_i + \epsilon_i \rightarrow [2]$$

where $\mathbf{X}_i$ refers to all of the social economic variables and state, religion and location dummies used in Equation 1. The instrumental variable is the policy variable which is a binary policy variable equal to one if a womans district was affected by the national policy for school latrine construction before she reached puberty and zero otherwise, described in section **1.3.2.2**.

My first stage estimates in Table 1.7 show that the school sanitation policy has a significant effect on womens years of schooling both statistically and in magnitude. I find that going to school in a district that had an increase in the percentage of functional girls school toilets in middle school and high school results in an increase of 0.8 years of education completed by a woman compared to a woman who attended school in a district that did not experience an increase in the percentage of functional girls middle school and high school toilets. These results are consistent with Adukia

(2014) who finds an 11 percent increase in female enrollment due to the construction of a female latrine which is statistically significant at the 1 percent level. The results also suggests family background are have a positive and significant effect on a woman's education as expected. The effect of the policy is positive and significant even after controlling for the average school funding received by the school in the district, the percentage schools in rural areas and the average household income of the district (See appendix Table 6A).

Once the first-stage results are obtained, the predicted value of years of education completed a woman replace the observed years of education completed in Stage 2, namely, Equation 3:

$$GroomPrice_i = \beta_0 + \beta_1 \textit{Woman's Years of education completed}_i + \beta_n \mathbf{X_i} + \theta State_i$$

$$+\gamma Religion_i + \alpha Urban_i + \epsilon_i \rightarrow [3]$$

My 2SLS estimates in Table 1.8 compared to my OLS estimates show that the 2SLS estimate for the effect of a womans education on her groom price is larger in magnitude. My OLS estimates show that a woman with an additional year of education pays on average an extra Rs. 14,314 for her groom price, while my 2SLS results indicate that a woman with an additional year of education pays on average an extra Rs. 22,283 for her groom price, which is 6 percent of the average groom price in my sample. The relationship between the years of schooling completed by highest educated male in her parental household and daughters groom price remains unchanged and positive although the magnitude decreases with 2SLS. This makes sense as I have used the education level of the highest educated male and female in her parental household as a proxy for the womans family background and so the education level of the highest educated male and female may capture the effect of family income. The relationship between the years of schooling completed by highest educated female in her parental household and daughters groom price changes to negative but is no longer statistically significant with 2SLS.

There may be a possibility that the relationship between groom price and daughter's human capital investment is different between wealthy households and poor households. So, I also run my regressions separately for individuals who are above the poverty line and those who are above the poverty line. My results for the first-stage estimates in Table 1.9 are statistically significant and similar in magnitude to the full sample estimates. The school sanitation policy has a significant effect on womens years of schooling both statistically and in magnitude both for poor and non-poor samples with a coefficient of roughly 1 year for poor and 0.7 years for the non-poor. This seems plausible that the policy would have a larger effect on those below the poverty-line. The OLS results by poor and non-poor in Table 1.10 are both positive and significant so that both poor and non-poor pay extra groom price with an additional year of education. Although, poor households have a coefficient of Rs. 7,426 while non-poor households have a coefficient of Rs. 14,732 compared to the full sample estimate of Rs. 14,314. The 2SLS results for poor and non-poor households in Table 1.11 also are positive for the relationship between woman's year's of education and her groom price. However, they are not statistically significant with the coefficient for non-poor having a significance level of 17 percent and the coefficient for poor having a significance level of 48 percent, suggesting that due to small sample size the estimates may be less precise.

It is also meaningful to see how my 2SLS estimates compare to the structural model in Frijters and Sharma (2002). While Frijters and Sharma estimate a year increase in a womans education increases her groom price by Rs. 21,200, my 2SLS indicates that a woman with an additional year of education pays on average an extra Rs. 22,283 for her groom price. The relationship between the education of the highest educated male in her parental household and daughters groom price is positive and significant in my 2SLS estimate while the relationship between fathers education and daughters groom price in Frijters and Sharma is negative. This could be because I have used the education level of the highest educated male and female in her parental household as a proxy for the womans family background and so the education level of the highest educated male and female may capture the effect of family income due to the absence of data on ever-married womans parents household income which is estimated by Frijters and Sharma (2002) to increase groom price by Rs. 1,470.

Frijters and Sharma (2002) address potential endogeneity issues, by estimating regressions in which the male offsprings dowry, female education, male siblings average level of education, the number of female offspring, and the number of male offspring are treated as dependent variables, to obtain imputed values of these control variables to be used in the female offsprings dowry equation. These control variables are imputed using household income, fathers education, mothers education, age of household head, caste, fathers age at the time of his marriage, years passed since parents marriage, fathers dowry, whether mother is a housewife, and whether father is a government employee. However, there are still factors such as social network, behavior of peers or parental preferences that are not captured by the data that can affect both groom price and daughters education. It is less likely that the Indian governments national school sanitation policy affects groom price. It is possible that the omission of such unobservables cause Frijters and Sharma (2002) to underestimate the effect of daughters education and groom price. a greater proportion of the responses in their data are the planned levels of education and not the actual levels of educational attainments.

Also, Frijters and Sharma (2002) data on the daughters Years of schooling contains both ex-ante and ex-post information; a greater proportion of the responses in their data are level(s) of education parents are planning to make available to their female children and not actual years of education completed where actual daughters years of education completed is unavailable, so their result may be affected by measurement error. My sample includes only women who have either completed their education to avoid this issue.

Finally, Frijters and Sharma (2002) state that a limitation of their study is the smaller sample size that primarily captures the perceptions of middle class residents of Patna on dowry related issues. My paper thus adds to the literature by analyzing data that include households both above and below the poverty-line and are from 22 out 34 states and roughly half the districts of India.

The relationship between groom price and womens education has important implications for womens welfare. Groom price is one of the factors behind female foeticide, violence against women and children and the welfare of female household members. Groom price affects the status of the female child as well as women in the household. Legal sanctions have had limited success or no success in ending the practice of groom price and its ramifications. If we assume there is a positive relationship between education and groom price as estimated by Frijters and Sharma (2009) and myself, this would imply parents face the indirect cost of groom price in addition to the direct costs of educating their daughters. This would suggest that groom price is an extra hurdle in female education. Does this imply there is no hope for female education? Perhaps not, if we assume positive assortative matching in the marriage market (Becker, 1981), it makes sense to control for the effect of a womans education on her groom price through her grooms quality which can also be affected by a womans education through complementarity between the quality of marriage partners. For the 7,489 ever married women in my sample I have information on their spouses completed years of education, age, and their family background which I use to estimate the effect of woman's education on her groom quality which measure using spousal education.

Education, which reflects the quality of a potential spouse at the time of marriage (Becker, 1981), is an important determinant of groom price. However, as discussed, it is easily argued that this is an endogenous variable. Parents of girls plausibly must decide, when their daughters are young, whether to invest more in their daughters education, or save for her groom price(Anderson, 2004; Peters and Siow, 2002). These variables are then simultaneously determined, although the investment in education occurs prior to the payment of groom price. As education reflects the quality of a potential spouse at the time of marriage, parents are similarly aware their investment in their daughters human capital may affect their daughters groom quality. So, parent's investment in their daughter's education factors into the quality of her groom. So, to address for the endogeneity between a womans education, her groom, and her groom price, I estimate the effect of a woman's education on her groom's education. The education of grooms is estimated using the following specification which I estimate with both OLS and 2SLS method, for the 2SLS estimation I use the same sanitation policy instrument for women's education:

$$Groom's Years of education completed_i = \beta_0 + \beta_1 \textit{Woman's Years of education completed}_i$$

$$+\beta_n \mathbf{X_i} + \theta State_i + \gamma Religion_i + \alpha Urban_i + \epsilon_i \rightarrow [4]$$

The vector X contains the individual womans years of schooling completed, the womans age, the years of schooling completed by highest educated male in her parental household, the years of schooling completed by the highest educated female in her parental household, whether the individual herself is the highest educated female in her household, and religion of household, the percentage of schools that are in rural areas in a district, the average household income and school development funds for each district. The geographic control variables include state and district of the household and whether the household is in an urban or rural location, as well as, a binary variable for whether the individual herself is the highest educated female in her household.

The OLS estimate for the effect of woman's education on her groom's education in Table 1.13 indicates that a year increase in a woman's years of education results in her groom's education to be 0.5 years higher. The 2SLS estimate in Table 1.13 shows an effect of the same magnitude however, the 2SLS estimates are much more noisier than the OLS results. This may be due to much fewer married women being affected by the school sanitation policy as shown in Table 1.12 and so the instrument may not have enough variation causing larger standard errors. The coefficients for all other control variables are almost equal for both OLS and 2SLS although, the coefficients for 2SLS estimate not statistically significant (See Appendix Table A11).

Again using the first-stage results obtained from equation (2) for the predicted values of woman's years of education completed and the predicted values of groom education from estimations of equation (4) then enter into the estimation of groom price to identify the effect of groom's education on groom price using the same 2 SLS regression as equation 3 but including predicted groom's years of education as a control variable:

$$GroomPrice_i = \beta_0 + \beta_1 \textit{Woman's Years of education completed}_i + \beta_n \mathbf{X_i}$$

$$+\beta_2 \textit{Predicted Groom's Years of education completed}_i$$

$$+\theta State_i + \gamma Religion_i + \alpha Urban_i + \epsilon_i \rightarrow [5]$$

where $\mathbf{X}_i$ refers to all of the social economic variables and state, religion and location dummies used in previous estimations.

The results in Table 1.14 suggests that after controlling for groom's education, woman's education has a negative effect on her groom price. The two estimations yield almost identical coefficients for both woman's education and her groom's education. Both the estimates using OLS predicted values of groom's education and IV predicted values of groom's education show the effect of woman's education on her groom price to be negative and statistically significant. While the relationship between groom's years of education and groom price is positive and significant. These results would suggest that parents are paying for spousal quality.

1.5 Conclusion

This paper attempts to get a more recent, broader, and possibly clearer picture of the state of parental investment in daughters in India. My results suggest that parental transfer of wealth to their daughters appears to be occurring through two mechanisms, investing in their daughter's education to increase her potential future income and investing in a higher quality spouse who would also have higher expected income, both contributing to their daughter's wealth (Anderson, 2004; Peters and

Siow, 2002). It could be that the lack of opportunities in the labor market make investing in a quality groom a better means of securing a daughter's future wealth than investing in her human capital for other than the returns to education in the marriage market. This would coincide with data from the World Bank (WB) which show that despite the increasing number of women pursuing secondary and post-secondary education, Indias women keep dropping out of the labor force (Figure 2). Since 2005, more than 25 million Indian women have left the labor force and research on the state of women and work in India does not yet offer a clear explanation. Also data suggests, women want to work. The Indian National Sample Survey (NSS) data show that 31 percent of women who spend the majority of their time performing domestic duties would like some kind of job. The proportion of educated rural women who want to work is even higher: upwards of 50 percent would like a job apart from their domestic work.

Although, according to Anderson and Bidner (2015) and Peters and Siow (2002) paying a groom price is inefficient compared to investing in daughter's human capital and will be ultimately eliminated by human capital investment. However, groom price may persist or even exacerbate during a period when a society begins to experience an improvement in women's legal rights and bargaining power. The results in this paper suggest that India has not reached the stage where Anderson and Bidner (2015) theoretical model suggests investment in women's human capital will eliminate groom price payment. Also, these results do not account for any possible improvements in womens bargaining power within the household due to an increase in education (See Table 1.18) that may result in higher groom price payments (Ambrus, Field, and Torrero, 2010). Similarly, these results cannot identify whether parents are paying for a higher quality groom to keep their daughters from participating in the labor force or if parents are paying a higher quality groom due to the lack of opportunities for their daughters in the labor market. Given only 6.68 percent of the women in my sample have a salaried position, of which only 3.66 percent have full-time positions, it would be meaningful to investigate whether an increase in women's education has resulted in any welfare gains within the household in terms of their bargaining power, decision-making, or greater access to household resources.

1.6 Robustness Check

First of all, I include state fixed effects in my first-stage estimation to control for systematic unobserved differences between states since it is noted that states in India have cultural variations. In the first stage estimations in Table 1.15, I compare results where I do not control for state fixed effects to results where I do control for state fixed effects. The coefficient for Whether woman was affected by school sanitation policy remains positive and statistically significant at the 1 percent level and the magnitude of the coefficients are almost identical, 0.786 percentage point increase in years of education if affected by the sanitation policy without across states variation and 0.79 percentage point increase in woman's years of education if affected by the school female latrine construction policy and controlling for unobserved heterogeneity between states. The effect of family background and woman's age also remain similar in magnitude and direction, and are statistically significant for both estimations.

A potential issue regarding my instrument could be that there exist underlying (inherent) time constant (persistent) differences in groom price between districts which experienced an increase in girls toilets due to the policy initiative relative to districts which did not experience such a change. Such unobservable differences could stem from local differences in social norms, and attitude towards paying groom price. These differences may be unobservable or difficult to quantify, and not controlled for in my first stage estimations in Table 1.7. So, I estimate my first stage equation (2) controlling for district fixed effects. In the first stage estimations in Table 1.16, I control for district fixed effects, thus comparing, within the same district, women who were attending school when the policy was implemented and women who were already 18 years old at this time assumed to have finished high school and so, just cut off at the margin of only a year before the policy was implemented, while controlling for any time constant differences that may exist across districts. These estimates are also statistically significant at the 1 percent level and show that the school sanitation policy increases womens years of schooling by 0.8 years. The coefficients for family background and woman age are statistically significant at the 1 percent level, have the same sign, and similar magnitude. However, after controlling for unobserved differences between districts, the school development funds received by schools a district on average have a statistically significant and negative, though small, effect on a woman's years of education while average district household income has a statistically significant, positive but small effect on woman's years of education.

I also control for any systematic unobserved differences between urban and rural areas because an estimated 68 percent of India's population resides in rural areas[11] In the first stage estimations in Table 1.17, I compare results where I do not control for location fixed effects to results where I do control for location fixed effects. The coefficient for Whether ever-married woman was affected by school sanitation policy remains positive and statistically significant at the 1 percent level with similar magnitude in both estimations. It is interesting to see that if the location of the household being in an urban or rural area is not controlled for, the coefficient for percentage of schools in rural areas within a district which is otherwise statistically insignificant, becomes statistically significant at the 1 percent level and becomes more the double in magnitude. This suggests that living in an urban area has a strong and positive impact on women's educational attainment. This result also indicates that those living in rural areas are also attending school in rural areas as the effect of 'percentage of a district's school in rural areas' on woman's years of education becomes insignificant once household location has been accounted for.

11. http://data.worldbank.org/indicator/SP.RUR.TOTL.ZS.

1.7 Tables

Table 1.2: **Frijters & Sharma and paper sample Groom Price stats**

		Frijters & Sharma (2009)
Groom price	**mean**	**mean**
	354,309.9	316,426
	(365,869.8)	(391,798)
Number of observations =	11,187	166

Prices in 2012 Indian rupees.

Table 1.3: **Comparison between Groom Price and Social functions**

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Groom Price	354,309.9	365,869.8	0	6,260,000
Social functions	6,712	319,46.2	0	850,000

Table 1.4: **2SLS Results: Effect of woman's education on wedding guests**

VARIABLES	(1) Bride's family guests	(2) Groom's family guests	(3) total wedding guests
Woman's years of education completed	11.882	10.885	22.26
	(11.816)	(13.393)	(22.96)
Education of highest educated male in household	2.712	3.623*	6.417*
	(1.817)	(2.012)	(3.526)
Education of highest educated female in household	-1.698	-1.474	-3.025
	(3.687)	(4.339)	(7.319)
Age of woman	3.098	1.969	5.008
	(2.009)	(2.101)	(3.724)
Whether woman is highest educated female in household	-23.858	-15.174	-38.07
	(27.219)	(30.871)	(52.21)
(mean) School Development funds received	0.000	-0.000	0.000176
	(0.001)	(0.001)	(0.00254)
(percentage) schools in district	-26.454	-56.131	-82.65
	(37.593)	(36.886)	(67.90)
(mean) district household income	0.000	0.000	0.000362
	(0.000)	(0.000)	(0.000377)
Observations	10,830	10,829	10,828
R-squared	0.083	0.063	0.076

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1.5: **Descriptive Statistics**

	mean	**sd**	**min**	**max**
Dependent Variable				
Groom price(Rs[1])	354,309.93	365,869.83	0	6,260,000
Control variables				
Woman's years of education completed	8.509	3.415	0	16
Education of highest educated male in household	9.077	4.515	0	16
Education of highest educated female in household	6.889	5.099	0	16
Age of woman	25.321	5.556	15	35
Whether woman is highest educated female in household	0.565	0.496	0	1
(mean) School Development funds received	5,638.364	3,589.824	12.744	58,504.376
(percentage) schools in district	0.832	0.175	0	0.996
(mean) district household income	139,764.20	62,148.33	25,307.15	464,727
Number of observations = 11,187				

[1]Groom price is in year 2012 Indian rupees.

Table 1.6: **OLS Results**

VARIABLES	(1) Groom price
Woman's years of education completed	14,314***
	(2,033)
Education of highest educated male in household	5,673***
	(830.6)
Education of highest educated female in household	2,449***
	(626.2)
Age of woman	2,731***
	(637.5)
Observations	10,865
R-squared	0.237

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.7: **First Stage Results**

VARIABLES	(1) Woman's years of education completed
Whether woman was affected by school sanitation policy	0.791***
	(0.0896)
Education of highest educated male in household	0.136***
	(0.00775)
Education of highest educated female in household	0.321***
	(0.00738)
Age of woman	-0.116***
	(0.00665)
Observations	10,865
R-squared	0.464

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.8: **OLS and 2SLS Results**

VARIABLES	(1) OLS Groom price	(2) 2SLS Groom price
Woman's years of education completed	14,314***	22,283*
	(2,032.62)	(12,579)
Education of highest educated male in household	5,672.95***	4,609**
	(830.63)	(1,874)
Education of highest educated female in household	2,449.32***	-17.66
	(626.15)	(3,784)
Age of woman	2,731.15***	4,001*
	(637.55)	(2,044)
Observations	10,865	10,865
R-squared	0.24	0.234

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.9: **First-Stage Results Poor & Non-Poor**

VARIABLES	Poor Woman's years of education completed	Non-poor Woman's years of education completed
Whether woman was affected by school sanitation policy	0.989***	0.730***
	(0.215)	(0.0993)
Observations	1,969	8,894
R-squared	0.335	0.472

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.10: **OLS Results Poor & Non-Poor**

VARIABLES	(1) OLS Poor Groom Price	(2) OLS Non-poor Groom Price
Woman's years of education completed	7,426***	14,732***
	(1,956.6)	(2,453)
Observations	1,969	8,894
R-squared	0.258	0.223

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.11: **2SLS Results Poor & Non-Poor**

VARIABLES	(1) Poor Groom Price	(2) Non-poor Groom Price
Woman's years of education completed	11,804	21,596
	(16,839)	(15,685)
Observations	1,969	8,894
R-squared	0.256	0.221

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.12: **Ever-married Women Statistics**

	mean	**sd**	**min**	**max**
Groom price(Rs[1])	362922.31	377031.07	0	5,600,000
Spouse years of education completed	8.753	4.039	0	16
Woman's years of education completed	8.278	3.267	0	16
Education of highest educated male in household	9.729	4.165	0	16
Education of highest educated female in household	7.04	4.770	0	16
Age of woman	27.397	4.761	15	35
Whether woman is highest educated female in household	0.565	0.496	0	1
(mean) School Development funds received	5,674.09	3,584.38	12.74	58,504.38
(percentage) schools in district	0.833	0.174	0	0.996
(mean) district household income	139,935.33	61,979.18	25,307.15	464,727
Treated = 937				
Number of observations = 7,489				

[1]Groom price is in year 2012 Indian rupees.

Table 1.13: **OLS and 2SLS Results: Effect of woman's education on groom's education**

VARIABLES	(1) OLS Groom Education	(2) 2SLS Groom Education
Woman's years of education completed	0.534***	0.530
	(0.018)	(0.469)
Observations	7,467	7,467
R-squared	0.332	0.332

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.14: **OLS and 2SLS Results controlling for groom education**

VARIABLES	(1) Groom price OLS Predicted Groom Educ	(2) Groom price IV Predicted Groom Educ
Woman's years of education completed	-71,106**	-70,032**
	(34,712.342)	(28,151)
Groom's years of education completed	161,170***	160,202***
	(63,096.26)	(52,034.7)
Education of highest educated male in household	-12,133*	-12,105*
	(7,077.731)	(6,372)
Education of highest educated female in household	-4,075*	-4,273*
	(2,445)	(2,342)
Age of woman	-2,106	-2,032
	(2,685)	(2,188)
Observations	7,479	7,479
R-squared	0.226	0.226

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.15: **State Fixed Effects**

VARIABLES	(1) Woman's years of education completed	(2) Woman's years of education completed
Whether woman was affected by school sanitation policy	0.786*** (0.092)	0.790*** (0.0896)
Education of highest educated male in household	0.127*** (0.009)	0.136*** (0.00775)
Education of highest educated female in household	0.332*** (0.008)	0.321*** (0.00738)
Age of woman	-0.106*** (0.007)	-0.116*** (0.00665)
Whether woman is highest educated female in household	2.432*** (0.061)	2.354*** (0.0610)
(mean) School Development funds received	-0.000 (0.000)	-0.00000169 (0.0000107)
(percentage) schools in district	-0.383 (0.298)	-0.360 (0.266)
(mean) district household income	0.000*** (0.000)	0.00000107 (0.000000821)
State Fixed Effects	No	Yes
Observations	10,865	10,865
R-squared	0.464	0.497

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.16: **District Fixed Effects**

VARIABLES	(1) Woman's years of education completed	(2) Woman's years of education completed
Whether woman was affected by school sanitation policy	0.791***	0.813***
	(0.090)	(0.0919)
Education of highest educated male in household	0.136***	0.133***
	(0.008)	(0.00780)
Education of highest educated female in household	0.321***	0.309***
	(0.007)	(0.00765)
Age of woman	-0.116***	-0.121***
	(0.007)	(0.00677)
Whether woman is highest educated female in household	2.353***	2.313***
	(0.061)	(0.0613)
(mean) School Development funds received	-0.000	-0.00216***
	(0.000)	(0.000311)
(percentage) schools in district	-0.361	0.548
	(0.266)	(0.436)
(mean) district household income	0.000	0.0000146***
	(0.000)	(0.00000103)
District Fixed Effects	No	Yes
Observations	10,865	10,865
R-squared	0.458	0.464

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.17: **Location Fixed Effects**

VARIABLES	(1) Woman's years of education completed	(2) Woman's years of education completed
Whether woman was affected by school sanitation policy	0.809*** (0.091)	0.791*** (0.0896)
Education of highest educated male in household	0.139*** (0.008)	0.136*** (0.00775)
Education of highest educated female in household	0.329*** (0.008)	0.321*** (0.00738)
Age of woman	-0.114*** (0.007)	-0.116*** (0.00665)
Whether woman is highest educated female in household	2.388*** (0.061)	2.353*** (0.0610)
(mean) School Development funds received	0.000 (0.000)	-0.00000168 (0.0000107)
(percentage) schools in district	-0.847*** (0.256)	-0.361 (0.266)
(mean) district household income	0.000*** (0.000)	0.00000106 (0.000000821)
Location Fixed Effects	No	Yes
Observations	10,865	10,865
R-squared	0.458	0.464

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.18: **Household Welfare Outcomes**

VARIABLES	(1) access to HH bank account	(2) access to cash for expenses	(3) co-owner/lessee of home	(4) unrestricted movement	(5) allowed to work
Woman's years of education completed	0.225***	0.193**	0.009	0.159**	-0.0250
	(0.083)	(0.076)	(0.033)	(0.074)	(0.0634)
Education of highest educated male in household	-0.037***	-0.028**	-0.002	-0.021*	0.00807
	(0.014)	(0.012)	(0.005)	(0.011)	(0.00979)
Education of highest educated female in household	-0.083**	-0.080**	-0.001	-0.059*	0.0145
	(0.034)	(0.032)	(0.014)	(0.031)	(0.0255)
Age of woman	0.039***	0.027***	0.006***	0.026***	-0.00530
	(0.006)	(0.006)	(0.002)	(0.005)	(0.00470)
Whether woman is highest educated female in household	-0.777**	-0.709**	-0.008	-0.569**	0.144
	(0.316)	(0.286)	(0.126)	(0.279)	(0.229)
(mean) School Development funds received	0.000	0.000	-0.000	0.000	0.00000681*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.00000405)
(percentage) schools in district	-0.207**	-0.054	-0.097	0.016	0.0581
	(0.083)	(0.065)	(0.072)	(0.071)	(0.146)
(mean) district household income	-0.000**	-0.000	-0.000	-0.000	-0.000000416*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.00000024)
Observations	5,480	7,695	7,474	7,627	5,858

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

1.8 Figures

Figure 1.1: Indian school latrine construction statistics

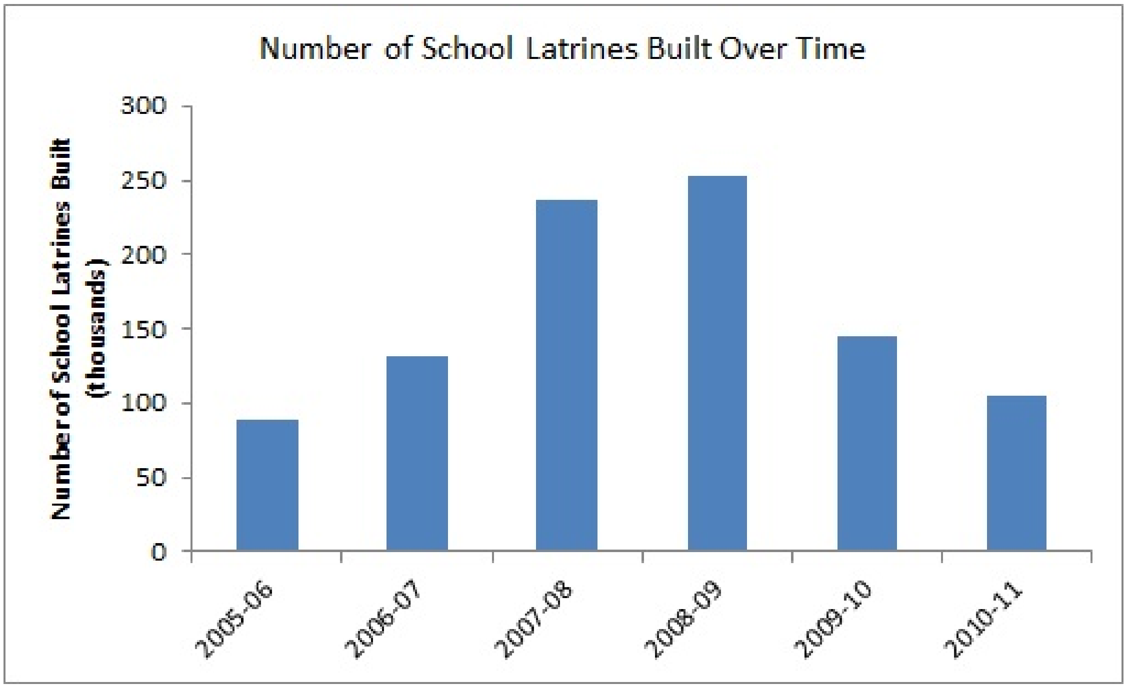
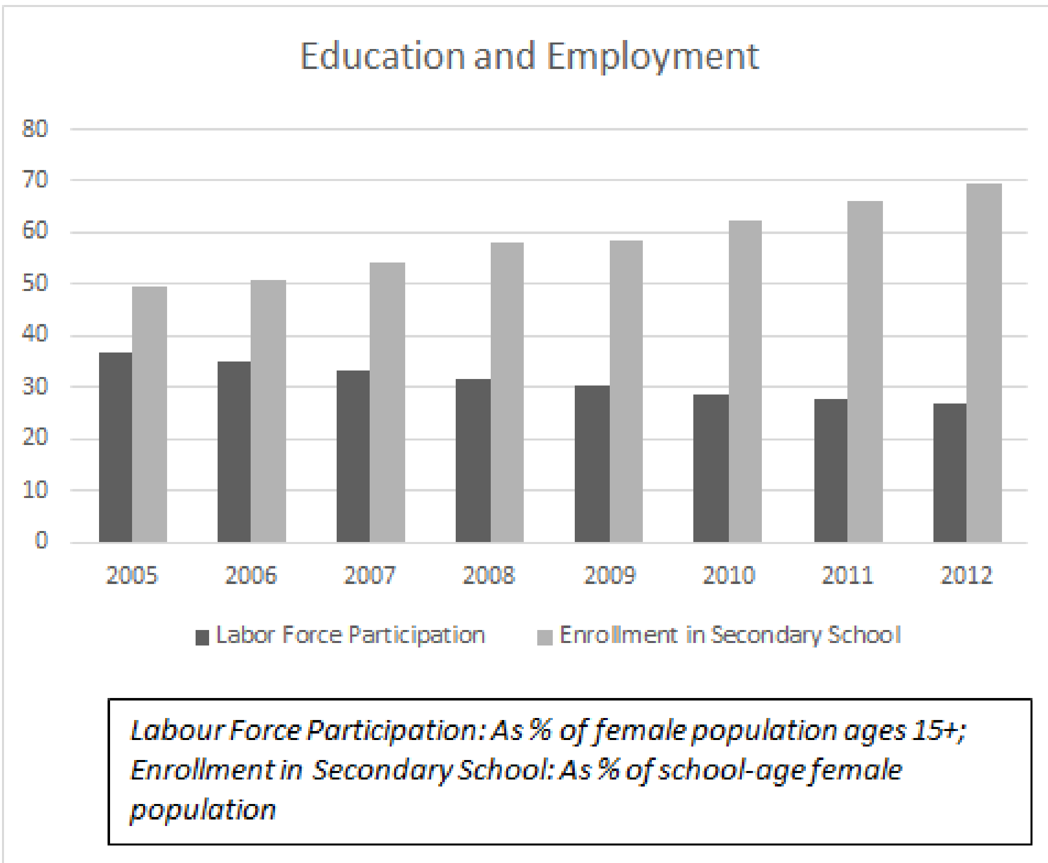


Figure 1.2: Women's Education and Labor force participation



Chapter 2

Peer Effects in Irrigation in the Southeastern US

2.1 Introduction

This paper investigates the extent to which social factors specifically, the behavior of peers, affect the adoption of irrigation in the Southeastern US states of Alabama, Florida, Georgia, North Carolina, and South Carolina. The relevance of peer effects in irrigation arises from the fact that previous literature on social learning (Foster and Rosenzweig, 1995) suggests farmers may learn from observing the behavior of their peers when they have imperfect information. In the case of peer effects in adoption of new technology in agriculture (Foster and Rosenzweig, 1995; Conley and Udry, 2001) farmers have imperfect information because they have little or no experience using the technology and learning from peers who use this technology provides them with additional information they can use for deciding whether to adopt that technology and the optimal use of that technology to maximize their profit. This suggests that neighbors can affect both the adoption of a new technology and the intensity of its use. Learning from peers reduces the uncertainty and risk of adopting new technology.

In this paper, I look at whether learning from peers occurs when there is uncertainty due to imperfect information on the variability of weather and climate. Studies show that irrigation can help farmers reduce risk due to unpredictability in weather and climate (Boggess et al., 1983; Lin, Mullen, and Hooganboom, 2012; Payero and Khalilian, 2014). Lin, Mullen, and Hooganboom (2012) provide evidence that irrigation is an important risk management strategy for corn production in Georgia, even when there is weather insurance available. Boggess et al. (1983) find that one of the major benefits of irrigation in the Southeast is reduction in yield variability. At the same time research suggests there has been an increase in variability of weather and climate, such as increased variations in precipitation trends, warmer average temperatures, increased storm frequency, etc. (Ficklin et al., 2015; Wallander et al., 2013; Ingram et al., 2013; Li, Li, and Barros, 2013). There have been recent research and extension efforts to help farmers adapt to seasonal and long-term variability of weather and climate in the Southeast by developing an information system to provide climate forecasts and information to help them make better management decisions (Fraisse et al., 2009). Fraisse et al. (2009) state that these efforts are in response to farmers' interest in climate change. Given this interest and the fact that irrigation can help farmers reduce risk due to unpredictability in weather and climate, it would be interesting to see whether farmers are affected by their peers' irrigation decisions.

Much of the previous literature on US irrigation practices is limited in geographic area to one or two states. Frisvold and Deva (2012) state that because detailed data on US irrigation practices are only easily available in cross-tab form the data are rarely used for statistical analysis of irrigator behavior due to the limitation this format places by merging data into broad categories such as farm size. This essentially reduces the information and flexibility of the data to be analyzed. This paper attempts to utilize US Agriculture Census data on farmers and their irrigation decisions to study irrigation behavior for a larger geographic area by analyzing data aggregated at the county-level, although I do not study the effects of the same factors on irrigation as the previous literature. Lastly, although there has been research on factors that affect irrigation in the Southeastern US (Boggess et al., 1983; Gonzalez-Alvarez, G Keeler, and D Mullen, 2006; Lin, Mullen, and Hooganboom, 2012), there has not been any study on whether peers' affect the decision to irrigate in the Southeast. By studying the effects of peers on irrigation decisions I hope to understand if and what role social learning has on irrigation decisions in the Southeastern US.

2.2 Literature Review

2.2.1 Peer effects in Agriculture

Foster and Rosenzweig (1995) use a three-year panel of household-level data from rural Indian households from 250 villages to study how learning by doing and learning from others affects the adoption of agricultural technology, specifically the adoption of High Yield Variety seeds (HYV). They use average characteristics of all other households within a village as neighbor characteristics. Foster and Rosenzweig (1995) find that imperfect knowledge about how to use new technology can be a significant barrier to adoption. They find that own and neighbors' experience influence profitability net of the adoption of HYVs in addition to affecting the rates of adoption which suggests that experience affects the ability of farmers to make appropriate decisions about the use of new technology. The rapid decline over time in the influence of experience on profitability indicates, however, that the importance of this barrier substantially diminishes in the first few years of use as experience increases. Second, they find evidence of learning spillovers, farmers with experienced neighbors are significantly more profitable than those with inexperienced neighbors and are likely to devote more of their land to the new technologies.

2.2.2 Irrigation adoption and practices

Frisvold and Deva (2012) investigate how farm size (measured by sales class) is associated with (i) use of water management information, (ii) investment in irrigation improvements, and (iii) participation in conservation programs. They find that farm size is positively associated with the sources used for information on irrigation management, whether farmers acquire information, use of management-intensive irrigation methods, and participation in conservation programs. Their study looks at farms in the Southwestern US, specifically Arizona and New Mexico using data from the 2008 Farm and Ranch Survey. Frisvold and Deva (2012) do not estimate the effect of peers on irrigation but their analysis of data by number of farms and farm size show that neighboring farmers were one of the top sources for irrigation information in Arizona and New Mexico for all farm sizes. They also find that adoption of scientific irrigation scheduling methods was low for all groups, but especially low for small-scale irrigators. Frisvold and Deva (2012) find that smaller-scale irrigators rely more on information provided by intermediaries instead of direct sources such as media and internet reports.

2.3 Conceptual Framework

Several studies suggest that social learning can facilitate technology adoption in an agricultural context. However, even having identified the existence of such peer effects, there is considerable debate about the precise mechanisms which underlie them. Young (2001) identifies three mechanisms through which social interactions may influence adoption. 'Pure conformity' refers to situations in which fashion dictates behavior and individuals adopt a technology because they receive a benefit from 'fitting in'. 'Instrumental conformity' suggests a role for coordination in the adoption of technologies. Sometimes referred to as 'network effects' such conformity may occur when the return to adoption increases in the fraction of one's network that adopts a technology. Finally, 'informational conformity' emphasizes the role of peers in being a source of information and facilitating adoption. This latter mechanism has typically been described as 'social learning'. Most economic modeling of peer effects has focused on social learning and informational constraints. In these situations, social learning is modeled as a Bayesian learning process (Jovanovic and Nyarko, 1996). As such, social learning may be described as the process through which agents learn by observing or sharing information about the behavior of others.

Disentangling between imitation, learning and coordination effects is difficult because they have very similar empirical predictions. I assume in this paper that social learning comprises of mimicking, gaining proficiency or both. Coordination effects are unlikely because aside from learning externalities, peers' irrigation does not provide any external benefit to a farmer's own profit unlike for example, pest management.

Learning externality exists when new information affects behavior and results in outcomes for an individual that are closer to the private optimum. The model of learning from others developed by Foster and Rosenzweig (1995) established that farmer's decisions about technology use, depend not only on a farmer's evaluation of its profitability, but also on the experience of his information network. In the case of irrigation in the Southeast US, the learning externality arises from imperfect information on the optimal usage of water, climate variability such as changes in precipitation, frequency of drought, and soil conditions. Although irrigating crops increases yield (Payero and Khalilian, 2017), prevents damage from drought, the expected net profit from irrigated crops must be greater than that of non-irrigated crops for a farmer to invest in irrigation. The farmer's objective is to maximize his profit p, which is revenue minus cost:

$$y_i = f(x)$$

$$\pi_i(p, w) = \max_x pf(\mathbf{x}) - w\mathbf{x}$$

where, p = price of output, y_i = farmer's output, w is the vector of input prices, x is the vector of inputs used to produce y. If I assume the price of output, p is given, then to maximize his profit, the farmer must choose the optimal amount of inputs used that will produce the optimal amount of output, y* and one of these inputs is water.

The costs that a farmer considers in his decision to irrigate depends on the cost of installing an irrigation system, cost of maintaining an irrigation system, cost of applying water, and the cost of acquiring knowledge on optimal amount of water to use to produce y*. The variability of climate introduces uncertainty in whether to invest in irrigation and the amount of irrigation required to produce y* as farmers have imperfect information regarding climate variability (Foster and Rosenzweig, 1995; Boggess et al., 1983; Negri, Gollehon, and Aillery, 2005). Although farmers may know what the average climate conditions are, they have imperfect knowledge regarding how the climate conditions may vary and make their decisions based on their beliefs on how climate conditions may vary. This uncertainty gives rise to potential learning from peers. When farmers share common agronomical conditions, observing neighboring farmers' behavior gives a farmer additional information about how climate conditions may vary, which affects the need and level of irrigation to produce y*. The farmer then updates his beliefs and changes his decision to irrigate based on the information he gets from his peers' irrigation behavior (Conley and Udry, 2010). For example, if a farmer thinks that there is an increase in variation in rainfall and considers investing in irrigation and observes his neighboring farmer also invest in irrigation, this reinforces his beliefs about the variation in rainfall. Another example can be when a farmer is considering, based on his beliefs about the variation of moisture levels, to irrigate once or twice a week and observes his neighboring farmer irrigating once a week, this gives the farmer some more information he can use to make his decision on the frequency of irrigating. Even when information is available free of cost through extension services, the irrigation practices of peers in neighboring areas may provide more precise information for a localized area and time, at a lower opportunity cost. I can also consider the situation where an extension agent might only be able to give a farmer an estimate of the average amount of irrigation he needs for optimal y* given his specific farming conditions. In this case, the farmer will still have imperfect information when there is climate variability that may require him to deviate from this average and the behavior of peers will give him additional information in this situation. Thus, information from peers can reduce the cost of producing y* which will maximize a farmer's expected profit in the presence of uncertainty from climate variability. This is especially applicable for part-time farmers as studies suggest off-farm work discourages management intensive practices due to a higher opportunity cost of on-farm managerial time (Fernandez-Cornejo, 1998).

2.4 Data

2.4.1 Data Source

The data on farm operations are from the US Census of Agriculture (USDA) from the years 2012, 2007, and 2002. The data set is a three-year panel of county-level farm characteristics from the five southeastern states of Alabama, Florida, Georgia, North Carolina, and South Carolina. There is a total of 439 counties in these five states and the dataset has 1,310 observations over the 3 years with the county being the unit of observation. County population data is obtained from the US Census Bureau. County income data is obtained from the Small Area Income and Poverty Estimates (SAIPE) program of the U.S. Census Bureau. Data used to control for climate conditions affecting irrigation decisions are from the U.S. Drought Monitor.

2.4.2 Variables

Construction of Peer Data Matrix

Matrix **D**:

$$\begin{bmatrix} x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{d1} & x_{d2} & x_{d3} & \dots & x_{dn} \end{bmatrix}$$

$$x_{ij} = \begin{cases} 1, & \text{if county j is a neighbor of county i and } i \neq j \\ 0, & \text{otherwise} \end{cases}$$

Matrix **W**:

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{d1} & a_{d2} & a_{d3} & \dots & a_{dn} \end{bmatrix}$$

$$a_{ij} = \begin{cases} \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}, & \text{if county j is a neighbor of county i and } i \neq j \\ 0, & \text{otherwise} \end{cases}$$

$\mathbf{W} \times \mathbf{X} =$ matrix of peer characteristics

My dependent variable is the percentage of farm operations that irrigate in a county i. **X** is the matrix of variables which include average farm size in a county, the county-level proportion (in percentages) of farmer operators categorized by characteristics of age, sex, race, farm ownership, and whether the farm operator resides on the farm operation location and if their primary occupation is farming or not. The farm characteristics such as farm size, type of crop produced vary significantly by these farm operator characteristics. Both economic theory and findings in previous literature (Frisvold and Deva, 2012; Skaggs and Samani, 2005; Leib et al., 2002) suggest that the relationship between farm size and both the magnitude and likelihood of irrigation are positive and significant. Studies suggest that whether the farm operator resides on the farm operation location and if their primary occupation is farming or not, affect the adoption of farm practices (Fernandez-Cornejo, 2007; Hoppe, 2002; Fernandez-Cornejo, 1998) with off-farm operators less likely to adopt management intensive practices and smaller farms more likely to have operators whose primary occupation is not farming. Furthermore, smaller farms are less likely or slower to adopt and use variable input such as irrigation due to lower technical capacity, farm wealth, and human capital levels (Foster and Rosenzweig, 1995; Feder and Slade, 1984). The differences in farm characteristics by the primary occupation of farm operators can be seen in the USDA Census of Agriculture data, which is reported in Table.1. Farms with operators who consider farming to be their primary occupation have on average 68 percent more acres in use and 86 percent more agricultural sales in dollars. Summary of USDA Census of Agriculture data by farm operator race suggest that there is a correlation between crops grown and farm operator race and the percentage of harvested area irrigated differs considerably by types of crop (figures 2.1-2.4) . I also include race interaction terms to investigate the presence of any same race effect on irrigation adoption.

I also control for differences in production conditions by including measures that capture the variation in the opportunity cost of growing different types of crops between counties. I construct a measure of variation in the opportunity cost of growing different types of crops by multiplying number of farm acres allocated to three broad categories of crops, fruit and nuts, vegetables, and field crops and hay, by the price index of each crop category for the respective panel year. I control for drought conditions by including county-level measures of drought that occur over the entire length of the panel and for 2 years before 2002, the first cross-section of the panel. Comprehensive drought data at the county-level, for the specific states, are only available at the US Drought Monitor (USDM) and the data only exist from 2000. So, only the past two years of drought conditions can be measured for the 2002 cross-section instead of the 5 years used for the 2012 and 2007 cross-sections. The drought measures used are as defined by the U.S. Drought Monitor which is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. I use the weekly county-level estimates of dryness which range from D0-abnormally dry to D4-exceptional drought and vary by percentage area of county to construct two different measures of drought. One measure of drought is based on the number of consecutive weeks a county has experienced D2-severe to D4-exceptional drought conditions, these are defined as drought spells. I distinguish further between short-term and long-term drought which may capture different responses. Short-term drought may cause farm operations which already have irrigation infrastructure to apply water but may not be damaging enough to induce farms that do not currently irrigate and do not have irrigation systems in place to start irrigating. The short drought spells are defined as periods of a minimum eight consecutive weeks but less than 24 weeks (6 months) during which a county at least experienced severe drought conditions. The reason for selecting eight weeks as the minimum threshold is the U.S. Department of Agriculture uses the measure of a county shown in severe drought on the U.S. Drought Monitor for eight consecutive weeks to declare drought disasters and allocate drought relief. As this criterion is held equivalent to the previously established criteria of a 30 percent production loss of at least one crop county-wide, it suggests eight weeks of at least severe drought can be used as an indicator of crop loss. The upper threshold of less than 6 months is set by the US Drought Monitor definition of Short-Term (drought), typically less than 6 months (e.g. agriculture, grasslands). Long drought spells have been estimated as any period of consecutive weeks greater than 24, with at least severe drought conditions or worse by US Drought Monitor definition of Long-Term (drought), typically more than 6 months (e.g. hydrology, ecology). I also construct a measure of drought that is the percentage area of a county that has experienced severe to exceptional drought conditions. The data suggest that between 2000 to 2012 irrigation and drought spells have been following the same trend as in the Southeastern US, (figures 2.5-2.9), although regression results do not show any significant impact of drought on the percentage of farmers that irrigate in a county.

2.5 Econometric Model and Estimation

The estimation equation is based on the social interactions framework incorporating the mechanisms outlined in Manski (1993) with exogenous effects and correlated effects included in the empirical specification as follows:

$$Y_{it} = \alpha \ + \lambda W_{p(-i)} Y_{p(-i)t} \ + X_{it}\beta + W_{p(-i)} X_{p(-i)t}\delta + u_i + \sigma_t + \varepsilon_{it} \rightarrow [1]$$

Where Y_{it} is the percentage of farm operations which irrigate in a county i, in year t, $W_{p(-i)}Y_{p(-i)t}$ is the weighted average percentage of farm operations which irrigate in counties adjacent to county i and are county i's peers p (excluding i) for year t, X_{it} is a vector of county farm characteristics for year t, $W_{p(-i)}X_{p(-i)t}$ is the same set averaged over the peer group for year t, u_i is a county-specific effect, and σ_t is a time effect. Using Manski (1993) terminology, λ is known as the endogenous effect, the impact of i's neighbors' choices on i's choice, which is peer effects. The parameter δ represents a vector of effects stemming from i's neighbors' characteristics, known as exogenous effects. The weight matrix, $W_{p(-i)}$, identifies the adjacency of counties within the sample. The network is defined as those counties which a geographical border or point as neighbors. In the weight matrix, counties and their neighbors are given a 1 while all other elements are zero. Further, the weight matrix is transformed so that $W_{p(-i)}$ is a square matrix where $W_{ij} = 1/n_{ij}$ if county j is adjacent to county i, and 0 otherwise. This setting is referred to as row-normalization because the sum of each row is equal to 1, and this model is called the local average network model. Conceptually, county i's outcome is affected by the average behavior of i's neighboring counties, which is the social norm mechanism. For simplicity, I will refer to neighboring counties as peer counties or peers throughout the rest of this paper.

There are two primary challenges to the identification of λ, the parameter of interest. The first is a result of Manski's 'reflection problem', where the regression of own peer outcomes $W_{p(-i)}Y_{p(-i)t}$ on own outcomes Y_{it} are endogenous. The reflection problem results in λ to be unidentifiable because $W_{p(-i)}Y_{p(-i)t}$ is correlated with the error term e_{it}. In the extreme case where peer groups are perfectly transitive, it is difficult to separately identify peer effects λ and the set of contextual effects δ which are the effect of peer characteristics $W_{p(-i)}X_{p(-i)t}$ on an individual county's outcome, Y_{it}. However, when peer or neighbor groups are partially overlapping (i.e. when the peers of i's peers can reasonably be excluded from i's peer set) identification is made possible by exploiting variation in characteristics of these excluded peers (Bramoulle, Djebbari, and Fortin, 2009). In this paper, as peers are determined by spatial adjacency, I can select peers of i's peers as those counties that are adjacent to the peer counties but not adjacent to county i itself, excluding peers of i's peers from i's peer set. Also, the exogeneity in location of agriculturally viable land allows us to reasonably assume the assignment of peers to be random and so identify exogenous changes in $Y_{p(-i)}$. This allows us to estimate (1) with two stage least squares (2SLS) using the average farm characteristics of counties adjacent (peers of peers) to neighboring counties (peers) as instruments to address the reflection problem.

$$Y_{p(-i)t} = \alpha + W_{p(-j)} Y_{p(-j)t}\beta + u_j + \sigma_t + \varepsilon_{jt} \rightarrow [2]$$

The second concern is distinguishing peer effects from correlated effects which can be a problem due to two issues, 'common cause' or homophily. This can happen when peers are affected by common background characteristics or shocks which also predict adoption. For example, if irrigation depends on unobserved (to the researcher) fertility of land, suitability of land for crop type, climate conditions, etc., then the extent of irrigation will be correlated across counties even in the absence of peer effects. Similarly, if the endogenous sorting of farms, in a county, into peer groups is marked by homophily, then correlated adoption decisions might solely be the result of correlated individual characteristics, such as wealth or risk aversion.

Concerning the problem of 'common cause' there are few things to consider, 1) I am studying counties within a group of states that are in a specific climate region, the Southeast, 2) I control for county-level population and income, average farm size, drought, average farm area allocated by crop type, race and demographics of farm operators. Although these factors are not exhaustive in their measure of common conditions or characteristics which may affect the decision to irrigate, controlling for these factors reduces the magnitude of bias that may exist due to correlated effects. One possible solution for the problem of 'common cause' is based on the argument that, if farmers are learning from their peers' behavior, they can only learn from what their peers have done in the past or present but not what their peers will do in the future. Thus, if it is peers' irrigation outcomes that are affecting a county's own irrigation outcomes, then the county's own irrigation outcomes should not be affected by peers' future irrigation outcomes. To test whether the relationship between the number of irrigators on average among peer counties and the number of irrigators in a county is due to peer effects or an artifact of common cause among peers, I estimate equation (1) using the previous period (1') and the future period (1") values of the percentage of irrigators on average among peer counties and peer farm characteristics using two-stage least estimation method.

$$Y_{it} = \alpha \; + \lambda W_{p(-i)} Y_{p(-i)(t-1)} \; + X_{it}\beta + W_{p(-i)} X_{p(-i)(t-1)}\delta + u_i + \sigma_t + \varepsilon_{it} \rightarrow [1']$$

$$Y_{it} = \alpha \; + \lambda W_{p(-i)} Y_{p(-i)(t+1)} \; + X_{it}\beta + W_{p(-i)} X_{p(-i)(t-1)}\delta + u_i + \sigma_t + \varepsilon_{it} \rightarrow [1'']$$

Regarding the problem of homophily, the exogeneity in location of agriculturally viable land allows us to reasonably assume the assignment of peers to be random, that is farmers' location is determined by availability of agriculturally viable land rather than the presence of individuals with similar preferences.

I use instrumental variables two-stage least squares within fixed-effects method to estimate my model in equation (1) where the u_i term captures the between county differences and the parameters of the explanatory variables are within-effects estimators. Fixed-effects estimation method is used instead of random effects estimation method because using random effects method requires the assumption that any time-invariant county specific unobserved heterogeneity is uncorrelated to the explanatory variables in my estimation. If this assumption is incorrect, then my coefficient estimates will be inconsistent. In this case it is not reasonable to assume that there is no correlation between time-invariant county specific unobserved heterogeneity and the explanatory variables. This is because counties are likely to vary in quality of agricultural land, soil type, the depth of ground-water sources, etc., which are likely to affect the explanatory variables farm size, types of crops produced, average percentage of farms that irrigate in peer county.

2.6 Results

2.6.1 Instrumental Variable Panel Regression

First-Stage Estimation

First, I estimate the first-stage following empirical model using a panel of three years, 2002, 2007, and 2012:

$$P_{it} = \alpha + W_{p(-i)} N_{p(-i)t}\beta + u_i + \sigma_t + \varepsilon_{it} \rightarrow [2]$$

Where P_{it} is the percentage of farm operations which irrigate in a peer county i, in year t, $W_{p(-i)}N_{p(-i)t}$ is a vector of the weighted average of farm characteristics of counties adjacent to peer county i and are peer county i's peers p (excluding i) for year t. The vector WN contains the following characteristics farm size, percentage of principal farm operators whose primary occupation is farming, county population, and median county household income. The term $u_i$is a county-specific effect and σ_t is a time effect.

The estimates of the first-stage regression in equation (2) for all variables in the current period, t are in Table 2.14. I find that the weighted average farm characteristics of peers of peer counties have a significant effect on percentage of farms that irrigate in peer counties both in magnitude and statistically. The percentage of farms that irrigate in a peer county increases by 0.15 percentage points for a 10 percentage point increase in the average farm size of peers of peer counties. The percent of farms with principal farm operators who are full time farmers and the percent of farms with principal operators residing on farm have larger effect on a peer countys percentage of irrigating farms. The percentage of farms that irrigate in a peer county increases by about 3 percentage points for a 10 percentage point increase in the average percentage of farms with principal farm operators who are full time farmers in peers of peer counties. While a 10 percentage point increase in the average percentage of farms with resident principal operators in peers of peer counties increases the percentage of farms that irrigate in a peer county by 3 percentage points as well.

2.6.2 2SLS Estimation

I use the predicted values of the percentage of farms that irrigate in a peer county from my first-stage estimation to replace the observed percentage of farms that irrigate in a peer county to estimate equation (1) using two-stage least squares. The result of the two-stage least squares regression of equation (1) for all variables in the current period, t is in Tables 2.7 and 2.8. I find that a 1 percentage point increase in the number of irrigators on average among peer counties increases the number of irrigators by 2.091 percentage points for the average county in the Southeastern US which is significant at the 5 percent level of significance. I find that farm size matters, a 1 percentage point increase in a countys average farm size increases the number of irrigators by 0.014 percentage points for the average county in the Southeast and significant at the 5 percent level of significance. The effect of operators primary occupation is not economically significant or statistically significant. The effect place of residence of operator is not statistically significant. The length of drought as measured by drought spells or the percentage of area of a county in exceptional levels of drought, where extensive crop damage is likely, do not have a statistically or economically significant effect on the number of irrigators in a county. I do not find any peer effects of race on farm irrigation as the race interaction terms are all statistically insignificant and most are small in magnitude as well. This may be due to the data being aggregated at the county-level. However, given the very small percentage of farmers in race groups other than white, suggests that if farmers place more weight on or confine themselves to information from peers who are of the same race, learning would be less than optimal even if learning within the same race were less costly compared to learning from operators of different race.

Common Cause Problem

Aside from the reflection problem, I discussed that a second concern is distinguishing peer effects from correlated effects. When peer groups are affected by common background characteristics or shocks which also predict adoption, peers' irrigation and a county's own irrigation will be positively correlated even in the absence of peer effects, such that the relationship between the number of irrigators on average among peer counties and the number of irrigators in a county is positive and statistically significant.

To test whether the relationship between the number of irrigators on average among peer counties and the number of irrigators in a county is due to peer effects or an artifact of common cause among peers, I estimate equation (1) using one period lagged (1') and lead (1") values of the measure of peers irrigation and peer farm characteristics. The two-stage least squares regression estimates of equations (1') and (1") are in Tables 2.9-2.10 and Tables 2.12-2.13 respectively.

I find that a 1 percentage point increase in the number of irrigators on average among peer counties in period (t-1) increases the number of irrigators in period t by 0.76 percentage points for the average county in the Southeastern US which is significant at the 5 percent level of significance. While 1 percentage point increase in the number of irrigators on average among peer counties in period (t+1) increases the number of irrigators in period t by 0.40 percentage points for the average county in the Southeastern US and is not significant at the conventional level. One reason that the effect of irrigation of peers in the future period (t+1) on current period irrigation of a county is still half of the magnitude of the effect of irrigation of peers in the previous period (t-1) may be due to the presence of a common factor affecting irrigation in all counties in the data. However, the larger magnitude and statistical significance of the effect of peers irrigation in the previous period (t-1) on current period irrigation of a county suggests that farmers irrigation practices in a county are influenced by their peers irrigation practices. I also estimate the marginal effects of lagged peers irrigation on countys own irrigation evaluated at the mean, 25th percentile, 50th percentile, and 75th percentile of the lagged values of peer farm size and own farm size in Table 2.11. Again, I find that farm size matters, marginal effect of the number of irrigators in peer counties in period (t-1) for the average peer and own county farms with area in the 25th percentile on the number of irrigators in a county in period t is 0.51 percentage points, 0.34 percentage points for average peer and own county farms with area in the 50th percentile, 0.06 percentage points for the average peer and own county farms with area in the 75th percentile, and 0.22 percentage points for the mean values of average peer and own county farm size. This suggests that smaller farms are more likely to be influenced by their peers. This may be because smaller farms are much more likely to have operators who are part-time farmers and have a higher opportunity cost for gather information on irrigation or learning about water management themselves and benefit more from observing their peers irrigation methods. The effect of operators primary occupation is not economically significant or statistically significant. A 1 percentage point increase in the number of farm operators who reside on farm on the number of irrigators for a county is 0.237

percentage points and is statistically significant at less than 1 percent significance level. The length of drought as measured by drought spells or the percentage of area of a county in exceptional levels of drought, where extensive crop damage is likely, do not have a statistically or economically significant effect on the number of irrigators in a county. I do find some suggestion of the effects of race on farm irrigation as the race interaction terms for Hispanics and the race category of Native Hawaiian and Pacific Islander are statistically significant with a coefficient of 0.22 for Hispanics and 49.5 for Native Hawaiian and Pacific Islander. The very large magnitude of the race interaction term for Native Hawaiian and Pacific Islander may be spurious considering this race group comprise on average about 0.04 percent of farmers in a county, but this might also be result of this particular group being geographically concentrated.

The number of farmers who irrigate in a county is increasing from 2002 to 2012 for 4 out of 5 states in the Southeast, Alabama, Georgia, North Carolina, and South Carolina (figures 2.5-2.9). However, the number of farmers who irrigate decreased from 2002 to 2012 in Florida due to a significant number of citrus groves being affected by citrus greening (Singerman, A. and P. Useche, 2016). All of citrus crop is irrigated (Morgan, Zotarelli, and Dukes, 2010) and citrus greening has caused a major loss of citrus groves in Florida (NIFA, 2016), reducing Florida's orange crop by two-thirds over 20 years . This common cause affecting irrigation in Florida may have caused the effect of peers' irrigation on a county's own irrigation to be over-estimated.

2.7 Conclusion

To the best of my knowledge, this paper is the first to investigate the effect of peers on farm irrigation in the Southeastern US. My results suggest that peers do affect farmers decision to irrigate given the positive and statistically significant relationship between the average percentage of irrigating farmers in peer counties and the percentage of irrigating farms in an individual county. The learning mechanism here is either farmers gaining information from peers by observing their peers irrigation practices such as whether peers have irrigation systems, if peers are applying water, what irrigation schedules peers are following etc., or directly gaining information through social interaction with peers.

Although climate change and variation has not been as acute in the Southeastern US as that in the Southwest, it may have a more pronounced impact on irrigation in the future, given the suggested findings in climate research in agriculture. The US Department of Agriculture has been gearing programs that were previously aimed at conservation towards supporting farmers prepare for climate variations and changes (**(Wallander2013**) given the US recent experience of extensive drought. The USDA has also funded research to develop extension services to help farmers prepare for climate variability (Fraisse et al., 2009). By looking at peer effects in irrigation in the Southeast, this paper hopes to provide some insight into one of the mechanisms through which farmers make their decision to irrigate given irrigation is one of the means to adapt and prepare for the effects of climate variability in agriculture.

2.8 Tables

Table 2.1: **Farm statistics by Full-time vs Part-time Farmer**

Farm Operator Occupation (US Total)	Farming Primary Activity	Other Primary Activity
Acres farmed	674	214
Agriculture sales	$340,421	$46,789
Government payments	$13,546	$5,213
Age	60	57
Years on operation	26	20
Years farming	29	22

Source: USDA 2004, 2012 Census of Agriculture (NASS 2004, 2004f; NASS 2014, 2014f)

Table 2.2: **Average Age of Farmer in SE 2002-2012**

Year	**Mean**	**Std. Dev.**	**Min.**	**Max.**
2002	52.38	8.52	29.41	87.01
2007	42.68	7.61	22.73	71.43
2012	46.48	8.64	23.33	88.89
Observations	439			

Source: USDA 2004, 2012 Census of Agriculture (NASS 2004, 2004f; NASS 2014, 2014f)

Table 2.3: **Descriptive Statistics**

Dependent Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Percentage of irrigating farms in a county	12.363	10.821	0	73.841
Control variables				
Percent of farm operations with female principal operators in county	14.692	6.165	0	55.263
average county farm size (acres)	236.363	182.325	5.667	1,766
county population	103,720	214,192	1,680	2,591,035
county median household income	37,810	9,099	18,455	87,380
Percent of the area of county in exceptional drought, averaged over each 5 year period	3.1836	3.3028	0	16.3104
Number of short drought spells, averaged over each 5 year period	0.7821	0.8596	0	7
Percent of farm operations with principal operator whose primary occupation was farming	47.177	9.174	22.727	88.889
Percent of farm operations with principal operators who resided on farm	76.372	9.6	11.111	100
land in orchards (acres) × Price Received Index (Fruits & Nuts, base year=2011)	201491	894236	0.00	11300000
land in field crops and hay (acres) × Price Received Index (Field crops & Hay, base year=2011)	1927835	2982454	0.00	22300000
land in vegetables (acres) × Price Received Index (Vegetable, base year= 2011)	112653	382696	0.00	6277431
Number of observations		1,317		

Number of observations for average county farm size (acres) = 1,310
Number of observations for land in orchards, land in field crops and hay, and land in vegetables (acres) = 1,173, 1,258, and 1,131 respectively

Table 2.4: **Descriptive Statistics**

Percentage of farms with principal farm operator in the following age groups				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
younger than 25 years	0.47	0.918	0	8.621
(25-34) years	3.869	2.852	0	55
(35-44) years	11.597	4.369	0	32.432
(45-54) years	23.529	5.233	0	47.826
(55-59) years	14.291	3.874	0	43.396
(60-64) years	14.004	4.162	0	44.186
(65-69) years	11.886	3.812	0	46.667
older than 70 years	20.354	5.494	0	47.826

Percentage of farms with principal farm operator in the following racial groups				
Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**
White	93.612	6.919	53.947	100
African American or Black	5.681	6.97	0	47.152
Hispanic	1.893	3.55	0	56.669
Asian American	0.523	1.206	0	15.789
Native American or Alaskops	0.903	2.327	0	42.083
Native Hawaiian or Pacific Islander	0.044	0.177	0	2.542
Multiracial	0.684	0.872	0	11.111

Table 2.5: **Descriptive Statistics**

Dependent Variable	**Mean**	**2002**	**2007**	**2012**
Percentage of irrigating farms in a county		12.545	12.466	12.079
Control variables				
Percent of farm operations with female principal operators in county		12.797	16.008	15.271
average county farm size (acres)		245.62	225.667	237.915
county population		95,926	104,676	110,559
county median household income		33,672	40,049	39,709
Percent of the area of county in exceptional drought, averaged over each 5 year period		3.6609	2.82	3.0701
Number of short drought spells, averaged over each 5 year period		0.8656	0.5877	0.8929
Percent of farm operations with principal operator whose primary occupation was farming		52.377	42.677	46.476
Percent of farm operations with principal operators who resided on farm		78.005	75.975	75.135

Table 2.6: **Descriptive Statistics**

Percentage of farms with principal farm operator in the following age groups				
Variable	**Mean**	**2002**	**2007**	**2012**
younger than 25 years		0.602	0.406	0.402
(25-34) years		3.997	3.898	3.712
(35-44) years		14.462	11.412	8.916
(45-54) years		26.228	23.991	20.37
(55-59) years		13.815	14.63	14.427
(60-64) years		12.337	14.502	15.174
(65-69) years		10.206	11.752	13.699
older than 70 years		18.353	19.41	23.3
Percentage of farms with principal farm operator in the following racial groups				
Variable	**Mean**	**2002**	**2007**	**2012**
White		93.981	93.594	93.261
African American or Black		5.585	5.543	5.914
Hispanic		1.721	1.772	2.188
Asian American		0.321	0.564	0.683
Native American or Alaskops		0.725	1.098	0.885
Native Hawaiian or Pacific Islander		0.044	0.048	0.038
Multiracial		0.416	1.033	0.602

Table 2.7: **2SLS Results: All variables are in current period, t**

Dependent Variable: Share of irrigating farms	
average percentage of farms that irrigate in neighboring counties	2.09119**
	(0.82265)
(average percentage of farms that irrigate in neighboring counties) **x** county *i* farm size	-0.00082
	(0.00050)
ave. farm size of peer counties **x** county *i* farm size	0.00004
	(0.00003)
(average percentage of farms that irrigate in neighboring counties) **x** farm size of peer counties	-0.00243**
	(0.00124)
Percent of farm operations with female principal operators in county	-0.00745
	(0.03451)
average county farm size (acres)	0.01372**
	(0.00699)
Number of short drought spells, averaged over each 5 year period	0.09132
	(0.11662)
Percent of the area of county in exceptional drought, averaged over each 5 year period	-0.00595
	(0.05173)
Percent of farm operations with principal operator whose primary occupation was farming	0.02917
	(0.02682)
Percent of farm operations with principal operators who resided on farm	0.05237
	(0.03387)
(average for peer counties) Percent of farm operations with female principal operators in county	0.04821
	(0.08727)
(average for peer counties) average county farm size (acres)	0.02799*
	(0.01540)
(average for peer counties) Percent of farm operations with principal operator whose primary occupation was farming	-0.07213
	(0.08735)
(average for peer counties) Percent of farm operations with principal operators who resided on farm	-0.03793
	(0.08124)
Time dummies	Yes
County fixed effects	Yes
Observations	1,309
R-squared	0.15223

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.8: **2SLS Results: All variables are in current period, t**

Share of irrigating farms	
Percentage of farms with principal farm operator in the following age groups	
younger than 25 years	-0.08090
	(0.17088)
(25-34) years	0.01818
	(0.06282)
(35-44) years	0.11377**
	(0.05065)
(55-59) years	0.05811
	(0.04162)
(60-64) years	0.05691
	(0.05117)
(65-69) years	0.05632
	(0.05590)
older than 70 years	-0.04084
	(0.04170)
Farm operator race interaction terms (%)	
African American or Black	-0.00311
	(0.00634)
Hispanic	-0.01094
	(0.01041)
Asian American	0.16225
	(0.15939)
Native American or Alaskops	-0.02270
	(0.02930)
Native Hawaiian or Pacific Islander	4.37602
	(3.84248)
Multiracial	0.24685
	(0.25902)
Observations	1,309
R-squared	0.15223

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.9: **2SLS Results: Lagged Peers' irrigation & farm characteristics, period (t-1)**

	Share of irrigating farms
Lagged Farms that irrigate in neighboring counties (%)	0.76332**
	(0.38717)
Lagged Farms that irrigate (%) **x** Lagged county i farm size in neighboring counties	-0.00251***
	(0.00061)
Lagged ave. farm size of peer counties **x** Lagged county i farm size	0.00010***
	(0.00003)
Lagged Farms that irrigate **x** Lagged farm size of peer counties in neighboring counties	0.00019
	(0.00049)
Percent of farm operations with female principal operators in county	-0.09733
	(0.08817)
average county farm size (acres)	-0.00613
	(0.01457)
Primary occupation farming (%)	-0.07665
	(0.05819)
(average for peer counties) Percent of farm operations with female principal operators in county	0.57275***
	(0.22014)
(average for peer counties) average county farm size (acres)	-0.00927
	(0.01658)
(average for peer counties) Percent of farm operations with principal operator whose primary occupation was farming	-0.07181
	(0.13096)
(average for peer counties) Percent of farm operations with principal operators who resided on farm	-0.03647
	(0.14418)
Time dummies	Yes
County fixed effects	Yes
Observations	218
R-squared	0.69543
Number of counties	109

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.10: **2SLS Results: Lagged Peers' irrigation & farm characteristics, period (t-1)**

Share of irrigating farms	
Percentage of peer farms with farm operator in the following age groups	
younger than 25 years	-0.01810
	(0.34212)
(25-34) years	0.13669
	(0.19803)
(35-44) years	-0.01092
	(0.10553)
(55-59) years	-0.39819***
	(0.09929)
(60-64) years	-0.24954***
	(0.08943)
(65-69) years	-0.36267***
	(0.10286)
older than 70 years	-0.19841**
	(0.09539)
Farm operator race interaction terms	
African American or Black	-0.00050
	(0.01895)
Hispanic	0.22859***
	(0.05818)
Asian American	-0.71221*
	(0.38814)
Native American or Alaskops	0.00905
	(0.03408)
Native Hawaiian or Pacific Islander	49.53044***
	(11.97515)
Multiracial	0.12845
	(0.77662)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.11: **Marginal Effect of lagged peers irrigation on countys own irrigation (%) for given lagged values of peer farm size and own farm size**

	Std. Err.	Peer farm size & Own farm size (values in acres)
0.2183505	0.3151239	Mean
		Percentiles
0.5096848	0.3445778	25%
0.3361739	0.3237363	50%
0.0616736	0.3060831	75%

Table 2.12: **2SLS Results: Lead Peers' irrigation & farm characteristics, period (t+1)**

Share of irrigating farms	
Lead Farms that irrigate in neighboring counties (%)	0.40446
	(0.32788)
Lead Farms that irrigate (%) **x** Lead county i farm size in neighboring counties	-0.00011 (0.00080)
Lead ave. farm size of peer counties **x** Lead county i farm size	0.00010**
	(0.00004)
Lead Farms that irrigate **x** Lead farm size of peer counties in neighboring counties	-0.00081 (0.00091)
Percent of farm operations with female principal operators in county	-0.34385** (0.14543)
average county farm size (acres)	0.05471***
	(0.01663)
Primary occupation farming (%)	-0.04504
	(0.06105)
(average for peer counties) Percent of farm operations with female principal operators in county	0.23381 (0.29023)
(average for peer counties) average county farm size (acres)	0.04960
	(0.03178)
(average for peer counties) Percent of farm operations with principal operator whose primary occupation was farming	-0.14338 (0.13096)
(average for peer counties) Percent of farm operations with principal operators who resided on farm	0.04270 (0.14520)
Time dummies	Yes
County fixed effects	Yes
Observations	200
R-squared	0.60332
Number of counties	109

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.13: **2SLS Results: Lead Peers' irrigation & farm characteristics, period (t+1)**

Share of irrigating farms	
Percentage of peer farms with farm operator in the following age groups	
younger than 25 years	0.14530
	(0.34540)
(25-34) years	0.15831
	(0.18049)
(35-44) years	-0.07324
	(0.10704)
(55-59) years	0.19849
	(0.16768)
(60-64) years	-0.07241
	(0.14369)
(65-69) years	-0.03448
	(0.11164)
older than 70 years	-0.02190
	(0.09593)
Farm operator race interaction terms	
African American or Black	-0.03098
	(0.02477)
Hispanic	-0.01720
	(0.01859)
Asian American	1.53768
	(0.97744)
Native American or Alaskops	-0.15045
	(0.15039)
Native Hawaiian or Pacific Islander	-218.98223***
	(58.04855)
Multiracial	-2.22964**
	(1.01994)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.14: **First-Stage Results period (t)**

average percentage of farms that irrigate in neighboring counties	
(neighbors' peers) average county farm size (acres)	0.01519***
	(0.00442)
(neighbors' peers) average share of farm operations with principal operator whose primary occupation was farming	0.33637***
	(0.02960)
(neighbors' peers) average share of farm operations with principal operators who resided on farm	0.30325***
	(0.03996)
(neighbors' peers) average county population	-0.00011***
	(0.00001)
(neighbors' peers) average county median household income	-0.00010
	(0.00007)
Time dummies	Yes
Observations	1,317
R-squared	0.42968
Number of counties	439

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.15: **First-Stage Results period (t-1)**

average percentage of farms that irrigate in neighboring counties	
(neighbors' peers) average county farm size (acres)	0.02093***
	(0.00400)
(neighbors' peers) average share of farm operations with principal operator whose primary occupation was farming	0.27953***
	(0.03807)
(neighbors' peers) average share of farm operations with principal operators who resided on farm	0.33581***
	(0.06030)
(neighbors' peers) average county population	-0.00010***
	(0.00001)
(neighbors' peers) average county median household income	0.00006
	(0.00012)
Time dummies	Yes
Observations	878
R-squared	0.37298
Number of counties	439

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

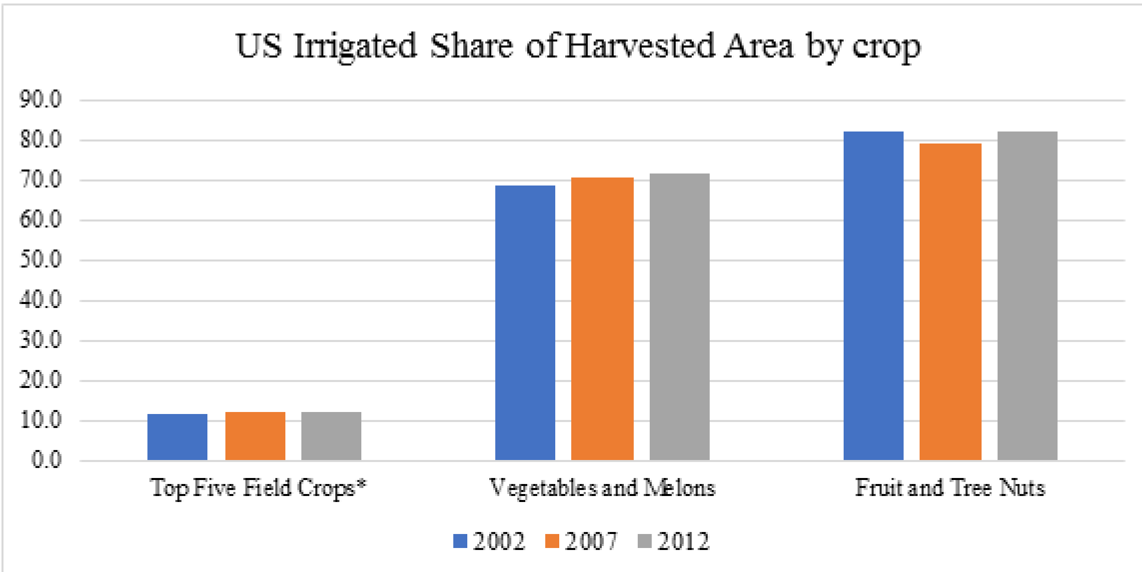
Table 2.16: **First-Stage Results period (t+1)**

average percentage of farms that irrigate in neighboring counties	
(neighbors' peers) average county farm size (acres)	0.00700
	(0.01020)
(neighbors' peers) average share of farm operations with principal operator whose primary occupation was farming	0.12734**
	(0.04948)
(neighbors' peers) average share of farm operations with principal operators who resided on farm	0.25119***
	(0.05031)
(neighbors' peers) average county population	-0.00017***
	(0.00002)
(neighbors' peers) average county median household income	-0.00033**
	(0.00013)
Time dummies	Yes
Observations	878
R-squared	0.29716
Number of counties	439

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

2.9 Figures

Figure 2.1: Shares of crop irrigated



Top field crops do not include all oilseed and grain crops. See US Census Bureau, 2012 North American Industry Classification Systems, (NAICS) Definition for crop details.

Figure 2.2: Share of field crop grown by race

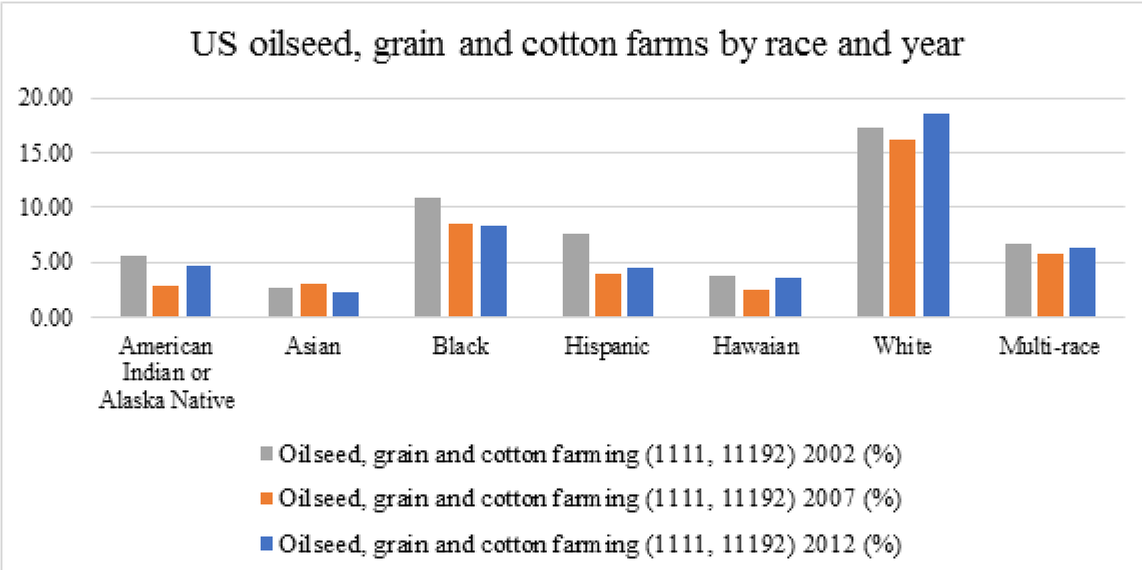


Figure 2.3: Share of vegetables grown by race

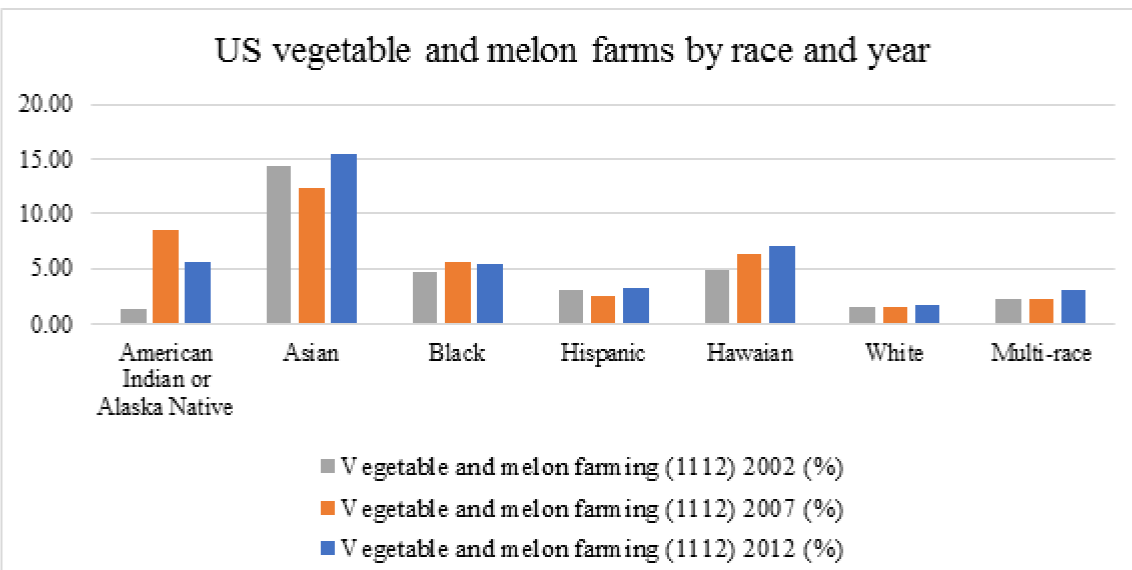


Figure 2.4: Share of fruits and nuts grown by race

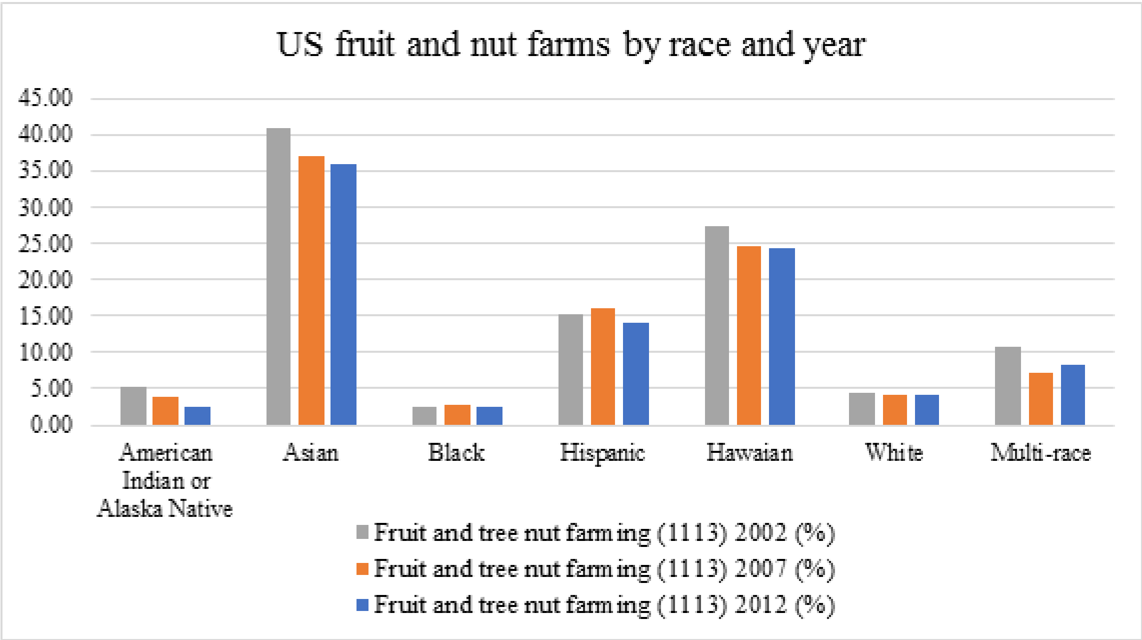
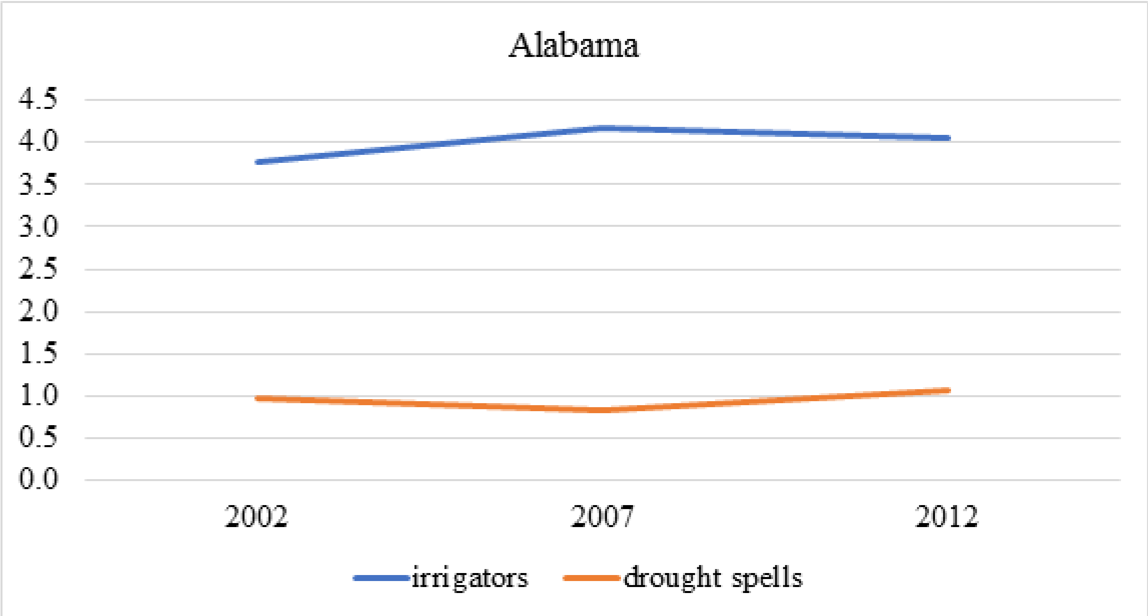
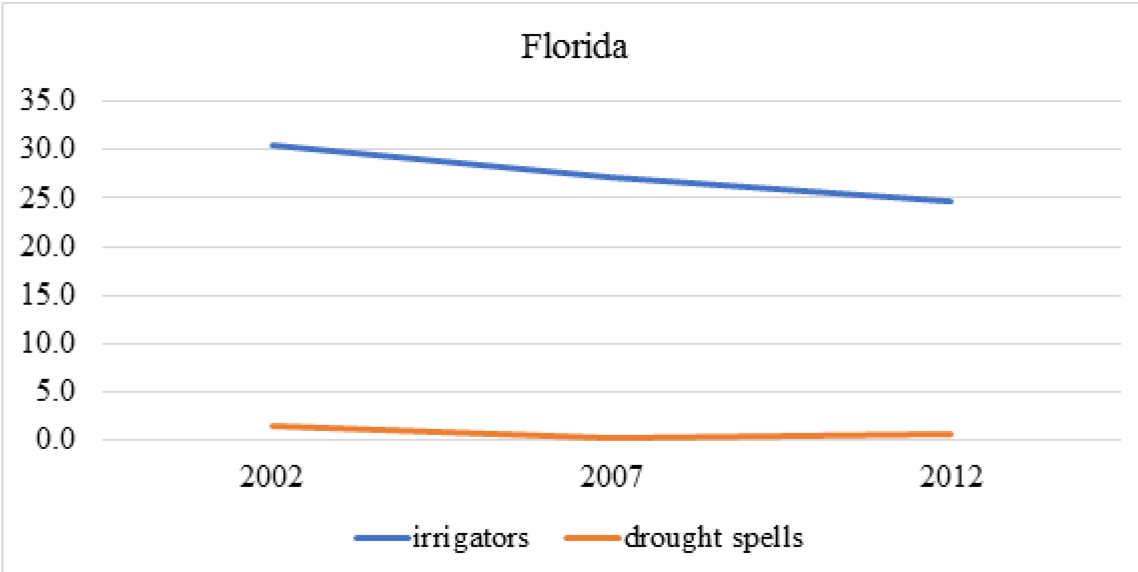


Figure 2.5: Alabama irrigation trend



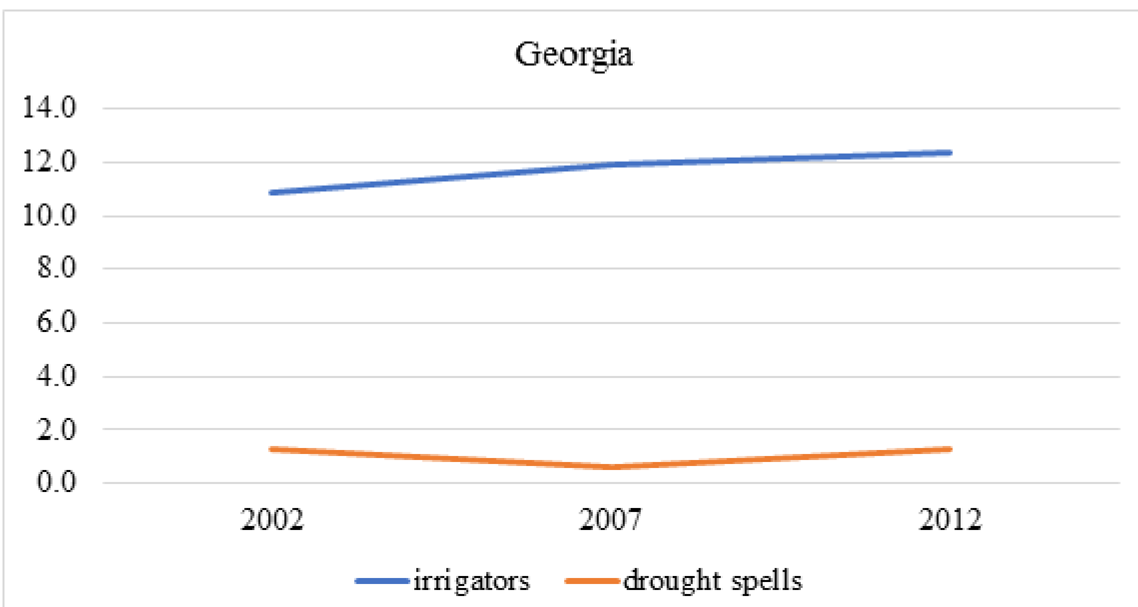
(NASS 2004, 2004a; NASS 2014, 2014a; USDM)

Figure 2.6: Florida irrigation trend



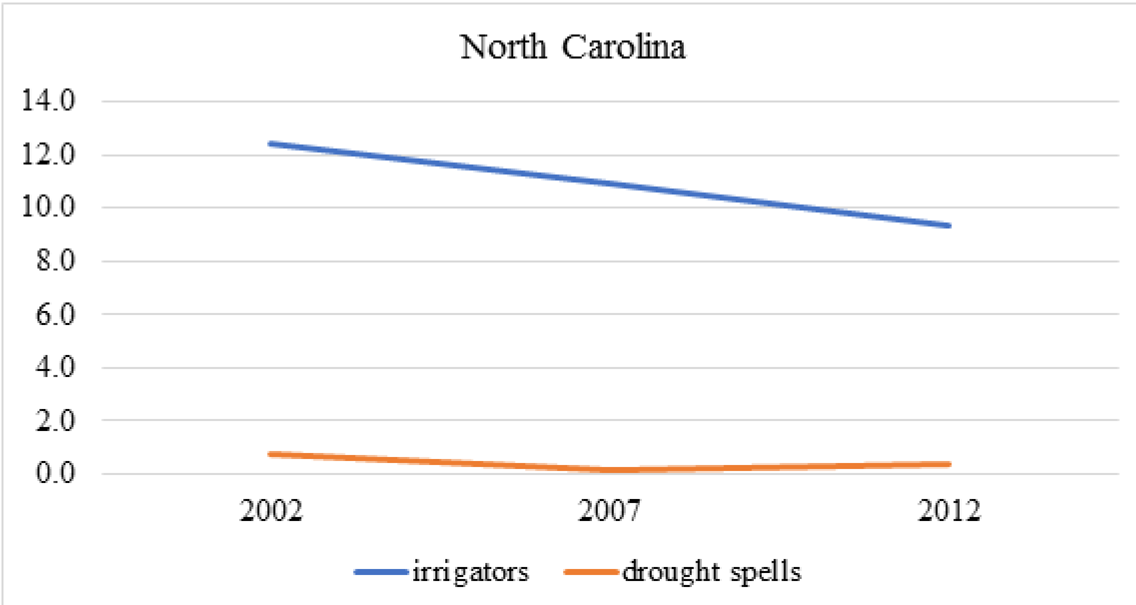
(NASS 2004, 2004b; NASS 2014, 2014b; USDM)

Figure 2.7: Georgia irrigation trend



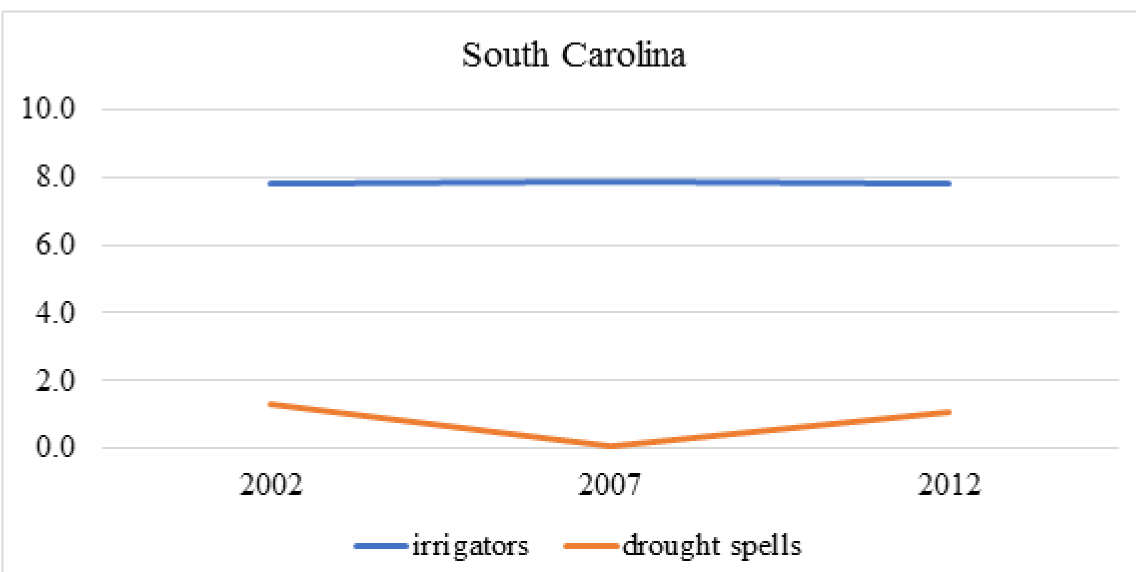
(NASS 2004, 2004c; NASS 2014, 2014c; USDM)

Figure 2.8: North Carolina irrigation trend



(NASS 2004, 2004d; NASS 2014, 2014d; USDM)

Figure 2.9: South Carolina irrigation trend



(NASS 2004, 2004e; NASS 2014, 2014e; USDM)

Appendices

Appendix A Chapter 1

Table A1: **Definitions of Martial Tranfers**

Definitions	Components of Expenses for a Daughters Wedding for a Household
Dowry	Dowry is the transfer of money and assets made by brides parents at the time of marriage. This transfer includes both a pre-mortem bequest to their daughter as her inheritance and a payment to the groom and his family to secure an agreement of marriage.
Groom Price	Groomprice is the marriage payment made by brides parents to the groom and his family to secure an agreement of marriage.
Bequests	Bequest is a "pre-mortem" inheritance to a daughter enabling her to obtain a share of her paternal estate that she would not customarily be entitled to on the death of her father in India due to Indian inheritance laws which until 2005 did not give a daughter any right to her fathers ancestral property.

Table A2: **Examples of Martial Tranfers**

	Examples of Components of Expenses for a Daughter's Wedding for a Household
Groom Price	1. Durable consumer goods such as a car, washing machine, or television, transferred from bride's family to groom's family at the time of the wedding on demand of the groom or his family as part of agreement to the marriage. 2. Money transferred from bride's family to groom's family at the time of the wedding on demand of the groom or his family as part of agreement to the marriage. 3. Specific amount of jewelry given to groom or groom's family members from bride's family at the time of the wedding on demand of the groom or his family as part of agreement to the marriage. 4. Specific household goods such furniture or dinnerware, transferred from bride's family to groom's family at the time of the wedding on demand of the groom or his family as part of an agreement to the marriage. 5. Specific wedding event arrangements that are paid for by bride's family on demand of the groom or his family as part of an agreement of the marriage. For example, wedding venue, number of guests invited on behalf of the groom or his family. 6. Ownership of a house or condominium is transferred from bride's family to grooms family at the time of the wedding on demand of the groom or his family as part of agreement to marriage.
Bequest	1. Bride's family chosen transfer of household goods to bride as her property without any demand from the groom or his family as part of agreement to marriage. 2. Bride or Bride's family transfer of land or home ownership to bride as her property at the time of the wedding. 3. Specific amount of jewelry given to bride from bride's family at the time of the wedding without any demand from the groom or his family as part of agreement to the marriage. 4. Bridal trousseau given to bride by bride's family at the time of the wedding without any demand from the groom or his family as part of agreement to marriage.
Wedding Celebrations	1. Bride or Bride's family chosen wedding event arrangements that are paid for by bride's family, such as brides attire, venue of wedding, number of wedding guests, decoration of bride's family abode. 2. Bride's family purchase of attire for the wedding that are for by bride's family members.

Table A3: **Desired Outcome Variable**

Components of Desired Outcome Variable		
Groom Price	Part of Bequest that can be appropriated by groom	Wedding Celebration Expenses demanded by grooms family

Table A4: **Outcome Variable Data**

Components of Outcome Variable Data				
Groom Price	Part of Bequest that remains bride's property	Part of Bequest that can be appropriated by groom	Wedding Celebration Expenses demanded by grooms family	Brides family desired Wedding Celebrations Expenses

Table A5: **OLS Results**

VARIABLES	(1) Groom price
Woman's years of education completed	14,314***
	(2,033)
Education of highest educated male in household	5,673***
	(830.6)
Education of highest educated female in household	2,449***
	(626.2)
Age of woman	2,731***
	(637.5)
Whether woman is highest educated female in household	-5,958
	(6,251)
(mean) School Development funds received	-2.718**
	(1.299)
(percentage) schools in district	-119,465**
	(58,496)
(mean) district household income	0.213
	(0.211)
Observations	10,865
R-squared	0.237

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A6: **First Stage Results**

VARIABLES	(1) Woman's years of education completed
Whether woman was affected by school sanitation policy	0.791***
	(0.0896)
Education of highest educated male in household	0.136***
	(0.00775)
Education of highest educated female in household	0.321***
	(0.00738)
Age of woman	-0.116***
	(0.00665)
Whether woman is highest educated female in household	2.353***
	(0.0610)
(mean) School Development funds received	-0.00000168
	(0.0000107)
(percentage) schools in district	-0.361
	(0.266)
(mean) district household income	0.00000106
	0.00000082)
Observations	10,865
R-squared	0.464

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A7: **OLS and 2SLS Results**

VARIABLES	(1) OLS Groom price	(2) 2SLS Groom price
Woman's years of education completed	14,314***	22,283*
	(2,032.62)	(12,579)
Education of highest educated male in household	5,672.95***	4,609**
	(830.63)	(1,874)
Education of highest educated female in household	2,449.32***	-17.66
	(626.15)	(3,784)
Age of woman	2,731.15***	4,001*
	(637.55)	(2,044)
Whether woman is highest educated female in household	-5,957.89	-23,832
	(6,251.12)	(28,820)
(mean) School Development funds received	-2.72**	-2.705**
	(1.30)	(1.270)
(percentage) schools in district	-119,465.27**	-116,650**
	(58,495.93)	(58,146)
(mean) district household income	0.21	0.204
	(0.21)	(0.210)
Observations	10,865	10,865
R-squared	0.24	0.234

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A8: **First-Stage Results Poor & Non-Poor**

VARIABLES	Poor Woman's years of education completed	Non-poor Woman's years of education completed
Whether woman was affected by school sanitation policy	0.989*** (0.215)	0.730*** (0.0993)
Education of highest educated male in household	0.114*** (0.014)	0.135*** (0.00867)
Education of highest educated female in household	0.269*** (0.016)	0.322*** (0.00806)
Age of woman	-0.087*** (0.016)	-0.122*** (0.00711)
Whether woman is highest educated female in household	1.789*** (0.135)	2.410*** (0.0634)
(mean) School Development funds received	0.000*** (0.000)	-0.00000816 (0.0000119)
(percentage) schools in district	-0.846 (1.043)	-0.227 (0.247)
(mean) district household income	0.000 (0.000)	0.000000589 (0.000000844)
Observations	1,969	8,894
R-squared	0.335	0.472

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A9: **OLS Results Poor & Non-Poor**

VARIABLES	(1) OLS Poor Groom Price	(2) OLS Non-poor Groom Price
Woman's years of education completed	7,426***	14,732***
	(1,956.6)	(2,453)
Education of highest educated male in household	3,234**	6,019***
	(1,518.3)	(851.7)
Education of highest educated female in household	2,111	2,318***
	(1,398.9)	(690.7)
Age of woman	53.493	3,145***
	(873.54)	(733.9)
Whether woman is highest educated female in household	15,474	-11,961
	(13,391.8)	(7,658)
(mean) School Development funds received	-1.350	-2.782**
	(2.706)	(1.384)
(percentage) schools in district	-19,524	-124,560**
	(114,570.4)	(60,627)
(mean) district household income	0.131	0.211
	(0.216)	(0.223)
Observations	1,969	8,894
R-squared	0.258	0.223

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A10: **2SLS Results Poor & Non-Poor**

VARIABLES	(1) Poor Groom Price	(2) Non-poor Groom Price
Woman's years of education completed	11,804	21,596
	(16,839)	(15,685)
Education of highest educated male in household	2,755	5,111**
	(2,554)	(2,199)
Education of highest educated female in household	985.3	178.3
	(4,651)	(4,748)
Age of woman	693	4,249*
	(2,544)	(2,550)
Whether woman is highest educated female in household	8,151	-27,781
	(32,843)	(37,023)
(mean) School Development funds received	-1.514	-2.727**
	(2.836)	(1.375)
(percentage) schools in district	-15,559	-123,092**
	(110,208)	(60,110)
(mean) district household income	0.128	0.207
	(0.218)	(0.222)
Observations	1,969	8,894
R-squared	0.256	0.221

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A11: **OLS and 2SLS Results: Effect of woman's education on groom's education**

VARIABLES	(1) OLS Groom Education	(2) 2SLS Groom Education
Woman's years of education completed	0.534***	0.530
	(0.018)	(0.469)
Education of highest educated male in household	0.114***	0.114
	(0.012)	(0.0700)
Education of highest educated female in household	0.036***	0.0371
	(0.013)	(0.195)
Age of woman	0.036***	0.0355
	(0.009)	(0.0337)
Whether woman is highest educated female in household	0.101	0.114
	(0.120)	(1.782)
(mean) School Development funds received	-0.000	-0.0000112
	(0.000)	(0.0000184)
(percentage) schools in district	-119,465**	-116,650**
	(58,496)	(58,146)
(mean) district household income	0.000***	0.00000344
	(0.000)	(0.00000114)
Observations	7,467	7,467
R-squared	0.332	0.332

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A12: **OLS and 2SLS Results controlling for groom education**

VARIABLES	(1) Groom price OLS Predicted Groom Educ	(2) Groom price IV Predicted Groom Educ
Woman's years of education completed	-71,106**	-70,032**
	(34,712.342)	(28,151)
Groom's years of education completed	161,170***	160,202***
	(63,096.26)	(52,034.7)
Education of highest educated male in household	-12,133*	-12,105*
	(7,077.731)	(6,372)
Education of highest educated female in household	-4,075*	-4,273*
	(2,445)	(2,342)
Age of woman	-2,106	-2,032
	(2,685)	(2,188)
Whether woman is highest educated female in household	-21,994**	-24,009**
	(10,237)	(14,746)
(mean) School Development funds received	-0.503	-0.510
	(2.153)	(2.309)
(percentage) schools in district	-97,511	-97,898*
	(60,218)	(57,610)
(mean) district household income	-0.335	-0.332
	(0.427)	(0.361)
Observations	7,479	7,479
R-squared	0.226	0.226

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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