Look to history and you will find plenty of examples of farming communities where women worked as much as - or more than - the men. But in plough-intensive societies, where cultivation and planting relied on physical strength, men were the primary farmers. This point was made by the historian Fernand Braudel: the agricultural shift from the use of hoes to the utilization of the plough in ancient Mesopotamia caused that society to shift from a matriarchy to a patriarchy as physically stronger men (able to handle the plough) replaced women (who used hoes) in the grain fields.

In their paper "On the origin of gender roles: Women and the plough" (QJE, 2013), economists Alberto Alesina, Paola Giuliano and Nathan Nunn investigate whether such shift to plough-intensive societies has also had permanent and long-term effects on gender norms. In other words, they study whether descendants of societies that traditionally practiced plough agriculture have less equal gender norms, even today. This exam is roughly based on their work.

The authors estimate the following equation:

$$y_c = \beta_0 + \beta_1 Plough_c + \boldsymbol{x_c'}\gamma + u_c,$$

where y_c indicates outcomes of interest in each country c today, $Plough_c$ is an estimated proportion of citizens with ancestors that used the plough in pre-industrial agriculture in country c, $\boldsymbol{x_c'}$ is a vector of characteristics at the country level and u_c an unobservable error term.
More precisely, y_c represents three different dependent variables:

- *Female labor force participation* is the percentage of women in the labor force, measured in 2000. The variable ranges from 0 to 100.

- *Share of firms with female ownership* is the percentage of firms in the World Bank Enterprise Surveys with some female ownership. The surveys were conducted between 2003 and 2010, depending on the country. The variable ranges from 0 to 100.

- *Share of political positions held by women* is the proportion of seats in parliament held by women, measured in 2000. The variable ranges from 0 to 100.

Additionally, the control variables $Plough_c$ and the vector $\boldsymbol{x_c}$ include:

- $Plough_c$ is an estimated fraction of citizens with ancestors that used the plough in pre-industrial agriculture. Being a fraction, the variable ranges from 0 to 1.

- *agricultural suitability*, which measures the fraction of land that is defined as suitable for the cultivation of crops. The variable ranges from 0 to 1.

- *tropical climate*, which measures the fraction of land within a 200-kilometer radius from the center of a country that is defined as being tropical or subtropical. The variable ranges from 0 to 1.

- *large animals*, is an indicator variable that equals one if large domestic animals were present in the society in the past.

- *political hierarchies*, which measures the levels of jurisdictional hierarchies in the society. The variable ranges from 1 to 5 possible levels.

- *economic development*, measured using the density of ethnic groups' settlements. Ethnicities are grouped into the following categories: (1) nomadic or fully migratory, (2) semi-nomadic, (3) semi-sedentary, (4) compact but not permanent settlements, (5) neighborhoods of dispersed family homesteads, (6) separate hamlets forming a single community, (7) compact and relatively permanent settlements, and (8) complex settlements. With this information, the authors construct a variable that takes on integer values, ranging from 1 to 8 and increasing with settlement density.

- *GDP*, which measures the natural log of a country's real per capita GDP measured in 2000.

Note that in some specifications, the authors also add continent fixed effects.
Table 1 below shows the main results from the analysis.

Table 1: Gender attitudes and the plough.

	Female labor force participation		Share of firms with female ownership		Share of political positions held by women	
	(1)	(2)	(3)	(4)	(5)	(6)
$Plough_c$	-14.895	-15.962	-16.243	-17.806	-2.522	-2.303
	(3.318)	(3.881)	(3.854)	(4.475)	(1.967)	(2.353)
Agricultural suitability	9.407	9.017	1.514	4.619	1.009	-0.687
	(3.885)	(4.236)	(5.358)	(5.836)	(2.799)	(2.925)
Tropical climate	-8.644	-12.389	-11.091	-3.974	-7.671	-5.618
	(2.698)	(3.302)	(3.608)	(5.542)	(2.370)	(2.265)
Large Animals	10.903	2.35	-0.649	4.475	-9.152	-7.338
	(5.032)	(5.956)	(9.130)	(10.034)	(4.052)	(4.774)
Political hierarchies	-0.787	0.447	1.502	0.52	0.906	0.699
	(1.622)	(1.624)	(1.845)	(1.773)	(0.740)	(0.777)
Economic development	0.17	1.157	1.81	0.517	1.082	0.727
	(0.849)	(0.859)	(1.023)	(1.351)	(0.491)	(0.510)
GDP (log)	-34.612	-32.685	10.766	6.385	-6.53	-6.616
	(6.528)	(7.023)	(9.986)	(10.482)	(4.071)	(4.335)
Continent fixed effects	no	yes	no	yes	no	yes
R^2	0.22	0.28	0.18	0.23	0.17	0.2
N	177	177	128	128	153	153

Notes: The OLS estimator has been used throughout. OLS estimates are reported with robust standard errors in brackets. The unit of observation is a country. Check text for explanation of all dependent and independent variables.

(a) (15 points) Interpret all the coefficients in column (3).

(b) (10 points) Given all the results available, at a 5% significance level test the main research question, namely whether the findings suggests that the agricultural shift to the plough has had long-lasting effects on gender roles.

(c) (10 points) Consider now only column (1) and (2). Carefully justifying your answer, explain which model you prefer.

(d) (20 points) A commentator suggests that fertility plays an important role in determining labor force participation and occupational choices for women. The commentator therefore suggests adding a variable that indicates the average fertility rate in each country. Comment on this proposition.

(e) (10 points) Do you think it is necessary to use, as the authors do, "robust standard errors"?

(f) (20 points) The authors write: "A potential concern with the OLS estimates reported up to this point is that locations that historically had less equal gender-role attitudes may have had a higher likelihood of invent- ing or adopting the plough. This would bias the OLS estimates away from zero." Why can they draw this conclusion?

(g) (15 points) The authors use also an instrumental variable technique. They use two measures of soil suitability as an instrument for the adoption of the plough. In practice, they identify plough-positive and plough-negative ancestral suitability, which are used as instrumental variables. Plough-positive ancestral suitability measures the proportion of the population with ancestors that lived in climates that could grow cereals that would most benefit from the use of the plough, for example because their planting conditions are met only during narrow windows of time or these are crops that require larger tracts of land to cultivate (e.g., wheat, barley, and rye). Plough-negative ancestral suitability is defined as the proportion of ancestral population that lived in climates that could not benefit from the plough because they could only grow crops suitable for swampy, sloped, rocky, or shallow soils, all of which make the plough less efficient or impossible to use (e.g., sorghum, foxtail millet, and pearl millet). Outline the key identifying assumptions that the authors need for the instruments to be used in recovering the causal effect of plough usage on gender roles today. In your discussion, make sure you reflect on the validity of these particular instruments.