# Gender Roles and Agricultural History: The Neolithic Inheritance*

Casper Worm Hansen[†] Aarhus University

Peter Sandholt Jensen[‡] University of Southern Denmark

Christian Skovsgaard[§] University of Southern Denmark

**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 on a world sample and a sample of European regions. The analysis reveals a strikingly robust negative association between years of agriculture and female labor force participation rates, as well as other measures of equality in gender roles. Thus, we find strong support for the proposed hypothesis.

**Key Words**: Economic development; agricultural revolution, culture; gender roles.

**JEL**: J70; N50; O11; O17.

*Acknowledgements

[†]Corresponding author: Fuglesangs Allé 4, 8210 Aarhus V, Denmark; Email: cworm@econ.au.dk; Phone: +45 2288 3244.

[‡]Campusvej 55, 5230 Odense, Denmark; Email: psj@sam.sdu.dk

[§]Campusvej 55, 5230 Odense, Denmark; Email: chsko@sam.sdu.dk.

# 1 Introduction

Wide disparities in gender roles exist across countries and regions as observed in e.g. the large cross-country variation in female labor force participation rates, see Alesina et al. (2012). 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 appropriate policy can be designed to reach this goal arguably depends on research providing understanding of the underlying causes of the variation in gender roles. Recent research has taken up this challenge and suggests that, to some extent, the observed divergence can be explained by cultural beliefs—with strong historical origins—on the proper role of women in society (Fernandez, 2007; Fernandez and Fogli, 2009; Alesina et al., 2012).[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 which give rise to less equality in gender roles.[2] We test this hypothesis by studying the relation between the timing of the Neolithic Revolution—the prehistorical transition from a hunter-gatherer to an agricultural society—and contemporary gender roles as measured by e.g. 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 would be adopted. Societies with earlier Neolithic revolutions have been subject to these cultural beliefs for a longer period of time and these beliefs, therefore, are likely to become more ingrained over time. Thus, they 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.

We build on the work of Iversen and Rosenbluth (2010). They note that evidence suggests that Hunter-Gatherer societies were characterized by more independent women as compared to agricultural societies. First, it has been demonstrated that the gathering activity of women pro-

[1] For other research papers in which gender plays a role see, for example, Galor and Weil (1996), Klasen (2002), Miller (2008), Dopeke 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).

vided three quarters of the daily calorie intake of their community. Second, meat—as provided by male hunting activity—was not strictly necessary for survival. Thus, they conclude that the bargaining power between men and women was relatively equal in the hunter-gatherer society. They further argue that the cultural norms and beliefs shifted as societies became agricultural. With increased population growth[3] and land scarcity, cultivation of food became more intensive as also suggested by the work of Boserup (1970) and Burton and White (1984). Iversen and Rosenbluth (2010) suggest that agricultural intensification created "a premium on male brawn in plowing and other heavy farm work" (p.32). This led to a division of labor within the family in which the man used his physical strength in food production, and the woman took care of child rearing, 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). The seminal work of Boserup (1970) puts strong emphasis on the adoption of plow agriculture as a source of agricultural intensification, but as noted by Burton and White (1984), intensification can be achieved in a variety of ways even without the plow. In fact, Boserup (1965) defines agricultural intensification as shortening of the fallow by any method as pointed out by Burton and White (1984). They also stress that agricultural intensification and the associated shift in gender roles do not require the plow.[4]

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. Put schematically, we argue that an early Neolithic Revolution (years of agriculture) $\Longrightarrow$ agricultural intensification $\Longrightarrow$ historical

[3] Ashraf and Galor (2011) demonstrate that early neolithic revolutions are associated with higher population density in 1 CE, 1000 CE and 1500 CE. This corroborates the view of Iversen and Rosenbluth (2010) that the neolithic revolution led to higher population density which in itself may trigger agricultural intensification as suggested by Boserup (1965, 1970).

[4] In particular, they point to three factors behind lower female participation in agriculture: (1) Labor intensification under seasonal constraints. (2) Capital intensification due to introduction of the plow. (3) The role of domesticated animals in intensive ecosystems. In these systems women are argued to take care of the animals which spend more time close to the household under intensification. Burton and White (p.573) argue that when dependence on animals is high, intensification may lead to "sharply curtailed female agricultural inputs."

female agricultural contribution $\Longrightarrow$ contemporary gender roles.

We implement our test by using data on the number of years that a country has been an agrarian society in 1500 CE on the one hand, and measures of equality in gender roles on the other. We find support for the proposed hypothesis using both a world sample of countries and within-country variation in a sample of European regions. In fact, the empirical analysis shows a robust negative relation between years of agriculture and female labor participation rates. We also demonstrate that the result holds for other indicators of equality in gender roles such as 'years since women's suffrage' and 'female seats in parliament'. For the cross-country analysis, we use data on the timing of the transition to agriculture from Putterman and Trainor (2006). In the cross-country data, the "world migration matrix", developed by Putterman and Weil (2010), makes it possible to adjust the years since the transition for Post-Columbian migration flows. Therefore, we can use both unadjusted and adjusted measures. The empirical analysis shows—somewhat surprisingly—that the migration adjusted measure is markedly stronger associated with gender inequality.[5] Moreover, as the basic mechanism, arguably, operates via informal institutions, rather than formal institutions, we also provide a test of the hypothesis based on the European regional sample. In particular, making use of within-country variation in the timing of the transition to agriculture, from Pinhasi (2005),[6] removes any country-specific fixed effects affecting gender roles—such as economic institutions, political environment, and so on. While a significant part of the variation in the female labor force participation rate occurs between countries, the regional data also support the cultural mechanism.

Alesina et al. (2012) provide evidence consistent with Boserup's (1970) hypothesis that plow agriculture is behind present day gender roles. In particular, they construct a measure of the share of the population that has ancestors who were plow users. They note that one caveat associated with this approach is that they cannot measure whether the plow was adopted early, since a longer period of plow agriculture is likely to have led to stronger and more ingrained

[5] In particular, because Putterman and Weil (2010) find that the adjusted years since the Neolithic Revolution are stronger related to output per capita, one might have expected a stronger relation to equality in gender roles also.

[6] Other papers also using this dataset on the timing of the Neolithic transition include Ashraf and Michalopoulos (2011) and Olsson and Paik (2012).

values and beliefs on appropriate gender roles. In contrast, we have a measure of how long ago agriculture was adopted, and report evidence suggesting that the longer the agricultural history of a society, the stronger are cultural beliefs regarding genders as observed in actual measures of equality in gender roles. This is consistent with the idea that societies that experienced early agriculture also have more experience with agricultural intensification. The caveat is that our argument builds on any type of agricultural intensification that may shift gender roles. For the world sample, the evidence in Alesina et al. (2012) suggests that not all agricultural societies used plows historically. In contrast, for Europe they observe that "little variation in plough use exist". In fact, the transition to agriculture and the transition to plow agriculture is difficult to distinguish for Europe, as "agriculture and the plow originated 10–13 millennia ago in the Fertile Crescent of the Near East [...] and were introduced into Greece and southeastern Europe 8000 years ago", Soil and Tillage (2007:p.1). Further, Fussel (1966:p.177) notes that the plow 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". It therefore seems plausible to interpret the transition to agriculture in Europe as a transition to plow agriculture, and thus, a long agricultural history arguably proxies for a long history of plow agriculture. Thus, we provide new evidence consistent with the hypothesis that agricultural intensification in any form via its effects on cultural beliefs is a source of modern gender roles. Moreover, the European evidence corroborates the conjecture of Alesina et al. (2012) on years of plow agriculture.

We also contribute to the literature on the consequences of the Neolithic revolution. This literature has emphasized the consequences for both historical and contemporary development.[7] We add evidence that the Neolithic revolution—as a consequence of agricultural intensification—

[7]This literature highlights the importance of early agricultural adoption on comparative economic development on a world wide scale. The empirical analysis in Olsson and Hibbs (2004) supports this type of hypothesis formulated in the work of Diamond (1997). In addition, using a refined measure on the timing of Neolithic Revolution from Putterman and Trainor (2006), Putterman (2008), Petersen and Skaaning (2010), and Bleaney and Dimico (2011) confirm 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 also is in the Spirit of Diamond's hypothesis. In line with this view, our basic result is also strengthened when allowing for continental fixed effects in the regressions.

led to patriarchal cultural beliefs on gender roles which still affect contemporary gender roles.

The rest of this paper is organized as follows. In section 2 we present the data used in the analysis. Section 3 outlines the estimation framework. Sections 4 contains results and discussion. Section 5 concludes.

# 2 Data and descriptive statistics

This section presents a short overview of the dataset assembled to perform the empirical analysis (data sources are given in Table A1). 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, it is the main indicator used in other research on gender roles, e.g. Alesina et al. (2012) and Fernandez and Fogli (2009). However, we also consider the following alternative indicators: date of female suffrage, fraction of female seats in national parliaments, fraction of female legislators, female literacy, and a 'gender equality' index to be explained below.

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 get data from Putterman and Trainor (2006), which is weighted with the post-1500 migration flow (Putterman and Weil, 2010). For the regional European sample, data are obtained from Pinhasi et al. (2005).[8]

As control variables, we include a range of variables accounting for geographical, socioeconomic, historical, and other country (regional) specific characteristics, see Table A1 for details. In general, the control variables are introduced as the analysis progresses. The summary statistics of all variables are reported in Table 1.

[8] In particular, Pinhasi et al. (2005) provide calibrated carbon-dates from various Neolithic sites in Europe. From this, we attain average transition dates of each nuts 2 region in ArcGIS.

# 3 Estimation framework

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

$$FLPR_i = \alpha + \beta NRM_i + \gamma \mathbf{X}_i + D_k + \varepsilon_i, \tag{1}$$

where $i$ denotes country, $FLPR_i$ is the female labor force participation rate in 2000 CE, $NRM_j$ 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, soil suitability for plow-use), $D_k$ is continental fixed effects, and $\varepsilon$ denotes the disturbance term. Formally, the hypothesis to be tested is that $\beta < 0$: years of agriculture is negatively related to female contribution to the formal labor market.[9] We also implement a version of equation (1) in which we use the unadjusted years of agriculture in 1500 CE denoted by $NR_i$.

A key methodological challenge for this type of analysis is to separate the effect of culture from the effect of formal institutions and other national specific conditions. Even though the approach in (1) attempts to deal with this by including a range of possible confounders, one might still wonder how much of the magnitude of $\beta$ is still related to national institutions. To deal with this issue, we follow the approach in Tabellini (2010) and estimate the following model on the European regional sample:

$$FLPR_{ji} = \alpha + \beta NR_{ji} + C_i + \mu \mathbf{Z}_{ji} + \epsilon_j \tag{2}$$

where $j$ denotes region,[10] $FLPR_{ji}$ is the female labor participation rate in 2008 in region $j$ of country $i$, $NR_{ji}$ is the years of agriculture in 1500 CE (in 1000s), $C_i$ is country fixed effect for country $i$, $Z_j$ denotes some additional control variables (e.g., income, income$^2$, distance to Wittenberg, latitude, soil suitability for plow-use), and $\epsilon_j$ is the unexplained part.

[9] In this analysis, we also adopt an instrumental variables strategy by using variation in the numbers of prehistoric domesticable animals (Hibbs and Olsson, 2004) as an exogenous source of variation in years since the Neolithic revolution.

[10] Regions follow Eurostat's definition of regions at the NUTS2 level, which categorizes regions based on population sizes ranging from 800,000 to 3 million.

Table 1 about here

# 4 Results

We report the results in three subsections. Section 4.1 reports the main results based on the world sample. Section 4.2 considers the robustness of these results. Section 4.3 demonstrates that the results are robust to country fixed effects in a sample of European regions.

## 4.1 Main results

Columns (1)-(4) in Table 2 display the results of estimating equation (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 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 out of the formal labor market. To get a feeling of the economic significance, the result implies that a thousand year earlier transition is associated with 3.9 percentage point lower female participation in the year 2000.

Table 2 about here

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 coefficient from 3.9 to 6.0. Moreover, this also attests to a positive continental development effect on female labor force participation, possibly through an early transition date.

Next controls for economic development and geography are added. First, as 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, 2011), such a relation is warranted in the model. Second, various aspects of geography are possibly related to both gender roles and the timing of the Neolithic Revolution. Therefore, we also include: fraction of tropical land,

fraction of arable land, log distance to coast or river, and a dummy for landlocked countries. In column (3), we see that the magnitude of the basic result is relatively stable to the inclusion of these 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.

Figure 1 about here

The timing of the Neolithic Revolution, and thereby years of agriculture, can be viewed as predetermined—as it cannot be influenced by feedback effects from the current labor market. Still, omitted variable or attenuation bias may be a concern, and therefore column (4) uses the availability of prehistoric domesticable animals as a geographical instrument for the timing of the Neolithic Revolution. Given that this only influences female labour force participation rates through adoption of agriculture, we can rule out that the results are driven by omitted variable or attenuation bias. Comparing columns (3) and (4) shows that the 2SLS estimate is larger in magnitude than the corresponding OLS estimate, which is possibly due to attenuation bias from measurement error in our explanatory variable.[11]

In columns (5)-(8), 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. Second, and more importantly, the proposed hypothesis is consistent with the notion that the history of a population's ancestors matters more than the history of geographical places (Putterman and Weil, 2010). As with the adjusted measure, the regressions show a significant negative association. However, the absolute value of the coefficients on the unadjusted measure are smaller in magnitude. Although these results are quiet about the role of formal versus informal institutions, one might interpret them as showing that immigrants with long histories of agriculture haven taken with them certain values and norms that still affect the view on role of women in the labor market today.

[11] Using prehistorical domesticable wild plants as an extra instrument gives similar results and, in this specification, we are not able to reject that the instruments are unrelated to the error term.

## 4.2 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 demonstrates robustness of results to potential confounding factors, alternative samples, and alternative outcomes.

**Potential confounding factors** The results from potential alternative interpretations are reported in Table 3. 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 and since state history is positive related to the timing of Neolithic Revolution, this channel might be what drives our results. Along similar lines, the seminal work of Acemolgu et al. (2001) finds that Europeans tended to setup extractive institutions in places with early development. This together with the results in Ashraf and Galor (2011) also constitute an alternative explanation for the presented evidence. To address these issues, we augment the model specification from column (3) in Table 2 with an index of state history from 0 to 1500 (Bockstette and Putterman, 2007), 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, in fact, 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. (2012: p.30). While religion can be regarded as a channel through which agricultural history might affect gender roles, we still wish to explore the importance of this specific channel. Column (4) includes the fraction of Muslims and the fraction of Protestants and column (5) also includes religious fractionalization. We find that absolute value of the coefficient reduces from 5.36 to 2.98, but it remains statistically and economic significant, suggesting that years of agriculture does not only impair gender equality through the doctrines of religion.[12]

[12]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).

In a reduced form way, column (6) demonstrates that the negative effect of agricultural history on gender roles cannot be attributed to whether a country historically has adopted the plow or not. In particular, this specification includes the fraction of land that is (not) suitable for plow-use, as defined in Alesina et al. (2012). As seen, however, this has no effect on the estimated coefficient.

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 (7) adds years passed since the Demographic Transition (Reher, 2004)—as an additional measure of the gender wage-gap—but again, the coefficient on years of agriculture is stable. Finally, in column (7), the above-mentioned controls are entered simultaneously. Compared to the baseline specification the magnitude is cut in half. Even so, we still find a sizable negative effect associated with years of agriculture.

Table 3 about here

**Alternative sub-samples** Table 4 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 the basic association to be driven by countries in this area of the world. But, as 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. The remaining columns of Table 4 consider the proposed hypothesis continent by continent. While the basic estimate loses some magnitude and precision in the Americas (column 7), we otherwise 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).

Table 4 about here

**Alternative outcomes** Finally, Table 5 considers alternative outcomes. In column (1) we propose a falsification test based on the idea that long histories of agriculture may contribute to lower labor force participation rates for both genders. Column (1) tests whether years of agriculture is related to the year 2000 male labor force participation rate and, in accordance with the proposed hypothesis, there is no evidence of such a relation. This suggests that our results are not explained by variation in the general economic activity level. Column (2) shows that we reach an identical conclusion using an alternative year (1980) for the female labor force participation rate. Indeed, the estimated coefficient is very similar to our baseline result, which also provides some evidence for persistent gender roles. The remaining columns of Table 5 look at alternative measures of equality of gender roles. In column (3), we witness a negative association between the date of the extension of the franchise to women and years of agriculture. Thus, on average, countries with long histories of agriculture granted women political rights later on. Moreover, from column (4) it is evident that contemporary female political representation likewise is lower for countries with an early Neolithic Revolution. In the last three columns, we use fraction of female legislators, female literacy, and a 'gender equality' index which measures the extent to which a country has installed institutions promoting equal access for men and women in education, health and the economy. Again the same conclusion is reached.

Table 5 about here

Overall, the results in Tables 3-5 support the hypothesis that years of agriculture is a stumbling block for equality in gender roles—as measured by various indicators. Thus, the evidence corroborates that, countries with an early Neolithic Revolution hold a more patriarchal view on women's role in the economy and society at large.

## 4.3 European regional analysis

One issue in our cross-country investigations is to the role of country-specific characteristics for the understanding of the results. Not surprisingly, given previous work (e.g., Putterman, 2008), we have in mind the part that has to do with national formal institutions. One approach in addressing this issue it to utilize the within-country variation in years of agriculture, which

is available for mainly European countries (Pinhasi, 2005). This allows removing any country-specific effects that are potentially both related to years of agriculture and gender roles. As expected, the analysis shows that a substantial part of the variation in the female labor participation rate is explained by country specific characteristics.[13] Yet, years of agriculture continues to play a significant role in explaining female labor participation, supporting the view that our basic result is in line with a cultural interpretation.

The results are presented in Table 6. Column (1) contains the unconditional estimate, with a magnitude that is actually larger than the previous cross-country estimates. 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 equator is put into the model. In line with the research of Alesina et al. (2012), and as in the previous section, we also include the fraction of land that is (not) suitable for plow-use. Becker and Woessmann (2009) argue that distance to Witternberg—the birthplace of Martin Luther—influences the regional prevalence of Protestantism. Therefore, we use distance to Wittenberg, as a reduced form variable, to capture the influence of Protestantism on gender roles. Adding these variables, however, only has a negligible effect on the estimated coefficients on years of agriculture (see columns 4-6). Finally, it is worthy of note that the coefficient on distance to Wittenberg is strongly negatively related to female labor force participation (not reported), which is line with cross-country findings of e.g. Feldmann (2007).

Table 6 about here

[13] This is demonstrated by the fact that $R^2$ increases from 0.65 to 0.86 by the inclusion of country dummies.

# 5 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 argue that an early Neolithic Revolution is related to contemporary gender roles through agricultural intensification and the associated historical sexual division of labor. Second, the patriarchal values and beliefs—with strong origins in agriculture—have become more ingrained over time. Hence, these values and beliefs are more persistent in countries with long histories of agriculture.

The cross-country analysis demonstrates a remarkably robust negative relationship between female labor participation and years of agriculture. In addition, we show similar relations for alternative indicators of equality of gender roles. Finally, utilizing within-country variation in the European regional data, we also demonstrate that our basic results cannot alone be attributed to country-specific effects which includes formal national institutions.

At this point, however, a discussion of the limitations of the results are warranted. We proposed that agricultural intensification led to a patriarchal division of labor and its associated cultural beliefs which still shape gender roles today. One source of this is plow agriculture as suggested by Boserup (1970) and Alesina et al. (2012). Our inclusion of variables capturing the possibility for adopting the plow go some way in ruling out that our results reflect historical plow use. Further, the European sub samples can arguably be interpreted as capturing differences in years of plow agriculture. Nonetheless, we are unable to disentangle to what extent years of agriculture reflect other types of agricultural intensification. While an interesting issue, we believe that this is better left for future research. One possible avenue might be to investigate the role of labor intensification and seasonal constraints caused by many dry months and a shorter growing season. For example, Machlachlan (1983) 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 make them more efficient farm managers when older. In line with this, Burton and White (1984) finds that women participate less in agriculture in communities with more dry months. Studying how inequality in gender roles relates to the

number of dry months would shed new light on the possible mechanisms that shape cultural beliefs about the proper role of women in society.

# References


[1] Acemoglu, D., S. Johnson, and J. Robinson, 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. American Economic Review, 91(5), 1369-1401.

[2] Alesina, A., A. Devleeschauwer, W. Easterly, S. Kurlat, and R. Wacziarg, 2003. Fractionalization. Journal of Economic Growth, (8)2, 155-194.

[3] Alesina, A., P. Giuliano, and N. Nunn, 2012. On the Origins of Gender Roles: Women and the Plough. Mimeo.

[4] Alesina, A., P. Giuliano, and N. Nunn, 2011. Fertility and the Plough. American Economic Review: Papers and Proceedings, 101(3), 499-503.

[5] Ashraf, Q. and O. Galor, 2011. Dynamics and Stagnation in the Malthusian Epoch. American Economic Review, 101(5).

[6] Ashraf, Q. and S. Michalopoulos, 2010. The Climatic Origins of the Neolithic Revolution: Theory and Evidence. Discussion Papers Series, Department of Economics, Tufts University 0751.

[7] Becker, S.O. and L. Woessmann, 2009. Was Weber Wrong? A Human Capital Theory of Protestant Economic History. Quarterly Journal of Economics, 124, 531–596.

[8] Bleaney, M. and A. Dimico, 2012. Biogeographical conditions, the transition to agriculture and long-run growth. European Economic Review, 55, 943-954.

[9] Bockstette, V. and L. Putterman, 2007. State Antiquity Index (Version 3). http://www.econ.brown.edu/fac/Louis Putterman/antiquity%20index.htm.

[10] Boserup, E., 1965. The conditions of agricultural growth. Earthscan Publications, Ltd.

[11] Boserup, E., 1970. Woman's Role in Economic Development. London: George Allen and Unwin Ltd.

[12] Burton, M.L., and D.R. White, 1984. Sexual Division of Labor in Agriculture. American Anthropologist, 86(3), 558-583.

[13] Diamond, J., 1997. Guns, Germs and Steel. New York: W.W. Norton.

[14] Doepke, M., and M. Tertilt, 2009. Women's Liberation: What's in It for Men? Quarterly Journal of Economics, 124 (4), 1541–1591.

[15] Doepke, M., and M. Tertilt, 2011. Does Female Empowerment Promote Economic Development? CEPR Discussion Paper No. DP8441

[16] Feldmann, H., 2007. Protestantism, Labor Force Participation, and Employment Across Countries. American Journal of Economics and Sociology, 66(4), 795-816.

[17] Fernandez, R., 2007. Women, work and culture. Journal of the European Economic Association, 5(2–3), 305–332.

[18] Fernandez, R., and A. Fogli. 2009. Culture: An empirical investigation of beliefs, work, and fertility. American Economic Journal: Macroeconomics, 1(1), 146-177.

[19] Fussel, G.E., 1966. Ploughs and Ploughing before 1800. Agricultural History, 40(3), 177-186.

[20] Galor, O., and D.N. Weil, 1996. The Gender Gap, Fertility, and Growth, American Economic Review, 86(3), 374-387.

[21] Galor, O., 2011. Unified Growth Theory. Princeton University Press.

[22] Gallup, J. L., A.D. Mellinger, and J.D. Sachs, 2001. Geography datasets. http://www.cid.harvard.edu/ciddata/geographydata.htm.

[23] Goldin, C., 1995. The U-shaped female labor force function in economic development and economic history. In: Schultz, T.P. (Ed.), Investment in Women's Human Capital. University of Chicago Press, Chicago and London, pp. 61–90.

[24] Hall, R.E., and C.I. Jones, 1999. Why do some countries produce so much more output per worker than others? Quarterly Journal of Economics, 114 (1), 83-116.

[25] Hariri, J., 2012. The Autocratic Legacy of Early Statehood. American Political Science Review, (forthcoming).

[26] Hibbs, D., and O. Olsson, 2004. Biogeography and long-run economic development. European Economic Review, 49, 909-938.

[27] Iversen T., and F. Rosenbluth, 2010. The Political Economy of Gender Inequality. Yale University Press.

[28] La Porta R., F. Lopez-de-Silanes, and A. Shleifer, 2008. The Economic Consequences of Legal Origins. Journal of Economic Literature, 46(2), 285-332.

[29] Klasen, S., 2002. Low Schooling for Girls, Slower Growth for All? Cross-Country Evidence on the Effect of Gender Inequality in Education on Economic Development. World Bank Economic Review, 16(3), 345-373.

[30] Machlachlan, M.D. Why they did not starve: biocultural adaption in a South Indian village. Institute for the study of human issues press, Philadelphia.

[31] Miller, G., 2008. Women's suffrage, political responsiveness and child survival in American history. Quarterly Journal of Economics, 124(3), 1287-1327.

[32] Olsson, O., and C. Paik, 2012. A Western Reversal Since the Neolithic? The Long-Run Impact of Early Agriculture. Mimeo.

[33] Petersen, M.B., and S.E. Skaaning, 2010. Ultimate Causes of State Formation: The Significance of Biogeography, Diffusion, and Neolithic Revolutions. Historical Social Research, 35(3), 200-226.

[34] Pinhasi, R., J. Fort, and A. Ammerman, 2005. Cultural Transmission and the Diffusion of Innovations: Adoption dynamics indicate that biased cultural transmission is the predominate force in behavioral change, PLoS Biology 3(12), (e410).

[35] Putterman, L., 2008. Agriculture, Diffusion, and Development: Ripple Effects of the Neolithic Revolution. Economica, 75(300), 729-748.

[36] Putterman, L., and C.A. Trainor, 2006. Agricultural Transition Year Country Data Set. Brown University.

[37] Putterman, L., and D.N. Weil, 2010. Post-1500 Population Flows and the Long-run Determinants of Economic Growth and Inequality, Quarterly Journal of Economics, 125(4), 1627-1682.

[38] Ramirez, F.O., Y. Soysal, and S. Shanahan. The Changing Logic of Political Citizenship: Cross-National Acquisition of Women's Suffrage. American Sociological Review, 62(5), 735-745.

[39] Reher, D.S., 2004. The demographic transition revisited as a global process. Population Space and Place, 10(1), 19-41.

[40] Ross, M., (2009). Oil, Islam, and Women. American Political Science Review, 102(2), 1-18.

[41] Soil and Tillage, 2007. Evolution of the plow over 10,000 years and the rationale for no-till farming. Soil and Tillage 93, 1-12.

[42] Tabellini, G., 2010. Culture and institutions: Economic development in the regions of Europe. Journal of the European Economic Association, 8(4):677–716.

[43] Tam, H., 2010. U-shaped female labor participation with economic development: Some panel data evidence. Economics Letters, 110, 140-142.

[44] United Nations, 2011. Accelerating progress towards the Millennium Development Goals: options for sustained and inclusive growth and issues for advancing the United Nations development agenda beyond 2015. Annual report of Secretary-General, July, 2011.

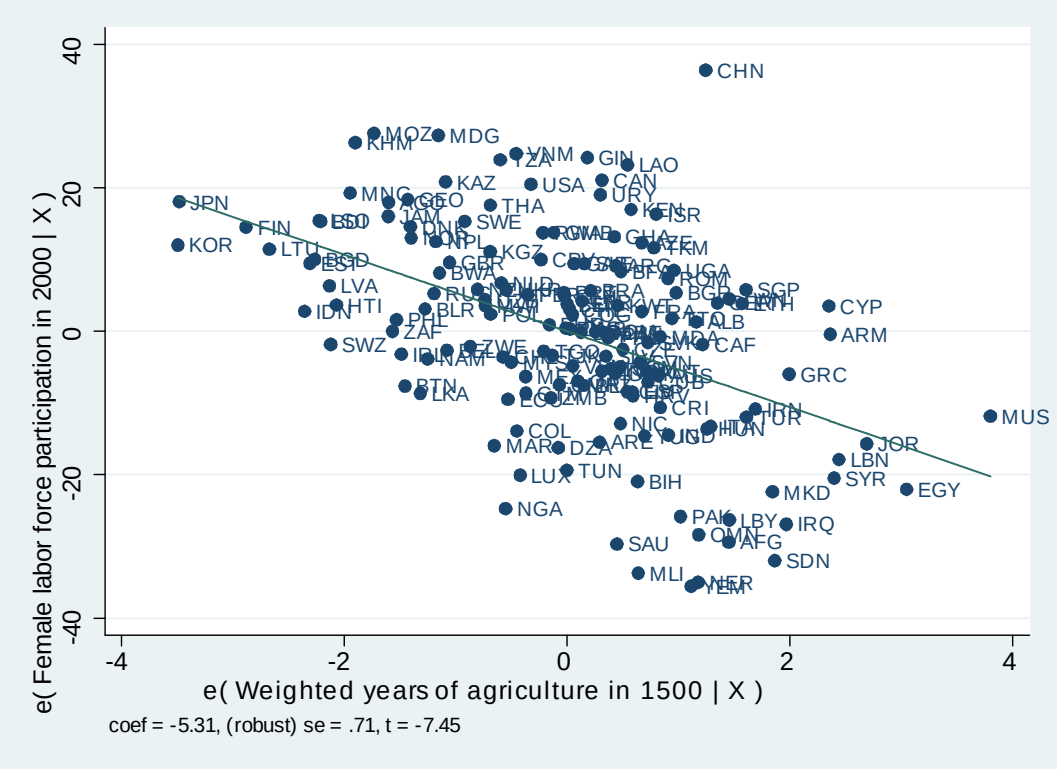


Figure 1: The partial relationship between female labor force participation and years of agriculture in 1500.

Data source: Column 3 of Table 2.

Table 1: Summary statistics

| Variable description: | #Obs: | Mean: | Std. Dev: | Min: | Max: |
|---|---|---|---|---|---|
| **Cross-country dataset:** | | | | | |
| Migration-adjusted years of agriculture in 1500 | 155 | 4.92 | 2.15 | 0 | 9.9 |
| Years of agriculture in 1500 | 155 | 4.36 | 2.45 | 0 | 10 |
| Female labor force participation in 2000 (age 15+) | 155 | 55.40 | 16.75 | 13.4 | 91.4 |
| Female labor force participation in 1980 (age 15+) | 147 | 52.66 | 19.96 | 10.1 | 91.4 |
| Log GDP per capita in 2000 | 154 | 8.62 | 1.19 | 5.78 | 11.21 |
| Fraction of land in the tropics | 155 | 0.46 | 0.47 | 0 | 1 |
| Fraction of arable land | 155 | 0.15 | 0.14 | 0.00 | 0.66 |
| Log distance to coast or river | 155 | 4.97 | 1.37 | 1.11 | 7.77 |
| Landlocked dummy | 155 | 0.24 | 0.43 | 0 | 1 |
| State development | 147 | 0.33 | 0.31 | 0 | 1 |
| Democracy in 2000 (Polity-2 variable) | 150 | 3.22 | 6.56 | -10 | 10 |
| Social infrastructure | 117 | 0.45 | 0.24 | 0.11 | 1 |
| Muslims share | 155 | 0.25 | 0.36 | 0 | 0.99 |
| Protestant share | 155 | 0.10 | 0.19 | 0 | 0.97 |
| Religious fractionalization | 154 | 0.43 | 0.23 | 0.00 | 0.86 |
| Plow positive soils | 146 | 0.11 | 0.20 | 0 | 0.84 |
| Plow negative soils | 146 | 0.09 | 0.16 | 0 | 0.72 |
| Animals | 102 | 3.70 | 4.12 | 0 | 9 |
| Axis | 102 | 15.10 | 6.78 | 5.00 | 30 |
| Years since fertility transition | 123 | 34.02 | 30.03 | 0 | 135 |
| Years since female suffrage | 153 | 53.45 | 20.22 | -5 | 107 |
| Female legislators and managers | 122 | 0.27 | 0.11 | 0.03 | 0.58 |
| Female literacy 15-24 | 109 | 0.76 | 0.25 | 0.11 | 0.99 |
| Female seats in parliaments | 133 | 0.17 | 0.09 | 0 | 0.48 |
| Gender equality index | 78 | 3.44 | 0.67 | 2 | 5 |
| **European dataset:** | | | | | |
| Years of agriculture in 1500 | 175 | 6.45 | 0.90 | 5.08 | 9.89 |
| Female labor force participation in 2008 (age 15+) | 174 | 48.33 | 10.50 | 3.8 | 68.04 |
| Log GDP per capita in 2008 | 170 | 9.79 | 0.67 | 7.93 | 10.87 |
| Distance to equator (in km) | 175 | 5341 | 554 | 4160 | 6454 |
| Distance to Wittenberg (in km) | 175 | 937 | 569 | 55 | 2867 |
| Plow positive area | 175 | 0.51 | 0.30 | 0 | 1 |
| Plow negative area | 175 | 0.01 | 0.05 | 0 | 0.30 |

Table 2: Main results

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | | OLS | | 2SLS | | OLS | | 2SLS |
| | Dependent variable: female labor force participation in 2000 | | | | | | | |
| Migration-adjusted years of agriculture | -3.90*** | -6.00*** | -5.30*** | -8.56** | | | | |
| | (0.56) | (0.75) | (0.70) | (3.53) | | | | |
| Years of agriculture | | | | | -2.68*** | -4.90*** | -4.79*** | -6.46*** |
| | | | | | (0.53) | (0.80) | (0.73) | (1.95) |
| Continent fixed effects | No | Yes | Yes | Yes | No | Yes | Yes | Yes |
| Income | No | No | Yes | Yes | No | No | Yes | Yes |
| Geography | No | No | Yes | Yes | No | No | Yes | Yes |
| # of countries | 155 | 155 | 154 | 102 | 155 | 155 | 154 | 102 |
| $R^2$ | 0.25 | 0.38 | 0.44 | 0.31 | 0.15 | 0.32 | 0.43 | 0.39 |
| First stage F-statistics | - | - | - | 5.26 | - | - | - | 14.07 |

Notes: Columns (1)-(3) and (5)-(7) report OLS estimates. Columns (4) and (8) report 2SLS estimates (the instrument is domesticable animals, from Olsson and Hibbs, 2004, are used as instruments). Migration-adjusted years of agriculture is time elapsed in 2000 since the Neolithic revolution in 1000s years (Putterman and Trainor, 2006) adjusted with a post-1500 migration matrix (Putterman and Weil , 2010) Income is GDP per capita and GDP per capita squared in 2000. Geography includes fraction of tropical land, fraction of arable land, log distance to coast or river, and a dummy indicating whether a country is landlocked. Constants are not reported. Robust standard error in the parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table 3: Robustness to confounders

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Dependent variable is female labor force participation in 2000 | | | | | | | |
| | Institutions & democracy | | | Religious shares & fractionalization | | Plow suitability | Fertility Trans. | All Controls |
| Migration-adjusted years of agriculture | -5.18*** | -3.71*** | -3.72*** | -2.98*** | -3.15*** | -5.71*** | -5.08*** | -2.81** |
| | (0.72) | (0.70) | (0.79) | (0.74) | (0.74) | (0.75) | (0.85) | (1.12) |
| State development | Yes | Yes | Yes | No | No | No | No | Yes |
| Legal origin dummies | No | Yes | Yes | No | No | No | No | Yes |
| Democracy | No | Yes | Yes | No | No | No | No | Yes |
| Social infrastructure | No | No | Yes | No | No | No | No | Yes |
| Muslims & Protestants | No | No | No | Yes | Yes | No | No | Yes |
| Religious frac. | No | No | No | No | Yes | No | No | Yes |
| Plow suitable soils | No | No | No | No | No | Yes | No | Yes |
| Fertility transition | No | No | No | No | No | No | Yes | Yes |
| # of countries | 146 | 143 | 111 | 154 | 153 | 145 | 122 | 95 |
| $R^2$ | 0.44 | 0.54 | 0.55 | 0.57 | 0.57 | 0.49 | 0.44 | 0.64 |

Notes: The table reports OLS estimates. All regressions include the same controls as in column (3) in Table 1. Ancestry-adjusted years of agriculture is time elapsed in 1500 since the Neolithic revolution in 1000s years (Putterman and Trainor, 2006) adjusted with a post-1500 migration matrix (Putterman and Weil , 2010). State development is a state history index from 0-1500 CE (Bockstette and Putterman, 2007). Democracy is the Polity-2 score (Polity IV Database). Legal origins dummies are from La Porta el al. (2008). Social infrastructure is from Hall and Jones (1999). Muslims and Protestants are shares of population. Religious fractionalization is from Alesina et al. (2003). Plow suitable soils is defined as in Alesina et al. (2010) and taken from FAO's Global Agro . Ecological Zones database Fertility transition 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.

Table 4: Sub samples

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Dependent variable is the female labor force participation rate in 2000 | | | | | | |
| | Base Sample | Excl. the Mid. East | The Old World | Europe | Asia | Africa | Americas |
| Migration-adjusted years of agriculture | -5.30*** | -4.29*** | -5.43*** | -3.33*** | -4.99*** | -7.24*** | -1.94 |
| | (0.70) | (0.94) | (0.73) | (0.93) | (1.24) | (1.56) | (3.82) |
| # of countries | 154 | 138 | 125 | 38 | 41 | 46 | 24 |
| $R^2$ | 0.44 | 0.34 | 0.47 | 0.35 | 0.46 | 0.61 | 0.45 |

Notes: The table reports OLS estimates. All regressions include the same controls as in column (3) of Table 1. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic revolution in 1000s 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.
*** p<0.01, ** p<0.05, * p<0.1.

Table 5: Alternative outcomes

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Dependent variable: | | | | | | |
| | Male labor force part. in 2000 | Female labor force part. in 1980 | Years since female suffrage | Female seats in parliaments | Female legislators & managers | Female literacy 15-24 | Gender equality index |
| Migration-adjusted years of agriculture | -0.23 | -5.99*** | -3.39*** | -1.45** | -2.23*** | -2.67** | -0.16** |
| | (0.32) | (0.83) | (0.98) | (0.59) | (0.74) | (1.21) | (0.07) |
| # of countries | 154 | 127 | 153 | 133 | 100 | 108 | 61 |
| $R^2$ | 0.47 | 0.52 | 0.45 | 0.23 | 0.41 | 0.59 | 0.52 |

Notes: The table reports OLS estimates. All regressions include the same controls as in column (3) in Table 1. Migration-adjusted years of agriculture is time elapsed in 1500 since the Neolithic revolution in 1000s years (Putterman and Trainor, 2006) adjusted with a post-1500 migration matrix (Putterman and Weil, 2010). Dependent variables are indicated in the columns. Constants are not reported. Robust standard errors in the parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6: European regional sample

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Dependent variable: female labor force participation rate in 2008 | | | | | |
| Years of agriculture | -9.317*** | -5.365** | -3.931*** | -3.371*** | -3.078*** | -2.867*** |
| | (1.283) | (2.528) | (0.703) | (0.661) | (0.424) | (0.494) |
| Country fixed effects | N | Y | Y | Y | Y | Y |
| Income | N | N | Y | Y | Y | Y |
| Distance to equator | N | N | N | Y | Y | Y |
| Plow suitable soils | N | N | N | N | Y | Y |
| Distance to Wittenberg | N | N | N | N | N | Y |
| # of regions | 174 | 174 | 169 | 169 | 169 | 169 |
| $R^2$ | 0.65 | 0.87 | 0.92 | 0.92 | 0.92 | 0.93 |

Notes: The table reports OLS estimates. Unit of observation is region (Nuts 2). Years of agriculture is time elapsed in 1500 since the Neolithic revolution in 1000s years (Pinhasi et al, 2005). Income is GDP per capita and GDP per capita squared in 2008 (Eurostat). Distance to equator in km (own calculations) Plow suitable soils is defined as in Alesina et al. (2010) and taken from FAO's Global Agro. Distance to Wittenberg in km (own calculations). Constants are not reported. Robust standard errors corrected for clustering at the country level in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table A1: Data description

| Variable: | Description: | Source: |
|---|---|---|
| **Cross-country dataset:** | | |
| *Years of agriculture* | Number of years in 1500 CE since the of adoption of agriculture (the Neolithic Revolution).in 1000 years | Putterman (2008) |
| *Post-1500 migration matrix* | Contains data on post 1500 population migration flows across the world. | Putterman and Weil (2010) |
| *State development* | State history index up to 1500 CE for the presence of a state each half century. | Bockstette and Putterman (2007) |
| *Legal origin dummies* | Dummies for Scandinavian, British, German, French, or Socialistic legal origin. | La Porta et al. (2008) |
| *Democracy* | The Polity-2 variable, which ranges from -10 (dictatorship) to 10 (democracy). | Polity IV Database |
| *Social infrastructure* | An index comprising two indexes: 1) Government Antidiversion policy index and 2) Years open index. | Hall and Jones (2001) |
| *Muslims & Protestants* | Fraction of population that is Muslim and fraction of population that is Protestant. | Alesina (2003) |
| *Religious fractionalization* | Religious fractionalization index. | Alesina (2003) |
| *Plow suitable soils* | As defined in Alesina et al. (2010): Plow positive soils (for wheat & rye) % of arable land & Plow negative soils (for millet & sorghun) % of arable land. | FAO's Global Agro Ecological Zones database |
| *Fertility transition* | Number of years in 2000 CE since the Fertility decline (demographic transition) | Reher (2004) |
| *Income* | Log real GDP per capita and Log real GDP per capita squared (in 1980 & 2000). | Penn World Tables 7.0 |
| *Geography* | Fraction of land in tropics, fraction of arable land, log distance to coast or river, and a dummy equal to one if a country is landlocked. | CIA World Factbook & Gallup et al. (2001) |
| *Plants & axis orientation* | Number of domestically plants and Axis orientation of the continent. | Hibbs and Olsson (2005) |

Table A1: Data description (continued)

| Variable: | Description: | Source: |
|---|---|---|
| **Cross-country dataset:** | | |
| *Female labor force participation* | Females age 15 and older that are economically active (% of all women). | World Development Indicators & International Labor Org. |
| *Male labor force participation* | Males ages 15 and older that are economically active (% of all men). | World Development Indicators |
| *Years since female suffrage* | Number of years in 2000 CE since women were granted the right to vote at national elections. | Ramirez et al. (1997) |
| *Female seats in parliament* | Proportions of seats held by women in national parliament, 2000 CE. | World Development Indicators |
| *Female legislators & Managers* | Share of legislators, senior officials and managers who are female. | World Development Indicators |
| *Female literacy* | Females ages 15-24 that can read (% of all females ages 15-24). | World Development Indicators |
| *Gender equality index* | Extent to which a country has installed institutions that promote equal access for men and women in education, health, the economy. | World Development Indicators |
| **European regional dataset:** *(Nuts 2 level)* | | |
| *Years of agriculture* | Number of years in 1500 CE since the of adoption of agriculture (the Neolithic Revolution) in 1000 years | Pinhasi et al. (2005) |
| *Female labor force participation* | Females age 15 and older that are economically active (% of all women), 2008 CE | Eurostat |
| *Income* | Log real GDP per capita and Log real GDP per capita squared, 2008 CE. | Eurostat |
| *Plow suitable soils* | As defined in Alesina et al. (2012): Plow positive soils (for wheat & rye) % of arable land & Plow negative soils (for millet & sorghun) % of arable land. | FAO's Global Agro Ecological Zones database |
| *Distance to Wittenberg* | Great circle distance to Wittenberg in kms | Own calculations |
| *Distance to equator* | Great circle distance to equator in kms | Own calculations |