On the Origins of Gender Roles: Women and the Plough*

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Abstract: This study seeks to better understand the historical origins of cross-cultural differences in beliefs about the appropriate role of women in society. We test the hypothesis that traditional agricultural practices influenced the historical gender division of labor and the evolution and persistence of gender norms. We find that, consistent with existing hypotheses, the descendants of societies that traditionally practiced plough agriculture, today have less equal gender norms, measured using reported gender-role attitudes and female participation in the workplace, politics and entrepreneurial activities. To test for the importance of culture, we examine second-generation immigrants living within Europe and the United States. We find that even among individuals born and raised in the same country, those with a heritage of traditional plough use exhibit less equal beliefs about gender roles today.

Keywords: Culture, beliefs, values, gender roles, historical persistence.

JEL Classification: D03, J16, N30.

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1. Introduction

It is becoming increasingly evident that many aspects of human behavior are guided by culture, defined as heuristics or rules-of-thumb that aid in decision-making, particularly in environments where the best decision is uncertain or difficult to determine (Boyd and Richerson, 1985). These heuristics often take the form of slowly changing beliefs about appropriate actions in different situations. A number of empirical studies have documented the persistence of these beliefs and their importance for decision-making (Henrich, Boyd, Bowles, Camerer, Gintis, McElreath and Fehr, 2001, Nisbett, 2003, Fisman and Miguel, 2007, Giuliano, 2007, Fernandez and Fogli, 2009, Algan and Cahuc, 2010, Voigtlander and Voth, 2012). Other studies, seeking to understand the origins of these differences, find that current cultural differences are explained by either historical factors (Greif, 1994, Guiso, Sapienza and Zingales, 2008a, Becker, Boeckh, Hainz and Woessman, 2010, Tabellini, 2010, Grosjean, 2011b, Nunn and Wantchekon, 2011) or environmental differences (Durante, 2010, Gneezy, Leibbrandt and List, 2011).[1]

This study aims to contribute to our understanding of the historical origins of current cultural differences in gender norms. In some societies, the dominant belief is that women should be allowed to participate freely, and equally to males, in employment outside of the home. In others, there is the very different view that the appropriate place for women is within the home, and they are discouraged from participating in activities outside of the domestic sphere. These differences can be most clearly seen in surveys that ask respondents their attitudes about gender roles. For example, the proportion of respondents in the *World Values Survey* that "agree" with the statement that "when jobs are scarce, men should have more right to a job than women" varies widely across countries, ranging from 3.6% (in Iceland) to 94.9% (in Egypt).[2]

We examine the origins of these differences by testing the well-established hypothesis, put forth by Ester Boserup (1970), that gender role differences have their origins in different forms of agriculture traditionally practiced in the pre-industrial period.[3] Boserup identifies important differences between shifting cultivation and plough cultivation. Shifting cultivation is labor intensive and uses hand-held tools like the hoe and the digging stick. Plough cultivation, by

[1] See Nunn (2012) for an overview of this literature.

[2] Objective outcomes, like female labor force participation (FLFP) that, to a large extent, reflect differences in gender beliefs also exhibit significant variation (Antecol, 2000, Fortin, 2005, Fernandez, 2007, Fernandez and Fogli, 2009). In 2000, the FLFP rate ranged from 16.1% (Pakistan) to 90.5% (Burundi).

[3] An important precursor to Boserup (1970) is Baumann's (1928) early study of the relationship between traditional gender roles and the use of the hoe in Africa.

contrast, is much more capital intensive, using the plough to prepare the soil. Unlike the hoe or digging stick, the plough requires significant upper body strength, grip strength, and burst of power, which are needed to either pull the plough or control the animal that pulls it. Because of these requirements, when plough agriculture is practiced, men have an advantage in farming relative to women.[4]

Given the important role of soil preparation in agriculture, which accounts for about one-third of the total time spent in agricultural tasks,[5] societies that traditionally practiced plough agriculture – rather than shifting cultivation – developed a specialization of production along gender lines. Men tended to work outside of the home in the fields, while women specialized in activities within the home. This division of labor then generated norms about the appropriate role of women in society. Societies characterized by plough agriculture, and the resulting gender-based division of labor, developed the belief that the natural place for women is within the home. These cultural beliefs tend to persist even if the economy moves out of agriculture, affecting the participation of women on activities performed outside of the home, such as market employment, entrepreneurship, or participation in politics.[6]

To test Boserup's hypothesis, we combine pre-industrial ethnographic data, reporting whether societies traditionally practiced plough agriculture, with contemporary measures of individuals' views about gender roles, as well as measures of female participation in activities outside of the home. Our analysis examines variation across countries, ethnic groups, and individuals. Consistent with Boserup's hypothesis, we find a strong and robust positive relationship between historical plough-use and unequal gender roles today. Traditional plough-use is positively correlated with attitudes reflecting gender inequality and negatively correlated with female labor force

[4]The gender-bias in ability is reinforced by the fact that when the plough is used, there is less need for weeding, a task typically undertaken by women and children (Foster and Rosenzweig, 1996). In addition, child care, a task almost universally performed by women, is most compatible with activities that can be stopped and resumed easily and do not put children in danger. These are characteristics that are satisfied for hoe agriculture, but not for plough agriculture, especially when animals are used to pull the plough.

[5]For example, Cain (1977), surveying the agricultural tasks of farmers in Bangladesh in 1976 and 1977, finds that ploughing accounts for one-third of the total time spent in agricultural activities. Similarly, according to a 1968 survey of farmers in the Ethiopian highlands, ploughing accounts for 30% of production costs for teff, 34% for wheat, and 30% for barley (McCann, 1995, p. 101).

[6]Boserup (1970), in her analysis, most strongly argues for a relationship between traditional plough use and gender norms when she hypothesizes that the use of the veil may be associated with the use of the plough in agriculture. She writes that plough cultivation "shows a predominantly male labor force. The land is prepared for sowing by men using draught animals, and this…leaves little need for weeding the crop, which is usually the women's task…Because village women work less in agriculture, a considerable fraction of them are completely freed from farm work. Sometimes such women perform purely domestic duties, living in seclusion within their own homes only appearing in the street wearing a veil, a phenomenon associated with plough culture and seemingly unknown in regions of shifting cultivation where women do most of the agricultural toil." (pp. 13–14)

participation, female firm ownership, and female participation in politics.

Although these findings support Boserup's hypothesis, they are also consistent with other interpretations. For example, we would observe the same relationships if societies with attitudes favoring gender inequality were more likely to adopt the plough historically and if these attitudes continue to persist today. To better understand whether traditional plough use has a causal impact on subsequent cultural norms, we undertake a number of different strategies.

The first is to control for an exhaustive set of observable characteristics. In our baseline set of covariates we control for a number of historical characteristics of ethnic groups: the suitability of their environment for agriculture, whether they had domesticated animals, the extent to which they lived in tropical climates, their level of political development and their level of economic development. In addition we also flexibly control for current country-level per capita GDP. In auxiliary regressions, we also control for a number of additional historical characteristics of ethnic groups which are potentially correlated with traditional plough use and beliefs about gender roles today. These include: the extent to which intensive agriculture was practiced, traditional private property rights, the practice of patrilocal vs. matrilocal marriage, the proportion of subsistence that is obtained from herding, the proportion of subsistence from hunting, the structure of family cohabitation, and the year that the historical characteristics were recorded. We also control for contemporary characteristics. These include: the intensity of civil and interstate conflicts over the past 200 years, an indicator for past experience under communism, the fraction of the current population that is of European descent, the trade-to-GDP ratio, the share of GDP in agriculture, the share in manufacturing, the share in services, the fraction of the population belonging to each of the five major religious denominations (Muslim, Hindu, Catholic, Protestant, and other Christian denominations). We find that the results remain robust to controlling for these observable characteristics, either individually or simultaneously. In all specifications, the point estimate for traditional plough use remains significant and of a similar magnitude as our baseline specification.

Our second strategy is to exploit variation in traditional plough use due to specific geo-climatic characteristics that impacted which types of crops could be grown in historical locations. As Pryor (1985) shows, the benefit of using the plough differs depending on the crop cultivated. The plough is more beneficial for crops that require large tracts of land to be prepared in a short period of time (e.g., due to multiple-cropping), and that can only be grown in soils that are not shallow,

not sloped, and not rocky.[7] These crops, which Pryor refers to as 'plough-positive', include teff, wheat, barley, rye and wet rice. These can be contrasted to 'plough-negative' crops, such as maize, sorghum, millet and various types of root and tree crops, which require less land to be prepared over a longer period of time, and/or can be cultivated on thin, sloped or rocky soils, where using the plough is difficult. Unlike plough-positive crops, plough-negative crops benefit much less from the adoption of the plough.

Using data from the FAO, we identify the geo-climatic suitability of finely defined locations for growing plough-positive cereals (wheat, barley and rye) and plough-negative cereals (sorghum and millet).[8] Except for their benefit from plough use the two types of cereals are otherwise very similar. Both have been cultivated in the Eastern Hemisphere since the Neolithic revolution; require similar preparations for consumption, all being used for flour, porridge, bread or in beverages; and produce similar yields and therefore are able to support similar population densities. We use the relative differences in ethnic groups' geo-climatic conditions for growing plough-positive and plough-negative cereals as instruments for historical plough use. Motivated by concerns that our instruments may be correlated with other geographic characteristics, we check that the estimates are robust to flexibly controlling for geographic covariates, including overall agricultural suitability, temperature, precipitation, soil depth and slope.

We find that the IV procedure generates estimates that are consistent with the OLS estimates. Traditional plough use is associated with attitudes reflecting greater gender inequality, as well as less female labor force participation, less female firm-ownership, and less female participation in politics.

Our analysis then turns to underlying mechanisms. It is possible that the long-term impact of the plough reflects persistent cultural beliefs. However, it is also possible that part of the long-term impact arises because historical plough-use promoted the development of institutions, policies and markets that are less conducive to the participation of women in activities outside of the home.[9] To distinguish these two channels we exploit the fact that cultural norms and

[7]For a recent study documenting the link between soil type and plough-use in modern India see Carranza (2010). In particular, she shows that in contemporary India plough technology is more likely to be adopted with deep loamy soils rather than shallow clay soils. She also shows that plough use is associated with less participation of women in agriculture.

[8]We are unable to include dry rice and wet rice in the two groups because the GAEZ 2002 database does not report grid-cell level suitability for the two types of rice separately.

[9]See the recent studies by Alesina, Algan, Cahuc and Giuliano (2010), Guiso, Sapienza and Zingales (2008b) and Tabellini (2008) that investigate feedback effects between culture and institutions.

beliefs – unlike institutions, policies and markets – are internal to the individual. Therefore, when individuals move, their beliefs and values move with them, but their external environment remains behind. Exploiting this fact, we examine variation in cultural heritage among second-generation immigrants living in either the US or Europe. All individuals born and raised abroad have been exposed to the same institutions and markets. In effect, the analysis holds external factors constant, while examining variation in individuals' internal beliefs and values. We find that individuals from cultures that historically used the plough have less equal gender norms, and that women from cultures that used the plough participate less in the work force. These results provide evidence that part of the importance of the plough arises through its impact on internal beliefs and values.

Our findings contribute to a deeper understanding of the origins of cultural norms and beliefs. Studies have documented the continuity of cultural norms over remarkably long periods of time (e.g., Voigtlander and Voth, 2012). Others show that historical factors influence the evolution of culture over time by affecting the relative costs and benefits of different cultural traits. Guiso et al. (2008a) provide evidence that the formation of medieval communes had a long-term impact on the levels of social capital within Northern Italy. Similarly, Becker et al. (2010) and Grosjean (2011b) provide evidence of historical state boundaries – the Habsburgs and the Ottomans – having lasting cultural impacts. Nunn and Wantchekon (2011) show that Africa's slave trades generated a culture of distrust which continues to persist until today.[10] Nisbett and Cohen (1996) and Grosjean (2011a) show that the 'culture of honor' in the US South has its origins in a tradition of herding among the Scots-Irish. The findings of our paper adds to this line of enquiry by providing additional evidence and showing that historical factors – namely differences in traditional farming practices – have shaped the evolution of norms and beliefs about the appropriate role of women in society.

Our findings also provide empirical evidence that complements existing descriptive studies, from history, anthropology and sociology, that consider the historical impacts of traditional plough use on gender norms (e.g., Baumann, 1928, Goody, 1976, Whyte, 1978, Braudel, 1998). Our analysis also contributes to these studies by showing that a tradition of plough agriculture has persistent impacts that are important for outcomes today.

[10] Another line of enquiry examines how a society's physical environment affect the cultural norms that developed. See for example Durante (2010) and Gneezy et al. (2011).

Our focus on a historical determinant of gender roles is not meant to imply that short-run other factors are unimportant. A number of existing studies have shown the importance of determinants like economic development, medical progress, and the production structure of the economy (e.g., Goldin, 2006, Ross, 2008, Albanesi and Olivetti, 2007, 2009, Iversen and Rosenbluth, 2010). As we show in section 4, even accounting for these important factors, there is a strong persistent impact of traditional plough use on gender norms today.

The paper is organized as follows. In the next section, we begin our analysis by first documenting that in societies that traditionally used plough agriculture, women did in fact participate less in farm-work and other activities outside of the domestic sphere. In section 3, we then explain the procedure used to link traditional plough use, which is measured at the ethnicity level, to contemporary data on gender norms and female participation outside of the home. Sections 4 reports OLS estimates of the relationship between traditional plough use and gender outcomes today, examining variation across individuals and countries. Section 5 turns to the issue of causality, reporting OLS estimates that control for an extensive set of observable characteristics, as well as the IV estimates. In section 6, we then turn to mechanisms, using second-generation immigrants in the US and European countries to test for persistent impacts of the plough working through cultural transmission. Section 7 offers concluding thoughts.

2. The historical impacts of traditional plough agriculture

We begin our analysis by first confirming that societies that traditionally used plough agriculture had lower female participation in agricultural activities. We also check whether plough use was associated with differences in other activities within and outside of the domestic sphere.

Our analysis uses information on pre-industrial plough use from the *Ethnographic Atlas*, a world wide ethnicity-level database constructed by George Peter Murdock that contains ethnographic information for 1,265 ethnic groups. Information for societies in the sample have been coded for the earliest period for which satisfactory ethnographic data are available or can be reconstructed. The earliest observation dates are for groups in the Old World where early written evidence is available. For the parts of the world without a written history, the information is from the earliest observers of these cultures. For some cultures the first recorded information is from the early 20th century; but even for these cultures, the data capture as much as possible the

characteristics of the ethnic group prior to European contact. For all groups in the dataset, the variables are taken from the societies prior to industrialization.

The database provides information on whether societies traditionally used the plough. Ethnicities are classified into one of three mutually exclusive categories: (*i*) the plough was absent, (*ii*) the plough existed at the time the group was observed but it was not aboriginal, and (*iii*) the plough was aboriginal and found in the society prior to contact. There are data on plough use for 1,158 of the 1,265 societies in the database. There is no evidence of groups switching from one form of agriculture to another and then back again. In other words, the use of the plough, once adopted, remains stable over time. Using this categorization, we construct an indicator variable for plough use which equals one if the plough was present (whether aboriginal or not) and zero otherwise.

It is possible that the plough has a larger impact on gender norms if it was adopted early. However, because of data limitation, we are unable to test for this. From the database we only know the approximate date of adoption if it occurred after European contact. For the others, we do not have any information on the timing of adoption. Given this, our estimates should be interpreted as the average effect of having adopted the plough among all ethnic groups that did so prior to industrialization. There may be heterogeneity within the group of adopters (e.g. based on date of adoption), but we are only able to estimate an average effect.

We measure traditional female participation in agriculture using information on the gender division of labor in agriculture reported in the *Ethnographic Atlas*. Ethnicities are grouped into one of the following five categories measuring relative participation in agriculture by gender: (1) males only, (2) males appreciably more, (3) equal participation, (4) female appreciably more, and (5) females only.[11] Using this information, we construct a variable that takes on integer values ranging from 1 to 5 and increases with female specialization in agriculture.[12]

When examining the relationship between the gender division of labor in agriculture and plough use, we control for a number of characteristics of ethnic groups that may be correlated with plough use and gender roles. We control for the presence of large domesticated animals, a

[11]The original classification in the *Ethnographic Atlas* distinguishes between "differentiated but equal participation" and "equal participation". Since this distinction is not relevant for our purposes, we combine the two categories into a single category of equal participation.

[12]For 232 ethnic groups, agriculture was not practiced and therefore there is no measure of female participation in agriculture. For an additional 315 ethnic groups, information for the variable is missing. These ethnic groups (547 in total) are omitted from the analysis.

measure of economic development, and a measure of political complexity. All measures are from the *Ethnographic Atlas*.[13] The presence of domesticated animals is measured with an indicator variable that equals one if domesticated bovine or equine animals were present. Economic development is measured using the density of ethnic groups' settlements. Ethnicities are grouped into the following categories: (1) nomadic or fully migratory, (2) semi-nomadic, (3) semi-sedentary, (4) compact but not permanent settlements, neighborhoods of dispersed family homesteads, (5) separate hamlets, (6) forming a single community, (7) compact and relatively permanent settlements and (8) complex settlements. With this information, we construct a variable that takes on integer values, ranging from 1 to 8, and increases with settlement density. Political complexity is measured by the levels of jurisdictional hierarchies in the society.

We also control for two measures of the geographic conditions of the traditional location of each ethnic groups. For each ethnicity we know the geographic coordinates of the centroid of the group historically. Using this information, we calculate the fraction of land within a 200 kilometer radius of the centroid that is defined as suitable for the cultivation of crops. The crop suitability data are from the FAO's *Global Agro-Ecological Zones* (GAEZ) 2002 database (Fischer, van Nelthuizen, Shah and Nachtergaele, 2002), which reports suitability measures for 5 arc minute by 5 arc minute (approximately 56 km by 56 km) grid-cells globally. We also use the same procedure to control for the proportion of land within a 200 kilometer radius that is defined as being tropical or subtropical.

OLS estimates examining the historical relationship between traditional plough use and female participation in agriculture are reported in column 1 of Table 1. The specification reported includes the five controls variables. The estimates identify a negative relationship between plough use and participation of women in agriculture. The use of the plough is associated with a reduction in the female participation in agriculture variable of 0.86, which is large given that the standard deviation of the variable is 1.0. This is consistent with the analysis of Boserup (1970), as well as the observations of anthropologists like Baumann (1928) and Whyte (1978).

A natural question that arises is the exact nature of this decline in female participation in agriculture; specifically, whether the decline is in all agricultural tasks or is it focused in only a few (such as soil preparation). Unfortunately, the *Ethnographic Atlas* does not provide similar information for specific tasks within agriculture. We therefore complement our analysis by

[13]Further details are provided in the paper's appendix.

Table 1: Traditional plough agriculture and female participation in agricultural activities.

	Dependent variable: Participation of females relative to males in the following tasks:						
	Overall agriculture		Land clearance	Soil preparation	Planting	Crop tending	Harvesting
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Traditional plough agriculture	-0.861***	-1.133***	-0.414**	-1.164***	-1.244***	-1.033***	-0.770**
	(0.217)	(0.272)	(0.200)	(0.355)	(0.341)	(0.367)	(0.308)
Ethnographic controls	yes	yes	yes	yes	yes	yes	yes
Observations	660	124	129	124	131	122	131
R-squared	0.135	0.223	0.151	0.133	0.131	0.185	0.190

Notes: The unit of observation is an ethnic group. In column 1 ethnic groups are from the *Ethnographic Atlas* and in columns 2-7 they are from the *Standard Cross Cultural Sample*. Each dependent variable measures female participation in a particular activity (e.g., agriculture). The variables take on integer values between 1 and 5 and are increasing in female participation. Coefficients are reported with robust standard errors in brackets. In column 1, we report Conley standard errors adjusted for spatial correlation (assuming a window that is sixty degrees latitude and sixty degrees longitude). ***, ** and * indicate significance at the 1, 5 and 10% levels.

using Murdock and White's (1969) *Standard Cross-Cultural Sample* (SCCS) which does contain this information. The SCCS contains ethnographic information on 186 societies, intentionally chosen to be representative of the full sample, and to be historically and culturally independent from the other ethnic groups in the sample. The database was constructed by first grouping the 1265 societies from the *Ethnographic Atlas* into 186 clusters of closely related cultures. A particularly well-documented and representative ethnic group was then chosen for each cluster and these constitute the observations in the SCCS.

Using the SCCS data, we first replicate the regression reported in column 1. As shown in column 2, we find a similar result: plough use is associated with a decline in female participation in agriculture of 1.13, which is equal to a one standard deviation change in the dependent variable. In columns 3–7, we estimate the association between plough use and female participation in the following agricultural tasks: land clearance, soil preparation, planting, crop tending and harvesting. The estimates show that plough use is associated with less female participation in all agricultural tasks, with the largest declines in soil preparation, planting and crop tending.

In columns 1–9 of Table 2, we consider the relationship between plough use and female participation in the following non-agricultural activities: caring for small animals, caring for large animals, milking, cooking, fuel gathering, water fetching, burden carrying, handicraft production and trading.[14] We find that the plough tends not to be significantly correlated with female participation in other activities. The exception is that plough use is associated with significantly

[14]If an activity is not present in a society, then the dependent variable is coded as missing. This accounts for the different number of observations in each regression.

Table 2: Historical plough use and female participation in non-agricultural activities and female well-being.

	Dependent variable: Participation of females relative to males in the following tasks:									
	Caring for small animals	Caring for large animals	Milking	Cooking	Fuel gathering	Water fetching	Burden carrying	Handicrafts	Trading	Female height / Male height
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Traditional plough agriculture	0.296	0.173	0.318	-0.006	-0.813*	-0.166	-1.138***	-0.310	-0.156	-0.013***
	(0.574)	(0.285)	(0.736)	(0.128)	(0.420)	(0.246)	(0.374)	(0.307)	(0.505)	(0.002)
Ethnographic controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	88	95	48	173	159	154	135	74	59	119
R-squared	0.036	0.054	0.094	0.039	0.046	0.045	0.162	0.164	0.086	0.410

Notes: The unit of observation is an ethnic group. In columns 1-9 ethnic groups are from the *Standard Cross Cultural Sample*. The dependent variable measures female participation in a particular activity. The variables take on integer values between 1 and 5 and are increasing in female participation. In column 10, the observation is an ethnicity from the Ethnographic Atlas for which skeletal height data by gender are available. Coefficients are reported with robust standard errors in brackets. The coefficient estimate in column (10) is from WLS estimates with weights given by the number of individuals for which height data are available in an ethnic group. ***, ** and * indicate significance at the 1, 5 and 10% levels.

less female participation in fuel gathering and burden carrying. We find some evidence of more female participation in caring for large animals, caring for small animals and milking, although none of the coefficients is statistically significant.

Ideally, in addition to measuring female participation in agricultural work, our analysis would also examine the relationship between past plough use and traditional attitudes about the role of women in society. Although direct measures of such outcomes are not available historically, an indirect proxy is available using gender-specific height data. Because adult height is impacted by the stock of nutritional investments during an individual's growing years, the relative heights of females relative to males reflects differential access to nutrition by gender, which is an objective measure of the perceived value of girls relative to boys. Height data by gender are from a wide variety of secondary ethnographic sources and has been compiled by Gustafsson and Lindenfors (2004).[15]

Column 10 reports WLS estimates of the relationship between traditional plough cultivation and the ratio of female-to-male heights. According to the estimates, plough use decreases the heights of females relative to males by 1.3 percentage points. This is a sizable impact given that the standard deviation of the height ratio is 0.012.

3. Linking the past to the present: Data and methodology

We next turn to an examination of the long-term impact of traditional plough use. To do this, we link historical plough-use, measured at the ethnicity level, with current outcomes of interest,

[15]Samples of various sizes are taken from 124 human populations. Heights are measured in centimeters.

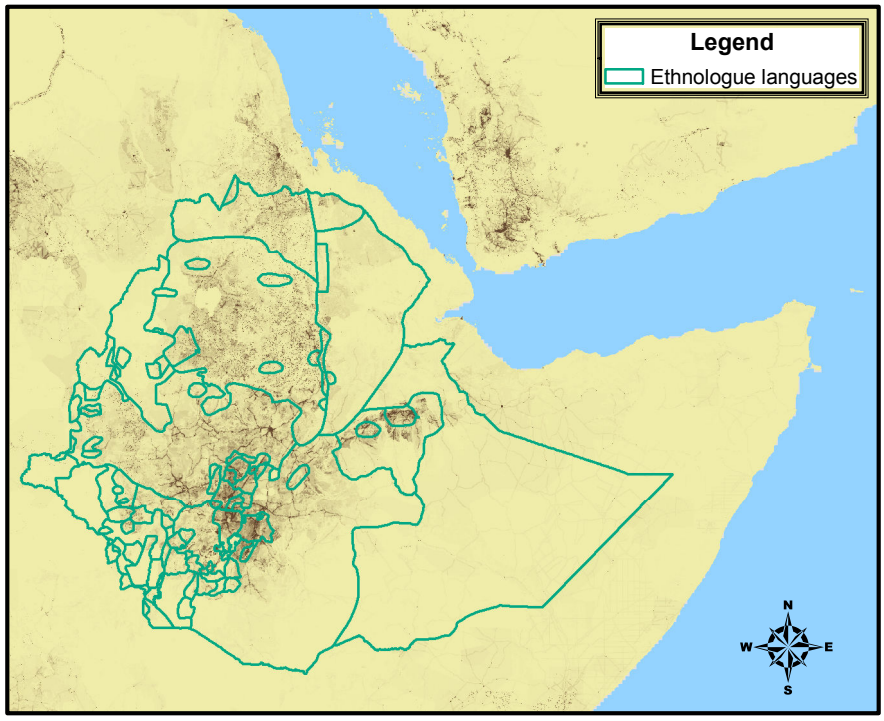
measured at the location-level (either countries or districts within countries) today. This requires an estimate of the geographic distribution of ethnicities across the globe today. We construct this information using the 15th edition of the *Ethnologue: Languages of the World* (Gordon, 2005), a data source that maps the current geographic distribution of 7,612 different languages, each of which we manually matched to one of the 1,265 ethnic groups from the *Ethnographic Atlas*. The *Ethnologue* provides a shape file that divides the world's land into polygons, with each polygon indicating the location of a specific language. We also use the *Landscan 2000* database, which reports estimates of the world's population for 30 arc-second by 30 arc-second (roughly 1 km by 1 km) grid-cells globally.[16] We combine the *Ethnologue* shape file with the *Landscan* raster file to obtain an estimate of the distribution of language groups across the globe today. This information is used to link the historical ethnicity-level data to our current outcomes of interest, measured at the location-level.

We illustrate our procedure with the example of Ethiopia. Figure 1a shows a map of the land inhabited by different ethnic groups, i.e. groups speaking different languages. Each polygon represents the approximate borders of a group (from *Ethnologue*). One should not think of the borders as precisely defined boundaries, but rather as rough measures indicating the approximate locations of different language groups. The map also shows the *Landscan* estimate of the population of each cell within the country. A darker shade indicates greater population.

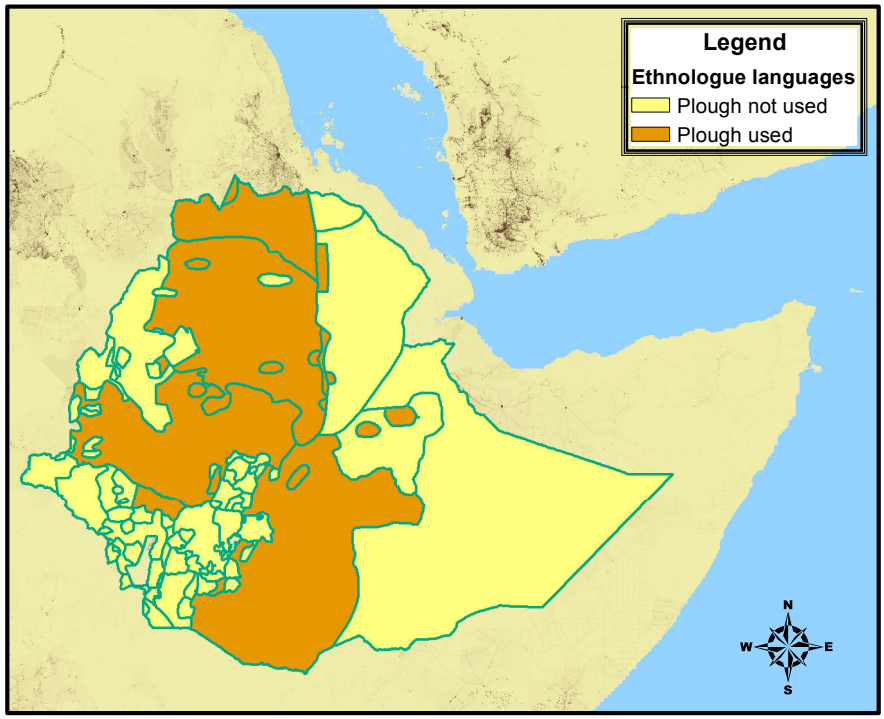
From the *Ethnographic Atlas* we know whether each ethnic group used the plough historically. We define I_e^{plough} to be a variable equal to one if ethnic group e engaged in plough agriculture and zero otherwise. By matching each of the 7,612 *Ethnologue* language groups to one of the 1,265 *Ethnographic Atlas* ethnic groups for which we have traditional plough-use information, we can identify, for each language group, whether their ancestors engaged in plough agriculture. This information is shown in Figure 1b.

We then use information on the location of modern district and country boundaries to construct district-level and country-level averages of traditional plough use. The procedure, which is shown visually for the district-level averages in Figures 2a and 2b, creates a population-weighted average plough measure for all grid-cells within a district (or country). This provides an estimate of the fraction of the population currently living in a district (or country) with ancestors that

[16]The *Landscan 2000* database was produced by Oakridge Laboratories in cooperation with the US Government and NASA.

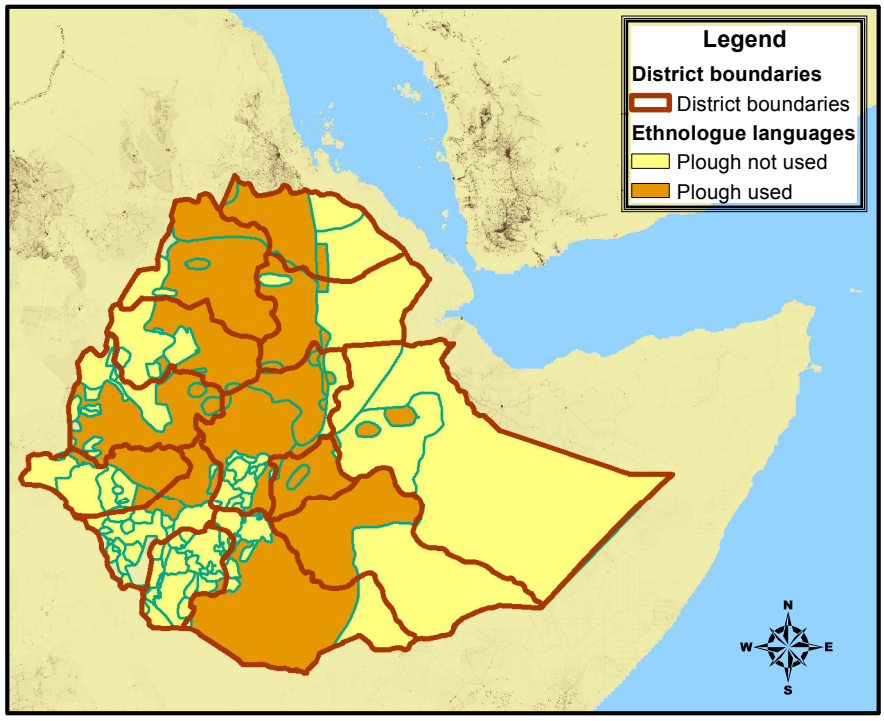


(a) Population density and language groups

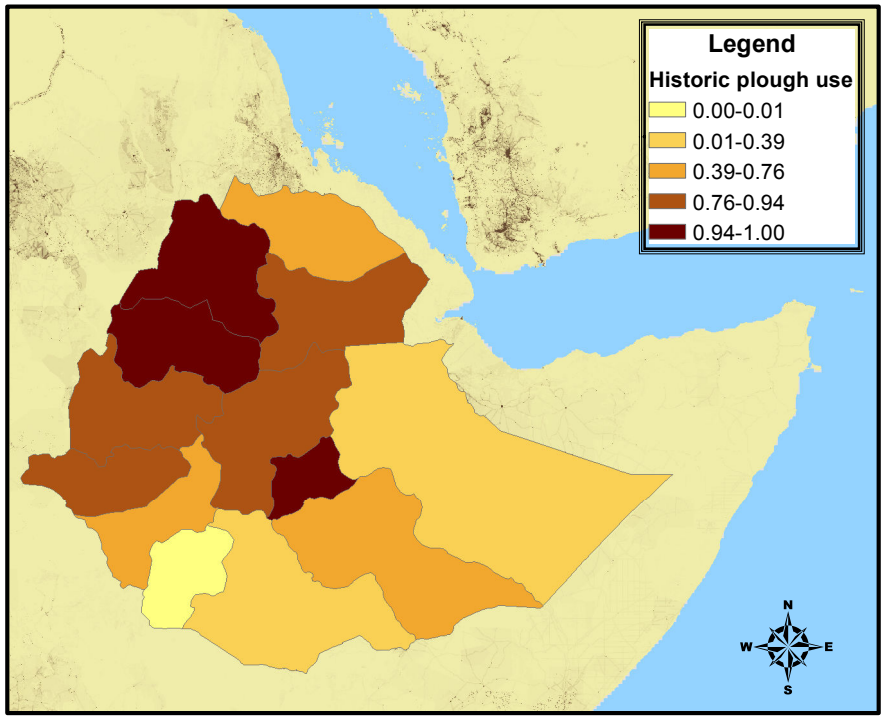


(b) Population density, language groups and their traditional plough use

Figure 1: Populations, language groups, and historical plough-use within Ethiopia.



(a) Population density, language groups their traditional plough use, and districts today



(b) District averages of plough use among inhabitants' ancestors

Figure 2: Traditional plough-use across districts within Ethiopia

traditionally engaged in plough agriculture.

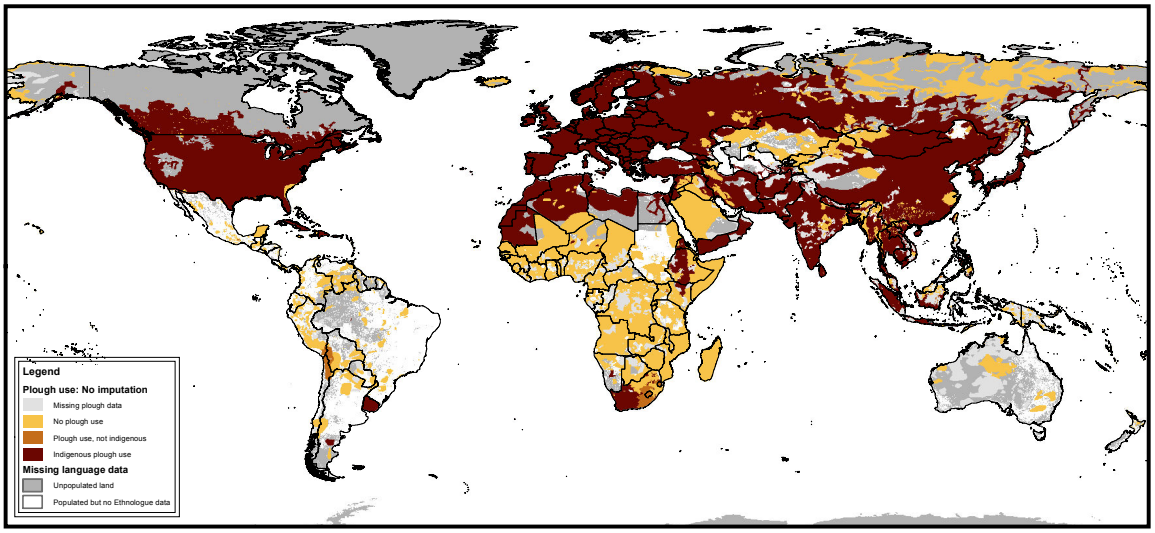
To be more precise, let $N_{e,i,d,c}$ denote the number of individuals of ethnicity e living in grid-cell i located in district d in country c. We construct a population-weighted average of I_e^{plough} for all ethnic groups living in a district d. The district-level measure of the fraction of the population with ancestors that traditionally used the plough, $\text{Plough}_{d,c}$, is given by:

$$\text{Plough}_{d,c} = \sum_e \sum_i \frac{N_{e,i,d,c}}{N_{d,c}} \cdot I_e^{plough} \tag{1}$$

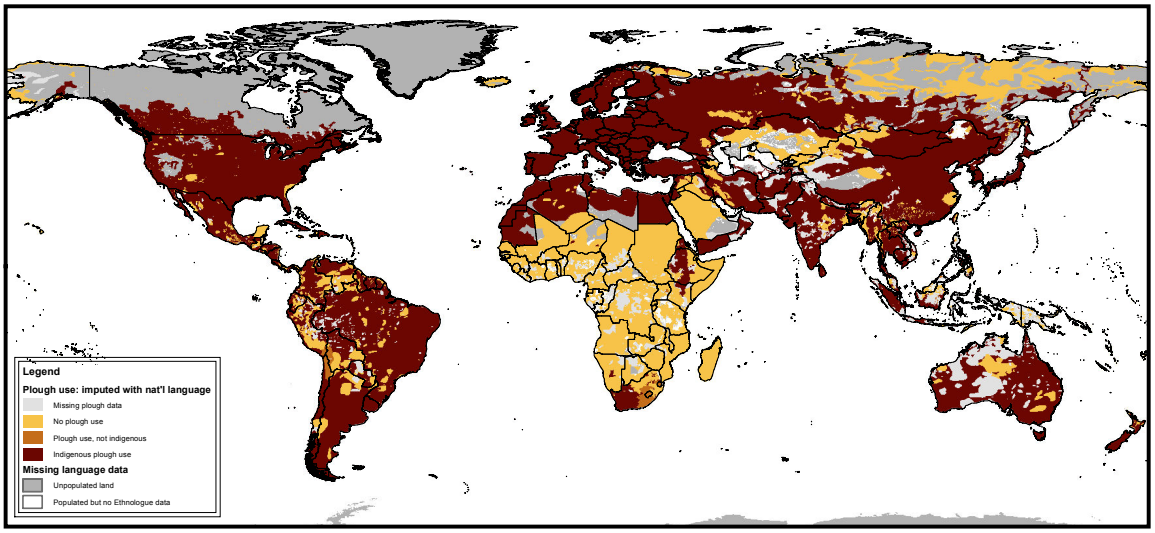
where $N_{d,c}$ is the total number of people living in district d in country c. The same procedure is also used to construct a country-level measure Plough_c, except that the average is taken over all grid-cells in country c.

Figure 3a shows the global distribution of languages based on the *Ethnologue* data, as well as the historical plough use for each group (i.e., the global version of Figure 1b). Uninhabited land is shown as dark grey. One shortcoming of the *Ethnologue* data is that information is missing for some parts of the world. This is due to uncertainty or a lack of information about the boundaries of some language groups. As is apparent from Figure 3a, this primarily occurs in Latin America and Australia. We undertake three strategies to address this issue. The first is to ignore the missing languages and calculate country and district measures using the data that exist. This is the strategy that has been undertaken by other studies using the *Ethnologue* language data (e.g., Michalopoulos, 2012). Our second strategy is to assume that all inhabitants in the unclassified territories speak the national language of the country. The spatial distribution of historical plough use using this imputation procedure is reported in Figure 3b. Our third strategy is to impute the missing data using information on the spatial distribution of ethnic groups from the *Geo-Referencing of Ethnic Groups* (GREG) database (Weidmann, Rod and Cederman, 2010). Like the *Ethnologue*, the GREG database provides a shape file that divides the world's land into polygons, with each polygon indicating the location of a specific ethnicity. The shortcoming of the GREG database is that ethnic groups are much less finely identified relative to the *Ethnologue* database. The GREG database identifies 1,364 ethnic groups, while the *Ethnologue* identifies 7,612 language groups.[17] The spatial distribution of traditional plough agriculture using this procedure is shown in Figure 3c.

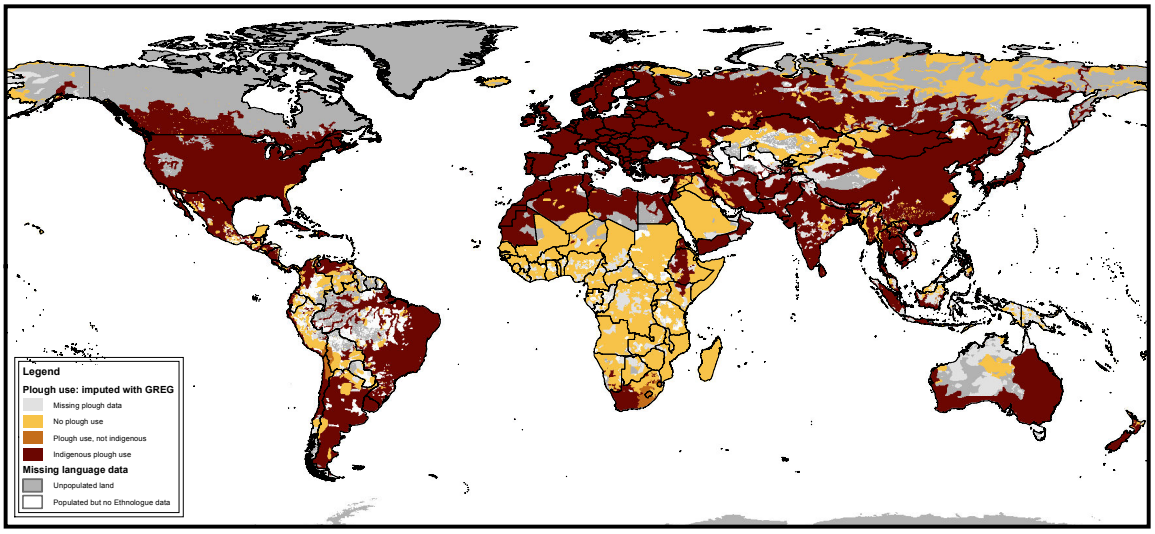
[17] An alternative strategy is to rely only on the coarser GREG classification and map. Our results are robust to this procedure as well.



(a) Missing language information not imputed

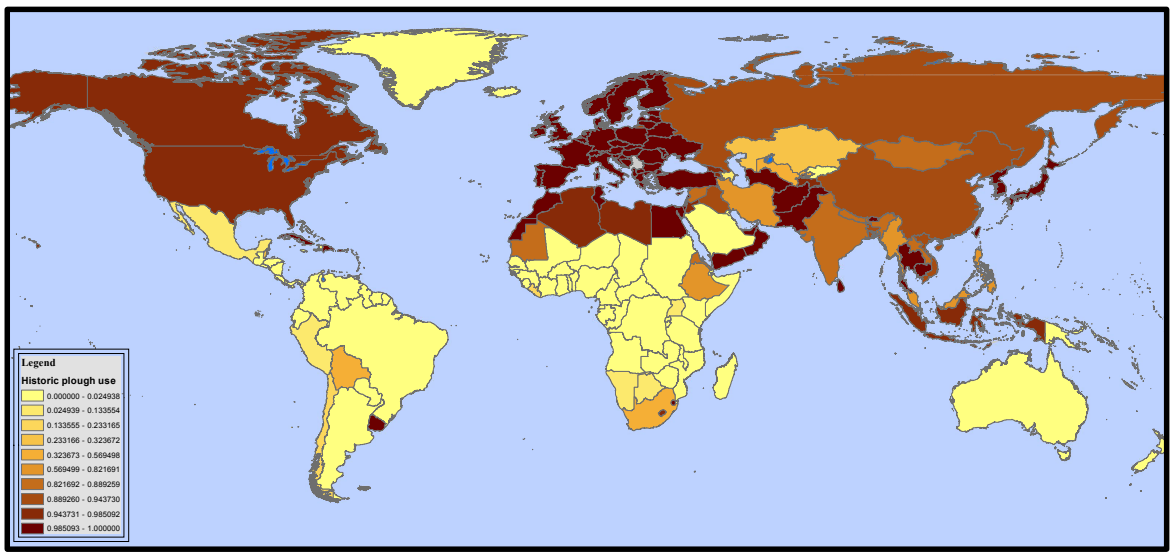


(b) Missing language information imputed using the country's official language

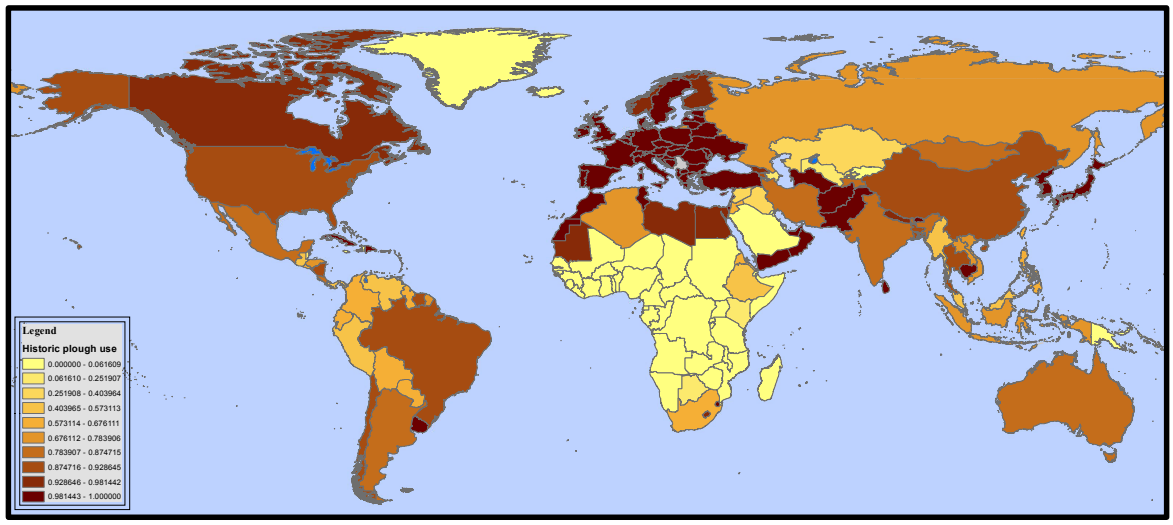


(c) Missing language information imputed using GREG ethnic groups

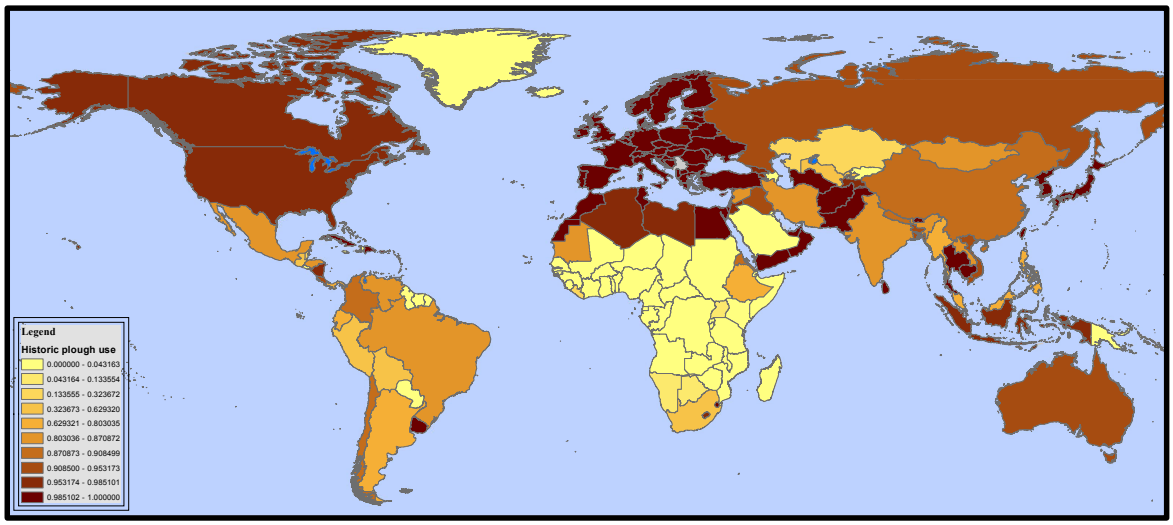
Figure 3: Historical plough use among the ethnic/language groups globally



(a) Missing language information not imputed



(b) Missing language information imputed using the country's official language



(c) Missing language information imputed using GREG ethnic groups

Figure 4: Average historical plough use among the ancestors of each country

In Figures 4a–4c, we report population weighted, country-level averages of historical plough use for each of the three strategies used to address the missing language data. In our analysis, we use the plough variable that was constructed without missing values imputed as our baseline measure. Our results are robust to the use of either method that imputes the missing language data. The robustness is explained by the high correlation among the three plough measures. At the country-level, the correlation between: (*i*) our baseline variable and the measure with missing languages imputed using the country's national language is 0.89; (*ii*) our baseline measure and the measure imputed using ethnic groups from the GREG database is 0.91; and (*iii*) the two variables with imputed values is 0.99.[18]

4. OLS estimates

Having constructed country- and district-level measures of traditional plough use, we are able to examine the relationship between historical plough use and the role of women in societies today. We begin by examining variation at the country level.

A. *Country-level estimates*

We test Boserup's hypothesis by estimating the following equation:

$$y_c = \alpha + \beta \, \text{Plough}_c + \mathbf{X_c^C \Gamma} + \mathbf{X_c^H \Pi} + \varepsilon_c \tag{2}$$

where y is an outcome of interest, c denotes countries, Plough_c is our measure of the historical use of the plough among the ancestors of the citizens in country c, and $\mathbf{X_c^C}$ and $\mathbf{X_c^H}$ are vectors of current controls and historical ethnographic controls, all measured at the country level. $\mathbf{X_c^C}$ includes the natural log of a country's real per capita GDP measured in 2000, as well as the variable squared. Allowing for a non-linear relationship is motivated by the well-established non-linear U-shaped relationship between economic development and female labor force participation (Goldin, 1995). Because many contemporary covariates could possibly be endogenous to the form of traditional agricultural, we begin by only controlling for a sparse set of contemporary variables. In subsequent analysis we include additional control variables, even those that are potentially endogenous to traditional agriculture, to assess the robustness of our results.

[18] Descriptive statistics for the three measures are reported in Appendix Table A1.

Our estimation includes a number of historical country-level control variables $\mathbf{X}_c^{\mathbf{H}}$, to control for historical differences between societies that had adopted plough agriculture and those that had not. They include: the presence of domesticated bovine or equine animals, economic development measured by the density of settlement, levels of political authority in the society, agricultural suitability, and the presence of a tropical climate. These are the same set of historical controls as in the regressions reported in Tables 1 and 2. We construct country-level measures of each variable using the same procedure that is used to construct the historical plough use variable. Thus, the ethnographic controls capture the historical characteristics of a country's ancestors.

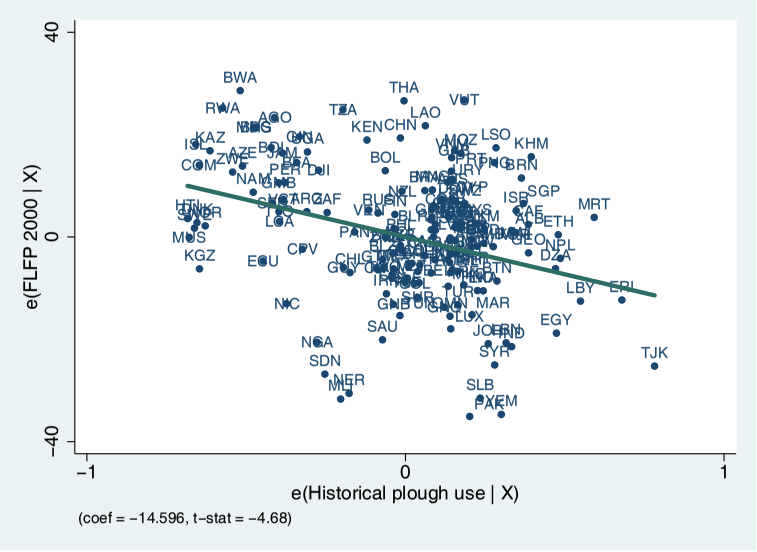
Table 3 reports country-level OLS estimates. In columns 1 and 2, the dependent variable is a country's female labor force participation rate (FLFP) in 2000.[19] In columns 3–6, we examine women's participation in more narrowly specified activities outside of the domestic sphere: entrepreneurship (measured by the share of firms with owners or managers that are female) and national politics (measured by the proportion of seats held by women in national parliament).[20] The even numbered columns include controls for continent fixed effects, while the odd numbered columns do not. The estimates show that in countries with a tradition of plough use, women are less likely to participate in the labor market, are less likely to own or manage firms, and are less likely to participate in politics.[21] All coefficients are negative and statistically significant.

The partial correlation plots for traditional plough use are shown in Figures 5a–5c (for columns 1, 3 and 5). From the figures it is clear that the coefficients for traditional plough use are not being influenced by a small number of countries. The plots also show that the coefficient estimates are not only identified from broad differences across regions, but from finer within-region variation. For example, we observe African countries in the Northwest corner (e.g., Rwanda, Madagascar) and in the Southeast corner (e.g., Eritrea, Mauritania, Ethiopia, etc). This is confirmed by the fact that the point estimates controlling for region fixed effects are essentially identical to the estimates without the fixed effects (comparing the odd numbered columns to the even numbered columns in Table 3).

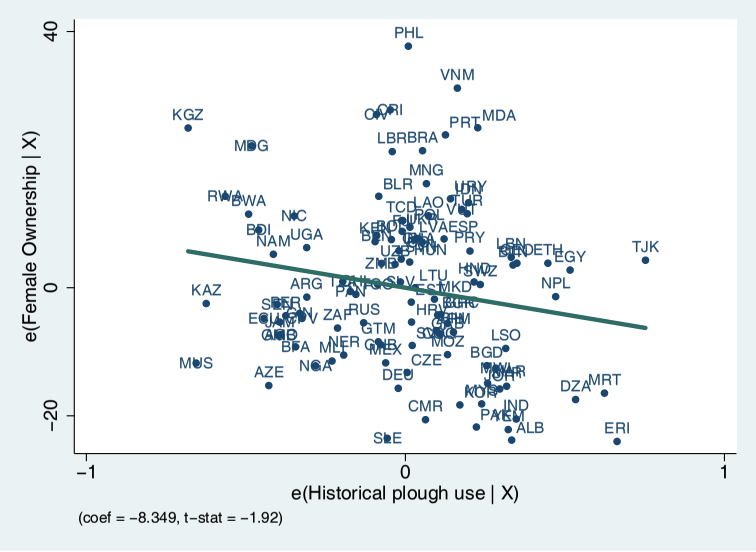
[19]FLFP is taken from the World Bank's *World Development Indicators*. The variable is measured as the percentage of women aged 15 to 64 that are in the labor force; it ranges from 0 to 100.

[20]The share of a country's firms with some female ownership is measured as the percentage of surveyed firms with a woman among the principal owners. The data are from the World Bank *Enterprise Surveys*. The proportion of seats in national parliament is measured as the percent of parliamentary seats, in a single or lower chamber, held by women. The variable, measured in 2000, is taken from the United Nations' *Women's Indicators and Statistics Database*.

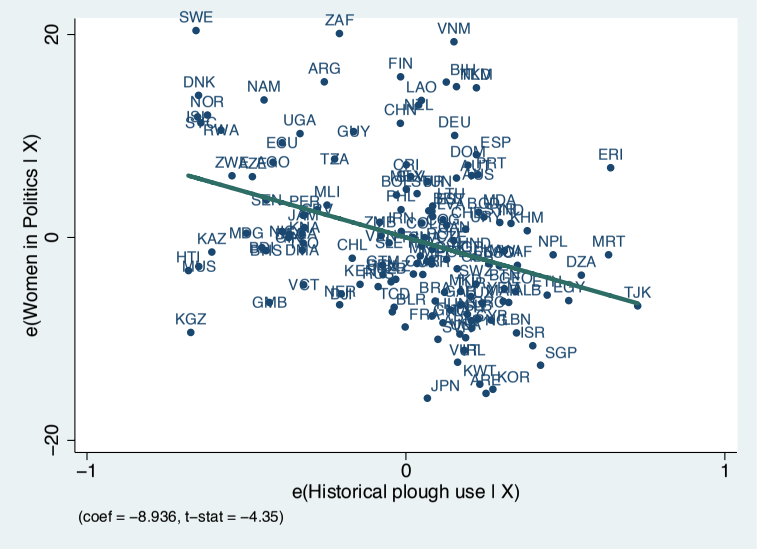
[21]Many countries have introduced quotas to increase the participation of women in politics. We have checked the robustness of our results excluding countries with gender quotas. For the restricted sample of 103 countries, the estimated coefficient is -10.65 with a standard error of 2.24.



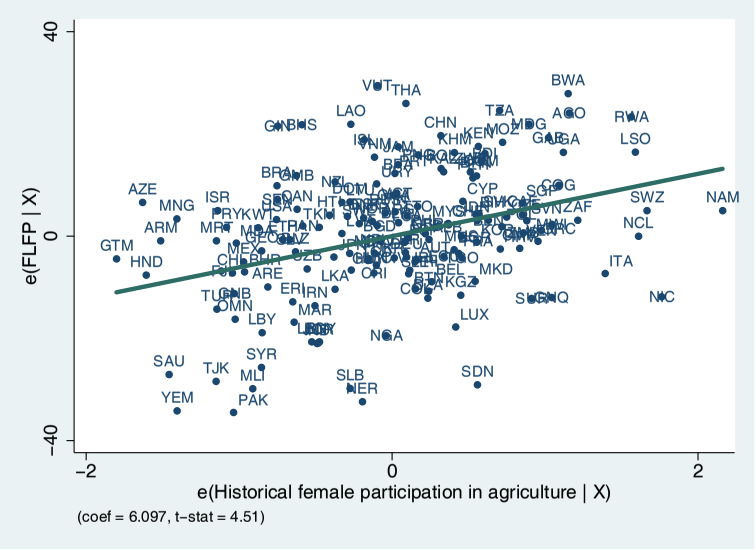
(a) Traditional plough use and current FLFP



(b) Traditional plough use and current female firm ownership



(c) Traditional plough use and current female participation in politics



(d) Traditional female participation in agriculture and current FLFP

Figure 5: Partial correlation plots.

Table 3: Country level OLS estimates.

	Dependent variable:							
	Female labor force participation		Share of firms with some female ownership		Females in politics		Average effect size (AES)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Traditional plough use	-14.596***	-13.542***	-8.349*	-11.569**	-8.936***	-8.930***	-0.896***	-0.934***
	(3.12)	(3.058)	(4.358)	(5.529)	(2.053)	(2.137)	(0.137)	(0.135)
Historical controls:								
Agricultural suitability	yes	yes	yes	yes	yes	yes	yes	yes
Domesticated animals	yes	yes	yes	yes	yes	yes	yes	yes
Tropics	yes	yes	yes	yes	yes	yes	yes	yes
Political hierarchies	yes	yes	yes	yes	yes	yes	yes	yes
Economic complexity	yes	yes	yes	yes	yes	yes	yes	yes
Contemporary controls:								
ln income, ln income^2	yes	yes	yes	yes	yes	yes	yes	yes
Continent fixed effects	no	yes	no	yes	no	yes	no	yes
Observations	163	163	106	106	144	144	138[a]	138[a]
R-squared	0.413	0.426	0.132	0.208	0.358	0.392		

Notes: OLS estimates are reported with robust standard errors in brackets. The unit of observation is a country. ***, ** and * indicate significance at the 1, 5 and 10% levels.

[a]This is the average number of observations in the regressions for the three outcomes.

Not only are the coefficient estimates statistically significant, but they are also economically meaningful. Based on the estimates from column 1, a one-standard-deviation increase in traditional plough use (0.470) is associated with a reduction of female labor force participation (FLFP) of 6.86 percentage points (14.596×0.470), which is equal to 13.4% of the sample average for FLFP and 44% of its standard deviation. The impact of the same increase in traditional plough use on the share of firms with some female ownership (based on the column 3 estimates) is a reduction of 3.92 percentage points, which is 12% of the outcome's mean and 28% of its standard deviation. The reduction on the participation of women in politics (using the column 5 estimate) is 4.20 percentage points, which is 35% of the outcome's mean and 47% of its standard deviation.[22]

Columns 7 and 8 report the estimated average effect size (AES) for the three dependent variables examined in columns 1–6. We computed the AES following Kling, Liebman, Katz and Sanbonmatsu (2004). Let β^k indicate the estimated plough-use coefficient for outcome variable k and let σ^k denote the standard deviation of outcome k. Then, the average effect size is equal to $\frac{1}{K}\sum_{k=1}^{K}\frac{\beta^k}{\sigma^k}$, where K is the total number of outcome variables. To properly calculate the sample variance of the AES, the coefficients β^k are jointly estimated in a seemingly unrelated regression framework.[23] The AES estimates confirm the findings when examining the outcomes individually: historical plough use is associated with less female participation in activities outside of the home today. Moreover, the implied magnitudes are similar. According to the AES estimates

[22]See Appendix Table A1 for the means and standard deviations of the variables.

[23]See Clingingsmith, Khwaja and Kremer (2009) for an alternative application and further details.

of column 7, a one-unit increase in traditional plough use is associated with an average decrease (across the three outcomes) equal to 0.90 standard deviations.

An alternative way to assess the magnitude of the estimates is to calculate the proportion of the total variation that they explain. By this metric, traditional plough use also explains a sizable proportion of differences in gender roles across countries. When female labor force participation is the dependent variable (column 1 of Table 3), the inclusion of the historical plough use variable increases the R-squared by 0.078 (from 0.335 to 0.413). Therefore, traditional plough use accounts for 7.8% of the total variation in FLFP and 11.7% of the residual variation left unexplained by the control variables.[24] For the share of firms with female ownership, traditional plough use accounts for 3.1% of the total variation and 3.4% of the residual variation. For women's participation in politics, historical plough use explains 9.4% of the total variation and 12.8% of the residual variation.

Although we do not report the coefficients for the control variables here, we find that they are generally as expected.[25] For example, we find evidence of a U-shaped relationship between per capita income and female labor force participation, which is consistent with previous studies that also find this same non-monotonic relationship (Goldin, 1995).

One concern with the estimates reported is that many of the control variables are potentially endogenous to traditional plough use. For example, plough use may have influenced historical income levels which could persist until today, affecting current income. For this reason, in the Table A2 of the paper's online appendix, we also report the relationship between past plough use and the current outcomes, controlling only for continent fixed effects. We continue to find statistically significant relationships with magnitudes that are very similar to those reported in Table 3.

The persistence of female labor force participation

To this point, we have shown that historical plough use is associated with less female participation in agriculture historically and with less female participation in the labor force today. These two correlations suggest long-term persistence in female participation in activities outside of the home. To confirm this, we regress female labor force participation today on the measure

[24]This is calculated as: $(0.413 - 0.335)/(1 - 0.335) = 0.117$ or 11.7%.

[25]The estimates for the control variables are available upon request.

of women's historical participation in agriculture constructed from the *Ethnographic Atlas*. The regression also controls for our full set of covariates from equation (2). The partial correlation plot illustrating the relationship between the two variables is shown in Figure 5d. As is apparent from the figure, there is strong persistence over time. Female labor force participation today and female participation in agriculture in the past are very strongly correlated.

Despite the evidence of persistence over time on average, it is important to recognize that there are well-documented exceptions to this rule. For example, Goldin and Sokoloff (1984) document that within the Northeastern United States, the low relative productivity of women and children in agriculture (and their low participation in this sector) allowed them to actively participate in the manufacturing sector. In this setting, initial female labor force participation in agriculture is inversely related to subsequent participation in manufacturing, showing a lack of continuity of female labor force participation overtime as industrialization occurred.

B. *Individual-level estimates*

We now turn to our specification that examines variation across individuals, linking them to a tradition of plough agriculture using the district in which they live. The analysis relies on data from the *World Value Survey* (WVS), a compilation of national individual-level surveys on a wide variety of topics, including attitudes and preferences. They also include information on standard demographic characteristics, such as gender, age, education, labor market status, income and religion.[26] Using the WVS we construct an indicator variable that equals one if a woman is in the labor force, which is defined as full-time, part-time or self-employment. Women are not in the labor force if they report being retired, a housewife or a student.[27]

We also examine two measures of individual (male and female) attitudes about the appropriate role of women in society. The first measure is based on each respondent's view of the following statement: "When jobs are scarce, men should have more right to a job than women". The respondents are then asked to choose between 'agree', 'disagree', 'neither' or 'don't know'. We omit observations for which the respondents answered 'neither' or 'don't know', and code

[26] Five waves of the WVS were carried out between 1981 and 2007. In our analysis, we use the four most recent waves of the survey, since the first wave does not contain information on the district in which the respondent lives. Because regional classifications often vary by wave, we use the wave with the most finely defined location data.

[27] The results are qualitatively identical if we exclude retired women and students from the sample.

'disagree' as 0 and 'agree' as 1.[28] Therefore, the constructed variable is increasing in the extent to which a respondent's view is characterized by gender inequality.

We also consider a second variable derived from a survey question that is based on the following statement: "On the whole, men make better political leaders than women do". Respondents are then asked to choose between 'strongly disagree', 'disagree', 'agree', 'agree strongly', or 'don't know'. We omit observations in which the respondent answered 'don't know' and create a variable that takes on the value of 1 for 'strongly disagree', 2 for 'disagree', 3 for 'agree' and 4 for 'agree strongly'. This variable, like the first, is increasing in the extent to which the respondent's view reflects gender inequality.

An appealing characteristic of the two subjective belief variables is that they provide measures of the values that form the foundation of the objective outcome variables from the cross-country analysis. The first question reflects differences in individual beliefs about whether women should have equal access to jobs, which is likely an important factor underlying observed differences in female labor force participation across countries. The second question reflects values about the ability of women to take on roles of leadership and responsibility, which likely affects observed differences in female participation in politics and female firm ownership and management. Therefore, there is a close link between the objective measures from the country-level analysis and the subjective measures in the individual-level analysis.

Examining the three outcomes – female participation in the labor force, attitudes about female employment, and attitudes about female leadership – we estimate the following individual-level equation:

$$y_{i,d,c} = \alpha_{r(c)} + \beta \, \text{Plough}_d + \mathbf{X}_c^{\mathbf{C}} \mathbf{\Gamma} + \mathbf{X}_d^{\mathbf{H}} \mathbf{\Pi} + \mathbf{X}_i \mathbf{\Phi} + \varepsilon_{i,d,c} \tag{3}$$

where i denotes an individual, d denotes a district within a country c, and $r(c)$ denotes the continent of country c. Plough_d is our measure of traditional plough use among the ancestors of individuals living in district d. $\mathbf{X}_c^{\mathbf{C}}$ are the same contemporary country-level controls as in equation (2), and $\mathbf{X}_d^{\mathbf{H}}$ includes the same historical ethnographic variables as in equation (2), but measured at the district level rather than the country level. $\mathbf{X}_i$ denotes current individual-level controls: age, age squared, marital status fixed effects, educational attainment fixed effects, town

[28] We omit observations that respond 'neither' because it is ambiguous whether this represents an intermediate view or whether they have chosen not to answer the question or whether they do not know their answer. If we interpret this response as reflecting an intermediate position and code a variable that takes on the values 0, 1, and 2, then we obtain qualitatively identical results to what we report here.

Table 4: Individual-level OLS estimates.

	Dependent variables:							
	FLFP	When jobs are scarce	Men better political leaders	Average effect size (AES)	FLFP	When jobs are scarce	Men better political leaders	Average effect size (AES)
	Plough use measured at the district level				Plough use measured at the country level			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Traditional plough use	-0.202***	0.239***	0.402***	0.459***	-0.228***	0.347***	0.565***	0.633***
	(0.040)	(0.026)	(0.079)	(0.061)	(0.052)	(0.029)	(0.089)	(0.066)
Individual controls	yes	yes	yes	yes	yes	yes	yes	yes
Contemporary country controls	yes	yes	yes	yes	yes	yes	yes	yes
Historical country controls	yes	yes	yes	yes	yes	yes	yes	yes
Continent fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	34,887	81,092	65,401	73,247	39,684	92,420	75,666	84,043
R-squared	0.195	0.202	0.171		0.185	0.222	0.187	

Notes: The table reports OLS estimates, with standard errors clustered at the country level. Individual controls are age, age squared, education, gender (for gender attitudes only), marital status and town size. Contemporary country controls include ln income and ln income squared. Historical district controls include agricultural suitability, domesticated animals, tropical areas, political hierarchies, and economic complexity. The AES reported in column 4 is for the two subjective belief measures from columns 2 and 3. ***, ** and * indicate significance at the 1, 5 and 10% levels. in the first four columns we associate to each individual the historical plough measure constructed at the district level; in columns 5-8 the association is done at the country level.

size, and gender (for the attitude regressions only). All estimates control for continent fixed effects $\alpha_{r(c)}$. Standard errors are clustered at the country level.

Columns 1-4 of Table 4 reports OLS estimates of equation (3). We find a negative relationship between traditional plough use and current female labor force participation, and a positive relationship between plough use and attitudes reflecting gender inequality. In terms of the magnitude of the effects, they are similar to the cross-country estimates. A one-standard-deviation increase in traditional plough use implies a reduction in female labor force participation of 0.09 or 9 percentage points, which is roughly equal to 16% of the sample average. The impact of a one standard deviation increase in the two attitude measures, is 0.01 and 0.17, respectively (roughly equal to 2% and 7% of the sample averages of these variables). According to the magnitude of the AES coefficient in column 4, a one unit increase in traditional plough use is associated with an average increase of 0.46 standard deviations for the two measures.

For most countries in the individual-level sample (roughly 75 percent), the value of the district-level plough variable is the same for all districts within the country. Given this fact, as a sensitivity check, we also estimate equation (3) using the country-level measure of traditional plough use. These alternative estimates, which are reported in columns 5-8 of Table 4, are very similar to the baseline estimates, although slightly larger. In addition, because of the limited subnational variation, controlling for country fixed effects, yields estimates that are extremely imprecise. We are, therefore, only able to control for continent fixed effects.

Individual-level heterogeneous impacts

One advantage of the individual-level regressions is that one is able to test for heterogeneous effects that may dependent on individual-level characteristics. We have tested whether the historical impact of ancestral plough use is different between rural vs. urban populations, men vs. women, or older vs. younger generations. We fail to find robust evidence of heterogeneity along any of these dimensions.

One interpretation of the findings reported to this point is that societies that traditionally used the plough continue use the plough today, and therefore women participate less in agriculture (and gender attitudes reflect this fact).[29] The finding of an impact of traditional plough use among individuals living in urban area that is similar to individuals living in rural areas provides suggestive evidence against this explanation. In other words, the impact of the plough is felt as strongly by individuals that are not currently engaged in agriculture.

In addition, the lack of heterogenous impacts by age and gender suggests that the effect of the plough is quite general and persistent. This is consistent with widely-diffused cultural attitudes being an important part of the underlying mechanism.

C. *Robustness to alternative plough measures and alternative samples*

We first consider the robustness of our results to the use of alternative plough measures. Using either of the two methods, described above, for imputing missing language data yields estimates that are qualitatively identical to the estimates using our baseline variable. As reported in Appendix Table A3, the alternative measures yield nearly identical point estimates that are highly significant.

We next examine the robustness of our results to the use of different samples. First, to ensure that our findings are not being driven by measurement error, we omit 17 countries that have a significant proportion of missing language data. The countries include Australia, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, New Zealand, Nicaragua, Panama, Paraguay, Peru and Venezuela. The estimates reported in Panel A of Table 5 show that the estimated impact of the plough remains robust.

[29] See Carranza (2010) for evidence for such a channel. She finds that within contemporary rural India plough use is associated with less female participation in agriculture and a male-biased sex ratio.

Table 5: Robustness of OLS estimates to alternative samples.

	Dependent variable:			
	FLFP	Share of firms with some female ownership	Females in politics	Average effect size (AES)
	(1)	(2)	(3)	(4)
	Panel A: Omitting countries with missing language data			
Tradtitional plough use	-15.579***	-9.409**	-8.753***	-0.949***
	(3.182)	(4.579)	(2.154)	(0.146)
Observations	146	92	128	122
R-squared	0.429	0.132	0.374	
	Panel B. Omitting Europe, USA, Canada, Australia, and New Zealand			
Traditional plough use	-16.033***	-8.677**	-6.574***	-1.010***
	(3.791)	(4.259)	(1.947)	(0.209)
Observations	124	85	105	105
R-squared	0.422	0.183	0.153	
	Panel C: Omitting sub-Saharan African countries			
Traditional plough use	-13.544***	-12.801**	-10.224***	-1.024***
	(3.602)	(6.049)	(3.071)	(0.159)
Observations	120	68	109	99
R-squared	0.339	0.176	0.386	

Notes: OLS estimates are reported with robust standard errors in brackets. The unit of observation is a country. Each regression includes the full set of control variables (historical and contemporary) from the baseline specification. ***, ** and * indicate significance at the 1, 5 and 10% levels. The countries with missing language data (Panel A) include: Australia, New Zealand, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, and Venezuela.

Motivated by the fact that there is little variation in plough use within Europe, we also test the robustness of our results to the omission of European and neo-European countries (United States, Canada, Australia and New Zealand) from the sample. As reported in panel B, the results remain robust.

Examining Figures 4a–4c, it is apparent that many of the countries with ancestors that traditionally did not use the plough are located in sub-Saharan Africa. We also check that our results do not only reflect differences between sub-Saharan Africa and the rest of the world by re-estimating equation (2) after omitting all sub-Saharan African countries. The results, reported in panel C, show that we obtain very similar estimates when we omit these countries from the sample.[30] An alternative strategy that addresses this issue is to disaggregate the African continent indicator variable into an indicator variable for sub-Saharan Africa and an indicator variable for Northern Africa. The estimates, which are reported in Appendix Table A4, are also robust to this procedure.

[30]We obtain similar estimates if we omit all African countries, not just sub-Saharan African countries.

5. Addressing the Issue of Causality

A. *Controlling for observable characteristics*

A potential concern with the OLS estimates reported to this point is that locations that historically had less equal gender-role attitudes may have had a higher likelihood of inventing or adopting the plough. This would bias the OLS estimates away from zero. It is also possible that locations that were economically more developed were more likely to have adopted the plough. Since these areas today tend to be richer and more prone to equal gender role attitudes, this would tend to bias the OLS estimates towards zero. Our first strategy to address these, and related, concerns is to control for observable characteristics.

A prominent determinant of cultural differences in gender role attitudes was proposed by Frederick Engels (1902). He argued that gender inequality arose due to the intensification of agriculture, which resulted in the emergence of private property, which was monopolized by men. The control of private property allowed men to subjugate women and to introduce exclusive paternity over their children, replacing matriliny with patrilineal descent, making wives even more dependent on husbands and their property. As a consequence, women were no longer active and equal participants in community life.

To account for this alternative determinant, we control for a measure of the proportion of a country's ancestors (*i*) practicing intensive agriculture, (*ii*) without land inheritance rules, (*iii*) with patrilocal post-marital residence rules, and (*iv*) with matrilocal post-marital rules. All of the controls are constructed using the *Ethnographic Atlas* and in the same manner as traditional plough use and the ethnographic control variables.[31]

Columns 1–3 of Table 6 report estimates of equation (2) with the additional controls included. The estimated impact of traditional plough use remains robust to the inclusion of the additional controls: the coefficient remains negative and statistically significant, and its magnitude changes little from the baseline value of 14.6. For brevity, we only report estimates with female labor force participation as the dependent variable. The estimates for the other outcomes variables are similarly robust to what we report here.

Our analysis make a distinction between traditional plough agriculture and all other forms of subsistence. In our coding, non-plough-societies include both agricultural societies practicing

[31]The controls are derived from variables v12, v28 and v75 from the *Ethnographic Atlas*. Full details of their construction are provided in the paper's appendix.

shifting hoe agriculture as well as societies not engaged in agriculture, such as hunter-and-gatherer and herding societies. It is possible that the status of women is also affected by the extent to which a society participates in these non-agricultural activities. We account for this by constructing two variables that measure the proportion of ancestors' subsistence that was provided by hunting and by the herding of large animals the average.[32] As shown in column 4, the inclusion of the two controls has little impact on the estimated coefficient for traditional plough use.

Another historical variable we consider is the traditional structure of the family. A priori, it is unclear how the traditional family structure may impact the evolution of gender norms. Some scholars, like Engels (1902), Boserup (1970), and Barry, Bacon and Child (1957), have hypothesized that cultures with large-extended families typically have more hierarchical and less egalitarian structures. If hierarchies tend to be dominated by men, this could result in a subordinate status of women. Others, most notably Whyte (1978), suggest an alternative mechanism. In large families with many adults, a gender division of labor can more easily develop, while in nuclear families with only a husband and a wife, it is more likely that either adult will need to substitute for the other, and the wife will more often participate in activities that would otherwise be dominated by men. We control for the potential impact of family structures by controlling for a measure of the proportion of a country's ancestors with a nuclear family structure and for the proportion with an extended family structure.[33] The estimates, reported in column 5, show that the results remain robust to the inclusion of the two variables.

In column 6, we control for the fact that in the *Ethnographic Atlas* ethnicities are observed at different points in time. In general, less-developed ethnic groups, without written records or with less external contact, tend to have information from more recent time periods. Although the characteristics of interest tend to be slow-moving and typically do not change significantly in short periods of time, this could still introduce some measurement error. Motivated by this concern, we check that the results remain robust to controlling for the average date of observation of ancestors in the *Ethnographic Atlas*. The estimates are very similar with this additional control.

We next turn to the possibility that warfare may have a systematic impact on beliefs about gender roles. As argued by Whyte (1978), a priori, the expected direction of the effect is unclear.

[32]The variables are constructed from variables v2 and v4 of the *Ethnographic Atlas*.

[33]The information is taken from variable v8 of the *Ethnographic Atlas*.

Involvement in warfare may cause societies to become more hierarchical and male dominated, suggesting a negative relationship between conflict and female work outside the home. On the other hand, being involved in warfare can generate a greater need for female involvement outside of the home, which may in turn affect the evolution of beliefs about gender.[34] We control for the potential impacts of warfare, by calculating, for each country, the number of years since 1816 (the first year data are available) that the country was involved in either internal or interstate warfare.[35] The results, reported in column 7, show that the impact of plough use is robust to controlling for a country's experience of warfare during the 19th and 20th centuries.

Communism was another historical episode that may have had a large impact on beliefs about gender. Communist regimes typically implemented policies to eliminate gender differences in the economy and promote female participation outside of the home. In column 8, we include an indicator variable that equals one if the country was under a communist regime in the post-WWII period. The estimates remain robust to the inclusion of this control.

A large part of the global variation in female labor force participation is a result of large historical migrations, most notably mass European migrations during the 17th to 20th centuries. Given this, there is a concern that for many parts of the world, traditional plough use may be associated with the diffusion of values and other characteristics from Western Europe. We account for this possibility by controlling for the fraction of each country's population in 2000 with ancestors from Western Europe.[36] The estimates, reported in column 9, show that the results remain robust.[37]

In a recent paper, Ross (2008) argues that a country's endowment of oil reserves is an important determinant of beliefs about the role of women in society. According to his hypothesis, oil causes a country's domestic currency to strengthen, making exports less competitive and causing a decline in light manufacturing, a sector particularly well-suited for female employment. We account for this possibility by controlling for per capita oil production and the trade-to-GDP ratio, both measured in 2000.[38] Estimates with the additional controls are reported in columns 10 and 11. The results remain robust.

[34]See Fernandez, Fogli and Olivetti (2004) for contemporary evidence for such an effect.

[35]The data are from version 4 of the *Correlates of War* database.

[36]The measure is taken from Nunn and Puga (2012), who calculate the variable using Putterman and Weil's (2010) *World Migration Matrix*.

[37]This finding is consistent with the more brut-force strategy, reported in Table 5, that omits all European and neo-European countries (Australia, New Zealand, Canada, the US) from the sample.

[38]The trade data are from the *World Development Indicators*, and the oil data are from BP Oil (2006).

The hypothesis by Ross (2008) also highlights the importance of a country's economic structure for female labor force participation. We therefore control for the economic structure of each country by including three variables that capture the share of GDP accounted for by agriculture, manufacturing and services.[39] As shown in column 12, the impact of the plough remains robust.

The last factor that we consider in our robustness checks is religion since different religions have varying views about the appropriate role of women in society. For all of our control variables there is the concern that they may be endogenous to traditional plough agriculture (and thus we are in danger of over controlling). However, this is particularly true for religion. Boserup's initial hypothesis was that traditional plough use had an impact on religious practices, namely women's wearing of the veil and the burqa (Boserup, 1970, pp. 13–14). Others have also argued that, historically, religious beliefs may be endogenous to plough use in agriculture. For example, Braudel (1998) describes how the adoption of the plough in Mesopotamia around the fourth millennium BCE was not only accompanied with a movement of women out of agriculture and a shift from matriarchy to patriarchy, but also in a change in the religion beliefs. There was a shift away from "the reign of the all-powerful mother goddesses and immemorial fertility cults presided over by priestesses" and towards "male gods and priests" (Braudel, 1998, p. 71). More generally, religious beliefs can be interpreted as one manifestation of a society's overall cultural views.

With this caveat in mind, we examine how the inclusion of religion affects the OLS estimates of the impact of traditional plough agriculture. In column 13, we control for five variables that measure the proportion of a country's population that is: Catholic, Protestant, other Christian, Muslim, and Hindu.[40] Including these controls reduces the impact of the estimated coefficient for traditional plough use to 11. Therefore, unlike every other set of controls that we consider, religion does have a noticeable impact on the point estimate for plough use. This is consistent with part of the impact of plough working through religious beliefs. However, even controlling for religion, traditional plough agriculture continues to have a sizable and statistically significant impact.

Lastly, in column 14, we include all the controls in one specification. Although the plough-use coefficient decreases slightly, it remains highly significant. Not surprisingly, if we include all

[39]The data are from the *World Development Indicators*.

[40]The data are taken from McCleary and Barro's (2006) Religion Adherence dataset.

controls except for the five religion variables, the point estimate is noticeably higher, 12.4 (with a standard error of 4.52).

Overall, the estimated impact of the plough remains highly robust across the various specifications reported in Table 6. The coefficient is always negative and statistically significant, and the point estimates remain fairly stable, ranging from -9.5 to -16.4.

B. *IV estimates*

The second strategy that we undertake to address the concern of causality is the use of instrumental variables. We exploit one determinant of historical plough use that has been emphasized in the anthropological literature: the type of crops grown in a particular location (Pryor, 1985).

The primary benefit of the plough is that it facilitates the cultivation of larger amounts of land over a shorter period of time. This capability is more advantageous for crops that require specific planting conditions that are only met during narrow windows of time or for crops that require larger tracts of land to cultivate a given amount of calories. The benefit of the plough is also reduced for crops grown in swampy, sloped, rocky, or shallow soils, all of which make the plough less efficient or impossible to use. Taking these factors into consideration, Pryor (1985) has classified crops into those whose cultivation benefits greatly from the adoption of the plough – he calls these plough positive crops – and those whose cultivation benefits less – called plough-negative crops. Plough-positive crops, which include wheat, teff, barley and rye, tend to have shorter growing seasons and tend to be cultivated on relatively large expanses of land (per calorie of output) that tends to be flat, with deep soil that is not too rocky or swampy. Plough negative crops, which include sorghum, maize, millet, roots, tubers, and tree crops, tend to yield more calories per acre, have longer growing seasons, and can be cultivated on more marginal land (Pryor, 1985, p. 732).[41]

Because the cultivation of plough-positive and plough-negative crops is an endogenous outcome, we do not use this as our instrument. Instead, we measure geo-climatic conditions that are unaffected by human actions, but which impact the suitability of a location for growing both types of crops. Our strategy uses two instruments. The first is a measure of the average suitability

[41] An examination of contemporary data confirms Pryor's hypothesis of a link between crop cultivation and plough use. For example, in the 1997 *Ethiopian Rural Household Survey* one observes a strong positive relationship between the cultivation of plough-positive crops (teff, barley, wheat, or wet rice) and the use of the plough. Examining variation across 1,175 households, the correlation between the two measures is 0.32. The correlation is also robust to controlling for farm size, which may affect both measures.

Table 6: Robustness of OLS estimates to alternative controls.

	Dependent variable: FLFP													
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Traditional plough use	-14.693***	-14.744***	-15.173***	-12.930***	-13.471***	-14.474***	-14.869***	-15.776***	-13.755***	-14.529***	-14.111***	-16.385***	-10.974***	-9.458**
	(3.823)	(3.288)	(3.180)	(3.387)	(3.095)	(3.094)	(3.166)	(3.181)	(3.259)	(3.123)	(3.165)	(3.549)	(3.904)	(4.178)
Historical controls:														
Practices intensive agriculture	yes													yes
Absence of private property		yes												yes
Patrilocal marriages			yes											yes
Matrilocal marriages			yes											yes
Prop. of subsist. from herding				yes										yes
Prop. of subsist. from hunting				yes										yes
Nuclear family structure					yes									yes
Extended family structure					yes									yes
Year ethnicity sampled						yes								yes
Contemporary controls:														
Years of civil conflict (1816-2007)							yes							yes
Years of interstate conflict (1816-2007)							yes							yes
Communism indicator								yes						yes
Fraction of pop. European descent									yes					yes
Oil production per capita										yes				yes
Trade-to-GDP ratio											yes			yes
Agricultural share of GDP												yes		yes
Manufacturing share of GDP												yes		yes
Services share of GDP												yes		yes
Fraction of pop. Catholic													yes	yes
Fraction of pop. Protestant													yes	yes
Fraction of pop. Christian (other)													yes	yes
Fraction of pop. Muslim													yes	yes
Fraction of pop. Hindu													yes	yes
Baseline controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	163	161	163	163	163	163	161	163	152	161	161	152	161	139
R-squared	0.413	0.408	0.420	0.447	0.451	0.418	0.411	0.430	0.435	0.414	0.417	0.416	0.568	0.67

Notes: OLS estimates are reported with robust standard errors in brackets. The unit of observation is a country. Each regression includes the full set of control variables (historical and contemporary). ***, ** and * indicate significance at the 1, 5 and 10% levels.

of the location of each observation's ancestors for cultivating plough positive cereal crops – wheat, barley and rye. The second is the same measure of ancestral suitability, but for cultivating millet and sorghum, which are plough-negative cereal crops. We intentionally choose to consider this set of crops because they are similar in many other dimensions except for the extent to which they benefit from the use of the plough. For example, we are not comparing cereals to ground crops which, according to Scott (2009), is a distinction important for the practice of 'escape agriculture' and state formation. Both sets of crops are cereals that have been cultivated in the Eastern Hemisphere since the Neolithic revolution (Mazoyer and Roudart, 2006, pp. 71–99, Lu, Zhang, biu Liu, Wu, yumel Li, Zhou, Ye, Zhang, Zhang, Yang, Shen, Xu and Li, 2009, Crawford, 2009). Both sets of crops require similar preparations for consumption, all being used for flour, porridge, bread or in beverages (Recklein, 1987). Both sets also produce similar yields and therefore neither clearly dominates the other in terms of the population it can support (Pryor, 1985, p. 732).

We obtain information on the suitability of a location for cultivating the plough-positive and plough-negative cereal crops from the FAO's *Global Agro-Ecological Zones* (GAEZ) 2002 database (Fischer et al., 2002). The database reports, for 5 arc minute by 5 arc-minute grid-cell globally, the suitability of the location for cultivating a variety of different crops. The data are constructed using the following geo-climatic characteristics of a location: precipitation, frequency of wet days, mean temperature, daily temperature range, vapor pressure, cloud cover, sunshine, ground-frost frequency, wind speed, soil slope, and soil characteristics. The characteristics are combined with the specific growing requirements of crops to produce a measure of whether each crop can be grown in each location, and if so, how productively. It is important to note that the models of crop growth are based solely on previously established technical requirements and constraints for crop growth. The model's parameters, and the final measures, are not affected by which crops are actually grown in a particular location. The final estimates are not simple functions of the geographic characteristics used, but are based on precise, highly non-linear crop-specific models of evapotranspiration, water-balance, temperature profiles, temperature growing periods, length of growing period and thermal regimes. This last point is particularly important as it allows us to check the robustness of our IV results to controlling for important geo-climatic characteristics which may differ systematically in plough-positive and plough-negative environments.[42]

We construct the instruments by first identifying the land traditionally inhabited by each ethnic

[42]For a detailed discussion of the data, and its use in a different application, see Nunn and Qian (2011).

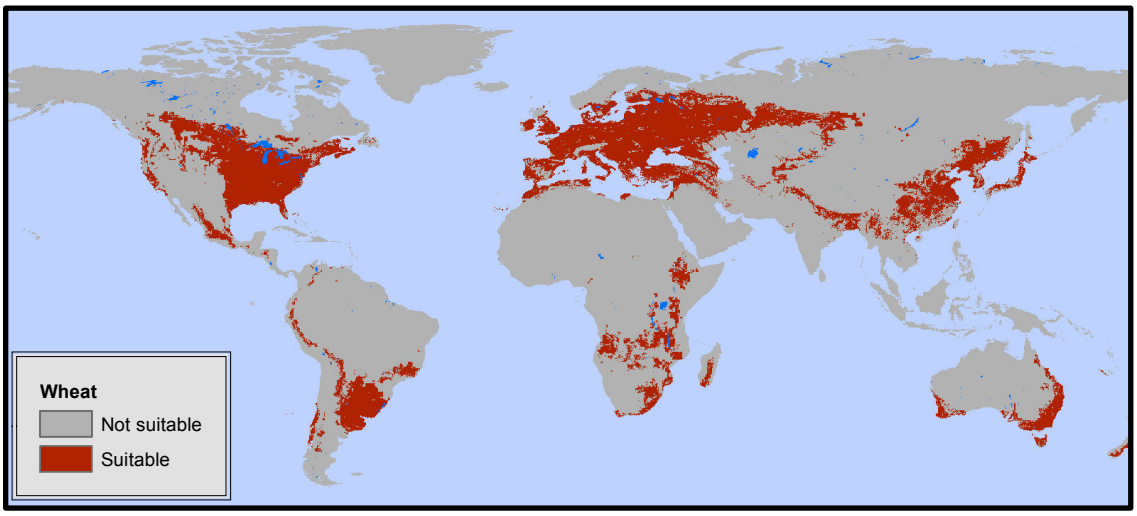
group in the *Ethnographic Atlas*. We use all land within 200 kilometers of an ethnic group's centroid and measure the amount of land within this area that can grow each of the cereal crops that comprise the instruments.[43] Let x_e^w, x_e^b, x_e^r, x_e^s, and x_e^m denote the amount of land that can cultivate wheat, barley, rye, sorghum and millet, respectively. Further, let x^{all} be the amount of land that could grow any crop (i.e., the amount of arable land). The ethnicity-level measures of suitability for plough-positive crops is given by: $Area_e^{pos} = \frac{1}{3}(x_e^w + x_e^b + x_e^r)/x_e^{all}$. While ethnicity-level measure of suitability for plough-negative crops is: $Area_e^{neg} = \frac{1}{2}(x_e^s + x_e^m)/x_e^{all}$. Intuitively, the instruments measure the average suitability for each type of crop, normalized by the overall suitability for cultivation in general.[44]

Using the procedure explained by equation (1), we then construct district- and country-level averages of our plough-positive and plough-negative instruments. Intuitively, the instruments measure the proportion of the population with ancestors that lived in climates that could grow plough-positive cereals (wheat, barley and rye) and the proportion that lived in climates that could grow plough negative cereals (sorghum and millet).

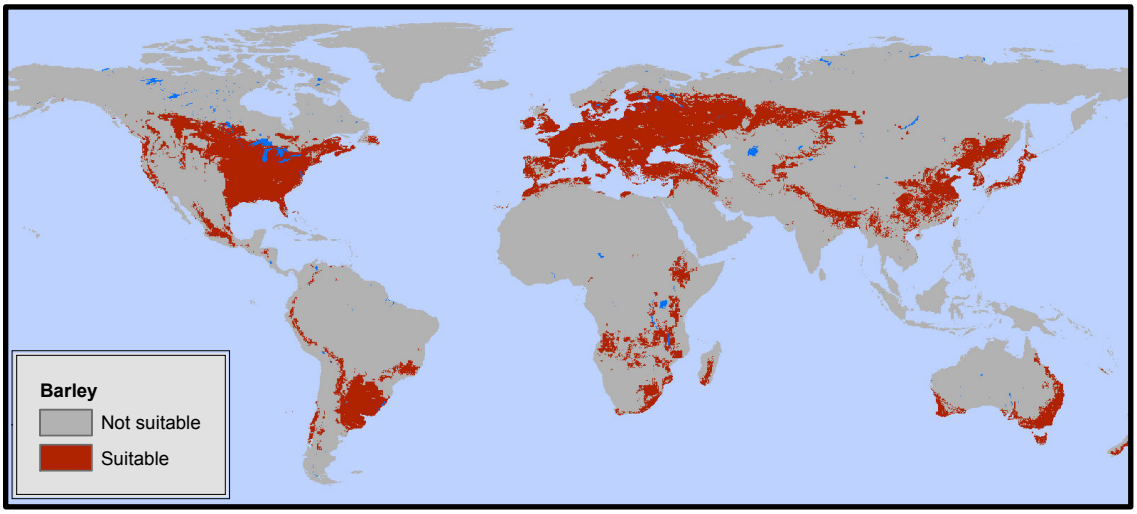
To provide the reader with a better sense of the instruments, Figure 6 shows the parts of the world that are classified as being suitable for the cultivation of the plough positive cereals – wheat, barley and rye – while Figure 7 shows suitability for the plough-negative cereals – millet and sorghum. A number of facts are apparent from the maps. First, there are many parts of the world that can grow plough-positive crops, but not plough-negative crops and vice versa. This provides an indication that the instruments may have variation independent from each other and therefore some predictive power. Second, plough-negative crops appear to be relatively better suited for tropical and subtropical climates and plough-positive crops better suited for temperate climates. If these differences in climate affect gender attitudes today through channels other than past plough use, then the exclusion restriction will not be satisfied. However, recall that the controls already include the proportion of land, historically inhabited by an ethnic group, that was tropical or subtropical. As well, the analysis below explicitly addresses this concern by flexibly controlling for additional geographic characteristics that may be correlated with the

[43]The GAEZ database measures suitability as a proportion of maximum attainable yield. We define locations that obtain at least 40% of the maximum yield as suitable. The results are robust to the use of other thresholds.

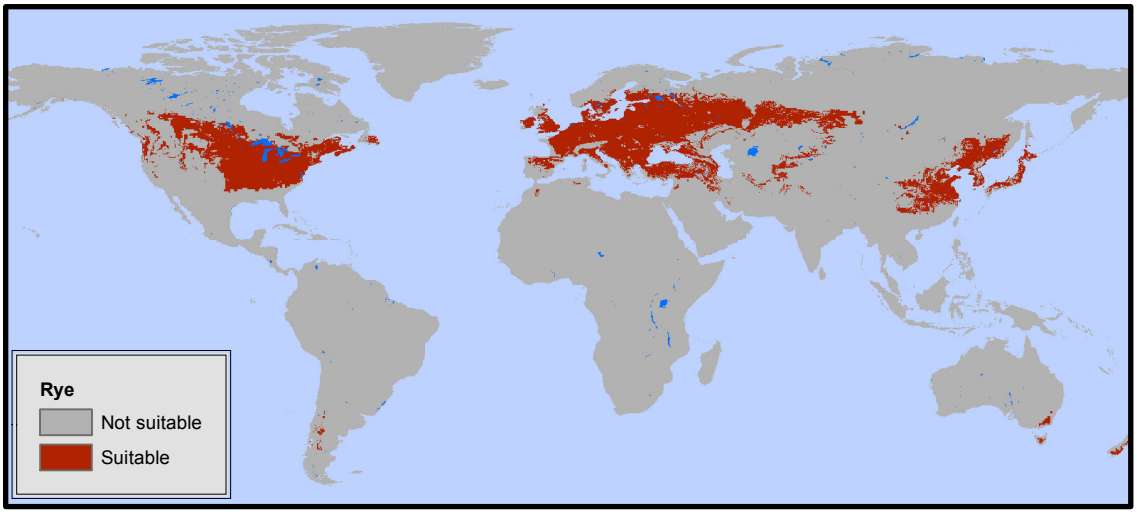
[44]Our procedure assumes that the GAEZ data provide an unbiased measure of historical suitability. In a different context, Nunn and Qian (2011) provide evidence of the validity of this assumption by showing that the GAEZ suitability measure for potatoes is highly correlated with historical potato production.



(a) Wheat suitability

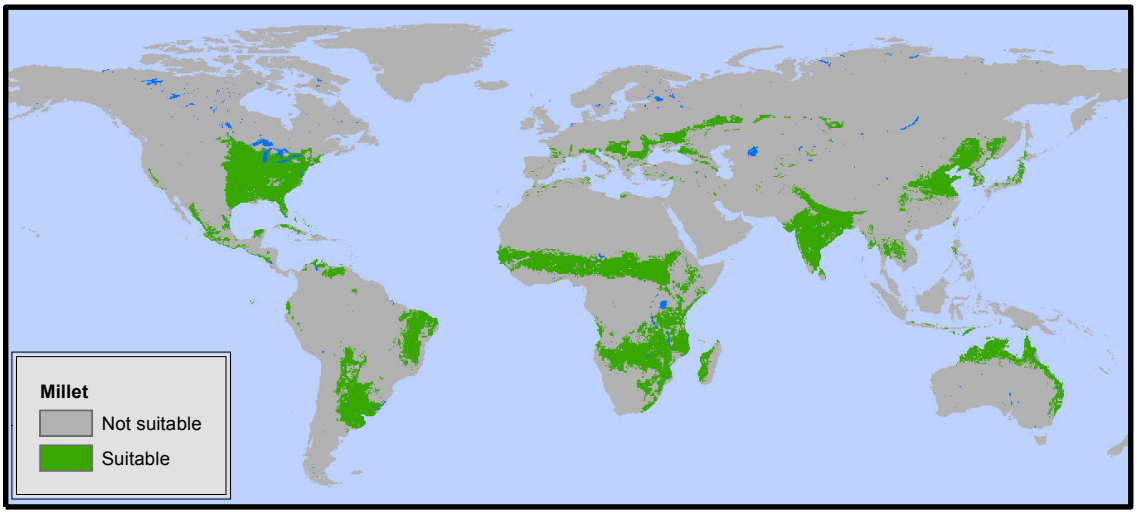


(b) Barley suitability

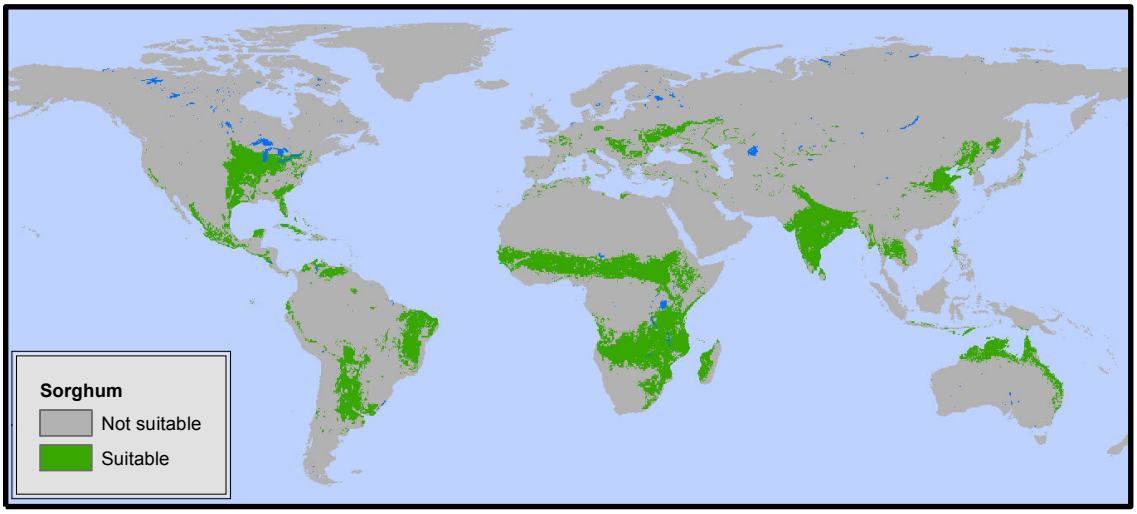


(c) Rye suitability

Figure 6: Maps displaying the global suitability of plough-positive crops, wheat, barley and rye.



(a) Millet suitability



(b) Sorghum suitability

Figure 7: Maps displaying the global suitability of plough-negative crops, millet and sorghum.

Table 7: Country-level IV estimates.

	Panel A. Second stage. Dependent variable:							
	Female labor force participation		Share of firms with some female ownership		Females in politics		Average effect size (AES)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Traditional plough use (2SLS)	-21.383***	-22.334**	-13.497	-20.841*	-9.531*	-14.216**	-1.594***	-1.998***
	(8.301)	(9.041)	(11.202)	(12.514)	(5.45)	(6.514)	(0.295)	(0.335)
Traditional plough use (LIML)	-22.06	-23.10	-16.94	-25.22	-9.55	-14.03	-1.650	-2.03
p-value	0.02	0.02	0.13	0.08	0.09	0.02	0.00	0.00'
CLR intervals	[-44.04, -4.24]	[-46.97, -3.81]	[-44.49, 5.49]	[-65.09, 3.42]	[-21.23, 1.65]	[-28.92, -1.92]	[-2.25, -1.13]	[-2.73, -1.46]
Historical controls	yes	yes	yes	yes	yes	yes	yes	yes
Contemporary controls	yes	yes	yes	yes	yes	yes	yes	yes
Continent FEs	no	yes	no	yes	no	yes	no	yes
Observations	162	162	106	106	143	143	137	137
	Panel B. First stage. Dependent variable: Traditional plough use							
Plough-positive environment	0.401***	0.442***	0.746***	0.654***	0.492***	0.495***	0.421***	0.458***
	(0.123)	(0.110)	(0.151)	(0.138)	(0.148)	(0.132)	(0.070)	(0.061)
Plough-negative environment	-0.193**	-0.129*	-0.001	0.031	-0.145	-0.099	-0.183***	-0.116***
	(0.097)	(0.077)	(0.100)	(0.077)	(0.111)	(0.089)	(0.055)	(0.043)
Equality of coefficients (*p*-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F-stat (excluded instruments)	12.35	10.85	13.42	11.37	11.19	9.06	42.86	36.25
Hausman test (*p*-value)	0.30	0.17	0.59	0.36	0.86	0.39	0.00	0.00

Notes: IV estimates are reported with robust standard errors in brackets. The unit of observation is a country. Historical controls include agricultural suitability, domesticated animals, tropics, political hierarchies and economic complexity. Contemporary controls include ln income and ln income squared. The number of observations for the AES estimates is the average number observations in the regressions for each outcome. ***, ** and * indicate significance at the 1, 5 and 10% levels.

suitability instruments.[45]

Table 7 reports IV estimates of the specifications from Table 3. The first-stage estimates, reported in panel B, show that the historical suitability for the cultivation of plough-positive cereals is positively correlated with the adoption of the plough, while suitability for the cultivation of plough-negative cereals is generally negatively correlated with plough use. In all specifications, the difference between the two coefficients is statistically significant. We also report the F-test for joint significance of the two instruments, which ranges from about 9–13, indicating that for some specifications there is a potential concern about weak instruments. For this reason we report conditional likelihood ratio (CLR) confidence intervals and LIML estimates in addition to the standard 2SLS estimates.

The second-stage IV estimates, which we report in panel A of Table 7, confirm the OLS estimates. Historical plough use is associated with less female labor force participation, less female firm ownership, and less female participation in politics. The magnitude of the IV coefficients

[45] An important final point arises from the fact that the plough-positive and plough-negative cereals used in the construction of our instruments were all originally grown in the Eastern hemisphere and were not cultivated in the Americas until after 1500. This is not a concern to identification, but it is a fact that makes the first stage relationship weaker than it would be otherwise. For the large proportion of the population in the Americas whose ancestors are from the Eastern hemisphere, the instrument will provide predictive power. It is only for the indigenous populations of the Americas that the instrument will not affect plough adoption. This should be kept in mind when interpreting the IV estimates as a local average treatment effect (LATE). In other words, the estimates are an average effect among the ethnic groups whose plough adoption was affected by the geo-climatic suitability for growing the cereal crops.

are consistently greater than the OLS estimates, a fact that can be explained by selection arising from the endogeneity of plough adoption. All else equal, historically advanced societies were more likely to adopt the plough. Furthermore, they are more likely to also be advanced today, with higher per capita incomes and more female participation in the labor market. Therefore, selection introduces a positive relationship between historical plough use and female labor force participation today, biasing the negative OLS estimates towards zero.

The validity of the IV estimates rests on the assumption that holding overall agricultural suitability constant, the specific type of cereal crop that a location could grow only impacts long-term gender attitudes through the past adoption of the plough. The primary concern with this strategy is that the difference between plough-positive and plough-negative environments may be correlated with geographic features that affect gender attitudes today through channels other than the plough. We check the robustness of our results to this concern by controlling for geographic characteristics that are potentially correlated with the suitability of the environment for plough-positive and plough-negative crops. Our controls include terrain slope, soil depth, average temperature and average precipitation of locations inhabited by each country's ancestors. Slope is measured as percent (i.e., rise over run). The soil depth control is the fraction of land that has no, few or slight soil depth constraints for cultivation. Average temperature is the average daily temperature (measured in degrees Celsius) between 1950 and 1959. Precipitation is the average monthly rainfall (in mm) over the same time period.

As reported in Table 8, the IV estimates remain robust to the inclusion of these geo-climatic characteristics. In columns 1–4, we control for each of the four measures individually. The point estimates remain positive and significant across each specification. In column 5, we include all four controls simultaneously. Column 6 allows for the possibility of non-linear effects by also controlling for the square of each variable, while column 7 allows for interaction effects by also including all pairwise interactions of the controls. In each of the specifications, the points estimates remain robust, with magnitudes that are positive, significant and very similar in magnitude to the baseline estimate of 21.4.

We also check the robustness of the IV estimates to controlling for the additional covariates from Table 6. The results, which are reported in Appendix Table A5, show that the IV estimates, like the OLS estimates, remain robust to these additional controls.

Like the country-level estimates, the individual-level estimates are also robust to the use

Table 8: Robustness of IV estimates to additional geographic controls.

	Dependent variable: FLFP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Traditional plough use	-26.799***	-19.005**	-23.289***	-19.248**	-23.807***	-31.459**	-24.705**
	(8.845)	(9.185)	(6.887)	(8.252)	(7.177)	(12.462)	(10.309)
Terrain slope	yes				yes	yes	yes
Soil depth		yes			yes	yes	yes
Average temperature			yes		yes	yes	yes
Average precipitation				yes	yes	yes	yes
Quadratic terms						yes	
Linear interactions							yes
Baseline controls	yes	yes	yes	yes	yes	yes	yes
Observations	162	162	162	162	162	162	162
R-squared	0.354	0.422	0.377	0.410	0.414	0.351	0.428

Notes: OLS estimates are reported with robust standard errors in brackets. The unit of observation is a country. Each regression includes the full set of control variables (historical and contemporary). ***, ** and * indicate significance at the 1, 5 and 10% levels.

of instrumental variables. As reported in Appendix Table A6, we find a negative effect of past plough use on the participation of women in the labor force, and a positive effect on the prevalence of attitudes of gender inequality. Like the country-level estimates, we find that the IV estimates are larger than the OLS estimates.

6. Cultural transmission as a mechanism: Evidence from immigrants in Europe and the U.S.

We now turn to a closer analysis of the causal mechanisms underlying our results. It is likely that part of the long-term impacts of traditional plough use may not be solely due to the evolution and persistence of cultural norms, but also to the development of institutions, policies, laws, and markets that are less conducive to the participation of women in activities outside of the domestic sphere. Through this channel, the plough causes less female participation in market activities because it affects the costs and benefits of these activities, not because it affects individuals' beliefs about whether these are appropriate activities for women. Our individual-level estimates, that show an impact of the plough on gender-role attitudes, provide evidence that the plough has impacted beliefs and values. However, these effects may also be due to differences in external factors (e.g., institutions, policies, markets, etc), which in turn shape individual beliefs.

To better isolate the causal impact of the plough on individual beliefs and values, we examine variation among second-generation immigrants, a group of individuals from diverse cultural

backgrounds and different histories of ancestral plough use, but facing the same external environment, including markets, institutions, laws, and policies.

The analysis examines immigrants in the United States and Europe. The US data are from the March Supplement of the *Current Population Survey* (CPS).[46] The European data are from the *European Social Survey* (ESS).[47] For both samples, we look at second generation immigrants – individuals who are born within the country, but whose parents were born abroad. Therefore, an individual's ancestry is defined by the country-of-birth of their parents.

A. *Evidence from the United States*

The sample of US immigrants includes women aged 15 to 64. The outcome of interest is the labor force participation of women in the sample. Because this decision is likely very different for married women, we also examine this group separately. Our estimating equation is given by:

$$y_{i,s,c} = \alpha_s + \beta \, \text{Plough}_c + \mathbf{X}_c^{\mathbf{C}}\mathbf{\Gamma} + \mathbf{X}_c^{\mathbf{H}}\mathbf{\Pi} + \mathbf{X}_i\mathbf{\Phi} + \varepsilon_{i,s,c} \tag{4}$$

where i denotes a second-generation woman currently living in state s, with country of ancestry c. Country of ancestry is defined using either the mother's country of birth or the father's. A list of the countries of ancestry and the number of immigrants for each is provided in the Appendix Table A8.

The dependent variable, $y_{i,s,c}$, is an indicator variable that equals one if woman i is in the labor market. As in equation (2), Plough_c denotes ancestral plough use of those from country c. α_s denotes state fixed effects, which control for state-varying differences in labor markets, laws, regulations, institutions, etc. $\mathbf{X}_c^{\mathbf{C}}$ and $\mathbf{X}_c^{\mathbf{H}}$ denote the same vectors of current and historical controls as in equation (2). $\mathbf{X}_i$ indicates a vector of individual level controls: fixed effects for educational attainment, a quadratic for age, marital status, fixed effects for whether the person lives in a metropolitan or rural area, and fixed effects for the year of the survey. When we examine the sample of married women, we also include controls for characteristics of the husband: a quadratic of the husband's age, the husband's education, and the natural log of his wage income. Because

[46] Because the Census stopped asking questions about parents' country of origin in 1970, this source cannot be used for the analysis. Starting in 1994, the CPS asks individuals about their country of origin and their parents' country of origin. We use all the years available since 1994.

[47] The ESS is a biennial cross-sectional survey administered within a large sample of European countries. Other surveys, like the CPS or the General Social Survey (GSS), cannot be used. The CPS does not contain information about individual beliefs about the role of women in society, and the GSS does not provide sufficiently detailed information on immigrants' country of origin. The GSS only identifies European countries and groups together immigrants coming from other parts of the world.

our variable of interest, Plough_c, only varies at the country of origin-level, we cluster all standard errors at this level.

OLS estimates of equation (4) are reported in Table 9. Columns 1–3 report estimates using the full sample of women. Column 1 identifies the women's ancestry by her father's country of birth, while column 2 uses the mother's country of birth. In column 3, we restrict the sample to women whose parents were both born in the same country. For all three specifications, we estimate a negative relationship between a tradition of plough-use in the home country and the women's participation in the labor force.

Columns 4–9 report OLS estimates for the sample of married women. Columns 4–6 reproduce the estimates of columns 1–3 with the married sample. We continue to find a negative impact of traditional plough use on female labor force participation, although we now find a smaller estimated impact when we identify ancestry using the father's country of birth. Among both samples, an interesting pattern emerges. The estimated impact of traditional plough use is stronger when using the mother's ancestry than when using the father's, and it is strongest when both parents have the same ancestry. This suggests that the transmission of values and beliefs (originating from traditional plough use) is stronger from mothers to daughters than from fathers to daughters, and it is strongest when both parent's have the same values.

We also consider the possibility that a married woman's participation in the labor market may be influenced by her husband's beliefs and values, which were transmitted from his parents and their cultural backgrounds. Columns 7–9 reproduce the estimates of columns 4–6, but identifying ancestry using the husband's parents rather than the wife's parents. The estimates provide evidence that a tradition of plough use among the husband's ancestors also affects the wife's participation in the labor market. Distinguishing between the husband's parents, we find a weaker effect when we use the husband's father's country of birth than the husband's mother's country of birth. As is the case when we examine the women's parents, the estimates show a weaker transmission from the father than from the mother.

The IV estimates of equation (4) are qualitatively identical to the OLS estimates. For brevity, we report these in Table A9 of the appendix.

By examining the sample of immigrants, we are able to estimate the impact of traditional plough use on FLFP, while holding constant external factors that vary at the state level. This provides increased confidence that the estimated impact more closely approximates the true impact

Table 9: Immigrant OLS regressions for the US.

	Dependent variable: Labor force participation indicator								
	All women			Married women					
	Women's ancestry			Women's ancestry			Husband's ancestry		
	Father's country	Mother's country	Parents same country	Father's country	Mother's country	Parents same country	Father's country	Mother's country	Parents same country
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Traditional plough use	-0.039***	-0.046***	-0.064***	-0.028	-0.047**	-0.056**	-0.023	-0.050*	-0.042*
	(0.010)	(0.011)	(0.013)	(0.020)	(0.023)	(0.025)	(0.019)	(0.025)	(0.022)
Individual controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Husband controls	n/a	n/a	n/a	yes	yes	yes	yes	yes	yes
Historical country controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
Contemporary country controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
State fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	48,910	47,219	27,550	8,864	8,261	5,832	9,505	8,886	7,211
R-squared	0.372	0.375	0.379	0.369	0.370	0.386	0.365	0.367	0.381

Notes: OLS estimates are reported with standard errors clustered at the country level. An observation is a US second generation immigrant woman. Individual controls include age, age squared, education and marital status. Husband controls include husband's age, age squared, education and wage income. Regressions include historical and contemporary country controls. All regressions also control for state, year and metropolitan area fixed effects. ***, ** and * indicate significance at the 1, 5 and 10% levels.

of the plough working through cultural transmission. Therefore, comparing the magnitudes of the immigrant-level estimates to the country-level estimates allows us to glean evidence of the importance of cultural transmission, relative to other channels.[48]

The impact of the plough on second-generation US immigrant women is much smaller than the estimated impact from the country-level regressions. Consider the estimated impact on female labor force participation from a one-unit increase in historical plough use. Using the country-level OLS estimates (column 1 of Table 3), this is associated with an increase in FLFP by 14.6 percentage points. The individual-level estimate (column 5 of Table 4) suggests an impacts of a similar magnitude: 22.8 percentage points. The magnitudes from the immigrant-level estimates are much smaller, generally ranging from 2.8 to 6.4 percentage points. Although one must interpret these findings with caution, they suggest that internal norms (as identified in the immigrant regressions) account for between 12 and 43 percent of the total effect.

B. ***Evidence from Europe***

We now turn to the European sample of immigrants from the ESS. One advantage of the sample is that the ESS, like the WVS, asks respondents their view about the statement: "When jobs are scarce, men should have more right to a job than women". The potential responses, however, are slightly different than in the WVS. The respondents are asked to choose between 'agree strongly', 'agree', 'neither agree nor disagree', 'disagree' and 'disagree strongly'.[49] From the survey question, we construct two measures. The first variable takes on integer values from 1 to 5 and is increasing in the strength of agreement with the statement. The second variable is an indicator that equals one if the individual agrees or strongly agrees with the statement and zero if he or she disagrees or strongly disagrees. People who neither agree or disagree are excluded from the sample in the construction of the dummy variable.[50] The second variable, although less precise than the first, is constructed in the exact same manner as the dependent variable used in the country-level analysis, providing the best comparison of the estimates from the individual-level regressions and the immigrant-level regressions.

[48]To facilitate such a comparison, we intentionally construct the country-level, individual-level, and immigrant-level estimating equations to be as similar as possible. For example, they all include exactly the same country-level historical and contemporary control variables.

[49]The responses in the WVS are: 'agree', 'disagree', 'neither' or 'don't know'.

[50]The estimates for the 1 to 5 integer variable are similar if we also exclude people who 'neither agree or disagree' from the regressions.

Table 10: Immigrant OLS regressions for Europe.

	Dependent variables: When job are scarce					
	Father's country		Mother's country		Same country	
	1-5 scale	Indicator	1-5 scale	Indicator	1-5 scale	Indicator
	(1)	(2)	(3)	(4)	(5)	(6)
Traditional plough use	0.203***	0.064***	0.233***	0.074***	0.263***	0.082***
	(0.064)	(0.024)	(0.062)	(0.024)	(0.076)	(0.029)
Individual controls	yes	yes	yes	yes	yes	yes
Contemporary origin-country controls	yes	yes	yes	yes	yes	yes
Historical origin-country controls	yes	yes	yes	yes	yes	yes
Destination-country fixed effects	yes	yes	yes	yes	yes	yes
Survey fixed effects	yes	yes	yes	yes	yes	yes
Observations	15,545	13,024	15,260	12,788	10,535	8,780
R-squared	0.177	0.165	0.175	0.163	0.174	0.167

Notes: The table reports OLS estimates, with standard errors clustered at the country level. An observation is a second generation immigrant. Individual controls are age, age squared, education, gender, marital status, urbanization fixed effects, country of destination fixed effects, and survey fixed effects. Contemporary country controls include ln income and ln income squared. Historical origin-country controls include the origin country's historical agricultural suitability, domestication of animals, tropics, political hierarchies and economic complexity.

We estimate the impact of the plough on immigrant populations using the following equation:

$$y_{i,d,c} = \alpha_d + \beta\,\text{Plough}_c + \mathbf{X}_c^{\mathbf{C}}\boldsymbol{\Gamma} + \mathbf{X}_c^{\mathbf{H}}\boldsymbol{\Pi} + \mathbf{X}_i\boldsymbol{\Phi} + \varepsilon_{i,d,c} \tag{5}$$

where i denotes a second-generation immigrant currently living in destination-country d with country of ancestry c. The dependent variable, $y_{i,d,c}$ is the gender role attitude measure described above. Plough_c denotes traditional plough use in country c;[51] α_d denotes destination-country fixed effects; $X_c^{\mathbf{C}}$ and $X_c^{\mathbf{H}}$ denote the same vectors of current and historical controls as in equation (4); and X_i denotes a vector of individual-level controls that includes years of education, age, age squared, gender, marital status, fixed effects for whether the person lives in a metropolitan or rural area, and fixed effects for the year of the survey.

The OLS estimates are reported in Table 10. The odd numbered columns report estimates using the dependent variable that ranges from one to five, and the even numbered columns report estimates using the indicator variable. Columns 1–2 identify a person's ancestry by their father's country of birth and columns 3–4 use the mother's country of birth. In columns 5–6, we restrict the sample to individuals for whom both parents were born in the same country. In all six specifications, we estimate a positive relationship between traditional plough use and beliefs about gender inequality. The IV estimates are reported in Appendix Table A10.

Interestingly, the same patterns are observed in the European sample as in the US sample: the estimated impact of traditional plough use is stronger when using the mother's ancestry than

[51] The origin countries and the number of immigrants from each are reported in Appendix Table A8.

when using the father's, and it is strongest when both parents have the same ancestry. This suggests that the transmission of values and beliefs is stronger from the mother than from the father, and is strongest when both parents have the same values.

As with the U.S. sample, the estimated impact of the plough is smaller when examining variation across immigrants. The estimates that are most directly comparable to the individual-level estimate (i.e., column 6 of Table 4) are the even numbered columns of Table 10. The estimated impact from the individual-level regression is 0.35, while the impacts from the immigrant-level regressions ranges from 0.047 to 0.066. This suggests that between 13 and 19 percent of the total impact identified in Table 4 is explained by cultural transmission. This is similar to the same figure for female labor force participation using the US immigrant sample (12 to 43 percent).

7. Conclusions

Social anthropologists have long-considered the use of shifting hoe cultivation vs. plough cultivation as an important determinant of the evolution and persistence of traditional gender roles and norms. We formally test this hypothesis by combining ethnographic data on traditional plough use, measured at the ethnicity level, with contemporary data measuring gender norms and female participation outside of the domestic sphere.

Our findings provide evidence that current differences in gender attitudes and female behavior are indeed shaped by differences in traditional agricultural practices. Specifically, we have shown that individuals, ethnicities and countries whose ancestors engaged in plough agriculture have beliefs that exhibit greater gender inequality today and have less female participation in non-domestic activities, like market employment, entrepreneurship, and politics. In an effort to better identify a channel of cultural persistence, we examined second-generation immigrants born and raised in the same country, but from different cultural backgrounds. We find that among these individuals, who face the same labor market, institutions, and policies, a history of plough use is associated with more unequal gender attitudes and less female labor force participation. Based on the relative magnitudes of the baseline and immigrant estimates, the results indicate that culture accounts for 12–43 percent of the total impact of traditional plough use on gender attitudes today.

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