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Traditional Agricultural Practices and Sex Ratios at Birth in Modern Times

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Abstract

This study examines the impact of cultural gender norms created by differences in traditional agricultural practices on observed sex ratios at birth over last four decades. Building on the plough hypothesis developed by Ester Boserup and the work of Alesina et al. (2013), this study provides a further empirical test of the legacy of the plough. I perform empirical analysis on micro level data from the Demographic and Health Survey in over 75 countries to develop a number of stylized facts on this relationship. Descendants of plough societies exhibit a more male skewed sex ratio at birth today. These descendants exhibit a highly male-skewed sex ratio of last birth, which is achieved through son-based fertility stopping preferences. From the 1980s onward the expected sex ratio at birth of plough descendants becomes highly male skewed at lower levels of total fertility, providing evidence that these descendants realize their son preference through sex selective abortions.

1. Introduction

The sex composition of a society is a core development concern. It is an intrinsic concern because a highly male-skewed sex ratio can only be achieved through gender based infanticide, neglect of female children, or through sex selective abortions. These methods insinuate a strong son preference or bias against daughters. This was brought to the world's attention by Amartya Sen when he coined the term 'missing women' in describing the problem of male skewed sex ratios in South Asian countries. The sex composition of a society is also an extrinsic concern. Highly males skewed sex composition has been shown to be correlated with human capital outcomes, poses demographic problems, impacts marriage markets, and can impact behavioral decision making (Sen, 1990; Jayachandran, 2014a; Jensen, 2003; Yamaguchi, 1989; Griskevicius et al., 2012).

Around the world today there is large variation in the sex composition or sex ratios of births. The most common measure of sex ratios at birth is reported in number of male births per 100 female births, with the assumed "natural" range of 103-107. For 2008 The *CIA World Factbook* estimates the worldwide sex ratio at birth at 107, with the Grenada and Liechtenstein having sex ratios at birth of 100 at the low end, and Armenia with a sex ratio at birth of 115 at the high end.

This large variation in sex ratios at birth has been widely attributed to cross-country variation in culture, but the empirical impact of these cultural norms on sex ratios at birth are difficult to estimate. This is due to the highly endogenous system through which cultural norms are generated, and their interaction with contemporaneous conditions that influence fertility decisions. Previously there was wide belief that economic development and increases in female education could counteract these endogenous cultural factors and mitigate the problem of male-sex ratios at birth. But recent evidence has shown in a number of developing countries that despite large gains in these areas, sex ratios have become even more male-skewed in recent years (Kishor and Gupta, 2009). Therefore, use of this 'residual' term of culture as an explanation for differences in sex ratio at birth has been further reinforced. In order to measure the impact that these cultural norms play in fertility decisions one must achieve plausibly exogenous variation the formation of these cultural norms. This study will exploit differences in traditional agricultural practices practiced by a given country's ancestors as plausibly exogenous variation, adding to the empirical literature on Ester Boserup's 'plough hypothesis'.

In her 1970 book, Ester Boserup developed the 'plough hypothesis' where she attributed differences in gender roles, and the cultural norms surrounding them, to differences in traditional agricultural practices (Boserup, 1970). She identifies key differences between shifting (using a hoe or digging stick) and plough-based cultivation techniques. The use of a plough requires significant upper body strength and burst power to either pull the plough or control the animal pulling it. This requirement gives men a comparative advantage over women for this type of agricultural labor. Contrast that with shifting cultivation, the necessary physical requirements do not provide a comparative advantage along gender lines. Therefore, traditionally in plough societies men specialized in agricultural labor and women specialized in activities within the home and child rearing. While in traditional shifting societies, the tasks of the household were split more evenly between men and women.

In plough societies this gender-based division of labor gave rise to cultural gender norms regarding the appropriate role of women and the value placed on sons relative to daughters. In plough societies daughters would not contribute to the family economically (in farm labor) as much as sons, so they were valued less. These cultural gender norms were further reinforced by endogenous ex-post societal responses. For example, Boserup argues that differences in agricultural practices resulted in differentiation in marriage payment customs. In shifting societies bride price was common, but in plough societies dowry was the norm. Therefore, in plough societies the prospect of the dowry payment further devalued daughters in the eyes of their parents, leading to greater son preference.

It has been shown that these historic cultural gender norms have been passed down over the generations, and persist long after the contemporaneous economic conditions that created them have faded away. Alesina et al. (2013) empirically test this hypothesis, and find that descendants of plough societies have lower female labor force participation (FLFP) and less equal gender norms today. In a companion paper the authors find that that historic plough use had an impact on fertility decision as well, finding descendants of plough societies have lower levels of total fertility today (Alesina et al. (2011). Therefore, building on these papers, male-skewed sex ratios at birth today can be understood to be a manifestation a latent measure of the son preference in a society, which I view as a subset of the overall set of historic cultural gender norms created by traditional agricultural practices.

This study will attempt to decompose this highly endogenous environment, and empirically test what impact cultural norms created by traditional agricultural practices have on sex ratios at birth today. Further, this study is the first to study this impact in a dynamic way, and estimate how this impact has evolved over the last half-century in developing countries around the world by using micro level data. The data sets I will use for this analysis are all available rounds of the Demographic and Health Survey conducted by USAID from 1986-2011 for over 65 countries (listed in Appendix Table A.1). My proxy variable for cultural gender norms created by traditional plough comes from Alesina, et al. (2013). This variable creates a measure of historic plough use intensity, by an ethnic population density of descendants of traditional plough societies at the country level in the year 2000 (described in Section III below).

This paper is unique by not only using mirco-level data to study impact of cultural norms on sex ratios at birth on a global sample, but by also examining this relationship dynamically. Further this paper provides a key contribution to the literature examining the impacts of historic gender norms on fertility decisions, and a possible explanation why economic development and female empowerment have not mitigated the problem of missing women. I have performed my empirical analysis at the country, mother, and child level to develop a number of stylized facts regarding the effect of historic cultural gender norms created by traditional agricultural practices on sex ratio at birth, and how this effect has changed over time.

Stylized fact 1: *Descendants of societies that practiced traditional plough agriculture exhibit more male-skewed sex ratios at birth in modern times. Further, the impact has not diminished over time.*
Stylized fact 2: *Descendants of plough societies exhibit highly male-skewed sex ratio of last birth (SRLB), and this has been a major driver of male-skewed sex ratios at birth overall. This is evidence that these descendants partially realize their latent son preference through son-based fertility stopping methods.*
Stylized fact 3: *Declining levels of average total fertility has become the dominant channel driving male-skewed sex ratios at birth since the 1980s, this coincides with the proliferation of ultrasound technology throughout much of the world.*
Stylized fact 4: *From the 1980s onward, the expected sex ratios at birth for descendants of plough societies is more male-skewed at lower levels of total fertility, but reverts back to the natural sex ratio (or even becomes skewed towards females) at levels of total fertility greater than or equal to four. This relationship is not seen in descendants of shifting societies, where the expected sex ratio at birth is relatively constant across levels of total fertility at the natural sex ratio.*

Stylized fact 5: *There is evidence that descendants of plough societies are using sex selective abortions in order to achieve desired son preference for birth order 4 and under. The results show descendants of plough societies have a strong preference for at least one son and a moderate preference for two, while descendants of shifting societies have a preference for gender parity.*

The rest of the paper is organized as follows: I begin in section 2 with a review of the relevant existing literature, provide a conceptual framework, and state this paper's contribution to this literature. Section 3 describes the data used for my empirical analysis. Section 4 will present the results from my empirical analysis, and Section 5 concludes.

II. Existing Literature & Conceptual Framework

In this section I provide an overview of the various strands of the existing literature that apply to this study, and tie them together to provide a conceptual framework for my data analysis. I will end with this paper's contribution to the existing literature.

2.1 The Plough and Gender Norms

In the plough hypothesis Boserup argues that differences agricultural FLFP, and the resulting cultural norms can be traced back to differences in traditional agricultural practices. She divides traditional agricultural practices into two distinct groups: shifting based cultivation and plough based cultivation. She defines shifting cultivation as the utilization of handheld tools, such as a hoe or digging stick, as the primary source of soil preparation. This process is much more labor intensive, as compared to plough cultivation, which is much more capital intensive. Also, compared to the use of the hoe, the plough requires much more upper body strength and burst power to either pull the plough or control the animal that is pulling it. This requirement of strength gives men a comparative advantage over women in agricultural labor when plough cultivation is practiced. Therefore, in plough societies men specialized in agricultural labor outside the home and women specialized in domestic work within the home and child rearing. This gendered agricultural labor specialization in plough societies is further reinforced because soil preparation is one of the most important and time-consuming activities in agriculture, and the use of the plough lowers the need for weeding (a job typically performed by women or children). This is contrasted with shifting cultivation, where the physical requirements are much more gender neutral, thus giving neither sex a clear comparative advantage. Boserup notes gender distribution of agricultural labor is much more equal in shifting societies, or in some cases tilted more towards women.

Boserup uses data to show that the gender distribution of agricultural labor in the developing world, at the time of writing her book, largely follows these two cultivation distinctions. Alesina et al. (2013) confirm this finding, and find that in pre-industrial societies plough use was associated with lower female labor force participation in all forms of agricultural work, after controlling for other societal characteristics. Alesina et al. (2013) go on to test for reverse causality of their findings, where societies with less equal gender norms about female participation in agricultural labor would be more likely to adopt plough cultivation, through an instrumental variable (IV) approach. The authors use a society's geo-climatic suitability for plough cultivation as an instrument for plough adoption. The results of the IV estimation are almost identical to the standard OLS results, thus disproving the possibility of reverse causality.

Alesina et al. (2013) go on to assert that these gender-based divisions in agricultural labor in plough societies create cultural norms or heuristics ("rules of thumb") regarding the role or value of women in society. This is based on the model from Boyd & Richardson (1985), where when information is costly to obtain it can be optimal for individuals to develop heuristics for decision-making. In practice these heuristics take the form of deeply held traditional values, and are developed in a society through a process determined by potential relative payoffs. Using this conceptual framework, plough societies may have over time developed gender norms that are less equal because they were reinforced by beneficial relative payoffs. Conversely, these gender norms may not have developed in shifting societies due to the differences in the relative payoff structure. Thus once these cultural gender norms have been established they may persist after a society industrializes due to the persistence, or 'stickiness', of cultural beliefs. The authors empirically test this and find that traditional use of plough agriculture negatively impacts views of gender equality in the workforce and female labor force participation (FLFP), ownership or firms, and participation in politics in the year 2000. They also confirm the 'stickiness' of these cultural gender norms, by showing second-generation immigrants to the US and Europe that are descendants of plough societies have less equal views on FLFP. These results show that once cultural norms have been developed in a society, they can persist long after the economic incentives that created them change. Although these cultural norms undoubtedly change over time, this result suggest these norms have a long 'half-life' and change much more slowly than contemporaneous economic conditions.

Traditional agricultural practices influence other cultural gender norms as well. Boserup notes that polygamy was traditionally more common in shifting agricultural societies, and more common in the descendants of those societies (Giuliano, 2014). Also, in societies with traditionally less female participation in agriculture marriage payments come from the bride's family (dowry), while conversely in societies where women perform most of the agricultural labor this payment comes from the groom's family (bride price). Further, Ebenstien (2014) traces the prevalence of patrilocality today back to historic differences in traditional agricultural practices. Patrilocality is a system where married couples live with or nearby to the husband's parents providing them support in their old age. Ebenstein traces the roots of patrilocality back to the intensity of agricultural practices in traditional societies. He builds on the hypothesis that intensification of agriculture caused a shift from matrilineal kinship patterns (in hunter gather societies) to patrilineal norms of inheritance (Engels 1902). In this framework plough cultivation techniques can be thought of as a necessary condition for the intensification of agriculture in pre-industrial societies. He finds that this switch to patrilineal inheritance norms caused by intensification of agriculture has endured and are associated with increased levels of patrilocality, or co-residence of sons with parents, in descendants of these societies today. He also finds that more male-skewed sex ratios at birth today are positively correlated with levels of co-residence of sons with parents today.

2.2 Direct & Indirect Effects of the Plough on Fertility & Sex Ratio

We can view traditional plough use having both a direct and indirect effect on fertility decisions. Alesina et al (2011) examine the direct effect of historic plough use on overall fertility. Their empirical results show that plough societies historically had a preference for fewer children than shifting societies. The authors attribute the historic result to two counteracting forces: the adoption of the plough lowered the cost of having children overall, but it also lowered the benefit. Gender based divisions in labor caused women's allocation of time to be focused within the home, and not spent working in agricultural production. Therefore, the plough lowered the cost of children overall, through lowering the opportunity cost of child rearing. But at the same time, the use of the plough required less agricultural labor overall, especially in regards to weeding, at task that was performed primarily by women and children. So this reduction in labor requirements historically lowered the marginal benefit of each additional child. From the empirical results we can conclude that the decreased benefit was the dominant effect.

Further, Alesina et al. (2011) find descendants of plough societies exhibit lower total fertility rates today, even for second-generation immigrants from plough societies to the United States. Almond and Edlund (2008) and Abrevaya (2009) also confirm the stickiness of the effect of gender norms on fertility decisions by finding evidence of male-skewed sex ratios among US residents of East & South Asian decent. Further, in an analysis of immigrants to the US it is shown that a women's level of total fertility is heavily predicted by her mother's level of total fertility and the average total fertility of her home country (Fernandez and Fogli, 2006). These results show that these fertility heuristics may remain even when the economic conditions faced by parents change drastically.

Boserup (1970) argues that these gender norms created by the plough influenced the sex composition of traditional societies as well. While in these traditional societies parents could not directly influence the sex ratio at birth, male skewed sex ratios in the overall population were achieved through active infanticide or passive neglect for daughters. Traditionally in some farming communities in Northern India, where the women were isolated in the home and dowry payments were the norm, it was customary to limit the number of daughters in a given family by infanticide. Further, that after the practice of active infanticide became taboo, this deficit of women in the overall population in these areas persisted due to excess female child mortality, caused by gendered based neglect of daughters. Das Gupta (2003) finds that presently in India the prospect of paying a dowry is cited as a key factor in parents' preference for sons relative to daughters.

Jayachandran (2014b) finds that Indian parents have a strong desire for *at least* one son, and after parents have the first son, their preferences change to a more even mix of sons and daughters. She attributes this finding to the Hindu tradition of the role of the eldest son in lighting the funeral pyre. Of note in this survey is that there was not much differentiation between the responses of men and women, suggesting that both parents' views can be thought of as unitary.

Now moving to the indirect effect of cultural norms on fertility outcomes. While the implicit assumption for the direct effect described above is a unitary household model for fertility decisions, the underlying assumption of the indirect effect is a non-unitary household model. A non-unitary household model of fertility decisions is based on negotiations between mothers and fathers, and the outcome is a result of the relative bargaining power of each parent. Relative contributions to household income of the husband and wife have been a long established proxy for bargaining power. Thus, the results from Alesina et al. (2013) can be interpreted as on average reducing women's bargaining power in households that are descendants of plough societies, due to a reduction in FLFP.

In a similar analysis to Alesina et al. (2013), Carranza (2014) uses an instrumental variable to examine the differences in agricultural FLFP and the impact sex ratios today between districts in India. The author exploits exogenous variation in the soil texture between districts, and differentiates between areas that are suitable and are not suitable for 'deep tillage.' This measure of the suitability of soil for deep tillage can be thought of as the suitability for plough cultivation. She finds that areas that are suitable for deep tillage have lower levels of agricultural FLFP. Then using soil texture as an instrument for agricultural FLFP, she finds that the districts with lower FLFP exhibit a more male-skewed sex ratio today. Carranza attributes this result to a reduction in female bargaining power in fertility decisions. Due to the author's IV approach, the assumption is that sex ratio is only affected through the channel of FLFP, but she cannot rule out other factors such as the influence of culture.

Another great example of this interaction of female bargaining power and fertility outcomes is the empirical work by Qian (2008). In this paper Qian studies the impact of economic reforms in China in the 1970s that made growing cash crops more lucrative, and exploits differentials in regions that specialize in tea versus apple cultivation. The conceptual model is that differentials in gendered comparative advantages in agricultural labor across regions will result in heterogeneous changes to intra-household bargaining power. Women have a comparative advantage in tea picking, where bushes are delicate and low to the ground. Men have the comparative advantage in fruit picking, where height and strength is an advantage. In the tea regions, relative to orchard regions, the survival rate of infant females increased, resulting in fewer "missing women." Her proposed mechanism for this increased survival rate is as follows. Since tea picking is primarily a female occupation, the economic reforms increased the women's share of household income, thus increased her bargaining power in fertility decisions. The females in this sample had a weaker son preference, so due to increases in the female bargaining power, the aggregate son preference of the households in tea regions decreased relative to apple regions.

2.3 Sex Ratios at Birth, Son Preference, and Economic Development

When looking a sex imbalance at birth, Jayachandran (2014a) argues that we must differentiate between desire for sons and gender based investment differentials separately. Using a Becker Quantity-Quality framework, parents' desires for number of sons versus daughters could be much different, while at the same time their preference for average quality across children would be the same. As evidence for this, she points to India and China, these countries are not outliers for differentials in educational investment in sons relative to daughters, but are outliers in terms of male-skewed sex ratios. One manifestation of this preference for number of sons can be observed in the sex ratio of last birth (SRLB). If the SRLB were heavily skewed towards males it would represent a son-based fertility stopping behavior implying a strong bias in the preference for the number of sons relative to daughters. This is one way in which the sex ratio of overall births can be slightly male-skewed without the presences of gender based infanticide, neglect or sex selective abortions. Using DHS data, she shows that in India there is a strongly male skewed SRLB. A heavily males skewed SRLB can have unintended negative impacts on the investments in girls even when parents desire the same quality for boys and girls. Son-based fertility stopping behavior results in girls on average growing up in larger families than boys (Yamaguchi, 1989; Clark, 2000; Jensen 2003). Therefore, while parents of daughters may invest equally in their sons and daughters, since daughters are growing up in larger families, on average there are fewer resources spent on each daughter.

The course of economic development has heavily influenced fertility preferences and decisions in a number of ways. First, the course of economic development across the world has led to technological advancements and the proliferation of ultrasound technology. Use of ultrasound allows parents to know the sex of the child before birth, and has lead to the rise of sex selective abortions. Chen et al. (2013) and Lin et al. (2014) have shown that the expansion of ultrasound has played a large role in the driving the male skewed sex ratio in China and Taiwan respectively. The ability for parents to know the sex of a child in-utero has allowed parents with strong son bias to substitute gendered post-natal discrimination for pre-natal discrimination. Anukriti et al. (2015) find in India the proliferation of ultrasound technology eliminated the problem of post-natal excess female mortality, but this postnatal gendered discrimination was substituted with pre-natal discrimination in the form of sex selective abortions. The authors estimate that for every additional girl that survived to age 5 from reductions in post-natal discrimination, 5.7 girls were "missing" as a result of sex-selective abortion. In a similar paper on India Bhalotra & Cochrane (2010) estimate that almost half a million girls were selectively aborted between 1995-2005. Another study finds that urban and more educated Indian women are more likely to have sex-selective abortions, which is attributed to these mothers' preference for lower total fertility levels (Portner, 2014)

These papers show how the access to ultrasound technology has interacted with the other outcomes of economic development. Levels of economic development also affect the latent measure of son and total fertility preferences. Jayachandran (2014a) uses a cross-country comparison to show that levels of economic development are associated with lower levels of reported preference for number of sons, but this reduction in son preference does not mitigate the problem of male-skewed sex ratios. She attributes this to the role that economic development plays in lowering total fertility preferences. Assuming a natural sex ratio (approximately 1.03-1.07 boys for every girl born), at lower levels of total fertility there is a greater chance that parents will not have their ideal number of boys. In this framework, if you hold preference for the number of sons constant and there is a decrease in total fertility preference, it puts upward pressure the desired number of sons relative to daughters, thus resulting in a more male-skewed sex ratio at birth.

In a separate paper, Jayachandran (2014b) notes the manifestation of this latent variable of son preference is tied into parents' preference for, and potential realizations of total fertility levels. Using survey data from Haryana, India the author finds that the respondents' desired sex ratio of children sharply increases as hypothetical total fertility levels decrease, and that the desired sex ratio falls below 1 (boys/girls) at total fertility levels of 4 or higher. Jayachandran categorizes these variable preferences as a strong desire to have at least one son, and a moderate desire to have at least 2 sons. She attributes this variability in sex ratio preference to cultural norms, because if this preference were based on contemporaneous economic factors, the sex ratio preference would look much more homothetic across total fertility levels. This is an especially interesting result since she also finds that respondents with a more male-skewed sex ratio preference also have a preference for more children overall, thus insinuating that some previous studies that find son preference is weaker at lower levels of fertility are most likely driven by omitted variable bias.

Using the results from the survey Jayachandran finds two additional pertinent results. First, she calculates that approximately 50% of the increase in the Indian male-skewed sex ratio at birth in the last 30 years can be explained through declining total fertility levels. Second, increases in women's education have had a null effect on sex ratios at birth. While increases in a women's education reduce her latent son preference, it also reduces her preferences for total fertility. These opposing forces result in a null effect on sex ratio at birth. These results help explain why the sex ratio has become more male skewed in India over the past several decades despite the economic development and gains in gender parity (Kishor and Gupta, 2009).

2.4 Conceptual Model and Contribution to Literature

In this section I will tie in the different strands of the existing literature described above to provide a conceptual framework for the empirical analysis below. The previously stated goal of this study is to use plausibly exogenous variation in traditional agricultural practices, and thus plausibly exogenous formation of cultural gender norms, to estimate the impact of cultural norms on sex ratios at birth today, and how that impact has changed due to the outcomes of economic development over the last half-century.

The existing literature shows that the use of the plough in traditional societies resulted in a gender based division of labor where men specialized in agricultural labor, and women were secluded within the home. This division of labor created cultural gender norms, or heuristics, regarding the value of daughters and appropriate role of women in society (Boserup 1970). These heuristics were then further reinforced by other ex-post societal responses, such as dowry payment practices (Das Gupta, 2003), and were passed down to the descendants of these societies through a cultural transmission pathway (Alesina et al., 2013). Thus based on the empirical evidence above, I view fertility choices made by parents to be influenced by these norms or heuristics that have been passed down through a cultural transmission pathway (Almond and Edlund, 200; Abrevaya, 2009; Fernandez and Fogli, 2006; Alesina et al. 2011). Therefore, these cultural gender norms have a long half-life, changing slowly over time, and do not necessary reflect the contemporaneous economic conditions faced by individuals.

One can view preferences regarding the number of sons relative to daughters (son preference) and total fertility levels as distinct subsets of the overall set of cultural norms that influence fertility decisions today. By viewing these two sets of fertility preferences as distinct, it allows for differentials in the rate of change of these preferences in response to changes in contemporaneous economic conditions. This study seeks to decompose the highly endogenous relationship of how these distinct subsets of latent preferences interact with each other to influence fertility decisions of parents. Further, how the co-evolution of these subsets with economic development are manifested in observed differentials in sex ratios at birth.

To provide a framework for how the interaction and co-evolution of these latent fertility preferences can impact sex ratios at first, I will first examine how differentials in the rate of change for each subset could impact sex ratios. Following the existing literature, I hypothesize that for descendants of traditional plough societies the subset of cultural norms influencing total fertility preference is less 'sticky' than the heuristics for son preference, and thus is more susceptible to contemporaneous changes in economic conditions. If this is correct, and son preference decreases at a lower rate than total fertility preference, this differential may combine to produce a more male-skewed sex ratio at birth at lower levels of average total fertility. There has been, on average, a vast reduction in total fertility levels around the world over the last half-century in response to changes in contemporaneous changes in economic development. This can be seen through the demographic transition that has taken place in many countries around the world as a contemporaneous response to levels of economic development. This hypothesis is supported by Jayachandran (2014a), where she finds that reported son preference and total fertility preferences are inversely correlated with levels of economic development, but male skewed sex ratio at birth is not. She attributes this result to a greater decrease in total fertility preferences relative to preferences for number of sons, which puts upward pressure on sex ratio at birth. Further, this effect should be more pronounced after the proliferation of ultrasound technology in the 1980s, which allowed parents newfound control over the realization of their fertility preferences. Therefore, this would predict that the impact of cultural gender norms created by traditional agricultural practices should increase over the course of economic development.

Now moving to potential mechanisms for the co-evolution and interaction of these distinct subsets of latent fertility preferences with economic development and possible implications for this interaction on sex ratios at birth. If one simply views this interaction through an intra-household bargaining framework, the predicted impact of economic development on the manifestation of these latent preferences in sex ratios at birth is ambiguous. Economic development, and especially increases in women's education, empowerment, and earning potential, should result in an increased female bargaining power in fertility decisions.

An increase in female bargaining power, ceteris paribus, could impact sex ratios at birth through changes to the latent measure of both total fertility and son preference, but the prediction for how these changes may impact sex ratios at birth are ambiguous. On one hand, if the mother has a strictly lower son preference than the father, an increase in female bargaining power would result in more female births relative to male births, thus decreasing the male-skewed sex ratio (Qian, 2008; Caranza, 2014). On the other hand, if both parents have the same level of son preference, then the increased bargaining power would have null effect on the aggregate son preference of the household.

While an increase in bargaining power could have an overall null effect on the latent measure of son preference, it could also impact the manifestation of that son preference in the sex ratio of births through a change in total fertility preference. An increase in a women's earning potential would raise the opportunity cost of children, and could serve to lower her preference for total fertility. Increased education for women in India has been shown to have an overall null effect on sex ratio at birth (Jayachandran 2014b), through lowering son preference but also lowering total fertility preference. As discussed above, if the decrease in son preference is strictly lower than the decrease in total fertility preference, it could then cause an increase in the male-skewed sex ratio at birth. The existing literature has found more male skewed sex ratios at lower levels of total fertility, and this increase would be more extreme if sex ratio preference is not homothetic across different levels of fertility (Jayachandran 2014b).

Now moving on to how the ability of parents to utilize sex selective abortions impacts sex ratios at birth through these latent fertility preferences. Before the diffusion of ultrasound technology around the world, parents had much less control over the realization of these latent fertility preferences. During this period, Male skewed sex ratios *at birth* could only be realized through son based fertility stopping techniques, while male skewed sex ratios in the *overall population* were also driven by excess female mortality. Therefore, the availability of ultrasound allows parents much greater control to realize their preferences for both the number of sons and total children through sex selective abortions. It has been shown that the diffusion of ultrasound technology to much of the developing world occurred during the 1980s. Thus, as stated above, the impact of son preference on sex ratios at birth should be more pronounced at lower levels of total fertility after the 1980s if sex selective abortion is the primary tool parents use to achieve their latent fertility preferences. But, the predicted impact of exposure to ultrasound technology on sex ratio of last birth (SRLB), ceteris paribus, is ambiguous. For example, if a set of parents prefer to have at least 2 boys and 3 children overall, they could use sex selective abortions to ensure that their first two children are male. Or, they could allow the sex of the first child to be selected naturally, and if that child is a girl, ensure that the following 2 children are boys through sex selective abortion. If parents opt to control the gender of lower birth order children, the SRLB become less male skewed after the 1980s. Conversely, if parents allow natural gender selection in lower birth order children, but use sex selective abortions in higher birth order children, the SRLB may remain constant or become even more male skewed.

This papers contribution to the literature will be to provide a number of stylized facts regarding the endogenous relationship between historic gender norms created through differences in traditional agricultural practices and sex ratio at birth, and how this relationship changes over time throughout the developing world. To my knowledge, this will be the first paper to investigate the heterogeneous impacts of the realization of the latent fertility preferences on sex ratio at birth. Further, I will explore the extent that sex selective abortion has played in realizing these latent preferences.

3. Data

I have used a number of different secondary data sources for the empirical analysis in this study. For the country level analysis below I have extracted a number of control variables from the World Bank Development Indicators. These variables include real GDP per capita and yearly averages of total fertility rates.

The main data set for my analysis is the Demographic and Health Survey (DHS) that is administered by USAID in developing countries around the world. The DHS performs household level surveys, interviewing both men and women of the household, and provides detail anthropological data on the men, women, and children of the household. For data sets made available by USAID to date, the DHS surveys have been completed in 67 countries with survey rounds of various years between 1986 and 2011 (Appendix Table A1). Many of the countries have had multiple rounds of the DHS survey. I have extracted the pertinent information from the individual recode files for all currently available rounds (I-VI) for these countries to create the global DHS data set in which I have worked with. I have transformed the data to create both a mother and child level global data sets. The full data set provides over 1.7 million unique mother (who have had children) level observations, and over 6.4 million unique child level observations.

My treatment variable of historic plough use comes from Alesina et al (2013). For a detailed construction of this variable please see the paper, below I will provide a brief overview of how the variable is constructed. The authors first use the *Ethnographic Atlas* dataset, which reports whether 1,265 distinct ethnic groups utilized the plough for agriculture in the pre-industrial period. To link the traditional plough use with current distributions of decedents of these societies the authors use the 15th edition of the *Ethnologue: Languages of the World*. The *Ethnologue* is a data source that maps the geographic population distribution of 7,612 languages. To link current ethnic population distribution with societies traditionally practiced plough agriculture, the authors manually matched the all the languages in the *Ethnologue* to the ethnic groups contained in the *Ethnographic Atlas*. They then further match the mapping from the *Ethnologue* with the *Landscan 2000* database, which spatially maps the world's population in 2000. This novel technique of matching multiple data sets through language gives them the spatial distribution of the decedents of traditional societies that practiced plough agriculture across the globe.

To create their plough treatment variable at the country level Alesina et al. use modern boundaries and the following equation

$$Plough_c = \sum_e \sum_i \frac{N_{e,i,c}}{N_c} * I_e^{plough}$$

Where I_e^{plough} is defined as a variable equal to 1 if ethnic group e practiced plough agriculture and 0 otherwise. $N_{e,i,c}$ Is the total number of individuals in ethnicity e living in Landscan grid cell *i* of country c, and N_c is the total population of country c. This equation generates the variable $Plough_c$ which is the population weighted average of I_e^{plough} for all ethnic groups living in country c. Due to the way the variable is constructed, the values of $Plough_c$ are restricted to be between {0,1}.

I have used this country level historic plough use intensity variable for my country, mother, and level analysis described in Section 4 below. Though I believe that this variable is suitable for the analysis I described below, I will now discuss a few caveats. For my dynamic analysis I will be going back to the decade of the 1970s as the earliest time period, which presents a potential threat to my identification strategy. The historic plough intensity variable constructed by Alesina et al. (2013) is a static variable based on ethnic population distribution within a country in the year 2000, and thus does not change for each country over time. There could be potential mass in and out migrations of certain ethnic groups, or large population growth of certain ethnicities relative to others in the period between 1970 and 2000, which would not be represented in the $Plough_c$ variable. Therefore, the ethnic population densities of each decade before 2000 in a certain country may not exactly match the ethnic population density in the year 2000. These changes in the makeup of the ethnic population density potential could potentially bias the estimation results either up or down. While this potential bias is a problem, I believe that this variable is adequate for this analysis. The change in ethnic population make up would have to be quite large over those years to make a practical difference in the value of the plough variable, and thus vastly bias the results. Therefore, I believe estimates reported in this paper should have minimal bias.

There is also a potential problem of precision in the mother and child level specifications by using this country level variable these specifications. Alesina et al (2013) shows that there exists a fair amount of heterogeneity in the proportion of descendants plough and shifting societies within certain countries. Therefore, by using the country level treatment variable I have lost some precision for the estimates by not directly matching the ethnicity of individual mothers and children to historic plough use. While the mother and child level analysis loses some precision, I do not believe that it nullifies the results. The variable provides a good proxy measure of the average ambient cultural norms within a country. Further, as can be seen in Appendix Figure A.1 (Histogram of values of $Plough_c$ at the country level), the vast majority of distribution of $Plough_c$ in my sample is clustered around 0 and 1. Therefore in my sample, while a few countries exhibit a high degree of heterogeneity in descendants of plough verses shifting societies, the majority of countries in the sample are very homogeneous. Finally, I have weighted all of my mother and child level regressions in order to be representative of the county a whole (Following DHS guidelines.

4. Methodology

4.1 Country Level Specification

First in regards to the country level, the base regression equation is as follows

$$Y_{ct} = \alpha + \beta Plough_c + \delta \mathrm{A}_{ct} + X_{ct}^{C} + \mathrm{X}_{c}^{H} + u$$

Where Y_{ct} is the dependent variable of interest for country *c* in decade *t*, I have used three separate dependent variables: overall sex ratio at birth, sex ratio of firstborn children, and sex ratio of lastborn children. For overall sex ratio at birth, the country level values of Y_{ct} were constructed by calculating the weighted proportion of total births that were female births by decade. The weighting was performed per the DHS protocols for producing unbiased country level statistics, in order to take into account oversampling of certain areas of groups within a country. Further the weights were adjusted to account for countries with multiple rounds of surveys, when necessary. Finally, in order to match the existing literature, sex ratio at birth is reported in number of male births per 100 female births. The same method was used to construct the sex ratio of first births (SRFB) and sex ratio of last births (SRLB)

The time component of this regression has been delineated by decade (1970-2000). A_{ct} is the average total fertility of country *c* in decade *t*, X_{ct}^{C} is a vector of contemporenous economic controls (log GDP per captia, and the measure squared, and X_{c}^{H} is a vector of historic controls used by Alesina et al. (2011, 2013). This vector of historic controls is used by Alesina et al. in an attempt to control for other differences in traditional societies and include: a measure of political complexity, a measure of density of settlement, agricultural suitability, and the fraction of land that is tropical.

4.2 Mother Level Specification

Moving on to the mother level analysis, the main regression specification will be as follows.

$$\Phi_i = \alpha Plough_c + \rho \mathrm{K} + \sigma Plough_c * \mathrm{K} + \mathrm{X}_i + u$$

Where Φ_i is the percentage of total children born to mother *i* that are female. K is a 7 x 1 vector of dummy variables that equals 1 for the mother *i*'s total number of children (total fertility), and is equal to 0 otherwise. All levels of total fertility great than or equal to 7 have been coded as 7+, to simplify the regression output. Further, this restriction does not change the results compared to including dummy variables for all levels of total fertility up to the maximum value of 22 children in the sample. I interacted $Plough_c$ with the total fertility dummy variables in order to extract heterogeneous treatment effects across different levels of fertility. Therefore, the conditional average effect of traditional plough agriculture on the sex composition of children to a given mother will be $\alpha + \sigma$, conditional on the mother's total level of fertility. I have chosen to add in the heterogeneous treatment effects to test the non-homothetic son preference in India that was revealed in Jayachandran (2014a) with the plough measure for my global dataset. I have added a host of individual controls X_i as robustness checks. X_i includes a vector of dummy variables for the highest level of education attained by both mothers and fathers.

Due to the repeated cross-sectional sampling nature of the DHS there are women in the sample that are at different stages of total fertility. To mitigate any bias in my mother level analysis when interacting the total fertility and plough variables, I restrict my regression analysis to women that have stated they prefer to have no more children, in a response to a question in the DHS questionnaire. Though this is not a perfect restriction, as some women may go on to have more children after the survey. I believe that it does indicate that they have fulfilled their total fertility preference, and therefore Φ_i and total fertility will have minimal bias.

In order to capture a time dimension in my regression analysis, I have further restricted the regression to decade of mother's birth. I have chosen to the time restriction for decade of mother's birth, over year of birth of the mother. This is because while the characteristics of each mother giving birth (such as age of first birth) in decade *t* are different, they are facing similar contemporaneous economic conditions at the time of their first birth. Even though there can be a lot of change in the contemporaneous conditions from on end of a decade to another, for example from 1980 to 1989, the delineation by decade provides an intuitive way to break up the dynamic component of this analysis.

4.3 Child Level Specification

The final specification will be performed at the child level to estimate the prevalence of sex selective abortions for descendants of plough societies as a mechanism to realize their latent son preferences. This specification has been adapted from the framework used in Bhalotra and Cochrane (2010) and Anukriti et al. (2015) to elicit evidence of sex selective abortions based on sibling composition. This specification is performed at the child level. The regression equation is as follows,

$$F_{ijdt} = \alpha + \beta_1[SC'_{ij} * Plough_c * L] + \beta_2[SC'_{ij} * Plough_c] + \beta_3[SC'_{ij} * L] + \beta_4[Plough_c * L] + \gamma_1 SC'_{ij} + \gamma_2 Plough_c + \gamma_3 L + u$$

This specification is a linear probability model, where the dependent variable F_{idjt} is a binary variable equal to 1 if child *j*, of mother *i*, birth order *d*, born in time period *t* is a female and 0 otherwise. This specification will be performed for birth orders d ={2,3,4} only, as the results for the mother level specification only show the expected sex ratio at birth in plough societies to be male skewed at levels of total fertility less than or equal to 4. SC_{ij} is a vector of dummy variables for all possible combinations of the gender composition of the previous siblings of child *i* to mother *j*, equal to 1 for the gender composition of older siblings of child *i* and 0 otherwise. This variable is coded as follows, for birth order d=2, SC'_{ij} will be a dummy variable equal to 1 if the firstborn child is a girl, with firstborn child being a boy as the omitted category. Further, or birth order d=3, SC'_{ij} will include dummy variables for two girls, one boy and one girl, with two boys being the omitted category, and for birth order d=4, SC'_{ij} will include dummy variables for three girls, one boy and two girl, two boys and one girl, with three boys being the omitted category. L is a dummy variable equal to 1 if child i is the lastborn child to mother j and mother j has indicated that she does not prefer to have any more children in the DHS questionnaire. By constructing the variable in this manner it allows me to identify the 'true' last child to mother *i*, based on her total fertility preference. The regression equations will be restricted by time periods of the child's birth to look at the differential impacts over time, and further restricted by birth order of the child. The time periods for this specification have been adjusted to match the time period breakdowns in the previous abortion literature (1960-1974, 1975-1984, 1985-1994, 1995-2011).

This regression equation utilizes a triple interaction term "treatment" variable, $SC'_{ij} * Plough_c * L$. Therefore, this triple interaction term will allow multiple control groups to illicit how sex selective abortions are used by descendants of plough societies. For example, for birth order=2, the control groups would be: all second born children who are descendants of shifting societies, second born children who have an older brother (regardless of ancestry), and second born children who are not 'true' lastborn children (descendants of plough societies). This regression equation not only allows me to determine what extent sex selective abortions are a mechanism for descendants of plough societies to realize their latent son preference, but also at what point during their overall fertility process parents opt into gender determination of children using sex selective abortions.

I have also adopted this specification to test for evidence of sex selective abortions for firstborn children. While, Bhalotra and Cochrane (2010) and Anukriti et al. (2015), assume that the sex of the firstborn child is exogenous. The results from the mother level specification imply if descendants of plough societies prefer to only have one child, the expected sex ratio at birth is extremely male skewed. For firstborn children the expected sex cannot be influenced by previous children, therefore SC'_{ij} has been removed from this equation and the revised regression equation is as follows,

$$F_{ij1t} = \alpha + \beta_1[Plough_c * L] + \beta_2[Plough_c * L] + \delta_1 Plough_c + \delta_2 L + u$$

This revised regression equation will allow me to test for evidence of sex selective abortions in for firstborn children, who's parents prefer to only have one child.

5. Results

5.1 Country Level Regression Results

Table 1 reports summary statistics for a number of fertility outcome variables at the country level in the overall sample, and broken down by decade. The mean values for the overall sex ratio at birth is relatively constant across decades, and is within the natural sex ratio of 103-105. The mean values for sex ratios of last birth (SRLB) are slightly more male skewed than the overall sex ratio at birth, and are also relatively constant across decades. The decadal mean value of total fertility is the only variable that changes significantly over time. The table shows a clear drop in average total fertility in the sample over time, with the mean of average total fertility in the 2000s (4.06) being roughly two-thirds of the mean value in the

1970s (6.08). This table provides evidence that total fertility preferences created by differences in traditional agricultural practices are much responsive to contemporaneous changes in economic development.

Table 2 reports the results of the cross-country pooled OLS regression for all decades with the dependent variable being the overall sex ratio at birth by decade. The table is a buildup of this regression with different combinations of the control variables (listed in section 4.1) included in each regression. The coefficient on the historic plough intensity variable is positive in all of the specifications, and highly statistically significant for five of the six. This provides evidence that the impact of traditional plough agriculture on sex ratios at birth is significant to a number of different controls, and does is not a represent a spurious relationship. Further, the coefficients on $Plough_c$ are relatively constant across the specifications, ranging between 2.2 and 3.1. This translates into a change from a country with all descendants of shifting society to one with all descendants of a plough society, would result the sex ratio at birth being more male skewed by approximately 2-3 males per 100 females.

Now moving to Table 3, which reports the results of the cross-country OLS regressions segmented by decade, for all 3 dependent variables. Due to the stability of the coefficient on $Plough_c$ in table 1, the regressions only include the current controls (X_{ct}^{C}). The historic controls have been removed due to potential issue with over controlling, since all of the variables were used by Alesina et al. (2011, 2013) for the basis of their instrumental variable estimations, and average total fertility has been included back in as a control in Table 4.

Table 3a reports the results of the OLS regression segmented by decade with the dependent variable of overall sex ratio at birth. When segmenting the regression by decade, the coefficient on historic plough intensity is positive and statistically significant to at least the 5% level for all decades in the sample. The magnitude of the coefficient ranges from 2.35 in the 1990s to 4.26 in the 2000s. The comparison of the coefficients by decade provide evidence that the impact on traditional plough agriculture on sex ratios has been relatively constant throughout the sample, not diminishing over time, and could possibly be increasing (since the magnitude of the coefficient is highest in the 2000s). This makes sense because the dependent variable of interest is sex ratios at birth in a given decade, thus it does not take into account post-natal gendered discrimination that was more prevalent before the proliferation of ultrasound technology. The practical significance of this average treatment effect in the 2000s in quite pronounced. In the 2000s the mean sex ratio at birth is approximately 105 male births per 100 female births, which is at the high end of the 103-105 range that is assumed to be the natural sex ratio at birth. A 1 standard deviation increase in historic plough intensity would increase the mean by 1.83 male births. The results from Table 2 and Table 3a provide the basis for stylized fact #1: *Descendants of societies that practiced traditional plough agriculture exhibit more male-skewed sex ratios at birth in modern times. Further, this impact has not diminished over time.*

Table 3b reports the results with the dependent variable of sex ratio of first birth (SRFB). The coefficients on $Plough_c$ are positive for all decades, and surprisingly, significant at the 10% level for the 1970s and 1980s. This is especially surprising for the 1970s since ultra-sound technology was not widely available during this time period. One possible explanation for this result is the under reporting of first-born females who did not survive infancy to DHS surveyors. In many of these countries official birth records may not be widely available for these years, thus the DHS surveyors would not be able to cross reference what is reported by the mother. This would then represent the active post-natal neglect of firstborn daughters that resulted in excess female mortality. This would match the previous literature described above, where parents with strong son bias substituted post-natal decimation for sex selective abortions once ultrasound technology became widely available.

Table 3c reports the results with the dependent variable of sex ratio of last birth (SRLB). Due to the sampling procedures of the DHS some of the children marked as "lastborn" in the sample will not be the last child born to their mother, as these mothers may give birth again after they have been surveyed by the DHS. Therefore, these coefficients are most likely biased downwards towards zero, if mothers are exhibiting son-based fertility stopping preferences. The magnitude of these coefficients of $Plough_c$ in the regressions on lastborn children are much larger than the coefficients on the overall sex ratio implying households in countries with higher proportion of descendants of plough societies are basing their fertility stopping decisions on the sex of the last born child. The large magnitude and positive sign of the coefficient translate into a highly male-skewed SRB for descendants of plough societies, and is a clear sign that these descendants are exhibiting son-based fertility stopping preferences in the sample. There is a big drop off from the magnitude of the coefficient from 1970s to 1980s, which coincides with the wide proliferation of ultrasound technology. This could be a result of ultrasound technology altering the established son-based fertility stopping preferences, by allowing parents to opt into sex selective abortions to achieve their desired number of sons earlier in their fertility cycle. There is also a large drop in magnitude of the coefficient from the 1990s to 2000s. I believe this is because a lower proportion of mothers having children in this decade have completed their total fertility at the time of survey, since most surveys were completed during the 2000s. The results of Table 3c provide the basis for stylized fact #2: *Descendants of plough societies exhibit highly male-skewed sex ratio of last birth (SRLB), and this has been a major driver of male-skewed sex ratios at birth overall. This is evidence that these descendants partially realize their latent son preference through son-based fertility stopping methods.*

To further decompose this relationship, Table 4 reports the results of the same cross country OLS regressions, segmented by decade, with the average total fertility for each country by decade added back in as a right hand side control variable. Further, Appendix Table A2 reports the results from the OLS regression of historic plough intensity on average total fertility by decade. These results are similar to the results from Alesina et al. (2011), and find that after controlling for levels of economic development, a higher proportion of descendants of plough societies are associated with a decrease in average total fertility rates for all decades in the sample. These regressions can be thought of as suffering from an "over-controlling" problem, since average total fertility levels today have been shown to be an outcome of the proportion of descendants of plough societies in a country. Never the less, these regression results illustrate the relationship between declining total fertility and sex ratios at birth. Columns 1-4 of Table 4 report the results with the overall sex ratio at birth as the dependent variable, while columns 5-8 report the results with SRLB as the outcome variable.

For columns 1-4, when including the average total fertility by decade the magnitude of the coefficients on $Plough_c$ are lower for all decades , compared to the results of Table 3a, and only the statistically significant coefficient is in the 1970s. For the regressions of the decades 1980-2000 the coefficients on average total fertility by decade are negative and statistically significant. This again coincides with the proliferation of ultrasound technology, and the newfound ability for parents to realize both their preferences for number of sons and number of total children simultaneously. These coefficients mean that when holding historic plough use and level of economic development constant, lower average total fertility levels are associated with a slightly more male skewed sex ratio. This suggests that the overall level of fertility plays a large role in producing male skewed sex ratios at birth; this result will be further investigated at the mother level. These results provide the basis for Stylized Fact 3: *Declining levels of average total fertility has become the dominant effect driving male-skewed sex ratios at birth since the 1980s.*

Columns 5-8 of Table 4 report the results with SRLB as the dependent variable. When including average total fertility as a control, the results are very similar to the results from table 3.c without the control. When controlling for the average level of total fertility, son based fertility stopping preferences was the main driver of male skewed sex ratios at birth in the 1970s. What is extremely interesting about these results is the sharp decline in the magnitude of the coefficient on the plough variable from the 1970s to the 1980s. This suggests that there was a change in the 1980s that affected the son-based fertility stopping preferences. This coincides with the proliferation of ultrasound technology and the ability of couples to perform sex selective abortions. This results suggest that while before the 1980s couples with male skewed gender norms were forced to continue to have children in order to achieve their desired number of sons, but after the 1980s couples were able to opt into sex selective abortions in order to achieve their desired number of sons. These results will be further investigated in section 5.4, and provides further evidence for the stylized fact 2.

5.2 Mother Level Regression Results

To further decompose the interaction of declining total fertility levels and sex ratios I move to the mother-level analysis. Table 5 reports the results for the mother-level OLS regression where the dependent variable is percentage of overall children (dead or alive) that are female. Since the dependent variable is a measure of the gender breakdown of all children born to mother *i,* regardless of whether of not the child survives, this analysis will not pick up the potential effect that excess female mortality has on driving male-skewed sex ratios. Again, the time dimension in these regressions is the decade in which a mother gives birth to her first child. The regressions include a vector of dummy variables for the individual mother's total fertility level, and those dummies interacted with the country level historic plough intensity variable. This specification will capture the potential heterogeneous impacts of the cultural gender norms created by traditional agricultural practices across different realized levels of total fertility. Again I have restricted these regressions to women who have indicated that their preference is to have no more children, therefore they have reached their total fertility preference whether or not they actually have additional children. Further the individual weighting terms for each observation have been adjusted by the population for each country, consistent with the DHS guidelines for OLS analysis for a pooled sample of multiple survey countries. For this adjustment the population for each country in the year 2000 was used. All standard errors are clustered at the country level.

This base specification does not include any right hand side control variables; in order understand the overall effect of historic gender norms across different levels of total fertility, regardless of the other parental characteristics. Levels of total fertility are highly predicted by household wealth, mother and father's education, urban vs. rural, etc. By adding these controls into the base specification, I may run into the problem of over-controlling in this endogenous environment. As a result, I have chosen to run the base specification without individual controls, and will add in educational controls as a robustness check in section 5.3

Column 1 of Table 5 reports the OLS estimates for all mothers who gave birth from 1970 to 2010, with columns 2-5 reporting the OLS estimates for the regression restricted by decade of the mother's first birth. In column 1 the statistical significance for all of the the coefficients on the historic plough intensity variable, the dummy variables for total fertility levels, and interactions terms is clear evidence of the heterogeneous impacts of traditional plough agriculture on the sex composition of children across different levels of fertility in the overall mother-level sample. What is extremely striking about this table is that in column 2 (women who started their fertility in the 1970s) none of the coefficients are statistically significant, but in column 3 (1980s) the coefficients on plough, total fertility dummies, and the interaction terms become highly significant. The results are even more striking moving to specification 2 through 5, when the regressions are restricted to decade of mother's first birth. For women who first gave birth in the 1970's there is no statistically significant effect of historic plough use on percentage of children that are female across overall or across any level of total fertility. But, when the analysis is moved to women who began their fertility in the 1980's and 1990's, the all of the coefficients on historic plough use the interaction terms become highly statistically significant. Again, this coincides with the proliferation of ultrasound technology and the accompanying ability to perform sex selective abortion to influence the gender make up of families. This is evidence in support of the hypothesis that before the proliferation of ultrasound technology parents were forced to use son-based fertility stopping methods to achieve their desired total number of sons. After the proliferation of this technology, parents with high son preference were able to use sex-selective abortion in order to achieve their total number of sons at lower levels of total fertility. The statistical significance of the heterogeneous treatment effects disappears in the 2000s, but I believe this is due to diminished sample size, since the number of women who have completed their preferred level of fertility is approximately one third of those in the 80's and 90's

The most illustrative way to understand the heterogeneous impacts reported in Table 5 is through expected value results reported in Table 6, and shown graphically in Figures 1 and 2. In order to produce these tables and figures I slightly altered the specification. I transformed the continuous [0,1] $Plough_c$ variable into a categorical variable. Coding $Plough_c$ values [0,0.15] as *Low Plough*, which can also be thought as primarily descendants of shifting societies, and $Plough_c$ values [0.85,1] as *High Plough*, which can also be thought as primarily descendants of plough societies. I ran the similar regression with these plough intensity categories interacted with levels of total fertility, just as I had done with the regression for Table 5. Then for Table 6, I transformed results of the predicted values (result of the conditional expectation function) of the interaction of these categorical plough variables with total fertility levels into sex ratios at birth.

Figure 1 and columns 1-2 report the results of the expected values of descendants of shifting societies (*low plough)* and the descendants of plough societies (*high plough)* across various levels of fertility for the full sample of women who gave birth between 1970 and 2010. The in the overall results for *low plough*, the expected value of the sex ratio is relatively constant across all levels of total fertility, and the point estimates all hover around the natural sex ratio at birth of 103-105. The results are quite different in the second column for *high plough.* The expected value of sex ratio is much more male skewed at lower levels of total fertility, with a break-even point when total fertility is equal to 4 (expected sex ratio reaches the natural level). When total fertility is equal to 1 the expected sex ratio is 127.8. This expected value drops over all levels of total fertility and is 102.8 at a total fertility of 7+, which just below the low end of the natural sex ratio at birth. It is striking how closely these results of observed sex ratios at birth mirror the results of sex ratio preference from

Jayachandran (2014a), with increased in the male skewed sex ratios at lower levels of total fertility and the disappearance of male-skewedness when total fertility is greater than or equal to 4.

Now moving to the results by decade of first birth, Figure 2 and columns 2-10 of Table 6. For women who starting giving birth in the 1970s the point estimates presented for expected sex ratio across levels of fertility must be taken with a grain of salt, because none of the individual coefficients for this regression reported in Table 5 are statistically significant. Although these point estimates are not statistically significant, the association seen in the overall sample holds for both *low plough* and *high plough*.

When moving to total fertility starting in the 1980s and 1990s it is striking how much more male-skewed the expected sex ratio is at lower levels of total fertility levels for *high plough*. In the 1980s the expected sex ratio of *high* plough societies is 131.5 for women who only have one children. Further, at levels of total fertility that are greater than or equal to 4, the expected sex ratio is either approximately the natural sex ratio or even skewed towards females. This is contrasted with the expectation results for *low plough societies*, where the sex ratio is relatively constant around the natural sex ratio. Though as one would expect, there exists more variation in the point estimates for these decades compared to the full sample of births. Again, it is striking how closely the results of Table 6 for women in *high plough* societies who starting their fertility in the 1980s and 1990s match the results from Jayachandran (2014b) on stated fertility preferences across different levels of total fertility. These results are evidence that once the technology became available, parents opted for using ultrasound technology and sex-selective abortions to achieve their latent son and total fertility preferences. Further, these results show that the manifestation of male-skewed sex ratios are being driven by the interaction of declining total fertility with cultural gender norms created by differences in traditional plough agriculture. These results provide the basis for Stylized Fact 4: *From the 1980s onward, the expected sex ratios at birth for descendants of plough societies is more male-skewed at lower levels of total fertility, but reverts back to the natural sex ratio (or even becomes skewed towards females) at levels of total fertility greater than four. This relationship is not seen in descendants of shifting societies, where the expected sex ratio at birth is relatively constant across levels of total fertility at the natural sex ratio.*

5.3 Mother Level Robustness Checks

I have two alternate specifications for this reduced form mother level analysis as robustness checks. First I have added in continent level fixed effects in order to test whether the differences in observed sex ratios at birth are a result of continent level differences. Second, I have added in a vector of dummy variables to control for levels of education of both parents, this will check to see if the heterogeneous treatment effects across different levels of fertility are being driven by omitted variable bias. The results of these robustness checks are reported in Table 7.

Columns 1 through 5 of Table 7 report the results of the mother level analysis with the inclusion of the continent level fixed effects. Comparing the coefficient point estimates to Table 5, the magnitude of these coefficients and standard errors across different levels of total fertility are very similar to the results from Table 4. Also, the general trend across different decades of first birth remains the same. While there is no statistically significant impact of the historic plough intensity variable or interaction terms across different levels of total fertility in the 1970s (column 2), when the analysis moves to the 1980s and 1990s the coefficients on the historic plough intensity variable and interaction terms become highly significant. The first 5 columns of Table 7 provide strong evidence that the results reported in Table 5 are not driven solely by differences between continents.

Columns 6 through 10 report the results of the inclusion of the vector of dummy variables for both the mother and father's education. The dummy variables are coded as 1 for the highest level of educational attainment, and 0 otherwise (none, primary, secondary, higher). In the regression the omitted category for both mother and father are those who have not completed primary school. Of note in these results are the positive and statistically significant coefficients on the dummy variables for mother's educational attainment. The coefficient on the dummy for mother completing primary school is statistically significant in for women who started their fertility in the 1980s 1990s and 2000s, while the coefficients on the dummies for secondary and higher education are only statistically significant for women for started their fertility in the 2000s. These results indicate that women with higher completed levels of education, compared to women who do not finish primary school, have on average a less male skewed sex ratio of children. But when controlling for different levels of educational attainment, the results of the interaction between historic plough use and total fertility levels mirror the results reported in Table 5. The conditional impact of historic plough use results in a lower percentage of daughters in a family at lower levels of total fertility for women who started their fertility in the 1980s and 1990s. Therefore, these results provide evidence that the results reported in Table 4 are not being driven by an omitted variable bias.

5.4 Child-Level Results

The results presented in section 5.3 imply that descendants of plough societies are using sex selective abortions in order to achieve their preference for number of sons at levels of total fertility of four and under. This section will use the third specification in order to show further evidence that sex selective abortions are the means through which these more males skewed sex ratios are achieved a lower fertility levels, and if the composition of previous children plays a role in the decision to opt in to sex selection. Table 8 will report the results from the regression specifications outlined in section 4.3.

Table 8a reports the results of the regression equation 4.3 for firstborn children. Column 1 reports the coefficients for firstborn children born in all years 1960-2011. While the coefficient on plough is statistically significant, the magnitude is very small, equating to a 0.5 percentage point reduction in the probability that a non 'true' lastborn, firstborn child is a female. The coefficient on the interaction between 'true' lastborn and plough is significant at the ten percent level. This coefficient means that for descendants of plough societies who prefer to have only one child, there is a 4 percentage point decrease in the probability of that child being a girl, compared to other descendants of plough societies who prefer to have more children. The coefficient is not significant for the interaction term for columns 2 and 3, which represent the pre-ultrasound diffusion periods, but the interaction term increases in magnitude and gains significance in the post ultrasound diffusion periods. The largest magnitude for the coefficient on the interaction term (and most statistically significant) is in column 4 (1985-1994), which is reported at -0.053 and is significant at the one percent level. This coefficient translates to a 7.7 percentage point decrease in the probability that an only child is a girl if the child's parents are descendants of a plough society compared to shifting, this represents a very large and practically meaningful decrease. It is interesting that the coefficient in column 5 (1995-2011) is lower in magnitude than in column 4, and loses some statistical significance (10% level). Regardless, the coefficients from this regression suggest that descendants of plough societies who only prefer one child are engaging in sex selective abortion to influence the gender of that child. This is an important result, as all previous papers on this topic have assumed that the gender of all first born children are exogenous.

Moving to Table 8b, which reports the results for second born children. This regression specification now includes the triple interaction term of $SC'_{ij} * Plough_c * L$, and the magnitude of the coefficients for the later time periods of this interaction are extremely large and highly significant. For column 5 (1995-2011), for second children who are descendants of plough societies and who's parents prefer to have only two children; there is an approximately 17 percentage point decrease in the probability of that child being a girl, compared if that the first child was a boy (35% chance of the child being a girl). What is extremely striking is that comparisons of the coefficients of the triple interaction term with the coefficient on the interaction term of plough and the dummy for older sister. Comparing these coefficient shows, for second born children, who are descendants of plough societies, and the firstborn child is a girl; there is an approximately 12 percentage point reduction in the probability that child is a girl if that child is the 'true' lastborn child. This differential is too large to occur naturally, and is explicit evidence that descendants of plough societies are utilizing sex selective abortions in order to achieve their desired number of sons at lower levels of total fertility.

Moving to Table 8c, which reports the results of regression equation (3) for second born children. For this table the triple interaction term takes on two different values for prior sibling composition: boy and girl, and two girls, with two boys being to omitted category. The coefficients on both triple interaction terms are not statistically significant in columns 2 (1960-194) and 3 (1975-984), but are both significant in column 5 (1995-2011), and the term with SC (girl, girl) is significant in column 4 (1985-1994). The coefficients on these interaction coefficients represent the differentials in marginal impact for relative to the omitted category of prior sibling composition of two boys. Therefore (looking at column 5) for lastborn third children of descendants of plow societies, if the parents do not have any prior sons, there is an almost 9 percentage points reduction in the probability that child is a girl, compared to if the parents had two previous sons. And the coefficient for if there was one previous son is about half that size. The results from Table 8b & 8c show that descendants from plough societies have a strong desire for at least one son, and a moderate desire for two sons.

This general relationship is confirmed in the results from Table 8d as well, with one difference. The coefficients on the triple interaction term in column 2 (1960-1974) are all positive and significant. Thus the prior sibling compositions included in these terms all result predict a higher probability that the fourth child is a girl than the omitted category of three boys. This is a very interesting result, but I believe that this is driven by the small sample size for this restricted regression. Moving on to the later decades, the results from the interaction term in column 4 (1985-1994) and column 5 (1995-2011), reaffirm the conclusion reached in the previous paragraph. The magnitude of coefficient on the interaction term becomes greater the fewer sons the parents have had in their first three children. For column 4 if the parents (descendants of plough societies, and this will be their last child) have previously had one son there is an approximately 9.5 percentage point reduction in the probability that fourth child is a girl, compared to those families that have had all boys. If the same parents have had no previous boys, there is a 14.3 percentage point reduction in the probability that fourth child being a girl, compared to those families that have had all boys. The results from the mother level specification combined with these results from Table 8 provide the basis for stylized fact 5: *There is evidence that descendants of plough societies are using sex selective abortions in order to achieve desired son preference for birth order 4 and under. The results show descendants of plough societies have a strong preference for at least one son, and a moderate preference for two. There is also evidence of descendants of plough societies engaging in sex selective abortions for firstborn children, if their desire is for only one child overall.*

6. Conclusion

This paper has produced the first (to my knowledge) global empirical analysis of the effect of cultural gender norms created by traditional agricultural practices on sex ratios at birth in the developing world in a global sample. Further, through various levels of empirical analysis this paper has shown how this effect has changed over the previous four decades, and how the course of economic has influenced this effect. The empirical analysis above has provided 5 distinct stylized facts regarding this relationship.

These stylized facts present a clear and deep understanding of the mechanisms behind why a number of countries with a high proportion of descendants of plough societies have recently experienced an increase in the male skewedness in the sex ratios at birth. Further, it illustrates that interventions that seek to limit overall fertility in areas with descendants of plough societies may have unintended consequences resulting in a greater deficit of girls at birth. Hopefully, the results from this paper will be able to spark future research on ways to reduce this latent measure of son preference in descendants of plough societies in order to push to sex ratios at birth down to natural levels.

WORKED CITED

Abrevaya, J. (2008). Are there missing girls in the United States? Evidence from birth data. *Evidence from Birth Data (February 2008)*.

Alesina, Alberto, Paola Giuliano, and Nathan Nunn. (2013). "On The Origins of Gender Roles: Women and the Plough." *The Quarterly Journal of Economics*. Vol. 128(2). 469-530.

Alesina, Alberto; Paola Giuliano; and Nathan Nunn. (2011). "Fertility and the Plough." *American Economic Review: Papers & Proceedings*. 101:3. 499–503

Almond, Douglas, and Lena Edlund. "Son-biased sex ratios in the 2000 United States Census." *Proceedings of the National Academy of Sciences*105.15 (2008): 5681-5682.

Anukriti, S., Bhalotra, S., & Tam, H. (2016). Missing Girls: Prenatal versus Postnatal Discrimination.

Bhalotra, S., & Cochrane, T. (2010). Where have all the young girls gone? On the rising trend in sex selection in India. *University of Bristol Working Paper*.

Boserup, Ester. (1970). *Woman's Role in Economic Development*. (London: George Allenand Unwin Ltd).

Boyd, Robert, and Peter J. Richerson. *Culture and the Evolutionary Process*. (Chicago: University of Chicago Press, 1985).

Carranza, E. (2014). Soil endowments, female labor force participation, and the demographic deficit of women in India. *American Economic Journal: Applied Economics*, *6*(4), 197-225.

Chen, Y., H. Li, and M. Lingsheng (2013). "Prenatal Sex Selection and Missing Girls in China: Evidence from the Di_usion of Diagnostic Ultrasound," *Journal of Human Resources*, 48, 36-70.

CIA World Factbook. Central Intelligence Agency. https://www.cia.gov/library/publications/the-world-factbook/fields/2018.html

Clark, S. (2000). "Son Preference and Sex Composition of Children: Evidence from India," Demography, 37, 95-108.

Das Gupta, M., Zhenghua, J., Bohua, L., Zhenming, X., Chung, W., & Hwa-Ok, B. (2003). Why is son preference so persistent in East and South Asia? A cross-country study of China, India and the Republic of Korea. *The Journal of Development Studies*, *40*(2), 153-187.

Ebenstein, A. (2014). Patrilocality and missing women. *Available at SSRN 2422090*.

Engels, F. (1902). The Origin of the Family, translated by Ernest Untermann.

Fernández, Raquel, and Alessandra Fogli. "Fertility: The role of culture and family experience." *Journal of the European Economic Association* 4.2-3 (2006): 552-561.

Giuliano, P. (2014). "The Role of Women in Society: from Preindustrial to Modern Times." *CESifo Economic Studies*, ifu019.

Griskevicius, V., et al. (2012). "The Financial Consequences of Too Many Men: Sex Ratio Effects on Saving, Borrowing, and Spending." *J Pers Soc Psychol.* 2012 January ; 102(1): 69–80.

Jayachandran, S. (2014a). "The Roots of Gender Inequality in Developing Countries." Working Paper 20380, *National Bureau of Economic Research.*

Jayachandran, S. (2014b). "Fertility Decline and Missing Women," Working Paper 20272, *National Bureau of Economic Research.*

Jensen, R. (2003). "Equal Treatment, Unequal Outcomes? Generating Sex Inequality Through Fertility Behavior," Mimeo, Harvard University.

Kishor, S., & Gupta, K. (2009). Gender equality and womens empowerment in India. National Family Health Survey (NFHS-3) India 2005-06.

Lin, M.-J., J.-T. Liu, and N. Qian (2014). "More Missing Women, Fewer Dying Girls: The Impact of Abortion on Sex Ratios at Birth and Excess Female Mortality in Taiwan," *Journal of European Economic Association*, 12.

Portner, C. C. (2014). Fertility in Developing Countries. *The Economics of the Family: How the Household Affects Markets and Economic Growth*, 209.

Qian, N. (2008). "Missing Women and the Price of Tea in China: The E_ect of Sex-Specific Earnings on Sex Imbalance," *Quarterly Journal of Economics*, 123.

Sen, A. (1990). "More Than 100 Million Women Are Missing," New York Review of Books, 37.

Yamaguchi, K. (1989). A formal theory for male-preferring stopping rules of childbearing: Sex differences in birth order and in the number of siblings.*Demography*, *26*(3), 451-465.

Table #1

Fertility Summary Statistics
Country Level
Reported Means / (Standard Deviations)

	(1) 1970-2010	(2) 1970	(3) 1980	(4) 1990	(5) 2000
Overall Sex Ratio at Birth	**104.18**	**103.81**	**104.34**	**103.82**	**104.93**
	(5.91)	(8.87)	(3.81)	(3.94)	(5.34)
Firstborn Sex Ratio at Birth	105.47	105.13	105.33	105.01	106.58
	(8.22)	(11.14)	(6.32)	(7.11)	(7.19)
Lastborn Sex Ratio at Birth	107.55	107.65	109.27	106.8	106.02
	(21.92)	(36.59)	(16.52)	(12.44)	(7.67)
Average Total Fertility	5.11	6.08	5.57	4.74	4.06
	(1.74)	(1.32)	(1.57)	(1.69)	(1.67)

Table #2

Country Level OLS Estimates with Control Variable Buildup
Dependent Variable: Average Sex Ratio at Birth by Decade for all Decades

	(1) Sex Ratio at Birth 1970-2010	(2) Sex Ratio at Birth 1970-2010	(3) Sex Ratio at Birth 1970-2010	(4) Sex Ratio at Birth 1970-2010	(5) Sex Ratio at Birth 1970-2010	(6) Sex Ratio at Birth 1970-2010
Historic Plough Intensity	2.381**	3.107***	2.343***	1.713	2.426***	2.173**
	(1.015)	(0.652)	(0.836)	(1.090)	(0.707)	(0.925)
Average Total Fertility				-0.408*	-0.457*	-0.192
				(0.227)	(0.257)	(0.269)
Constant	103.4***	93.95***	104.5***	105.8***	101.3***	106.7***
	(0.345)	(11.22)	(11.85)	(1.383)	(11.25)	(11.73)
Current Controls		✔	✔		✔	✔
Historic Controls			✔			✔
Observations	275	241	241	275	241	241
R-squared	0.031	0.106	0.176	0.042	0.123	0.179

OLS estimates are reported with robust standard errors in parentheses.
All contemporaneous Independent variables & dependent variable are averaged by decade
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table #3

Country Level OLS Estimates by Decade

3.a Overall Sex Raio at Birth by Decade

	(1)	(2)	(3)	(4)
	1970	1980	1990	2000
Historic Plough Intensity	2.719**	2.929***	2.346**	4.255**
	(1.306)	(1.011)	(1.061)	(1.744)
Constant	131.6***	90.33***	80.52***	87.62***
	(28.11)	(15.00)	(16.72)	(22.83)
Current Controls	✔	✔	✔	✔
Observations	53	66	66	56
R-squared	0.084	0.139	0.088	0.219

3.b Sex Ratio of Firstborn Children by Decade

	(1)	(2)	(3)	(4)
	1970	1980	1990	2000
Historic Plough Intensity	3.806*	2.772*	2.167	3.869
	(2.091)	(1.443)	(1.777)	(2.345)
Constant	93.20*	147.4***	70.69*	166.0***
	(50.52)	(25.72)	(36.86)	(47.60)
Current Controls	✔	✔	✔	✔
Observations	53	66	66	56
R-squared	0.071	0.073	0.051	0.277

3.c Sex Ratio of Lastborn Children by Decade

	(1)	(2)	(3)	(4)
	1970	1980	1990	2000
Historic Plough Intensity	14.63**	10.38***	11.06***	6.860***
	(5.814)	(3.238)	(3.271)	(2.421)
Constant	333.9***	77.19	79.28	73.71**
	(99.09)	(58.12)	(63.01)	(28.14)
Current Controls	✔	✔	✔	✔
Observations	53	66	66	56
R-squared	0.180	0.166	0.178	0.244

OLS estimates are reported with robust standard errors in parentheses .
All contemporaneous Independent variables & dependent variable are averaged by decade
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table #4

Country Level OLS Estimates by Decade

Dependent Variable: Sex Ratio at Birth & Lastborn Sex Ratio at Birth by Decade

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sex Ratio at Birth				Lastborn Sex Ratio at Birth			
	1970	1980	1990	2000	1970	1980	1990	2000
Historic Plough Intensity	3.250*	1.534	0.799	2.170	16.44**	7.989**	7.415**	3.728
	(1.687)	(1.219)	(1.261)	(2.022)	(7.538)	(3.674)	(3.545)	(3.451)
Average Total Fertility	0.617	-0.941*	-1.139**	-1.166*	2.106	-1.614	-2.682**	-1.751
	(0.917)	(0.521)	(0.482)	(0.661)	(3.526)	(1.430)	(1.204)	(1.078)
Constant	128.7***	102.7***	105.0***	115.5***	324.0***	98.38*	136.8**	115.6***
	(28.52)	(17.02)	(15.00)	(21.64)	(99.48)	(57.46)	(53.58)	(26.40)
Current Controls	✔	✔	✔	✔	✔	✔	✔	✔
Historic Controls								
Observations	53	66	66	56	53	66	66	56
R-squared	0.098	0.204	0.197	0.269	0.190	0.186	0.250	0.299

OLS estimates are reported with robust standard errors in parentheses.
All contemporaneous Independent variables & dependent variable are averaged by decade
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table #5

Mother Level: Percentage Female Children of Total Children OLS Regressions
By Decade of Mother's First Birth

	(1)	(2)	(3)	(4)	(5)
	1970-2010	1970	1980	1990	2000
Historic Plough Intensity	-0.0518**	0.0353	-0.0946***	-0.0673**	-0.0309
	(0.0196)	(0.0538)	(0.0227)	(0.0274)	(0.0188)
Total Fertility = 2	-0.00731**	0.0394	-0.0597***	-0.0191***	0.00676
	(0.00366)	(0.0310)	(0.0123)	(0.00703)	(0.00489)
Total Fertility = 3	-0.00851**	0.0290	-0.0553***	-0.0126**	-0.00312
	(0.00351)	(0.0340)	(0.00833)	(0.00503)	(0.00549)
Total Fertility = 4	-0.00917**	0.0234	-0.0512***	-0.0179***	0.00243
	(0.00382)	(0.0341)	(0.00940)	(0.00590)	(0.00602)
Total Fertility = 5	-0.00837**	0.0326	-0.0589***	-0.0139**	0.00509
	(0.00416)	(0.0353)	(0.0106)	(0.00642)	(0.00937)
Total Fertility = 6	-0.00879**	0.0270	-0.0545***	-0.0153**	0.00220
	(0.00407)	(0.0361)	(0.00897)	(0.00626)	(0.0203)
Total Fertility = 7+	-0.00674	0.0323	-0.0535***	-0.0155**	0.0544
	(0.00413)	(0.0344)	(0.00896)	(0.00651)	(0.0802)
Plough * Total Fertility = 2	0.0152	-0.0701	0.0661***	0.0386*	0.00654
	(0.0112)	(0.0611)	(0.0190)	(0.0230)	(0.0150)
Plough * Total Fertility = 3	0.0355*	-0.0498	0.0719***	0.0511*	0.0413**
	(0.0185)	(0.0566)	(0.0227)	(0.0281)	(0.0184)
Plough * Total Fertility = 4	0.0477**	-0.0483	0.0869***	0.0703**	0.0498**
	(0.0206)	(0.0532)	(0.0235)	(0.0307)	(0.0225)
Plough * Total Fertility = 5	0.0534**	-0.0469	0.0978***	0.0740**	0.0360
	(0.0220)	(0.0539)	(0.0240)	(0.0307)	(0.0336)
Plough * Total Fertility = 6	0.0578**	-0.0382	0.0956***	0.0908***	0.00934
	(0.0222)	(0.0555)	(0.0242)	(0.0324)	(0.0506)
Plough * Total Fertility = 7+	0.0552**	-0.0333	0.103***	0.0832***	-0.582
	(0.0227)	(0.0531)	(0.0261)	(0.0285)	(1.704)
Constant	0.498***	0.457***	0.546***	0.505***	0.484***
	(0.00377)	(0.0348)	(0.00935)	(0.00534)	(0.00490)
Observations	721,518	50,375	143,944	150,357	57,775
R-squared	0.002	0.001	0.003	0.003	0.001

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table 6

Expected Sex Ratios at Birth Across Levels of Total Fertility
Results Reported for High / Low Plough

	Overall		1970		1980		1990		2000	
Total Fertility	**Low Plough**	**High Plough**	**Low Plough**	**High Plough**	**Low Plough**	**High Plough**	**Low Plough**	**High Plough**	**Low Plough**	**High Plough**
1	103.67	127.79	108.77	123.71	102.84	117.39	102.43	131.48	105.34	132.56
2	107.47	121.73	104.50	117.39	107.90	123.71	110.53	121.73	104.50	119.30
3	104.92	110.97	104.08	111.42	104.92	112.31	104.08	110.08	110.97	106.19
4	105.76	106.61	105.76	108.77	106.19	106.61	105.34	103.25	107.90	100.40
5	105.34	102.84	103.25	106.19	107.90	101.21	104.50	99.20	106.19	104.08
6	103.67	100.80	105.34	103.67	101.61	98.41	104.08	95.69	104.08	119.78
7+	102.84	100.40	103.25	102.43	102.43	97.63	105.34	99.20		

Results are reported in as the point estimates for the expected sex ratio of birth (number of male births per 100 female births), from the base regression with the continuous Plough variable replaced with categorical Plough variable. Coding values of Plough [0.85, 1] as High Plough, and values of Plough [0,0.15] coded as Low Plough, with these categorical variables interacted with levels of total fertility.

Table 7
Robustness Checks
Mother Level: Percentage Female Children of Total Children OLS Regressions
By Decade of Mother's First Birth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1970-2010	1970	1980	1990	2000	1970-2010	1970	1980	1990	2000
Historic Plough Intensity	-0.0483**	0.0388	-0.0996***	-0.0644**	-0.0155	-0.0539***	0.0304	-0.0993***	-0.0727***	-0.0299
	(0.0187)	(0.0527)	(0.0252)	(0.0267)	(0.0136)	(0.0200)	(0.0546)	(0.0243)	(0.0270)	(0.0197)
Total Fertility = 2	-0.00695*	0.0384	-0.0601***	-0.0185***	0.00896	-0.00979**	0.0420	-0.0636***	-0.0211***	0.00649
	(0.00349)	(0.0309)	(0.0121)	(0.00685)	(0.00565)	(0.00488)	(0.0352)	(0.0144)	(0.00640)	(0.00874)
Total Fertility = 3	-0.00748**	0.0282	-0.0553***	-0.0111**	5.93e-06	-0.00968**	0.0299	-0.0576***	-0.0131**	-0.00245
	(0.00345)	(0.0338)	(0.00842)	(0.00537)	(0.00689)	(0.00444)	(0.0366)	(0.0103)	(0.00567)	(0.00734)
Total Fertility = 4	-0.00745*	0.0236	-0.0503***	-0.0156**	0.00610	-0.00990**	0.0250	-0.0530***	-0.0178***	0.00170
	(0.00375)	(0.0339)	(0.00969)	(0.00637)	(0.00693)	(0.00492)	(0.0372)	(0.0116)	(0.00609)	(0.00821)
Total Fertility = 5	-0.00604	0.0341	-0.0574***	-0.0111*	0.00893	-0.00744	0.0390	-0.0592***	-0.0134*	0.00752
	(0.00419)	(0.0354)	(0.0107)	(0.00657)	(0.0108)	(0.00567)	(0.0402)	(0.0128)	(0.00683)	(0.0110)
Total Fertility = 6	-0.00613	0.0297	-0.0526***	-0.0123*	0.00615	-0.00682	0.0336	-0.0533***	-0.0142**	0.00567
	(0.00415)	(0.0359)	(0.00920)	(0.00664)	(0.0221)	(0.00552)	(0.0401)	(0.0112)	(0.00647)	(0.0208)
Total Fertility = 7+	-0.00375	0.0361	-0.0509***	-0.0120*	0.0584	-0.00291	0.0405	-0.0500***	-0.0135**	0.0597
	(0.00416)	(0.0342)	(0.00933)	(0.00666)	(0.0800)	(0.00588)	(0.0385)	(0.0115)	(0.00649)	(0.0792)
Plough * Total Fertility = 2	0.0153	-0.0680	0.0693***	0.0390*	0.00618	0.0189	-0.0679	0.0726***	0.0465**	0.00703
	(0.0110)	(0.0608)	(0.0193)	(0.0229)	(0.0151)	(0.0122)	(0.0636)	(0.0209)	(0.0228)	(0.0184)
Plough * Total Fertility = 3	0.0353*	-0.0466	0.0774***	0.0511*	0.0400**	0.0393**	-0.0439	0.0777***	0.0581**	0.0431**
	(0.0184)	(0.0555)	(0.0238)	(0.0284)	(0.0182)	(0.0196)	(0.0571)	(0.0241)	(0.0282)	(0.0208)
Plough * Total Fertility = 4	0.0470**	-0.0456	0.0925***	0.0700**	0.0497**	0.0526**	-0.0407	0.0942***	0.0777**	0.0548**
	(0.0206)	(0.0520)	(0.0254)	(0.0316)	(0.0228)	(0.0220)	(0.0536)	(0.0253)	(0.0308)	(0.0249)
Plough * Total Fertility = 5	0.0521**	-0.0457	0.103***	0.0735**	0.0370	0.0573**	-0.0428	0.105***	0.0815**	0.0379
	(0.0221)	(0.0528)	(0.0263)	(0.0320)	(0.0335)	(0.0236)	(0.0555)	(0.0261)	(0.0313)	(0.0345)

Plough * Total Fertility = 6	0.0563**	-0.0381	0.101***	0.0901**	0.0126	0.0616**	-0.0332	0.102***	0.0982***	0.00950
	(0.0224)	(0.0541)	(0.0267)	(0.0337)	(0.0530)	(0.0237)	(0.0563)	(0.0261)	(0.0327)	(0.0503)
Plough * Total Fertility = 7+	0.0529**	-0.0345	0.107***	0.0825***	-0.590	0.0579**	-0.0288	0.107***	0.0908***	-0.706
	(0.0229)	(0.0517)	(0.0288)	(0.0301)	(1.704)	(0.0239)	(0.0539)	(0.0279)	(0.0286)	(1.643)
Husband Primary Education						0.00551***	0.00996***	0.00463	0.00658***	0.00967
						(0.00140)	(0.00316)	(0.00312)	(0.00211)	(0.00715)
Husband Secondary Education						0.00303*	0.0106***	0.00816**	0.00279	-0.00470
						(0.00160)	(0.00373)	(0.00352)	(0.00294)	(0.00726)
Husband Higher Education						0.00295	0.00994	0.00818	-6.07e-05	-0.0101
						(0.00318)	(0.00689)	(0.00542)	(0.00486)	(0.00941)
Mother Primary Education						0.00915***	-0.00264	0.00597*	0.00812**	0.0167*
						(0.00264)	(0.00304)	(0.00301)	(0.00362)	(0.00938)
Mother Secondary Education						0.0106**	0.00519	0.00523	0.00674	0.0208**
						(0.00492)	(0.00508)	(0.00481)	(0.00561)	(0.00998)
Mother Higher Education						0.0117**	0.0210	0.00741	0.00956	0.0265*
						(0.00544)	(0.0129)	(0.00813)	(0.00694)	(0.0134)
Constant	0.493***	0.451***	0.542***	0.501***	0.479***	0.487***	0.444***	0.537***	0.495***	0.465***
	(0.00429)	(0.0348)	(0.00987)	(0.00616)	(0.00761)	(0.00659)	(0.0389)	(0.0123)	(0.00749)	(0.0117)
Continent Level FE	✔	✔	✔	✔	✔					
Observations	724,769	50,375	143,944	150,357	57,775	704,824	49,748	141,883	145,488	52,557
R-squared	0.002	0.002	0.003	0.003	0.002	0.003	0.002	0.003	0.003	0.002

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table 8a

Linear Probability OLS Regression Child is Female

First Born Children

	(1)	(2)	(3)	(4)	(5)
	1960-2011	1960-1974	1975-1984	1985-1994	1995-2011
Plough	-0.00569***	-0.00866**	-0.0109***	-0.00153	-0.00313
	(0.00144)	(0.00420)	(0.00225)	(0.00205)	(0.00354)
Lastborn (and mother prefers no more children)	0.00929**	0.00466	0.0170	0.0238***	-0.000807
	(0.00406)	(0.0272)	(0.0106)	(0.00858)	(0.00378)
Plough * Lastborn	-0.0408*	-0.0188	-0.0263	-0.0534**	-0.0429*
	(0.0213)	(0.0442)	(0.0285)	(0.0214)	(0.0237)
Constant	0.489***	0.484***	0.489***	0.489***	0.490***
	(0.00113)	(0.00234)	(0.00148)	(0.00155)	(0.00159)
Observations	1,706,159	203,778	445,589	572,120	477,677
R-squared	0.000	0.000	0.000	0.000	0.000

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level

***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table 8b

Linear Probability OLS Regression Child is Female
Second Born Children

	(1)	(2)	(3)	(4)	(5)
TIME PERIODS	Overall	1960-1974	1975-1984	1985-1994	1995-2011
Plough	-0.0107***	-0.00466	-0.00755**	-0.00735**	-0.0189**
	(0.00319)	(0.00637)	(0.00350)	(0.00368)	(0.00794)
Lastborn (and mother prefers no more children)	0.0402***	0.0577**	0.0618***	0.0469***	0.0273***
	(0.00504)	(0.0288)	(0.0108)	(0.00979)	(0.00665)
Plough * Lastborn	0.0138	-0.0153	-0.0105	-0.00699	0.0373*
	(0.0137)	(0.0447)	(0.0217)	(0.0163)	(0.0192)
Previous Sibling Composition = G	0.00748***	0.0255***	0.00971***	0.00662**	0.00141
	(0.00179)	(0.00414)	(0.00271)	(0.00290)	(0.00322)
Plough * Sibling Comp = G	0.0214***	-0.00196	0.00915**	0.0173***	0.0508***
	(0.00513)	(0.00732)	(0.00444)	(0.00550)	(0.0133)
Lastborn * Sibling Comp = G	-0.0799***	-0.0847*	-0.100***	-0.0842***	-0.0680***
	(0.00806)	(0.0429)	(0.0132)	(0.0127)	(0.0121)
Plough * Lastborn * Sibling Comp = G	-0.122***	-0.0412	-0.0713***	-0.108***	-0.168***
	(0.0172)	(0.0530)	(0.0236)	(0.0187)	(0.0258)
Constant	0.485***	0.473***	0.482***	0.487***	0.490***
	(0.00177)	(0.00376)	(0.00262)	(0.00202)	(0.00298)
Observations	1,374,568	137,322	351,329	481,791	401,312
R-squared	0.003	0.001	0.001	0.003	0.005

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table 8c
Linear Probability OLS Regression Child is Female
Third Born Children

TIME PERIODS	(1) Overall	(2) 1960-1974	(3) 1975-1984	(4) 1985-1994	(5) 1995-2011
Plough	-0.00954**	-0.00139	-0.00586	-0.00981	-0.0125*
	(0.00368)	(0.00838)	(0.00552)	(0.00622)	(0.00684)
Lastborn (and mother prefers no more children)	0.0476***	0.0949***	0.0551***	0.0484***	0.0388***
	(0.00641)	(0.0335)	(0.0198)	(0.0115)	(0.00699)
Plough * Lastborn	0.00692	-0.0461	-0.00239	0.0158	0.00602
	(0.0115)	(0.0513)	(0.0239)	(0.0188)	(0.0182)
Previous Sibling Composition = BG	0.00830***	0.0204***	0.0120***	0.00756**	0.00268
	(0.00197)	(0.00620)	(0.00399)	(0.00340)	(0.00303)
Previous Sibling Composition = GG	0.0152***	0.0459***	0.0144**	0.00939*	0.0144***
	(0.00285)	(0.00937)	(0.00551)	(0.00475)	(0.00403)
Plough * Sibling Comp = BG	0.00841	-0.00315	-0.00375	0.0132	0.0178*
	(0.00591)	(0.00912)	(0.00631)	(0.00977)	(0.00931)
Plough * Sibling Comp = GG	0.0152**	-0.0208	0.00760	0.0204*	0.0301**
	(0.00620)	(0.0132)	(0.00742)	(0.0102)	(0.0145)
Lastborn * Sibling Comp = BG	-0.0548***	-0.107**	-0.0531**	-0.0640***	-0.0431***
	(0.00829)	(0.0508)	(0.0217)	(0.0162)	(0.00896)
Lastborn * Sibling Comp = GG	-0.102***	-0.227**	-0.104***	-0.101***	-0.0951***
	(0.0138)	(0.0861)	(0.0331)	(0.0167)	(0.0171)
Plough * Lastborn * Sibling Comp = BG	-0.0333***	0.0338	-0.0305	-0.0376	-0.0411**
	(0.0126)	(0.0655)	(0.0323)	(0.0227)	(0.0157)
Plough * Lastborn * Sibling Comp = GG	-0.0856***	0.0935	-0.0552	-0.123***	-0.0878***
	(0.0252)	(0.105)	(0.0485)	(0.0256)	(0.0302)
Constant	0.484***	0.468***	0.481***	0.485***	0.489***
	(0.00215)	(0.00621)	(0.00380)	(0.00312)	(0.00278)
Observations	1,017,075	87,836	255,530	372,463	300,229
R-squared	0.002	0.001	0.001	0.002	0.002

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level
***, **, * indicated significance at the 1%, 5%, and 10% levels.

Table 8d

Linear Probability OLS Regression Child is Female

Fourth Born Children

TIME PERIODS	(1) Overall	(2) 1960-1974	(3) 1975-1984	(4) 1985-1994	(5) 1995-2011
Plough	-0.00686	0.000743	-0.00172	-0.00558	-0.0163*
	(0.00471)	(0.0119)	(0.00610)	(0.00934)	(0.00912)
Lastborn (and mother prefers no more children)	0.0361***	0.142***	0.0325	0.0318**	0.0329**
	(0.00951)	(0.0394)	(0.0218)	(0.0139)	(0.0150)
Plough * Lastborn	0.0265	-0.216***	0.0189	0.0374	0.0365
	(0.0166)	(0.0507)	(0.0289)	(0.0245)	(0.0261)
Previous Sibling Composition = BBG	0.0154***	0.0257**	0.0189***	0.0130**	0.0131**
	(0.00351)	(0.0111)	(0.00495)	(0.00516)	(0.00628)
Previous Sibling Composition = BGG	0.0116***	0.0112	0.0161***	0.00761	0.0125**
	(0.00343)	(0.0105)	(0.00571)	(0.00534)	(0.00608)
Previous Sibling Composition = GGG	0.0208***	0.0367***	0.0232***	0.0254***	0.00991
	(0.00411)	(0.0126)	(0.00659)	(0.00810)	(0.00771)
Plough * Sibling Comp = BBG	-0.00424	-0.0181	-0.00665	-0.000402	-0.00616
	(0.00515)	(0.0163)	(0.00698)	(0.00986)	(0.00938)
Plough * Sibling Comp = BGG	0.00502	0.00342	-0.0121	0.0106	0.0219
	(0.00657)	(0.0166)	(0.00799)	(0.0105)	(0.0137)
Plough * Sibling Comp = GGG	0.0145*	-0.0121	0.00149	0.00668	0.0493**
	(0.00760)	(0.0227)	(0.0101)	(0.0143)	(0.0200)
Lastborn * Sibling Comp = BBG	-0.0287**	-0.129**	-0.0312	-0.0248	-0.0250
	(0.0122)	(0.0545)	(0.0281)	(0.0168)	(0.0181)
Lastborn * Sibling Comp = BGG	-0.0518***	-0.142*	-0.0611**	-0.0436***	-0.0515***
	(0.0115)	(0.0768)	(0.0263)	(0.0130)	(0.0166)
Lastborn * Sibling Comp = GGG	-0.0961***	-0.258***	-0.103**	-0.102***	-0.0796***
	(0.0170)	(0.0641)	(0.0447)	(0.0167)	(0.0240)
Plough * Lastborn * Sibling Comp = BBG	-0.0308**	0.194***	-0.0207	-0.0394*	-0.0351
	(0.0154)	(0.0686)	(0.0398)	(0.0232)	(0.0271)
Plough * Lastborn * Sibling Comp = BGG	-0.0624***	0.208**	-0.0392	-0.0952***	-0.0696**
	(0.0177)	(0.0985)	(0.0387)	(0.0193)	(0.0312)
Plough * Lastborn * Sibling Comp = GGG	-0.112***	0.250***	-0.0705	-0.143***	-0.136***
	(0.0308)	(0.0902)	(0.0621)	(0.0383)	(0.0402)
Constant	0.481***	0.468***	0.477***	0.483***	0.483***
	(0.00296)	(0.00751)	(0.00461)	(0.00468)	(0.00506)
Observations	719,838	53,183	176,999	272,403	216,890
R-squared	0.001	0.001	0.001	0.002	0.002

OLS estimates are reported with standard errors in parentheses. Standard errors are clustered at the country level

***, **, * indicated significance at the 1%, 5%, and 10% levels.

Figure #1
Expected Sex Ratio At Birth Across Levels of Total Fetility
All births between 1970 - 2009

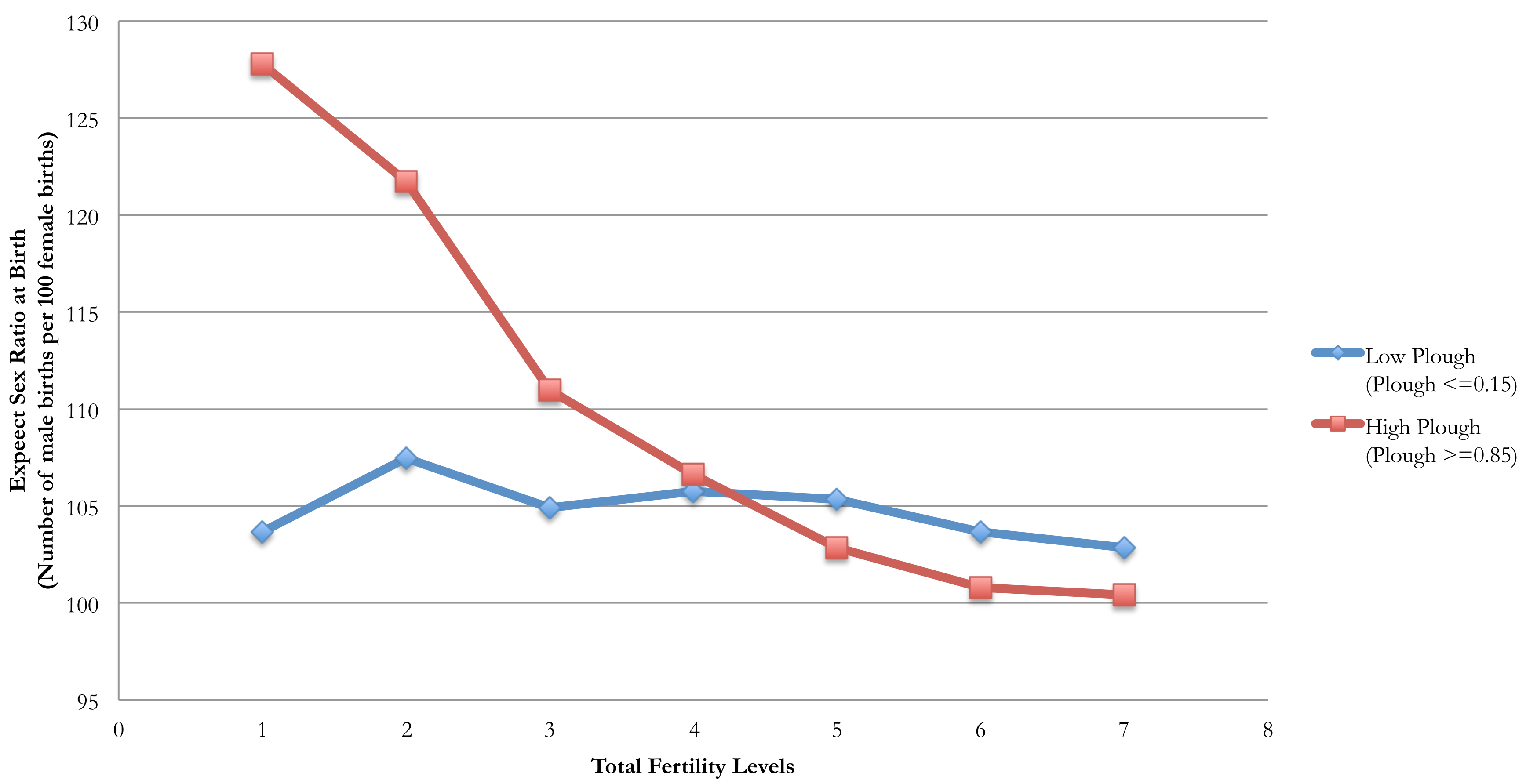
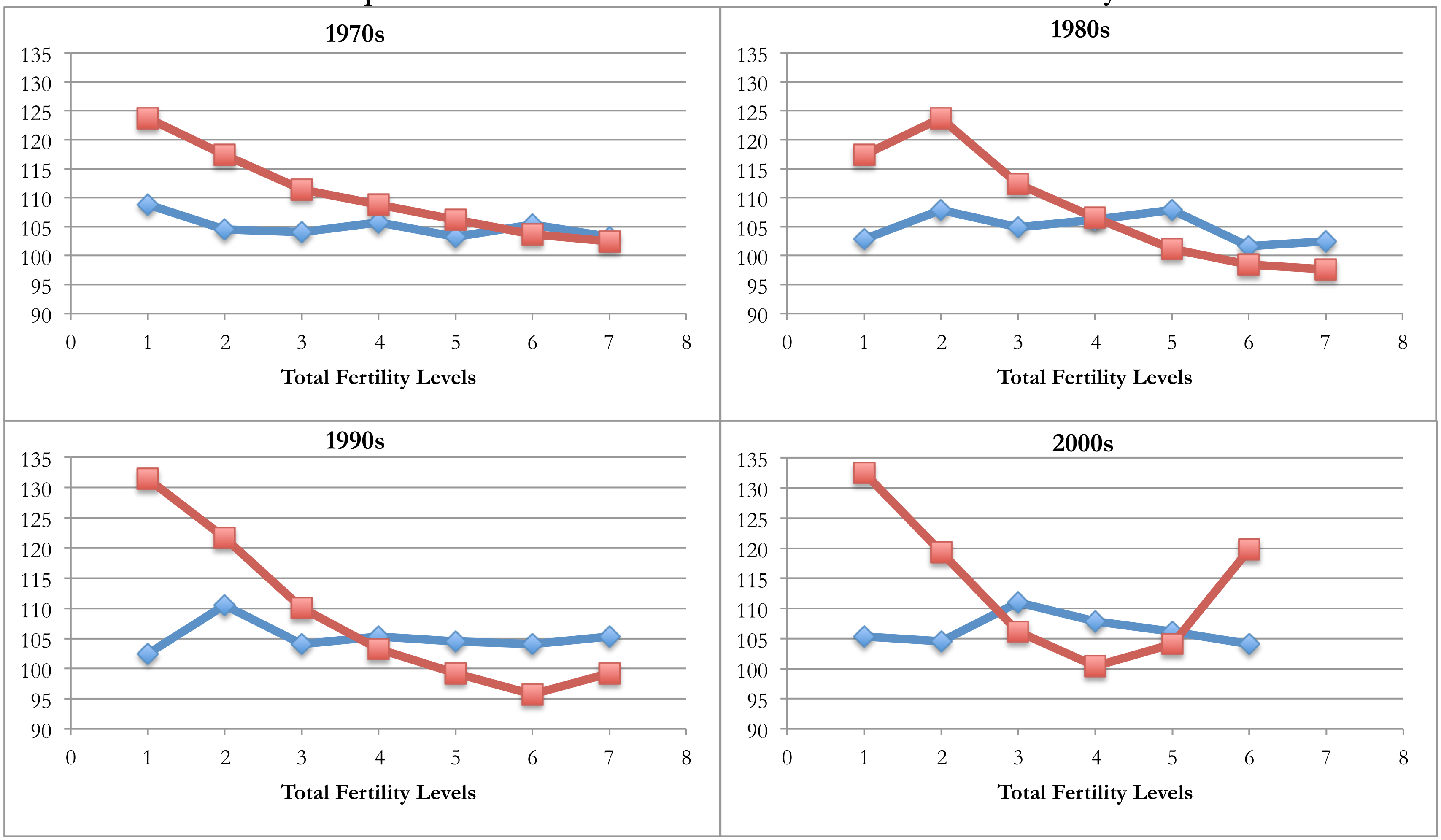


Figure # 2

Expected Sex Ratio At Birth Across Levels of Total Fertility



APPENDIX

Appendix Table A.1
List of Countries in Sample and DHS Survey Years

Country	Year of Survey						
Albania	2008-09						
Angola	2006-07	2011					
Armenia	2000	2005					
Azerbaijan	2006						
Bangladesh	1993-94	1996-97	1999-00	2004	2007	2011	2014
Benin	1996	2001	2006	2011-12			
Bolivia	1989	1994	1998	2003	2008		
Brazil	1986	1991	1996				
Burkina Faso	1993	1998-99	2003	2010			
Burundi	1987	2010	2014				
Cambodia	2000	2005	2010				
Cameroon	1991	1998	2004	2011			
Central African Republic	1994-95						
Chad	1996-97	2004					
Colombia	1986	1990	1995	2000	2005	2010	
Comoros	1996	2012					
Congo Brazzaville	2005	2011-12					
Congo DRC	2007	2013-14					
Cote d'Ivoire	1994	1998-99	2011-12				
Dominican Republic	1986	1991	1996	1999	2002	2007	2013
Ecuador	1987						
Egypt	1992	1995	2000	2005	2008	2014	
Ethiopia	2000	2005	2011				
Gabon	2000	2012					
Ghana	1988	1993	1998	2003	2008		
Guatemala	1987	1995					
Guinea	1999	2005					
Guyana	2009						
Haiti	1994-95	2000	2005-06				
Honduras	2005-06						
India	1992-93	1998-99	2005-06				
Indonesia	1987	1991	1994	1997	2002-03	2007	
Jordan	1990	1997	2002	2007			
Kazakhstan	1995	1999					
Kenya	1989	1993	1998	2003	2008-09		
Kyrgyz Republic	1997						

Lesotho	2004	2009					
Liberia	1986	2007	2009	2011			
Madagascar	1992	1997	2003-04	2008-09	2011		
Malawi	1992	2000	2004	2010			
Maldives	2009						
Mali	1987	1995-96	2001	2006			
Mexico	1987						
Moldova	2005						
Morocco	1987	1992	2003-04				
Mozambique	1997	2003					
Namibia	1992	2000	2006-07				
Nicaragua	1998	2001					
Niger	1992	1998	2006				
Nigeria	1990	1999	2003	2008	2010		
Pakistan	1990-91	2006-07					
Paraguay	1990						
Peru	1986	1991-92	1996	2000			
Philippines	1993	1998	2003	2008			
Rwanda	1992	2000	2005	2010			
Sao Tome Principe	2008-09						
Senegal	1986	1992-93	1997	2005	2006	2008-09	2010-11
Sierra Leone	2008						
South Africa	1998						
Sri Lanka	1987						
Sudan	1989-90						
Swaziland	2006-07						
Tanzania	1991-92	1996	1999	2004-05	2010		
Thailand	1987						
Togo	1988	1998					
Trinidad and Tobago	1987						
Tunisia	1988						
Turkey	1993	1998	2003				
Uganda	1988-89	1995	2000-01	2006	2009	2011	
Ukraine	2007						
Uzbekistan	1996						
Vietnam	1997	2002					
Yemen	1991-92						
Zambia	1992	1996	2001-02	2007			
Zimbabwe	1988	1994	1999	2005-06	2010-11		

Appendix Table A.2

Country Level OLS Estimates

Dependent Variable: Average Total Fertility By Decade

VARIABLES	(1) Average Total Fertility 1970-2010	(2) Average Total Fertility 1970	(3) Average Total Fertility 1980	(4) Average Total Fertility 1990	(5) Average Total Fertility 2000
Historic Plough Intensity	-0.782***	-0.715	-0.907**	-0.703**	-0.764***
	(0.230)	(0.449)	(0.386)	(0.331)	(0.274)
Constant	10.16***	4.450	7.960	15.31***	15.82***
	(3.138)	(6.220)	(5.522)	(4.814)	(4.322)
Observations	265	53	66	72	74
R-squared	0.555	0.465	0.679	0.688	0.740

OLS estimates are reported with robust standard errors in brackets.
All contemporaneous Independent variables & dependent variable are averaged by decade
***, **, * indicated significance at the 1%, 5%, and 10% levels.