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Modern gender roles and agricultural history: the Neolithic inheritance

Casper Worm Hansen[1] · **Peter Sandholt Jensen**[2] · **Christian Volmar Skovsgaard**[2]

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Abstract This research proposes the hypothesis that societies with long histories of agriculture have less equality in gender roles as a consequence of more patriarchal values and beliefs regarding the proper role of women in society. We test this hypothesis in a world sample of countries, in a sample of European regions, as well as among immigrants and children of immigrants living in the US. This evidence reveals a significant negative relationship between years of agriculture and female labor force participation rates, as well as other measures of equality in contemporary gender roles. This finding is robust to the inclusion of an extensive set of possible confounders, including historical plough-use and the length of the growing season. We argue that two mechanisms can explain the result: (1) societies with longer agricultural histories had a higher level of technological advancement which in the Malthusian Epoch translated into higher fertility and a diminished role for women outside the home; (2) the transition to cereal agriculture led to a division of labor in which women spend more time on processing cereals rather than working in the field.

Keywords Economic development · Culture · Gender roles

JEL Classification J70 · N50 · O11 · O17

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✉ Casper Worm Hansen
casper.worm.hansen@econ.ku.dk

Peter Sandholt Jensen
psj@sam.sdu.dk

Christian Volmar Skovsgaard
chsko@sam.sdu.dk

[1] University of Copenhagen, Øster Farimagsgade 5, 1353 Copenhagen, Denmark

[2] University of Southern Denmark, Campusvej 55, 5230 Odense, Denmark

1 Introduction

Wide disparities in gender roles exist across countries and regions as can be observed in, for example, the large cross-country variation in female labor force participation rates (Alesina et al. 2013). The existence of these disparities has become a concern for policy makers. One manifestation of this is the third Millennium Development Goal, which aims at promoting more equality in gender roles (United Nations 2011). Whether or not an appropriate policy can be designed to reach this goal arguably depends on research to provide an understanding of the underlying causes of the variation in gender roles. Recent research has taken up the challenge and suggests that, to some extent, the observed divergence can be explained by cultural beliefs, which are strongly rooted in history, about the proper role of women in society (Fernandez 2007; Fernandez and Fogli 2009; Alesina et al. 2013).[1]

This paper follows this line of research and proposes the hypothesis that societies with long histories of agriculture have stronger patriarchal values and beliefs that give rise to less equality in gender roles.[2] We test the hypothesis by studying the relation between the timing of the Neolithic Revolution, which is the prehistorical transition from a hunter-gatherer to an agricultural society, and contemporary gender roles as measured by female labor force participation and other indicators of equality in gender roles.

The idea is that the Neolithic Revolution puts societies on a path on which patriarchal norms and beliefs are adopted. Societies with earlier Neolithic Revolutions have been subject to these cultural beliefs more intensely and for a longer period of time. For these reasons, such beliefs are likely to become more ingrained and may still serve as a stumbling block for more equality in gender roles in terms of female labor force participation as well as female participation in politics. If so, this would be important for our understanding of the role of culture for gender roles, and would be highly relevant for policy makers, who want to promote gender equality.

In a world sample of countries, we document robust negative relationships between years of agriculture in 1500 CE and different measures of equality in gender roles, such as female labor force participation and female seats in parliament. As the proposed mechanism operates via informal institutions (i.e., culture) rather than formal institutions, we also test the hypothesis using a sample of European regions. In particular, exploiting the within-country variation in the data in this sample, we find evidence of a negative association between years of agriculture and female labor force participation. Moreover, when we study the mechanism among immigrants and children of immigrants living in the US, we obtain the same conclusion.[3] The evidence from the latter two samples is therefore consistent with a cultural mechanism.

The proposed hypothesis builds on the work of Ashraf and Galor (2011), Diamond (1987), Iversen and Rosenbluth (2010) and others. Diamond (1987) proposes that not only did the move to agriculture lead to an increase in social inequality, but gender inequality also increased. Diamond (1987, p. 66) describes the mechanism as follows: "Freed from the need to transport their babies during a nomadic existence, and under pressure to produce more hands to till the fields, farming women tended to have more pregnancies than their hunter-

[1] For examples of other research papers in which gender plays a role see Galor and Weil (1996), Klasen (2002), Miller (2008), or Doepke and Tertilt (2009, 2011).

[2] Patriarchy is defined by the dominance of males in social, economic, and political organization (Iversen and Rosenbluth 2010, p. 17).

[3] While the analyses for the world sample and the European sample are carried out on data relatively close to the present, the US data cover the periods 1850–1880, 1900–1930 and 1950–1970. The US analysis, therefore, simultaneously allow us to exploit individual level data, and permit us to evaluate the validity of our findings across time.

gatherer counterparts." [4] Moreover, as argued by Galor (2011, p. 167), the Malthusian Epoch was characterized by technological progress being channeled into population growth with a minuscule effect on income per capita. Ashraf and Galor (2011) provide evidence consistent with this using the timing of the Neolithic Revolution as a proxy for technological advancement. Thus, societies with early Neolithic Revolutions arguably experienced higher levels of fertility, which left women with less time to other activities than child rearing. As a consequence, patriarchal values are likely to have become stronger in these societies.

An alternative mechanism[5] builds on the work by Iversen and Rosenbluth (2010), who emphasize the task division within the household. They note that evidence suggests that hunter-gatherer societies were characterized by more independent women as compared to agricultural societies. First, some evidence from present-day hunter-gatherers indicate that the gathering activity of women provides more than half of the daily calorie intake of their communities as discussed below. Second, meat—as provided by male hunting activity—may not have been strictly necessary for survival, and gathered food served as an independent, more secure source of calories.[6] We add evidence that societies relying more on hunting/gathering are more gender equal on a number dimensions. We show that the following outcomes are more likely in these societies: marriage customs which involve reciprocal gift exchange, matrilocality,[7] equal preference for boys and girls, equal punishment for pre-marital sex and equal division of inheritance. By contrast, the Neolithic Revolution set the stage for different social norms based on patriarchy.[8] Moreover, Iversen and Rosenbluth (2010, p. 32) argue that the move to agriculture created "a premium on male brawn in plowing and other heavy farm work." This premium arises in societies which adopted cereal based agriculture rather than root crop agriculture. In fact, Ember (1983) and White et al. (1981) argue that agriculture based on cereals (as opposed to root crops) leads to lower female participation in agriculture. We discuss this in more detail below, but the authors stress that cereal production usually means that women spend more time on processing the cereals rather than working in the field. Interestingly, the transition to agriculture as recorded by Putterman and Trainor (2006) was a transition to cereal-based agriculture in Europe, Asia and Africa.[9] Consistent with these arguments, we report empirical evidence indicating that societies with relative more suitability for growing root crops (compared to cereal crops) had later Neolithic Revolutions and are more equal in gender roles today. We demonstrate this using both cross-country data, and subnational level data for African countries.

Thus, the move to agriculture led to a division of labor within the family, where the man used his physical strength in food production and the woman took care of child rearing,

[4] In line with this view, Lerner (1986) associates the origin of partriarchy with the Neolithic Revolution and argues that: "sometime during the agricultural revolution relatively egalitarian societies with a sexual division of labor based on biological necessity gave way to more highly structured societies […]. The more complex societies featured a division of labor no longer based only on biological necessity, but also on hierarchy and the power of some men over other men and all women." Moreover, Dyble et al. (2015) provide evidence of gender equality in hunter-gathering societies and also associate the rise of gender inequality with agricutural societies in which heritable resources became important fo reproductive success.

[5] We pay special focus to these two mechanisms, though one could also posit other mechanisms e.g. related to the general rise in inequality or religion. We discuss this more below.

[6] The ≠Kade San of the Kalahari is an example of hunter-gatherers that survive without animal food, but not vegetable food (Tanaka 1976, p. 13).

[7] This denotes the situation in which a married couple settles with the wife's family.

[8] Recent evidence from skeletons of Central European farmers in the early Neolithic suggests patrilocality, which denotes the situation in which a married couple settle with the husband's family (Bentley et al. 2012).

[9] This is also true for most of the Americas with the main exception of Venezuela and the Caribbean where early agriculture was based on the manioc root.

food processing and production and other family-related duties. The consequence was that women's role in society no longer gave "her economic viability on her own" (p. 32). In essence, the general shift in the division of labor associated with the Neolithic Revolution aggravated women's outside options (outside marriage), and this increased male bargaining power within the family, which, over generations, translated into norms and behavior which shaped the cultural beliefs on gender roles in societies.

Given the emphasis put on the plough by Boserup (1970) and Alesina et al. (2013), one question naturally arises: Is there evidence that the premium on male brawn existed without the presence of the plough? In fact, the archaeological evidence suggests that the plough is not necessarily required. Peterson (2002), for example, demonstrates that the muscle patterns of Neolithic males from the early cereal producing farming societies of the Southern Levant (present-day Jordan and Israel) are consistent with participation in timbering and tilling.[10] Importantly, the use of the plough cannot be inferred for the period studied (Peterson 2002, p. 49). Hinsch (2003) gives a second example for early Neolithic China 7000–8000 years ago where gender roles already appear to have existed. He observes that "excavation of Peiligang graves have revealed that work tools were often buried alongside the deceased. Some graves include stone agricultural and hunting implements such as shovels, axes, sickles, and arrowheads. Other graves lack these sorts of artifacts, but include tools for grinding grain. From this evidence, archaeologists have concluded that Peiligang work roles were allocated according to gender." Bray (1984, p. 155) discusses when the plough was introduced in China and notes that Wang Chen attributed it to the spring and autumn period (771 until 476 BCE), but considers other dates, the earliest one being 3300 BCE. Thus, plough-use cannot be inferred for this case either. A final example is the field study by Draper (1975) of the !Kung tribe, described below, which suggests that a stronger gender division of labor arises in the absence of the plough. We also demonstrate that societies which have cereals as their main crop have lower female contributions to subsistence even when we control for presence of the plough.

Alesina et al. (2013) provide evidence consistent with Boserup's (1970) hypothesis that plough agriculture is behind present-day gender roles. In particular, they construct a measure of the share of the population that has ancestors who were engaged in plough-use. They note that one caveat associated with this approach is that they cannot measure whether the plough was adopted early, since a longer period of plough agriculture is likely to have led to stronger and more ingrained values and beliefs on appropriate gender roles. In contrast, we provide evidence consistent with an effect of how long ago agriculture was adopted on modern gender roles. A caveat is that when we use a world sample, it is not possible to interpret years of agriculture narrowly as, for example, years of cereal-based or plough agriculture because a few countries did not make the move to cereal-based agriculture. We can address this by considering sub-samples for Europe, Asia, and Africa where we can narrow down the interpretation since early agriculture in these areas were based on cereals.[11]

[10] Tilling includes a range of activities from preparing the soil to the actual planting of seed. Timbering refers to land clearance activites. Peterson (2002, p. 110) stresses that tilling the soil with hoe, digging stick, or adze would require repetitive downward blows involving forearm flexion and extension.

[11] For the European subsamples we can plausibly interpret the transition to agriculture as a transition to cereal-based plough agriculture. The reason is that the transition to agriculture and the transition to plough agriculture practically coincide in Europe, as "agriculture and the plough originated 10–13 millennia ago in the Fertile Crescent of the Near East [...] and were introduced into Greece and southeastern Europe 8000 years ago", Lai (2007, p. 1). Further, Fussell (1966, p. 177) notes that the plough known as a *crook ard* "was commonly used by farmers all over Europe from Scandinavia to the Mediterranean during the late Neolithic Age and the Bronze Age." The European evidence is in line with the hypothesis of Alesina et al. (2013) on years of plough agriculture.

In sum, we provide new evidence consistent with the hypothesis that an early Neolithic Revolution, via its effects on cultural beliefs, is a source of modern gender roles. By doing so, we also contribute to the literature on the consequences of the Neolithic Revolution.[12]

The rest of the paper is organized as follows. Section 2 provides the building blocks of the paper by presenting evidence on gender equality in hunter-gatherer societies and discussing how gender inequality may arise in the absence of the plough. In Sect. 3, we present the data used in the main analysis. Section 4 outlines the estimation framework. Section 5 contains main results. Section 6 presents interpretation. Section 7 concludes.

2 Gender equality and the move to agriculture

This section presents the building blocks for our contention that an early move to agriculture had a negative impact on gender equality. The presence of the first mechanism is attested by the evidence in Ashraf and Galor (2011), who interpret the timing of the Neolithic Revolution as a proxy for the level of technological advancement. In the Malthusian epoch, higher technological advancement translated into higher fertilty, which naturally gave women less time to activities outside the home. However, as proposed in the introduction, this may not be the only mechanism at play. In Subsect. 2.1 and 2.2, we therefore present evidence showing that hunter-gatherers had relatively equal gender roles. While many anthropologists and ethnologists stress gender equality in these societies, there are some notable exceptions such as, in particular, Ember (1975, 1978) and to some degree Kaplan et al. (2000).[13] We therefore provide a discussion of the existing evidence on the contribution to subsistence, and to further substantiate gender equality among hunter-gatherers, we present suggestive correlations between measures of gender equality and the degree to which a society relies on hunting and gathering. In Subsect. 2.3, we move on to the question as to how the premium on male brawn may arise in the absence of the plough. Finally in Subsect. 2.4, we explain the duration effect associated with the timing of the Neolithic Revolution. Specifically, we discuss how an early move to agriculture transforms into norms by considering theory and historical examples. Subsection 2.5 sums up the discussion.

2.1 Contributions to subsistence

Much of the evidence on egalitarianism in hunter-gatherer societies are in the form of calculating subsistence contributions from men and women. Men are assumed to be hunters and women are assumed to be gatherers.[14] In general, two types of evidence exists: a small number of detailed case studies and the Ethnographic Atlas.

[12] This literature highlights the importance of early agricultural adoption on comparative economic development on a worldwide scale. The empirical analysis in Olsson and Hibbs (2005) supports this type of hypothesis formulated in the work of Diamond (1997). In addition, using a refined measure on the timing of the Neolithic Revolution from Putterman and Trainor (2006), Putterman (2008), Petersen and Skaaning (2010), and Bleaney and Dimico (2011) confirms the importance of early agricultural development. However, as suggested by Galor (2011) and indicated by Olsson and Paik (2012), these results seem to be explained by between-continent variation in economic development, which is also in the spirit of Diamond's hypothesis. Our basic result is, on the other hand, strengthened when allowing for continental fixed effects in the regressions.

[13] These observations are arguably not made on pre-historic hunter-gatherers, but on those societies that did not move to agriculture. Yet, as pointed out by Marlowe (2005, p. 54), "the ethnographic record of foragers provides the only direct observations of human behavior in the absence of agriculture."

[14] As illustrated by the case study below, gender roles are not that rigid in all hunter-gatherer societies.

Lee (1968) collected data on the !Kung cited above and reached the result that gathering contributes 60–80 % of the total diet, see Table 5 in Lee (1968). For other Bushmen, Tanaka (1976) and Gould (1977) have made similar estimates.[15] Lee also examined a sample from the Ethnographic Atlas and concluded that below the 42° latitude, gathering is more important, whereas hunting is more important above this latitude. Ember used 181 societies from the Atlas to conclude that men provide most of the calories in all hunter-gatherer societies, but her conclusions have been questioned by Hunn (2000) as explained below. Still, her results confirmed Lee's result that gathering is more important than hunting in the Sub-Saharan African societies in the Atlas. Kaplan et al. (2000) reported calorie contributions in 10 foraging societies and found that the lowest contribution from women is about 15–20 %, whereas the highest is 57 %. Most of the societies has at least a contribution of 30 % from gathering. Thus, Kaplan et al. (2000) study supports Ember's general results of the importance of hunting, but they also suggest a substantial contribution from gathering.

Hunn (2000) notes, and Ember acknowledges, that there is a dominance of North American hunting societies in the Atlas. This point has also been stressed by Wood and Eagly (2002) who state that because "the majority of Ember's (1978) sample was composed of North American societies, aggregating across societies yielded a strong tendency for men to contribute more than women to subsistence (i.e., in 83 % of these societies)." In fact 120 out 181 were North American societies. Hunn also points out that the codes in the Atlas indicating how much a society relies on hunting, gathering and fishing do not directly translate into exact subsistence level. In support of this, he argues that in many cases the codes are based on ethnographic reports that "are almost without exception mere impressions." (Hunn 2000, p. 192). For the case of the societies in the Columbia-Fraser Plateau of North America which according to the Atlas has relatively low contributions from gathering, he points to evidence that gathering is substantially more important. By reviewing the ethnohistorical and ethnographic record for these areas as well as performing time-and-motion studies of contemporary root-digging, he finds that the contributions from gathering are in the neighborhood of 70 %.

It is also instructive to consider Friedl's (1975) four types of hunter-gatherer societies. Three of the types have gathering contributions from women, but the fourth type, exemplified by North Alaskan Eskimos, has men providing almost all of the food. Eskimo groups are also singled out by Lee (1968) who notes that they have virtually no access to vegetable foods given their geographical location. A similar point has been made by Kuhn and Stiner (2006, p. 955), who note that in"some arctic and subarctic regions, there are comparatively few small animals to be had and no vegetable foods of dietary significance, so large game accounts for a very large proportion of all food consumed." The presence of these societies is obviously one factor contributing to hunting being more important above the 42° latitude. For the purpose of understanding the transition to agricultural societies, these groups may also be of limited interest as model for the hunter-gatherer societies that came to exist in Africa, Europe and elsewhere that experienced the transition to agriculture. The possibility for either significant gathering or moving to agriculture is not likely in these arctic or subarctic societies. Yet, some of the outcomes of these societies are in line with the idea that male dominated societies attribute less value to women. In arctic societies, female infanticide is more frequent due to the fact that they will not be able to hunt as adults (Schrire and Steiger 1974).

In sum, there is strong evidence that gathering is a significant contribution to subsistence in Sub Saharan African hunter-gatherer societies. Tanaka (1976, p. 166) summarizes this view, and extends it to the past. In fact, he argues that "we can hardly imagine that the ancient

[15] As noted above, Tanaka (1976) finds that the ≠Kade obtain around 81.3 % of their diet from vegetable foods. Gould (1977, p. 2) finds for the case of aborigines of Australia that "about 90 % of the time women furnish at least 80 % of food available to the group as a whole."

inhabitants of Africa once derived their diet primarily from hunting even if we take into account the difference in environment between the Pleistocene and the present." Whether this holds on average for hunter-gatherer societies has been called into question by Ember's results, but at least part of her conclusion may be attributed to a large share of North American societies, which include, e.g., Eskimo societies and the societies considered by Hunn where gathering activities are underreported. Moreover, the studies by Lee (1968), Tanaka (1976), Gould (1977), Hunn (2000), and Kaplan et al. (2000), which all have more direct observations on subsistence activities indicate that gathering provides significant contributions.

While the subsistence contributions of women may seem small in some societies, the food gathered by women is the more certain food source in these societies (see e.g. Peacock 1991). Moreover, gathered food is an independent food source from the meat provided by men. In cereal basaed agricultural societies, women do not contribute with an independent food source. Nonetheless, given the disagreement between anthropologists and ethnologists additional evidence on relatively high levels of gender equality is needed. This is what we turn to next.

2.2 Evidence from indicators of gender equality

In this section, we investigate alternative indicators of gender equality based on the Ethnographic Atlas. In particular, we study marriage customs practiced in hunter-gatherer societies. This provides evidence on the status and value of women (relative to men). In practice, we run regressions on binary indicators of gender differences on variables that capture how much societies rely on hunting or gathering. These results are reported in Tables 1 and 2. As noted above, Hunn (2000) stressed that some of the variables in the Atlas were, in some cases, constructed on the basis of impressions. To minimize the risk of spurious results, we use two different indicators for the extent to which a society relies on hunting or gathering: (1) a variable indicating the extent to which a society relies on hunting and (2) a variable indicating the extent to which a society relies on gathering. These two variables are positively, and significantly related with a correlation coefficient of roughly 0.51. Moreover, we refrain from making a direct subsistence interpretation, but simply assume that the collectors of the data would be able to evaluate the degree to which societies were based on hunting or gathering.

We first probe into which forms of gifts to the families of the bride and groom are more likely. Societies in which marriages are based on reciprocal gift exchange, which involves the "roughly equal exchange of gifts between the families of the bride and groom" (Ferraro and Andreatta 2010, p. 224), are arguably more gender equal. In fact, a simple linear probability model reveals that reciprocal gift exchange is more likely in hunter-gatherer societies, see columns (1)–(3) in Table 1. This holds when we regress a dummy for reciprocal gift exchange on the degree to which a society relies on hunting or alternatively use the degree to which a society relies on gathering.[16] This indicates the absence of gender bias, and when we estimate similar models for dowries or bride prices,[17] we find that these are both less likely to be practiced in societies that rely more on hunting or gathering.[18]

Next, we follow Briffault (1927, p. 310), who stressed the importance of matrilocal marriages which means that husband and wife settle in the wife's group. He went on to argue that

[16] We obtain similar results when using probit or logit models.

[17] Andersen (2007) notes that these systems date back to 3000 BC for bride price and 200 BC for dowry and the societies in which they arose were based on agriculture. Thus, it is hardly surprising that they are less prevalent in hunter-gatherer societies.

[18] We do not report this result, but it is available upon request.

Table 1 Correlations between marriage customs and hunting/gathering

	Dependent variable								
	Reciprocal gift exchange			Matrilocal marriages			Patrilocal marriages		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Reliance on gathering	0.0109***		0.0064*	0.0239***		0.0204***	−0.0576***		−0.0557***
	(0.0039)		(0.0037)	(0.0070)		(0.0074)	(0.0086)		(0.0091)
Reliance on hunting		0.0104**			0.0400***			−0.0522***	
		(0.0051)			(0.0077)			(0.0091)	
Cereal dominant crop			−0.0499***			−0.039*			0.0216
			(0.0012)			(0.0217)			(0.0262)
# of ethnic groups	1247	1247	1247	1242	1242	1242	1242	1242	1242
R^2	0.006	0.005	0.018	0.011	0.028	0.013	0.040	0.032	0.041

The table reports OLS estimates. All data are from the *Ethnographic Atlas*. Reliance on hunting or gathering is measured on an increasing scale from 1 to 5. Robust standard errors in the parentheses. Constants not reported.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 2 Gender equality and hunting/gathering based on SCCS

	Dependent variable											
	Equal preference for pre-marital sex				Equal punishment for boys and girls				Equal division of inheritance			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Reliance on gathering	0.130**		0.133**	0.126**	0.179**		0.179**	0.139	0.109		0.11	0.0468
	(0.052)		(0.054)	(0.058)	(0.078)		(0.079)	(0.088)	(0.079)		(0.077)	(0.075)
Reliance on hunting		0.038		0.008		0.103**		0.073		0.120**		0.114**
		(0.05)		(0.056)		(0.049)		(0.056)		(0.048)		(0.047)
Cereal dominant crop			−0.094	−0.088			−0.007	−0.048			−0.163	−0.177
			(0.12)	(0.116)			(0.124)	(0.129)			(0.131)	(0.127)
F-test				2.87*				3.85**				3.4**
# of ethnic groups	91	92	91	90	71	72	71	70	69	70	69	68
R^2	0.048	0.007	0.055	0.053	0.073	0.055	0.073	0.100	0.032	0.089	0.058	0.128

The table reports OLS estimates. All data are from the *SCCS*. Reliance on hunting or gathering is measured on an increasing scale from 1 to 5. Robust standard errors in the parentheses. The F-test is test of joint significance for the variables (reliance on) gathering and hunting. Constants not reported.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

whenever these marriages were present, they indicated that a matriarchal order had existed.[19] We do not make this claim, but stress that matrilocal marriages would indicate some power of women. In fact, the data suggest that matrilocal marriages are more likely in societies based on hunting or gathering, see columns (4)–(6) in Table 1. If we look at patrilocal marriages, they are less likely in hunting and gathering societies, see columns (7)–(9).[20] In columns (3), (6) and (9), we control for whether a society's dominant crop is cereal, as we argue below that the move to this type of crop excarbates gender inequality.

We have also investigated the correlation between the reliance on gathering/hunting and class stratification (measured from the absence of stratification to a society with social classes). Class stratification is negatively correlated with the presence of hunting or gathering and positively correlated with cereals as dominant crops. This lends support to the view that hunter-gatherers were relatively equal which could be related to the scope for inequality, see Diamond (1987) and Milanovic et al. (2010). Moreover, using data from the Standard Cross Cultural Sample (SCCS), we find that the contribution to gathering or hunting increases the probability of equal preference for boys and girls, equal punishment for pre-marital sex, as well as equal division of inheritance, see Table 2.

It is worthwhile to note that exogamy—the custom of marrying outside your group—is common in hunter-gatherer societies, but we showed above that this is more likely to be a type of exogamy where men move to the women's group. Briffault (1927, p. 280) noted that in the Kalahari "a man may not marry in the group to which he belongs. It is obligatory for him to join another group to find wives."[21]

Thus, these correlations suggest that societies that depend more on hunting and gathering are relatively egalitarian in gender terms and perhaps even to some extent more likely to be matriarchal, if we believe Briffault. In the main analysis we will use years of agriculture and note that this is a measure of how long ago societies depended mainly on hunting and gatherering.

2.3 Gender inequality with little or no plough-use

In this subsection, we first provide a case study of the !Kung[22] of the Kalahari which are divided into hunter-gatherer and agriculturalist groups. The evidence on the !Kung mainly comes from Draper (1975), who carried out field work on two groups of !Kung in 1968–1969. We then go on to discuss how cereal-based agriculture is associated with less gender equality.

[19] Korotayev (2003) presents evidence that non-matrilocality is very likely in societies where women contribute very little to subsistence. This suggests that postmarital residence and subsistence contributions are related.

[20] Ember (1975, 1978) argued that among hunter-gatherers, patrilocality is the most common settlement pattern. This is not the line we take, as we compare marriage patterns between societies that rely on hunting or gathering to varying degrees. Yet, we want to point out that Alvarez (2004) has analyzed the sources of the data in Ember (1975), and finds that, after careful revision, bilocality is a much more common settlement pattern. This is also more in line with the direct observations of ethnologists and a relatively high level of gender equality.

[21] We use an outcome based on variable 11 in the Ethnographic Atlas. This variable indicates the location of the couple after the first years of marriage. Briffault (1927, pp. 302–303) notes that in many of the cases he observed, marriage is not permanently matrilocal, but in some cases lasts only months and in others years. The alternative variable 13 which does not record a number of years in the Atlas reveals no tendency for either marriage pattern to be more likely in hunter- gatherer societies. This suggests that these societies practice some degree of matrilocality but that it is not permanent. This is consistent with limited gender inequality.

[22] The !Kung are also referred to as Ju/'hoansi; see Kent (1995, p. 513).

2.3.1 Case study of the !Kung

As mentioned, the !Kung are divided into hunter-gatherer and agriculturalist groups. This allows a comparison between the groups in terms of gender roles. Women contribute 60–80 % to the daily food intake in the hunter-gatherer group . This group is described by "sexual egalitarianism" (Draper, p. 96). The agriculturalist group—sometimes referred to as the Mahopa people[23]—had very recently settled at the time of study. They keep small herds of goats and plant small gardens of sorghum, squash, melon, and maize. Draper observes that in this group, gender equality has diminished, and she also describes the sexual division of labor. Importantly, none of the explanations provided by Draper refer to plough-use. Moreover, she indicated in personal communication that none of the Mahopa people were in possession of ploughs or oxen trained to the plough by the 1970s, and it is therefore implausible to attribute the sexual division of labor to plough-use. We also note that the crops grown are plough negative.

Draper concludes that the change to animal husbandry and crop planting was associated with a decrease in women's autonomy and influence relative to men's. In the sedentary society, men clear the fields and erect brush fences around the gardens to keep out the animals. They also attend to the goats. Women, on the other hand, do much of the processing of the food. Draper (p. 101) summarizes this and states that "under settled conditions food preparation is more complicated, although the actual diet is probably less varied in comparison with that of the foragers. Grains and squash must be brought in from the fields and set up on racks to dry. Sorghum and corn are pounded into meal; squash and melons are peeled and then boiled before eating. Women do the greatest part of the cooking, and they also do most of the drying and storing." She also emphasizes that women spend much more time near the home, and that, unlike the hunter-gatherer society, children are socialized in different ways with boys being taught to take care of the herd of goats, and the girls staying at home. Thus, a division of labor and gender inequality have arisen among the sedentary !Kung without the plough. Draper (1975, p. 78) also observes that gender roles are less rigid in the hunter-gatherer society compared to the agricultural society, since men in the former are more likely to carry out what is normally women's work.

As stressed above, Draper indicated in personal communcation that the !Kung studied did not have ploughs when she carried out her studies, and their villages consisted only of !Kung. However, she noted that Bantu speaking tribes used ploughs, and the !Kung living near them know of the plough, and some know how to use it. Yet, the described sexual division of labor appears not to be related to the plough. Since the early 1980s, the more patriarchal Bantu speaking people introduced, or heavily influenced, profound economic changes among the !Kung that may have changed gender roles (Kent 1995). We note that the study by Draper (1975) was carried out before these changes took place.

The case study is suggestive of a shift in gender roles associated with agriculture without the plough.[24] Next, we discuss literature that looks at factors explaining a sexual division in agriculture when the plough is absent.

[23] They are also referred to as the people from the "Dobe area" of Ngamiland, Botswana.

[24] A case study is by construction only one point, so many additional factors could have been in play. It is for example conceivable that the mentioned Bantu farmers had been influenced by e.g. Europeans and migrants with origins in the Fertile Crescent. We investigate these factors further in Sect. 6.4.

2.3.2 Cereal-based agriculture and gender equality

White et al. (1981) provide an analysis of 'the sexual division of labor' in African agriculture using 36 cultures. They note that one advantage of this is that plough-use is unlikely to be a factor behind gender roles in agricultures, as the societies in Africa have limited plough-use. In fact, they posit that certain factors contribute to differences in gender contributions to agriculture. In particular, they emphasize that growing cereal crops—which in the African context include millet and sorghum—rather than root crops contributes to lower female contributions to agriculture. They list a number of arguments for why this is so. First, cereal crops require more secondary processing than root crops, and this tends to be women's task. In line with this, Ember (1983, p. 290) argues that many root and tree crops seem edible with relatively little preparation, whereas cereals are often dried and as a consequence need more processing. She also notes that "cereals take a long time to cook if the kernels are dried and whole [...]. Many of the cereal grains (e.g., millet) also require threshing and winnowing before the kernels can be cooked, pounded, or ground." This is in line with Draper's observation on the !Kung. Second, root crops can usually be harvested at a more leisurely pace than cereal crops because the roots can be left underground. Cereal harvesting is therefore more likely to require mobilization of both men and women. By contrast, root crop harvesting is usually done by women alone.[25] In line with these arguments, White et al. (1981) find that areas that grow cereal crops have lower female participation in agriculture.[26]

The results of these data are also consistent with the historical account of Bauman (1928) who, as pointed out by White et al. (1981), saw a relation between the areas growing cereals and a more patriarchal form of agriculture (see also Lancaster 1976). Bauman (1928) believed that the earliest agriculture in Africa was likely to be based on root crops and large contributions of females to agriculture. He also believed that an ancient system based on cereals—somewhat younger in age than the one based on root crops—was the origin of patriarchy in African agriculture. Guyer (1991) provides circumstantial evidence that the system based on large contributions of females to agriculture is actually the more recent one. In fact, among the Beti of Cameroon the ancient system of crops was based on millet and yams, which include both a cereal and a root crop. According to Guyer (1991), millet typically has substantial male contribution to agriculture, which is in line with White et al. (1981). Moreover, early African agriculture as dated by Putterman and Trainor (2006) was cereal based.[27]

2.4 The duration effect

In this subsection, we discuss theory and examples which elaborate on why there would be a duration effect. Galor (2011, p. 75) argues that the Neolithic Revolution led to one large technological shock followed by a long discrete series of incremental aftershocks. The aftershocks were made possible by the rise of a non-food-producing class whose members were essential

[25] This would imply that in terms of contributions to subsistence men would add more due to increased participation in harvesting with cereal based agriculture.

[26] Other plausible mechanisms exist. As pointed out by an anonymous reviewer, important consequences of sedentary agriculture were the notion of storing goods and the notion of private property. Since root crops are less portable and are more perishable, these are easier to implement with cereal crops. This is in line with the narrative in Lerner (1986), who note that men were able to have control over surplus food.

[27] While this paper mainly highlights the common effect of cereal crops, recent research suggests that the type of cereal crop may matter for cultural attitudes (Talhelm et al. 2014). In this paper, we control in some regressions for different types of cereals according to whether they are plough positive or plough negative.

for the advancement of written language and other inventions. The initial shock seems also to have led to a particular gender division of labor which over time slowly resulted in cultural values that were actively promoted by writers from the non-food-producing class.[28] As pointed out by Galor (2011), time since Neolithic Revolution captures how many aftershocks a society has experienced. He demonstrates that societies with earlier Neolithic Revolution had higher technology levels in both CE 0 and CE 1000 (p. 79). Moreover, the technological differences are persistent, which is also in line with work by Comin et al. (2010). Thus, even after thousands of years of agriculture in all of the countries, they experienced technological divergence. We believe that it is plausible that this also translated into fertility differences as well as cultural divergence in terms of gender roles.

We can also appreciate the survival of values by appealing to the theories of the spread of the Neolithic Revolution. According to the "cultural diffusion model", indigenous hunter-gatherers adopted the agricultural package without a direct influence from immigrating farmers. In this model, the process of accumulating patriarchal values therefore started earlier on in societies with long histories of agriculture. According to the "demic-diffusion model." which posits that the Neolithic Revolution spread by migration, more years with agriculture in a country/region reflect a longer process of assimilation between hunter-gatherers and farmers. Thus, in a model of intergenerational transmission of culture (see, e.g., Bisin and Verdier, 2010), where culture is formed in the interaction between parental socialization (values transmitted from parents, which, in part, reflect the hunter-gatherer way of life) and economic variables such as the mode of production (agriculture production), traces of hunter-gatherer traits are less prevalent in societies with longer agricultural histories. In fact, evidence suggests that the settled farmers interbred with local hunter-gatherers (Bellwood 2005).[29] Morever, recent evidence by Skoglund et al. (2012) compare the alleles of Neolithic hunter-gatherers and farmers to present day Europeans, and find that "Neolithic hunter-gatherers shared most alleles with northern Europeans, and the lowest allele sharing was with populations from southeastern Europe. In contrast, the Neolithic farmer shared the greatest fraction of alleles with southeastern European populations (Cypriots and Greeks) and showed a pattern of decreasing genetic similarity to populations from the northwest and northeast extremes of Europe." This is in line with the Neolithic Revolution having a differential impact on European culture since it appears that genes from hunter-gatherers have persisted more strongly in the North.

The case study of China by Hinsch (2003) provides an interesting illustration of how norms might take a long time to become ingrained as well as the role played by intellectual elites. He notes that a gender division of labor existed quite early (7000–8000 years ago), yet it took a long time before this division translated into values and beliefs. Much later during the Eastern Zhou (1046–256 BCE) era, Hinsch (p. 598) notes "a major change in sexual segregation." Specifically, he argues that "men and women were still separated for much of the day because they did different kinds of work in separate places, and perhaps also because of exogamous marriage customs. But some thinkers began to see this physical separation of the sexes not as a mundane fact, but as a lofty ideal." In fact, Hinsch (2003, p. 599) notes

[28] This is in line with the Neolithic Revolution bringing around an upper class of intellectuals and rulers which would play a role in enforcing social norms. In the Chinese case discussed below, the Neolithic Revolution arguably brought about Confucius and his followers who helped establish patriarchal values based on the pre-existing gender division of labor. Patriarchy was not invented by Confucius, as it also arose in other parts of the world.

[29] Empirically, much evidence exists which favors the demic-diffusion model, but according to Gkiasta et al. (2003), there is also evidence of the cultural-diffusion model where adoption of agriculture is due to incoming ideas rather than people.

that by the Han dynasty (206 BCE–220 CE) the "ideal of men plowing and women weaving had become a mainstay of social discourse. It can be found in all major genres of writing." Thus, it took thousands of years before gender roles in agriculture were transformed into beliefs and norms in China. A second example comes from the Middle East. According to Schaneveldt et al. (2005, p. 80), gender roles were more egalitarian in the early days of Islam. In fact, women were encouraged to attain an education in both religious and social domains, but the status of women declined as "pre-Islamic (Neolithic) traditions reappeared." This is also consistent with our hypothesis that countries with early Neolithic Revolutions have more ingrained patriarchal values.[30]

Patterson's (1994, pp. 305–308) chapter on the division of labor in Ireland in the time around CE 700 suggests that the direct labor contribution from males was cultivation. Men had special claims to grain and they would have been involved in all facets of tillage including plowing. Yet, she notes that "wives undertook plowing" (p. 305) according to the Cáin Lánamna ('the law of marriage') of CE 700 and that the division of labor was less rigid in Ireland compared to many other European contries. Ireland had a relatively late transition to agriculture compared to, for example, Italy which had the transition 3000 years earlier. For the case of the !Kung, Draper's study indicates that values are changing among the sedentary !Kung. Yet young rebellious wives were not uncommon (Draper 1975, p. 97).

2.5 Summing up

We have provided and referred to evidence consistent with the proposed mechanisms. We have also provided a case study and discussed the possibility that the move to cereal-based agriculture has been associated with a gender division of labor which fits the one that Alesina et al. (2013, p. 475) attributes to plough agriculture: "Men tended to work outside the home in the fields, while women specialized in activities within the home."[31] This fits the situation of the sedentary !Kung people, and also fits with the other historical examples mentioned in this section and in the introduction. We have also explained how years of agriculture may be viewed as capturing the intensity of treatment. This provides the background for testing the proposed hypothesis.[32]

3 Data and descriptive statistics

This section presents a short overview of the dataset assembled for the empirical analyses. Data sources and the countries included in the various samples are reported in the online appendix. The female labor force participation rate in 2000 CE is used as our main indicator of contemporary equality in gender roles. We use this indicator for two reasons. First, the hypothesis presented above mainly relates to whether females participate in the labor market. Second, the female labor force participation rate is the main indicator used in other research on gender roles, e.g., Fernandez and Fogli (2009) and Alesina et al. (2013). Nevertheless, in the paper, we also consider the following alternative indicators: years since female suffrage in 2000 CE, fraction of female seats in national parliaments, fraction of female legislators

[30] Schvaneveldt et al. (2005, p. 77) state that "Historically, gender roles and family relationships in Middle Eastern culture have been very traditional and steeped in beliefs and customs stemming from Islam." This indicates that Middle Eastern patriarchy is not of recent date.

[31] As noted previously, this is not the only difference between hunter-gatherer and farming societies.

[32] Given the theoretical background, we note that the effect may not be so strong for the Americas given the presence of societies that moved to root-based agriculture.

Table 3 Summary statistics

Variable description	#Obs.	Mean	Std. dev.	Min	Max
Cross-country dataset					
Migration-adjusted years of agriculture in 1500	155	4.927	2.151	0	9.900
Years of agriculture in 1500	155	4.362	2.457	0	10
Female labor force participation in 2000	155	55.39	16.760	13.40	91.40
Log income/capita (in 2000)	154	8.627	1.195	5.790	11.21
Tropical climate	155	0.732	0.423	0	1
Fraction of arable land	155	0.156	0.146	0.0009	0.664
Ln distance to coast or river	155	4.972	1.374	1.115	7.777
Landlocked dummy	155	0.245	0.432	0	1
European dataset					
Years of agriculture in 1500	174	6.447	0.905	5.084	9.890
Female labor force participation in 2008	174	48.34	10.500	3.800	68.04
Ln income/capita (in 2008)	169	9.808	0.663	7.937	10.87
Distance to the Equator (in km)	174	5,345	553.400	4,173	6,454
Distance to Wittenberg (in km)	174	935.6	570.000	55.27	2,867
Plough-suitable share (positive)	174	0.518	0.304	0	1
Plough-suitable share (negative)	174	0.0167	0.0521	0	0.305

This table reports summary statistics for the baseline variables in the cross-country analysis and the European regional analysis

and managers, female-male schooling ratio, and a 'gender equality' index to be explained below. In addition, the online appendix reports results using cultural values from the World Value Survey (see Table 14A).

The main explanatory variable is years of agriculture in 1500 CE. Countries with a later transition than 1500 are set to zero years of agriculture. For the cross-country sample, we obtain data from Putterman and Trainor (2006), which are weighted by the post-1500 migration flow (Putterman and Weil 2010). For the regional European sample, data are obtained from Pinhasi et al. (2005).[33]

As control variables, we include a range of variables accounting for geographical, socioeconomic, historical, and other country (regional) specific characteristics; see Table 18A in the online appendix for details. In general, the control variables are introduced as the analysis progresses. The summary statistics for the baseline variables in the cross-country and European regional samples are reported in Table 3.

[33] In particular, Pinhasi et al. (2005) provide carbon dates from various Neolithic sites in Europe. From this, we obtain average transition dates of each NUTS 2 region in ArcGIS. See also Fig. 2 for a map depicting these data.

4 Estimation framework

We start out by testing the outlined hypothesis in a world sample of countries by using the following baseline specification:

$$FLPR_i = \alpha + \beta \text{ years of agriculture}_i + \mathbf{X}_i'\gamma + D_k + \varepsilon_i, \quad (1)$$

where i denotes country, $FLPR_i$ is the female labor force participation rate in 2000 CE, years of agriculture$_i$ is the migration-adjusted years of agriculture in 1500 CE (in 1000s), $\mathbf{X}_i$ is a set of control variables (e.g., income, income^2, formal institutions, geography, religion, historical plough-use), D_k is continental fixed effects, and ε_i denotes the disturbance term. Formally, the hypothesis to be tested is that $\beta < 0$: years of agriculture is negatively related to female participation in the formal labor market. We also implement a version of Eq. (1) in which we use the unadjusted years of agriculture in 1500 CE.

A key methodological challenge for this type of analysis is how to separate the effect of culture from the effect of formal institutions and other national specific conditions. Even though the approach in Eq. (1) attempts to deal with this by including a range of possible confounders, a concern may be how much of the magnitude of β relates to national institutions. This is dealt with in two ways. First, we follow the approach as in, for example, Tabellini (2010) and estimate the following model on a European regional sample:

$$FLPR_{ji} = \alpha + \beta \text{ years of agriculture}_{ji} + C_i + \mathbf{Z}_i'\mu + \epsilon_{ji}, \quad (2)$$

where j denotes region,[34] $FLPR_{ji}$ is the female labor participation rate in 2008 in region j of country i, years of agriculture$_{ji}$ is the years of agriculture in 1500 CE (in 1000s), C_i represents the country fixed effect for country i, Z_{ji} denotes additional control variables (e.g., income, income^2, distance to Wittenberg, distance to the Equator, plough-suitable share), and ϵ_j is the unexplained part. The specification in Eq. (2) controls for all national level factors and in this way rules out that β is contaminated by the effect of, for example, male-biased national formal institutions.

In the second approach, we study the mechanism among (female) immigrants and (female) children of immigrants living in the United States. The estimation equation is given by:

$$FLP_{jist} = \alpha + \beta \text{ years of agriculture}_i + \mathbf{X}_i'\pi + \mathbf{V}'_{jist}\gamma + \mu_s + \tau_t + \varepsilon_{jist}, \quad (3)$$

where FLP_{jist} is an indicator variable for the labor force status of a (female) immigrant or a (female) child of an immigrant j, with ancestry of country i, living in state s in year t. years of agriculture$_i$ is the number of years of agriculture in the father's country of origin in 1500 CE (unadjusted), $\mathbf{V}_{jist}$ denotes a set of individual-level controls (age, age^2, literacy or education level, years living in the US), μ_s is state fixed effects, τ_t is US census-year fixed effects, and ε_{jist} is the disturbance term. We identify the children of immigrants through their father's ancestor country. The remaining variables are defined as in Eq. (1).

Finally, it should be noted that we also study the hypothesis in samples with regional and individual data from the Demographic Health Survey and World Value Survey, respectively. These result are reported in Tables 12A and 14A in the online appendix.

[34] Regions follow Eurostat's definition of regions at the NUTS 2 level, which categorizes regions based on population sizes ranging from 800,000 to 3 million.

5 Results

We report the main results in two subsections. Section 5.1 presents the main results based on the world sample, whereas Sect. 5.2 considers the robustness of these results.

5.1 Main results

Columns (1)–(3) in Table 4 display the results of estimating Eq. (1). In column (1), the female labor force participation rate is regressed on the migration-adjusted number of years of agriculture. From this, we see a statistically significant and negative coefficient, and the R^2 indicates that agricultural history explains one-quarter of the variance in the year 2000 female labor force participation rate. This suggests that a long agricultural history is related to "traditional" gender roles with women being outside of the formal labor market. To obtain an impression of the economic significance, we note that the result implies that a thousand-year earlier transition is associated with 3.9 % points lower female participation. By the inclusion of continent dummies, column (2) checks whether the result is driven by between-continent variation in the outcome variable, but this actually increases the absolute value of the coefficient from 3.9 to 6.0.

The influence of controls for economic development and geography is demonstrated in column (3). Previous studies have argued that female labor force participation follows a U-shaped path in economic development (e.g., Goldin 1995; Galor and Weil 1996; Tam 2010), and we therefore include the natural log of income and its square.[35] The estimated coefficients on income and income squared confirm a U-shaped relationship. Moreover, various aspects of geography are possibly related to both gender roles and the timing of the Neolithic Revolution. Thus, the specification in column (3) includes the following geographical controls: fraction of tropical and subtropical land, fraction of arable land, log distance to coast or river, and a dummy for landlocked countries. We note that the magnitude of the basic result is relatively stable to the inclusion of these control variables. Figure 1 plots the partial correlation for the model in column (3), which we consider as our baseline result, and it suggests that the relationship is not driven by outliers.[36]

In columns (4)–(6), we repeat the estimations with the unadjusted years of agriculture as the explanatory variable. Doing so is interesting for two reasons. First, the post-1500 migration flow is possibly endogenous to current gender roles if areas with a "potential" for developing patriarchal cultural values attracted immigrants with long ancestral histories of agriculture. The unadjusted measure will by construction not suffer from this source of endogeneity. Second, and more importantly, the proposed hypothesis is consistent with the notion that the history of a population's ancestors matters more than its history of geographical places (Putterman and Weil 2010). This would suggest that results should be stronger with the adjusted measure. The regressions with the unadjusted measure show a significant negative

[35] Given that income is likely to be endogenous, it is important to run regressions which exclude this variable. This is done e.g. in columns (1) and (2) in Table 4. Yet, since many studies include this variable, we decided that it is, on balance, better to show specifications which include it.

[36] The online appendix reports results from using the availability of prehistoric domesticable animals and plants as "bio geographical" instruments for the timing of the Neolithic Revolution (see Table 15A). Given that this only influences female labor force participation rates through adoption of agriculture, we can rule out that the results are driven by omitted variable or attenuation bias. It could, however, be argued that the availability of prehistoric domesticable animals is invalid as an instrument, because it is related to the adoption of animal husbandry which could lead women to spend more time closer to home taking care of animals. Nevertheless, we obtain similar results when conditioning on a measure of actual historical use of domesticated large animals from Alesina et al. (2013).

Table 4 Main results—gender roles and years of agriculture

	Dependent variable is female labor force participation in 2000					
	(1)	(2)	(3)	(4)	(5)	(6)
Years of agriculture	−3.915***	−6.018***	−5.366***			
(migration-adjusted)	(0.564)	(0.757)	(0.806)			
	[0.582]	[0.758]	[0.791]			
Years of agriculture				−2.697***	−4.920***	−4.855***
(unadjusted)				(0.539)	(0.805)	(0.823)
				[0.552]	[0.772]	[0.791]
ln income/capita in 2000			−32.28**			−35.86**
			(14.92)			(16.58)
			[14.49]			[16.14]
ln income/capita in 2000			1.837**			1.938**
squared			(0.845)			(0.932)
			[0.824]			[0.911]
Tropical climate			−6.738			−5.852
			(4.261)			(4.127)
			[4.205]			[4.088]
Arable land			10.80			5.182
			(8.019)			(8.820)
			[0.076]			[0.087]
Ln distance to coast or			0.728			1.628*
river			(0.932)			(0.945)
			[0.899]			[0.927]
Landlocked			3.435			3.202
			(2.898)			(2.817)
			[2.738]			[2.695]
Continent fixed effects	No	Yes	Yes	No	Yes	Yes
# of countries	155	155	154	155	155	154
R^2	0.25	0.38	0.44	0.15	0.32	0.43

The table reports OLS estimates. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006) adjusted with a post-1500 migration matrix (Putterman and Weil 2010). Constants are not reported. Robust standard errors in the parentheses. Conley standard errors in the brackets that allows for spatial dependence between observations at a 5° level.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

association as expected from the high correlation between the two variables (circa 0.85). But the absolute values of the coefficients on the unadjusted measure are smaller in numerical magnitude. Therefore, although the results in this section are quiet about the role of formal versus informal institutions, they are consistent with the interpretation that people with long histories of agriculture have adopted certain values and norms that still affect their views on the role of women in the labor market today.

5.2 Robustness

The conclusion that long histories of agriculture matter for the contemporary role of women in society is corroborated by the strong robustness of the finding. In particular, this subsection

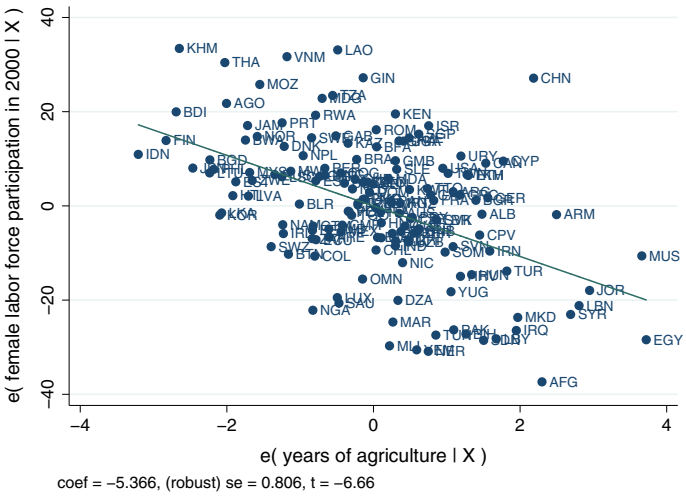

Fig. 1 The partial relationship between female labor force participation and years of agriculture. *Notes* Data source: Column (3) of Table 4

demonstrates the robustness of results to potential confounding factors, alternative samples, and alternative outcome measures.

The role of historical plough-use and growing season Table 5 investigates whether our key finding simply reflects the effect of historical plough-use or the number of growing days on modern gender roles. In columns (1)–(4), the historical plough-use variable from Alesina et al. (2013) has been added to the model and is negative and statistically significant in specifications (2) and (4), where we have added the baseline controls of Alesina et al. (2013).[37] Importantly, the coefficient on years of agriculture remains negative and statistically significant in all specifications, suggesting that long histories of agriculture do not merely capture historical plough-use. Further, we add the number of growing days per year in columns (5)–(8) to test whether the effect comes from the role of the length of the growing season as proposed by Burton and White (1984).[38] The variable is significant with a positive sign as expected, but adding it does not change our baseline result, which remains significant, even though the point estimate is reduced somewhat.[39]

Other potential confounding factors The results from specifications which control for other confounding factors are reported in Table 6. Columns (1)–(3) include variables that are intended to capture the effect of formal institutions on gender roles. Hariri (2012) finds that early statehood outside Europe is related to present autocratic rule which may itself

[37] These include the following variables: the economic and political development of the country in ancient times, the use of large domesticated animals, the overall agricultural suitability, the fraction of tropical and subtropical land, log GDP per capita, log GDP per capita squared, and continental fixed effects.

[38] Burton and White (1984) based this prediction on among other things a case study by Machlachlan (1983). He studied South Indian intensive farming and argued that a narrow seasonal window puts a premium on the labor of young men due to the soil preparation being physically demanding. He also argues that men gain critical farming experience while young, which then made them more efficient farm managers when older.

[39] We have also investigated whether our results are driven by, for example, the interaction between years of agriculture and historical plough-use, or the one between years of agriculture and the number of growing days per years. Including these interactions does not affect the significance of years of agriculture, and they are not significant themselves.

Table 5 Robustness—the roles of historical plough-use and growing days

	Dependent variable is female labor force participation in 2000							
	Historical plough-use				Seasonal constraints			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years of agriculture (migration-adjusted)	−5.104***	−4.641***			−3.802***	−3.507***		
	(0.786)	(0.822)			(0.784)	(0.816)		
Years of agriculture (unadjusted)			−4.610***	−3.943***			−3.323***	−2.615***
			(0.819)	(0.846)			(0.810)	(0.929)
Historical plough-use	−6.197	−8.982**	−6.939	−10.12**	−4.324	−7.102*	−4.903	−8.399**
	(4.378)	(4.355)	(4.191)	(4.408)	(3.855)	(4.037)	(3.691)	(4.077)
Growing days					0.0542***	0.0487***	0.0554***	0.0484***
					(0.0121)	(0.0122)	(0.0121)	(0.0138)
Alesina baseline controls								
Agricultural suitability		7.603*		6.553		9.463**		9.007**
		(4.136)		(4.215)		(3.947)		(4.266)
Tropical climate		−8.141*		−9.392**		−9.873**		−11.21**
		(4.433)		(4.125)		(4.629)		(4.310)
Presence of large animals		−0.971		0.366		−2.976		−2.254
		(5.998)		(6.469)		(5.293)		(5.843)
Political hierarchies		1.511		1.523		2.071		2.159
		(1.520)		(1.594)		(1.397)		(1.463)
Economic complexity		0.804		0.832		−0.696		−0.631
		(0.893)		(0.884)		(0.939)		(0.959)

Table 5 continued

	Dependent variable is female labor force participation in 2000							
	Historical plough-use				Seasonal constraints			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln income/capita in 2000		−33.13**		−35.59**		−36.87***		−38.67**
		(14.46)		(15.99)		(13.60)		(14.81)
ln income/capita in 2000 squared		1.848**		1.895**		2.085***		2.121**
		(0.816)		(0.890)		(0.773)		(0.833)
Baseline controls	Yes	No	Yes	No	Yes	No	Yes	No
Continent fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of countries	154	154	154	154	154	154	154	154
R^2	0.46	0.48	0.45	0.45	0.52	0.52	0.51	0.49

The table reports OLS estimates. Historical plough-use is the proportion of citizens with ancestors that used the plough in pre-industrial agriculture (Alesina et al. 2013). Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006) adjusted with a post-1500 migration matrix (Putterman and Weil 2010). Growing days are average yearly growing days from FAO GAEZ 2002. Baseline controls refers to the variables included in column (3) of Table 4. Constants are not reported. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

influence gender roles,[40] and since state history is positively related to the timing of the Neolithic Revolution, this channel might be what drives our results. Along similar lines, the work of Acemoglu et al. (2002) finds that Europeans tended to set up extractive institutions in places with early development. This, along with the results in Ashraf and Galor (2011), also constitutes an alternative explanation for the presented evidence if extractive institutions are male biased. To address these issues, we augment the model specification from column (3) in Table 4 with an index of state antiquity from 0 to 1500 CE (Putterman 2007),[41] legal origin dummies, the level of democracy in 2000, and an index of social infrastructure (Hall and Jones 1999). The regressions in columns (1)–(3) establish that our basic result is robust to these alternative institutional explanations.

Previous work argues that religion plays a significant role in explaining cross-country variation in female contribution to the labor market; see the discussion in Alesina et al. (2013: p. 33). While religion can be regarded as a channel through which agricultural history might affect gender roles, we nonetheless explore the importance of this specific channel. Column (4) includes the fraction of Muslims, the fraction of Protestants, the fraction of Catholics, the fraction of other Christians, and the fraction of Hindus, and column (5) also includes religious fractionalization. We find that the absolute value of the coefficient reduces from around 5 to 3, but it remains statistically and economically significant. Moreover, in Tables 10A and 16A in the online appendix, we demonstrate that similar estimates are obtained when using the same religious shares for the year 1900 instead. These findings suggest that years of agriculture does not only impair gender equality through the doctrines of religion.[42] Given that hunter-gatherers were more equal, we have, in some unreported specifications, also checked whether our results are driven by (persistent) inequality by including the gini coefficient.[43] We find that this does not affect results.

So far we have controlled for the effect of economic development on female labor force participation by the inclusion of income and income squared. Column (6) adds years passed since the demographic transition (Reher 2004), as an alternative predetermined control for economic development today, but again, the coefficient on years of agriculture is stable.

Finally, column (7) includes the above-mentioned controls simultaneously. While the magnitude and precision of the coefficient is reduced, we still find a sizable negative effect associated with years of agriculture. Moreover, if we compare the coefficient from this full specification to the coefficient from most restricted specification, reported in column (1) of Table 4, the influence of unobservable variables would need to be about 1.5 greater than that of the observable variables (included in column 7 of the current table) to explain our finding away (see Altonji et al. 2005; Nunn and Wantchekon 2011).

The online appendix further shows that our conclusion is robust to an extended set of controls. For example, physical distance to the Fertile Crescent, migratory distance to East

[40] Lerner (1986, p. 9) also links the creation of early states to gender roles and argues that they were organized in the form of patriarchy. Still, she also acknowledges that plough agriculture may have mattered as it demanded the strength of men and was not for pregnant women or lactating mothers (Lerner, p. 51).

[41] The state antiquity variable is migration adjusted. Similar results are obtained for the unadjusted variable.

[42] Ross (2009) argues that oil production rather than Islam reduces contemporary female labor market participation. In results available upon request, we demonstrate that our argument is robust to the inclusion of oil rent per capita (taken from Ross 2009).

[43] An alternative way of evaluating the importance of social inequality as a cause of gender inequality is to consider complex hunter-gatherers as found in e.g. the Pacific Northwest. According to Klein (1995), these societies have social hierarchies, though gender inequality is absent. Burchell (2006) reports evidence consistent with this by examining the extent to which men and women are buried with grave goods . Yet, Ames and Maschner (1999) found that men were more likely to be buried with grave goods.

Table 6 Robustness to confounders

	Dependent variable is female labor force participation in 2000						
	Institutions & democracy			Religion shares & fractionalization		Fertility Trans.	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Years of agriculture (migration-adjusted)	−5.228***	−4.280***	−3.350***	−2.990***	−3.088***	−5.187***	−2.340**
	(0.859)	(0.734)	(0.857)	(0.815)	(0.818)	(0.907)	(1.067)
State history (migration-adjusted)	−2.151	−3.372	−12.82*				−9.466
	(5.661)	(5.465)	(7.704)				(6.977)
Democracy		0.557**	0.410				−0.337
		(0.242)	(0.379)				(0.403)
Social infrastructure			9.049				1.968
			(11.64)				(8.932)
Religious fractionalization					2.909		−6.648
					(4.632)		(8.641)
Fertility transition						0.115	0.0871
						(0.0712)	(0.0696)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Legal origin dummies	No	No	Yes	No	No	No	Yes

Table 6 continued

	Dependent variable is female labor force participation in 2000						
	Institutions & democracy			Religion shares & fractionalization		Fertility Trans.	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Religion shares	No	No	No	Yes	Yes	No	Yes
# of countries	147	143	111	154	153	122	98
R^2	0.430	0.520	0.545	0.633	0.639	0.448	0.681

The table reports OLS estimates. Baseline controls refer to the variables included in column (3) of Table 4. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006) adjusted with a post-1500 migration matrix (Putterman and Weil 2010). State History is a State Antiquity Index from 0-1500 CE (Putterman 2007). Democracy is the Polity-2 score (Polity IV Database). Legal origin dummies are from La Porta et al. (2008). Social infrastructure is from Hall and Jones (1999). Religious fractionalization is from Alesina et al. (2003). Religion shares are: Muslim share, Catholic share, Protestant share, Hindu share, and Other Christians share (all in 2000). Fertility transitions is time elapsed since the fertility decline (the Demographic Transition) in 2000 (Reher 2004). Constants are not reported. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Africa and its square, colonial dummies, and the extended set of covariates used in Table VII of Alesina et al. (2013), see Tables 7A, 12A as well as 13A.

Sub-samples Table 7 provides the estimated coefficients on years of agriculture across different sub-samples of observations. For convenience, we repeat our baseline result in column (1). Because the forerunner countries in the transition to agriculture are located in the Middle East (e.g., Iraq, Jordan, Lebanon, and Syria), one might suspect that the basic association is driven by countries in this area of the world. But, as can be seen from column (2), excluding the Middle East only has a relatively small effect on the stability of the coefficient on years of agriculture. Next, in column (3), we observe that the basic result also turns up when only considering Old-World countries.[44]

To provide further insights into whether we are merely capturing a plough effect along the lines of Alesina et al. (2013), we restrict the sample to countries that did not engage in historical plough-use in column (4).[45] Within this small group of countries, we also recover a negative and statistically significant correlation, suggesting that our variable cannot only be attributed to historical plough-use. Moreover, the estimated coefficient is of the same magnitude as in our base sample. The remaining columns of Table 7 consider the proposed hypothesis continent by continent. While the basic estimate loses some magnitude and precision in the Americas (column 8), we find a significant negative relationship between the female labor force participation rate and migration-adjusted years of agriculture within each of the remaining continents (i.e., Africa, Asia, and Europe).[46] Moreover, for the European sample we argued that there is little variation in historical plough-use. Our assumption of nearly invariant historical plough-use within Europe is warranted, as this variable has a negative, but statistically insignificant coefficient in the European sub-sample (not reported). In fact, the coefficient is estimated with great imprecision with a t-value of -0.16. However, the coefficient on years of agriculture is practically unchanged and remains significant.

Finally, it can be noted that while column (4) only includes the countries with no historical plough-use, we have also investigated whether the relationship holds for different cut-offs of historical plough-use. All results are in line with the proposed hypothesis; see Table 6A in the online appendix.

Alternative outcomes Table 8 considers alternative outcomes. Column (1) reports a significant negative relationship between years of agriculture and women's labor force participation relative to that of men in the year 2000, ruling out that our results thus far are explained by variation in the general economic activity level. In columns (2) and (3), the outcome variable is the female labor force participation rate in 1980 and the 1960s, respectively. The estimated coefficients are similar to the baseline finding, which also provides evidence for persistent gender roles. The remaining columns of Table 8 look at alternative measures of the equality of gender roles. In column (4), we find a negative association between the number of years (in 2000) since the date of the extension of the franchise to women and years of agriculture, implying that on average, countries with long histories of agriculture granted women political rights later on. Column (5) shows that contemporary female political representation likewise is lower for countries with an early Neolithic Revolution. Column (6) documents that for countries with longer histories of agriculture, survival rates for boys are relatively higher

[44] See online appendix for a list of these countries.

[45] These countries are defined from the value zero in the variable traditional plough use from Alesina et al. (2013).

[46] Boserup (1970, Chap. 1) shows that women's participation in the agricultural workforce is substantially higher in Africa compared to Asia. Even so, there is variation within Asia, where some parts of, for example, China have quite high participation rates of women in agriculture, but still lower than what is observed in Africa. Boserup attributes this to the use of intensive agriculture with irrigation.

Table 7 Sub-samples

	Dependent variable is female labor force participation rate in 2000							
	Baseline sample	Excl. the Mid. East	The old world	No-plough countries	Europe	Asia	Africa	Americas
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years of agriculture (migration-adjusted)	−5.366***	−4.652***	−5.872***	−5.925***	−3.731***	−4.978***	−7.648***	−1.078
	(0.806)	(1.057)	(0.879)	(1.793)	(1.094)	(1.775)	(1.747)	(2.759)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of countries	154	138	125	35	38	41	46	24
R^2	0.44	0.34	0.47	0.70	0.35	0.46	0.61	0.45

The table reports OLS estimates. Baseline controls refer to the variables included in column (3) of Table 4. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006) adjusted with a post-1500 migration matrix (Putterman and Weil 2010). No-plough countries are countries with value zero in the historical plough-use variable from Alesina et al. (2013). Columns (1)–(4) all include continent fixed effects. Constants are not reported. Robust standard errors in the parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8 Alternative outcomes

	Dependent variable								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Relative labor force part. in 2000	Female labor force participation in		Years since female suffrage	Female seats in parliaments	Sex ratio at birth	Female legislators & managers	Female-male schooling ratio	Gender equality index
		1980	The 1960s						
Years of agriculture (migration-adjusted)	−0.0629***	−5.434***	−4.952***	−1.686**	−1.522**	0.00345***	−2.036***	−0.0159***	−0.116
	(0.00966)	(0.955)	(1.346)	(0.806)	(0.585)	(0.00131)	(0.719)	(0.00478)	(0.0754)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of countries	154	127	69	153	133	153	100	133	61
R^2	0.47	0.52	0.326	0.45	0.23	0.389	0.41	0.61	0.52

The table reports OLS estimates. Baseline controls refers to the variables included in column (3) of Table 4. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006) adjusted with a post-1500 migration matrix (Putterman and Weil 2010). The dependent variable is indicated in the column. Constants are not reported. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

than the for girls as reflected by the sex ratio at birth in 2000.[47] In the final three columns, we use the fraction of female legislators and manageres, the female-male schooling ratio in 2000 (Barro and Lee 2013), as well as a 'gender equality' index, measuresing the extent to which a country has installed institutions promoting equal access for men and women in education, health, and the economy. We find that these three outcomes are negatively related to years of agriculture, although the estimated coefficient is only statistically significant at the 15 % level when using the gender inequality index as outcome.

Finally, the online appendix documents three further important conclusions. First, very similar results are obtained if the outcome (i.e., the female labor force participation rate) in Tables 4, 5, 6, and 7 is replaced with the female labor force participation rate relative to the male labor force participation rate (see Tables 1A–4A). Second, using individual data from the World Value Survey, as in Table V in Alesina et al. (2013), we find that in countries with long histories of agriculture, women are less likely to participate in the labor market, and that the views that men have more right to jobs (when these are scarce) and that men are better political leaders are more likely (see Table 14A). Finally, the SCCS reveals that ethnic groups within countries with longer agricultural histories have lower contributions from women to agriculture, stronger preference for boys as well as lower overall contribution to subsistence from women once agriculture accounts for more than 10 % of the food supply (See Table 17A).

6 Interpretation of the results

The following subsections provide additional analyses that help narrowing the interpretation. First, the next two subsections address the concern that formal institutions drive results. Section 6.1 demonstrates that the results are robust to country fixed effects in a sample of European regions. Section 6.2 studies the hypothesis in samples of immigrants and children of immigrants living in the US for the periods: 1850–1880, 1900–1930, and 1950–1970. Then in Sect. 6.3, we return to the role of crop types for gender roles discussed earlier. Finally, we discuss whether our results can be attributed to an influence from the Fertile Crescent in Sect. 6.4.

6.1 European regional analysis

A concern regarding our cross-country investigations is the extent to which unobserved country-specific characteristics matter for our results. Based on previous work (e.g., Putterman 2008), we have in mind the part that has to do with national formal institutions. Our first approach in addressing this issue is to utilize the within-country variation in years of agriculture, which is mainly available for European countries (Pinhasi et al. 2005).[48] In particular, this allows us to remove any country-specific effects that are potentially both related to years of agriculture and gender roles. We depict the data for years of agriculture across European regions in Fig. 2. The map shows that there is pronounced regional variation within,

[47] Combining variation in suitability for growing tea and orchard cultivation across China with two post-Mao reforms that increased the value of planting tea and orchards relative to staple crops, Qian (2008) demonstrates that there is a positive, causal effect of women's income on the survival rates of girls. This is consistent with the mechanisms that we study.

[48] It should be noted that the original dataset also includes Middle Eastern countries. However, regional data on female labor market participation are not available for these countries.

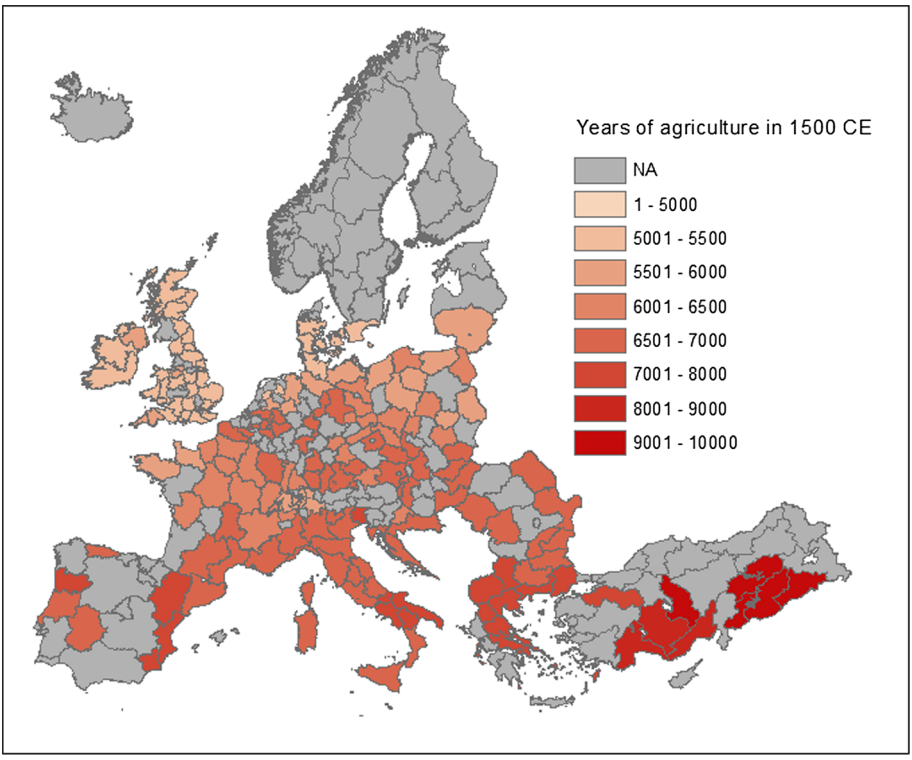

Fig. 2 Years of agriculture across European NUTS 2 regions. *Notes* Data source: Pinhasi et al. (2005), who provide carbon dates from various Neolithic sites in Europe. From this, we obtain average transition dates of each NUTS 2 region in ArcGIS

for example, France, Germany, and Italy, whereas in smaller countries such as Denmark and Ireland the variation is much smaller.

Table 9 shows that years of agriculture continues to play a significant role in explaining female labor participation even controlling for country-specific effects. Column (1) shows the unconditional estimate, with a magnitude that is actually larger than the previous cross-country estimates. It is also worthwhile to mention that the model which only includes years of agriculture produces an R^2 of 0.65, so years of agriculture explains a substantial fraction of the variation in female labor force participation. In column (2) we see that including country fixed effects reduces the absolute value of the coefficient. Nonetheless, the coefficient on years of agriculture is still negative and statistically significant. Further, column (3) reveals that this association cannot be attributed to regional variation in income.

The remaining three columns add potential geographical confounders. In order to capture a range of regional geographical characteristics—such as climatic conditions—distance to the Equator is put into the model. In line with the research of Alesina et al. (2013), and because there are no data on European regional variation in historical plough-use, we also include the fraction of land that is suitable and not suitable for plough-use. Becker and Woessmann (2009) argue that distance to Wittenberg—the place of origin of Protestantism—influences the regional prevalence of Protestantism. Accordingly, we use this as a reduced-form variable to capture the influence of Protestantism on gender roles. Adding these variables, however,

Table 9 European regional NUTS 2 sample

	Dependent variable is female labor force participation rate in 2008					
	(1)	(2)	(3)	(4)	(5)	(6)
Years of agriculture	−9.317***	−5.365**	−3.931***	−3.371***	−3.078***	−2.867***
(unadjusted)	(1.283)	(2.528)	(0.703)	(0.661)	(0.424)	(0.494)
ln income/capita in 2008			0.261	6.671	14.84	−3.895
			(28.61)	(23.75)	(22.42)	(21.11)
ln income/capita in 2008			0.608	0.280	−0.150	0.733
squared			(1.560)	(1.271)	(1.195)	(1.097)
Distance to the Equator				0.00225	0.00170	−0.000124
				(0.00272)	(0.00222)	(0.00195)
Plough-suitable share					2.822*	1.310
(positive)					(1.508)	(1.683)
Plough-suitable share					8.315	7.676
(negative)					(6.014)	(6.394)
Distance to Wittenberg						−0.00553*
						(0.00301)
Country fixed effects	No	Yes	Yes	Yes	Yes	Yes
# of regions	174	174	169	169	169	169
R^2	0.65	0.87	0.92	0.92	0.92	0.93

The table reports OLS estimates. Unit of observation is European NUTS 2 regions. Years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Pinhasi et al. 2005). Distance to the Equator is in kms (own calculations). Plough-suitable share are defined as in Alesina et al. (2013) and taken from FAO GAEZ 2002. Distance to Wittenberg is in kms (own calculations). Constants are not reported. Robust standard errors corrected for clustering at the country level in the parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1

only has a negligible effect on the estimated coefficients on years of agriculture; see columns (4)–(6). It is also worthy of note that the coefficient on distance to Wittenberg is negatively related to female labor force participation, which is line with cross-country findings of, for example, Feldmann (2007).

Overall, these results support the view that our basic result is in line with a cultural interpretation. Unsurprisingly, we also find that a substantial part of the variation in the female labor participation rate is explained by country-specific characteristics.[49] Finally, we note that the estimates in columns (3)–(6) are in the same order of magnitude as the European sub-sample in the cross-country analysis and that we obtain similar results when we use the relative measure of female labor force participation; see Table 5A in the online appendix.

6.2 Evidence from immigrants and children of immigrants living in the US

This section reports results from studying immigrants and children of immigrants living in the US. In particular, studying the basic mechanism among children of immigrants living in the US provides a second approach in separating the influence of culture from that of formal institutions as children of immigrants are affected by the same external environment (e.g., formal institutions), but their internal environment (e.g., cultural heritage) varies in relation

[49] This is demonstrated by the fact that R^2 increases from 0.65 to 0.87 by the inclusion of country dummies.

to their country of origin. In addition, by comparing these results to immigrants of the first generation possibly reveals information about how persistent the effect is. We implement these tests using data from US censuses for the periods 1850–1880, 1900–1930 and 1950–1970 (Ruggles et al. 2010). We repeat for convenience that ancestry is given by the father's country of origin.

The results are reported in Table 10. Since the outcome is a binary variable, the coefficients on years of agriculture should be interpreted as a marginal effect on the probability that a woman participates in the labor force.[50] Columns (1)–(4) report the results for (first-generation) immigrants in the US. Besides ancestor controls, US-census year and state fixed effects, columns (1) and (2) also control for the individual characteristics: age, age squared, and literacy. From column (1), we see that for the period 1850–1880, a female immigrant born in society with 1000 more years of agriculture is 2.9 % points less likely to participate in the official labor market. The size of this effect increases if the sample is restricted to European immigrants (see column 2).

Columns (3) and (4) exploit the fact that for the period 1900–1930 the US census provides individual information on the number of years the immigrant has been living in the US. The evidence reveals that female labor force participation is decreasing in the number of agricultural years in the home country to an extent that is *not* related to the number of years lived in US, suggesting that the effect does not diminish over time. In addition, comparing the results in columns (1)–(4) to the evidence from the children of immigrants, reported in columns (5)–(8), indicates that the effect transfers across generations unabated.

We note that the results from restricting the samples only to include immigrants with European ancestry, reported in the even-numbered columns, suggests that our findings in Table 10 are mainly driven by immigrants (or children of immigrants) from Europe. Finally, we emphasize that the evidence, reported in this section, supports the view that a cultural effect was also present from more than 150 years ago.

6.3 Cereal based agriculture and early Neolithic Revolutions

In this subsection, we provide evidence consistent with the hypothesis that adoption of cereal-based agriculture is one of the factors behind gender inequality. We provide three types of evidence. First, we follow White et al. (1981) and use the Standard Cross Cultural Sample (SCCS) to test whether societies whose principal crops are cereals have lower contribution from women compared to societies whose principal crops are root crops. White et al. (1981) focused on a small sample of 36 cultures, but this can be expanded to 128 societies that either have cereals or root crops as their principal crops. Table 11 shows the results of regressing Female contribution to agriculture measured in percent on a dummy which is equal to one when a society has cereals as its principal crops and zero when the principal crops are root crops. Column (1) shows a negative and statistically significant coefficient. We include a control for whether a society has the plough in column (2), and while we notice that the coefficient on the dummy indicating cereal crops is marginally reduced, the sign of the coefficient is still negative, and it continues to be statistically significant. In columns (3) and (4), we run tobit models to take into account that the contribution of females is bounded between zero and 100, and find similar results. To ensure that the results are not driven by the choice of using the SCCS, we use a more crude variable on contributions of men and women in agriculture from the Ethnographic Atlas, and find that the probability of men contributing more is higher in societies whose principal crops are cereals, see columns (5) and (6). The

[50] Similar results are obtained using non-linear probability models instead (not reported).

Table 10 Immigrants and children of immigrants in the US

	Dependent variable is labor force status							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Immigrants				Children of immigrants			
	1850–1880		1900–1930		1900–1930		1950–1970	
	all	only EU	all	only EU	all	only EU	all	only EU
Years of agriculture (unadjusted)	−0.0286***	−0.0404***	−0.0182**	−0.0325**	−0.0167***	−0.0199***	−0.00630**	−0.00454*
	(0.00737)	(0.00488)	(0.00705)	(0.0148)	(0.00504)	(0.00694)	(0.00278)	(0.00233)
Years of agriculture in the US × Years			0.000155	0.000785				
			(0.000162)	(0.000489)				
Ancestor-country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Census-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of individuals	63,460	58,393	189,543	161,775	220,560	202,445	149,239	124,920
R^2	0.152	0.149	0.116	0.124	0.097	0.099	0.036	0.032

The table reports OLS estimates. In columns (1)–(4) the unit of observation is female immigrant in the US. In columns (5)–(8) the unit of observation is female child of an immigrant living in the US, where we have used the father's country of origin to identify the ancestor country. The dependent variable is an indicator equal to one if the individual is in the labor force and zero otherwise. Years of agriculture is time elapsed in 1500 sincethe Neolithic Revolution in 1000 years (Putterman and Trainor 2006) in the ancestor country. Ancestor-country controls include: log distance to coast or river, log income/capita, log income/capita squared, fraction of tropical land, latitude, arable land and continent fixed effects. Individual controls in columns (1)–(6) are: age, age squared, and literacy fixed effects. Additional individual controls in columns (3) and (4) are years since immigration to the US. Individual controls in columns (7) and (8) are: age, age squared, and education fixed effects. All regressions include state and US census year fixed effects. Constants are not reported. The immigrant data are from IPUMS-US (US censuses). Robust standard errors corrected for clustering at the ancestor country level in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11 Evidence from the SCCS and Ethnographic Atlas

	Dependent variable						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Female contribution to agriculture				Male dominant in agriculture		Deference
	OLS		Tobit		OLS	Logit	OLS
Cereal principal crop	−13.43***	−11.38***	−13.79***	−11.61**	0.134***	0.661***	0.246*
	(4.429)	(4.339)	(4.593)	(4.499)	(0.037)	(0.197)	(0.136)
No plough		14.16***		14.80***			
		(4.332)		(4.545)			
# of ethnic groups	128	128	128	128	647	647	77
R^2	0.066	0.143			0.018		0.05

Columns (1), (2), (5) and (7) [(3) and (4)] report OLS (Tobit) estimates. Column (6) reports Logit estimates. Data for columns (1)–(4) and (7) are from the Standard Cross Cultural Sample. Female contribution to agriculture is measured between 0 and 100. Columns (5) and (6) use data from the Ethnographic Atlas. Male dominant in agriculture is a dummy variable equal to 1 if men do most of the work in agriculture. Deference is a equal to 1 if a wife's deference to her husband is institutionalized. Cereal principal crop is equal to one when the principal crop is cereals (rather than root crops). No plough indicates whether a society uses the plough. Constants are not reported. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

results in Table 1 and those discussed in Sect. 2.3.2 further corroborate that gender inequality is lower in these societies. Finally, we show in column (7) that the probability of "Wife to Husband Institutionalized Deference" is more likely in societies based on cereals.

Second, we posit that soil suitability for growing root and cereal crops explains the timing of the Neolithic Revolution. As detailed in Putterman and Trainor (2006), early agriculture was based on cereal crops in most places, and it is therefore plausible that those places which adopted early agriculture were those that had better conditions for doing so. This would suggest that areas with soil more suitable for growing roots would have later Neolithic Revolutions, and those with soil suitable for growing cereal crops would tend to have earlier Neolithic Revolutions. If this is indeed the case, the adoption of early agriculture would tend to be cereal-based, and given the results for the SCCS, the arguments outlined in Sect. 2, and our third piece of evidence presented here (see below), this would lead to adoption of a type of agriculture that tends to produce patriarchy. To test this, we regress years of agriculture on measures of soil suitability for growing root crops and cereals using data from the Food and Agriculture Organization (FAO).[51] The results are shown in Table 12. Column (1) shows that the timing of the Neolithic Revolution is significantly and negatively affected by relative root crops suitability (i.e., root crops suitability relative to cereals suitability). Thus, countries which had relatively better soil for cereal production had earlier transitions, even if both types of crops could be grown. In column (2), we see that this relationship is unaffected by the inclusion of continent dummies and the baseline geographical controls. Columns (3) and (4) demonstrate that the same conclusion is obtained adding the suitability measures separately.

[51] The cereals included in this measure are wheat, rice, maize, barley, sorghum, pearl and foxtail millet, and rye. FAO classify soil suitability into the following categories very low, low, medium low, medium, medium high, high and very high. The good soil suitability measure uses soil with medium high suitability or higher. The root crops included are cassava (also known as manioc root), white yam, greater yam, yellow yam, taro, and sweet potatoes. The measure also includes white potatoes which belong to the tuber category.

Table 12 Neolithic Revolution, cereals and root croops

	Dependent variable is years of agriculture			
	(1)	(2)	(3)	(4)
Roots suitability / Cereal suitability	−3.079***	−2.193***		
	(0.443)	(0.347)		
Roots suitability			−0.134***	−0.0832***
			(0.025)	(0.0139)
Cereal suitability			0.104***	0.0593***
			(0.021)	(0.0169)
Tropical climate		1.186***		1.168***
		(0.293)		(0.340)
Arable land		0.00887		0.00246
		(0.00840)		(0.0114)
Ln distance to coast or river		0.247***		0.268**
		(0.085)		(0.110)
Landlocked		−0.564**		−0.636**
		(0.221)		(0.252)
Continent fixed effects	No	Yes	No	Yes
# of countries	153	153	153	153
R^2	0.219	0.764	0.133	0.722

The table reports OLS estimates. Years of agriculture is time elapsed in 1500 since the Neolithic Revolution in 1000 years (Putterman and Trainor 2006). Roots suitability indicates average soil suitability for growing roots. Cereal suitability indicates average soil suitability for growing cereals. Constants are not reported. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

In particular, the coefficient on average soil suitability for growing roots is negative and statistically significant, whereas the corresponding coefficient for the cereal crops is positive and statistically significant.

Third, Exploiting the Demographic Health Survey (DHS) data, Table 13 reveals that regions in Africa that are relatively more suitable for growing roots crops have a higher percentage of women that have been working the last year (between the ages 15 and 49). Because the suitability for growing root and cereal crops vary at the regional level, we can show, in the even-numbered columns, that this finding is robust to the inclusion of country fixed effects.[52]

6.4 Fertile crescent influence

This subsection discusses the possible interpretation that our result is basically explained by the spread of agriculture from the Fertile Crescent, that is, gender inequality might only be related systematically to the agricultural package which came from the Fertile Crescent and not agriculture in general. While the effect of Fertile Crescent agriculture on gender inequality is a part of the hypothesis that we are testing, this interpretation narrows the external validity

[52] Table 11A in the online appendix documents evidence showing that relative root crops suitability is positive related to female labor force participation in 2000 in the cross-country sample as well.

Table 13 Gender roles and cereals and root crops in regions of Africa

	Dependent variable is percentage of women that have been working the last year (ages 15–49)			
	(1)	(2)	(3)	(4)
Roots suitability / cereal suitability	9.301***	4.619**		
	(3.018)	(1.710)		
Roots suitability			0.369***	0.234***
			(0.100)	(0.085)
Cereal suitability			−0.152	−0.223*
			(0.130)	(0.114)
Country fixed effects	No	Yes	No	Yes
# of regions	300	300	300	300
R^2	0.558	0.756	0.557	0.753

The table reports OLS estimates. The units of observation are Demographic Health Survey regions within Africa for the survey years: 1994–2013 (all the specifications include survey-year fixed effects). Roots suitability indicates average soil suitability for growing roots. Cereal suitability indicates average soil suitability for growing cereals. Robust standard errors in the parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

of our conclusion. Even though Table 7 shows that our finding is not driven by, for example, Middle Eastern countries and that a negative correlation is recovered continent by continent, these extensions do not as such reveal how much of our result is explained by Fertile-Crescent agriculture.

We begin by addressing this in Table 7A in the online appendix which shows the results of adding two additional controls and considering additional sub-samples. In particular, it shows that our main estimate is robust to the inclusion of controls for the percentage of population of European descent (i.e., to account for European influence) and physical distance to the Fertile Crescent. We also obtain a similar conclusion restricting the samples to countries south of the Sahara or south of the Sudanic belt. Moreover, we add a sample which includes the Americas, East Asia, and African countries south of the Sudanic belt. To further minimize the impact of outside influence, we use unadjusted years of agriculture (however, results are similar using adjusted years of agriculture). While the negative coefficient is not significant at conventional levels, this result is strongly driven by the inclusion of China. As we discussed above, Hinsch (2003) argued that pre-historic China was quite gender unequal. In support of this, Bauer et al. (1992, p. 333) state that "traditional, primarily Confucian attitudes and norms supported and reflected a strong hierarchy [...] in this system, women were subordinate to men." They also stress that the communist party viewed entry of women into the labor force as the way to liberate women, and note that evidence suggests that prior to 1949 female labor force participation was very low. Since 1949 women's labor force participation has risen markedly starting already in the 1950s (Bauer et al. 1992:p. 350). Thus, China may very well be an outlier driven by the big shock of communism. Once we remove China, we obtain a negative and statistically significant coefficient of a magnitude similar to the one in our other samples. Thus, these results tend to support the conclusion that the negative relationship between years of agriculture and gender equality is not an effect of Fertile-Crescent agriculture. We also note that neither the share of population of European descent nor the distance to the Fertile Crescent are significant themselves.

We also checked whether the result in the European regional sample is driven by the exclusion of distance to Fertile Crescent, as one additional concern related to the Fertile Crescent would be that our results mainly reveal an influence on those countries close to this area. Table 8A in the online appendix reveals that this is not the case. We note that the coefficient on years of agriculture is smaller in the parsimonious specifications (1) and (2), but once we add controls the coefficients are very similar to the those reported in Table 9. The coefficient on distance to the Fertile Crescent is positive and significant in the parsimonious specifications only. Thus, in the European case there is some support for the view that gender roles are driven by influence of the Fertile Crescent on its closest neighbors. Finally, it can be noted that our finding from the European regional sample is not driven by the regions in Spain, Greece, Italy, Turkey, Croatia, Romania, and Bulgaria (i.e., regions closest to the Fertile Crescent); see Table 9A in the online appendix. This table also reveals that the coefficient on distance to the Fertile Crescent is no longer statistical significant at conventional levels, and actually becomes negative once we control for country-fixed effects. This suggests that Southern Europe was culturally influenced by the Fertile Crescent in other ways than through agriculture, but this does not explain the effect of the Neolithic Revolution.

7 Conclusion

This research studies the hypothesis that years of agriculture has a persistent negative impact on the position of women in society. In short, this is motivated by two coherent assertions. First, we build on the the assertion of Diamond (1987), Iversen and Rosenbluth (2010), Lerner (1986) and others that patriarchy has its origin in the Neolithic Revolution. Second, the patriarchal values and beliefs—with strong origins in agriculture—have become stronger over time. Hence, these values and beliefs are more persistent in countries with long histories of agriculture. In sum, we provide evidence that the time since societies relied on hunting and gathering, or alternatively the time since they moved to cereal agriculture, is associated with less female labor force participation.

We believe that several features of this study makes it interesting. First, the cross-country analysis demonstrates a remarkably robust negative relationship between female labor participation and years of agriculture. The material presented in Sect. 2 suggests that this is not only due to an effect of the plough, as also confirmed by our many robustness checks presented in Sect. 5. Further, we can plausibly link this to a move to cereal agriculture which has been argued to lead to less female contribution to agriculture, and we substantiated this in Sect. 6. Second, we show similar relations for alternative indicators of equality of gender roles. Third, we show that our basic results cannot solely be attributed to country-specific effects which include formal national institutions utilizing within-country variation in the European regional data and the sample of children of immigrants living in the US. Finally, we demonstrate that the results hold for European, African, and Asian countries, European regions and children of immigrants living in the US.

In the course of the analysis, the paper generated two additional findings. First, we find evidence that both historical plough-use and years of agriculture matter. Second, we also establish that the number of growing days explain gender roles in a manner consistent with Burton and White (1984).

Ideally, we would want to compare different types of agriculture, such as shifting agricultural societies with hunter-gatherer societies. Unfortunately, this is not possible with our data. We do, however, find that societies with cereal based agriculture have lower contribution from

women compared to societies with agriculture based on root crops, and we also demonstrate that an early Neolithic Revolution is related to the former type of agriculture. Moreover, some circumstantial evidence (see Table 1 in White et al. 1981) suggests that societies based on shifting-agriculture relies much more on cereals and less on roots than horticulture which some authors (e.g. Lancaster 1976) note often also relies on hunting and gathering. If so, this is suggestive of the possibility that shifting agriculture may well be more gender unequal than hunter-gatherer societies. Yet, comparing hunting-gatherer societies more systematically with different types of agricultural societies is an important challenge for future research.

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