Supplementary material

Homeostasis

In biology, homeostasis is defined as follows:

Homeostasis, from the Greek words for "same" and "steady," refers to any process that living elements use to actively maintain fairly stable conditions necessary for survival. The term was coined in 1930 by the physician Walter Cannon. His book, The Wisdom of the Body, describes how the human body maintains steady levels of temperature and other vital conditions such as the water, salt, sugar, protein, fat, calcium and oxygen contents of the blood. Similar processes dynamically maintain steady-state conditions in the Earth's environment.

From https://www.scientificamerican.com/article/what-is-homeostasis/ (visited Nov 4 2021)

Homeostasis, any self-regulating process by which biological systems tend to maintain stability while adjusting to conditions that are optimal for survival. If homeostasis is successful, life continues; if unsuccessful, disaster or death ensues. The stability attained is actually a dynamic equilibrium, in which continuous change occurs yet relatively uniform conditions prevail.

From https://www.britannica.com/science/homeostasis (visited Nov 4 2021)

Clearly, the biological notion of homeostasis is related to the properties of dynamical systems, which are widely known in economics and in demography. Let us assume population dynamics follow a discrete scalar map:

$$P_{t+1} = \Phi(P_t), \tag{4}$$

such as the one implied by the textbook Malthusian model (Williamson 2018). Then,

Proposition 1 *given P_0, with $\Phi'(\cdot) > 0$ and $\Phi''(\cdot) < 0$,*

- *There is a globally stable steady state defined by $\bar{P} = \Phi(\bar{P})$*
- *Population Homeostasis is satisfied*
- *Population growth is negatively correlated with population density over time.*

Proof: See De la Croix and Gobbi (2017). ■

Proposition 1 is represented in Figure S1. It shows the increasing and concave map Φ, its globally stable steady state, the homeostasis property in blue and the correlation between growth (the fertility rate) and density in dark red.

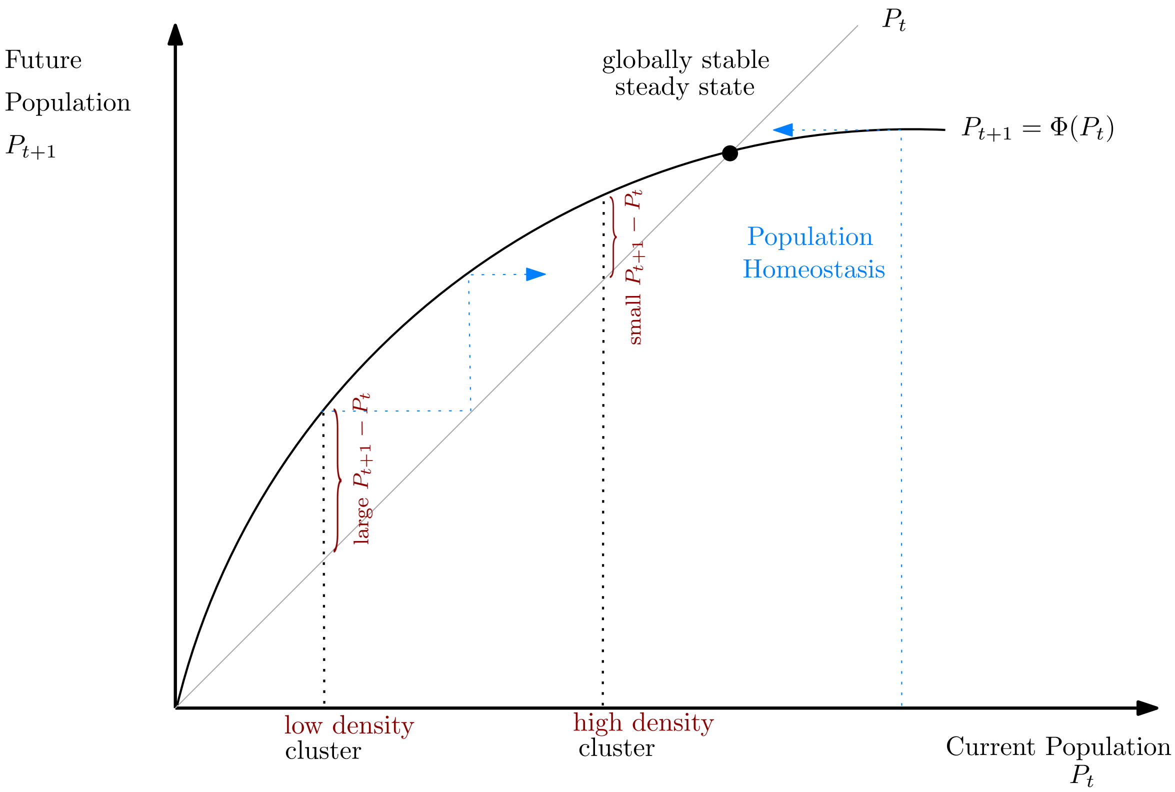

Figure S1: Population Homeostatis

To map the relationship between population density and population growth over time as a relationship across space, one can follow the standard approach provided by growth theory (Galor 1996). Consider a world consisting of different locations, each location isolated from the rest, and following the same law of motion, $\Phi(P_t)$, described in Proposition 1. If each location starts from a different initial condition P_0, then population growth is negatively correlated with population density across space.

Clearly, the assumptions of the above proposition, which ensure existence and global stability of the steady state, are only **sufficient conditions for homeostasis**. Homeostasis can be obtained under other configurations: for example, if population converges to a steady state with damped oscillations, or even if population does not converge to a steady state but rather to a limit cycle. This would be enough to ensure non-explosive behavior.

Note also that the homeostasis property is not incompatible with the idea of a demographic transition. To think about the link between the **demographic transition** and population homeostasis, one can model a simplified demographic transition as an upward shift of the function Φ, following a change in some of its parameters. There will thus be a new steady state with a larger population, and homeostasis will imply that actual population will converge to this new level, displaying a transition during which its growth rate would be high. This is admittedly a very simplistic representation of the demographic transition, which might be completed by incorporating the mortality aspect which is absent from our set-up.

The regression in Column (1) of Table 1 can be seen as an estimation of the linearized version of the dynamics (4) around its steady state:

$$P_{t+1} - \bar{P} = \Phi'(\bar{P})(P_t - \bar{P}) \Leftrightarrow P_{t+1} - P_t = \text{constant} + (\Phi'(\bar{P}) - 1)P_t$$

where the age at marriage and the age at first birth are directly related to the change in population $P_{t+1} - P_t$, P_t is population density, and $(\Phi'(\bar{P}) - 1)$ is the estimated coefficient.

In the other columns, we introduce control variables and what we call **"mediating" variables** (Baron and Kenny 1986). Control variables should be seen as reflecting location-specific parameters determining the position of the function Φ for each location. Mediating variables are variables which are affected by P_t and which affect P_{t+1}. M is a mediating variable if

$$P_{t+1} = \Psi(M(P_t), P_t) \quad = \Phi(P_t).$$

In that formulation, current population has a direct effect on future population and an indirect effect going through M. For example, education is expected to be a mediating variable: in location where density P_t is higher, schools are more accessible. Education is more developed in those areas, which reduces fertility and future population. We acknowledge however that this plausible mediating effect could be partly biased by omitted factors affecting both education and population density.

Data

Table S1 lists every sub-Saharan country for which GPS-coordinate information is available. Descriptive statistics for the data used in the analysis are provided in Table S2.

Notes on the individual recode: In a majority of DHS, eligible individuals include women of reproductive age (15-49). Some countries provide information for older women, but we did not keep these observations in the sample. We drop the observations for which the number of years of education is unknown or is higher than 30. All dates are expressed in Century Month Code (CMC). CMC is the usual way in which dates are coded in DHS. It counts time in terms of months and starts with the value 1 for January 1900. Mortality rates are computed as the difference between the number of children alive and the number of births, divided by the number of births born to a woman in the sample. Marital status is coded as either ever married (includes living with a partner, currently married, divorced, or widowed) or single (never married). Data on religion is available in almost all surveys except for those in Senegal, South Africa, and in DHS Phases VI and VII for Tanzania. Whenever this information is missing, we divide the sample into Muslims and Christians. Christians include women who belong to the Roman Catholic Church, the Evangelical Church, the Anglican Church, Protestants, Seventh-Day Adventists, Pentecostals, Methodists, the Salvation Army, Kimbanguists, the "églises réveillées", Presbyterians, the Apostolic sect, the "Iglesia ni Cristo", the Aglipayan Church (Philippine Independent Church), or those coded as "other Christians" by DHS. Missing information regarding ethnicity is a more common issue across countries (specific surveys have the subscript a in Table S1). This is the case in Angola, Burundi, Comoros, Lesotho, Liberia, Madagascar, Nigeria, Rwanda, Tanzania, Uganda, and Zimbabwe. Except for women whose ethnicity is unknown, every woman belongs to one of the 269 ethnicities documented across all countries. Ethnicities with less than 100 women in a country were not considered.

Notes on geolocation: In order to ensure the anonymity of respondents, urban clusters contain a minimum of 0 and a maximum of 2 kilometers of positional error. Rural clusters contain a minimum of 0 and a maximum of 5 kilometers of error, with a further 1% of rural clusters displaced a maximum of 10 kilometers.[13] To account for this error, we set the density in a cluster to the average density within a 2km radius around the center of this cluster if it is an urban cluster. For rural clusters, we set the radius

[13]DHS do not precisely define the urban-rural variable of the GPS dataset. In each country, they adopt a definition that can depend on the size of the population or on the breadth of infrastructures. See more at: http://dhsprogram.com/What-We-Do/GPS-Data-Collection.cfm

at 5km.[14] Finally, as the raster for the Caloric Suitability Index described above has a lower resolution than the population density raster, we impute the land productivity in each cluster from the value of the index in its given position.

[14]Due to the DHS displacement, two clusters in Uganda (DHS Phase IV) appear to be in Lake Victoria. We give each point the minimal radius so as to have positive population density. This is 13km for one cluster and 33km for the other. A similar problem was fixed for three clusters in Nigeria and one cluster in Tanzania.

Countries		DHS Phases	Years	Nobs	%
Angola	AO	VII[a]	2015-16	14,379	1.52
Benin	BJ	IV	2001	6,218	0.66
		VI	2011-12	16,522	1.74
Burkina Faso	BF	III	1998-99	6,378	0.67
		IV	2003	12,392	1.31
		VI	2010	16,115	1.70
Burundi	BU	VI[a]	2010	9,386	0.99
		VII[a]	2016-17	17,202	1.82
Cameroon	CM	IV	2004	10,599	1.12
		VI	2011	15,401	1.63
Central African Republic	CF	III	1994-95	5,884	0.62
Chad	TD	VII	2014-15	17,693	1.87
Comoros	KM	VI[a]	2012	5,074	0.54
Congo Democratic Republic	CD	V	2007	9,729	1.03
		VI	2013-14	17,399	1.84
Côte d'Ivoire	CI	III	1998-99	3,040	0.32
		VI	2011-12	9,793	1.03
Eswatini	SZ	V	2006-07	4,904	0.52
Ethiopia	ET	IV	2000	15,225	1.61
		V	2005	13,907	1.47
		VI	2011	15,789	1.67
		VII	2016	15,242	1.61
Gabon	GA	VI	2012	8,360	0.88
Ghana	GH	III	1993	4,562	0.48
		IV[d]	1998	4,841	0.51
		IV[d]	2003	5,665	0.60
		V	2008	4,802	0.51
		VII	2014	9,294	0.98
Guinea	GN	IV	1999	6,728	0.71
		V	2005	7,838	0.83
		VI	2012	9,140	0.96
Kenya	KE	IV	2003	8,168	0.86
		V	2008-09	8,421	0.89
		VII	2014	30,929	3.27
Lesotho	LS	IV[a]	2004	6,709	0.71
		VI[a]	2009	7,541	0.80
		VII[a]	2014	6,621	0.70
Liberia	LB	V[b]	2007	6,934	0.73
		VI	2013	9,229	0.97
Madagascar	MD	III[a]	1997	7,026	0.74
Madagascar		V[a]	2008-09	17,074	1.80

Countries		DHS Phases	Years	Nobs	%
Malawi	MW	IV[d]	2000	13,220	1.40
		IV[d]	2004	11,687	1.23
		VI	2010	22,480	2.37
		VII	2015-16	24,562	2.59
Mali	ML	III	1995-96	9,700	1.02
		IV	2001	12,767	1.35
		V	2006	14,455	1.53
		VI	2012-13	10,424	1.10
Mozambique	MZ	VI	2011	13,727	1.45
Namibia	NM	IV	2000	6,731	0.71
		V	2006-07	6,731	0.71
		VI	2013	6,731	0.71
Niger	NI	II	1992	6,503	0.69
		III	1998	7,577	0.80
Nigeria	NG	II[a]	1990	8,723	0.92
		IV	2003	7,571	0.80
		V	2008	33,332	3.52
		VI	2013	38,600	4.08
Rwanda	RW	V[a]	2005	11,177	1.18
		VI[a]	2010	13,671	1.44
		VII[a]	2014-15	13,485	1.42
Senegal	SN	II[c]	1992-93	6,310	0.67
		III[c]	1997	8,563	0.90
		IV[c]	2005	14,272	1.51
		VI[c]	2010-11	15,459	1.63
Sierra Leone	SL	V	2008	7,306	0.77
		VI	2013	16,638	1.76
South Africa	ZA	VII[c]	2016	8,510	0.90
Tanzania	TZ	IV[a]	1999	3,953	0.42
		VI[a,c]	2010	9,760	1.03
		VII[a,c]	2015-16	13,261	1.40
Togo	TG	III	1998	8,521	0.90
		VI	2013-14	9,475	1.00
Uganda	UG	IV[a]	2000-01	6,401	0.68
		V[a]	2006	7,742	0.82
		VI	2011	8,579	0.91
		VII	2016	18,231	1.92

Countries		**DHS Phases**	**Years**	**Nobs**	**%**
Zambia	ZM	V	2007	7,146	0.75
		VI	2013-14	16,347	1.73
Zimbabwe	ZW	IV[a]	1999	5,715	0.60
		V[a]	2005-06	8,852	0.93
		VI[a]	2010-11	8,853	0.93
		VII[a]	2015	9,955	1.05
Total number of individuals				947,191	100.00

[a] refers to surveys for which there is no available information on ethnicity.
[b] refers to surveys for which we use the variable dialect for ethnicity.
[c] refers to surveys for which there is no available information on religion.
[d] Ghana and Malawi had two surveys in Phase IV; we used both.

Table S1: DHS included in the analysis

	N. obs.	Mean	St. Dev.	Min	Max
From the Individual Recode					
Age (in completed years)	947,191	28.387	9.469	15	49
Education (in single years)	947,191	4.734	4.514	0	26
Partner's Education	637,604	5.090	5.054	0	25
Total number of children ever born	947,191	2.889	2.826	0	21
Total number of living children	947,191	2.444	2.359	0	16
Children's mortality rate	947,191	0.089	0.187	0	1
Motherhood rate	947,191	0.729	0.445	0	1
Marriage rate	947,191	0.738	0.440	0	1
Muslim (%)	914,920	0.322	0.467	0	1
Christian (%)	914,851	0.587	0.492	0	1
Age at first birth (in years)	690,406	19.086	3.775	8	48
Age at first birth (in months)	690,406	234.400	45.191	98	586
Age at first marriage (in years)	699,107	18.025	4.216	8	49
Age at first marriage (in months)	699,107	221.582	50.561	96	599
Moved from place of residence after 14 (%)	947,191	0.258	0.438	0	1
Ethnicity	947,164	269 categorical variables			
From the Household Recode					
Has electricity (percent)	936,401	0.301	0.459	0.000	1.000
Has a refrigerator (percent)	907,958	0.138	0.345	0.000	1.000
From CIESIN					
Population density in 1990 (pop. per km^2)	947,191	747.977	1,981.006	0.012	32,860.830
From Galor and Özak (2016)					
Caloric suitability index post 1500	947,191	10.006	2.816	0.000	17.684
From Ghosh et al. (2010)					
GDP per capita	947,191	0.002	0.010	0.00001	0.427

Table S2: Descriptive Statistics

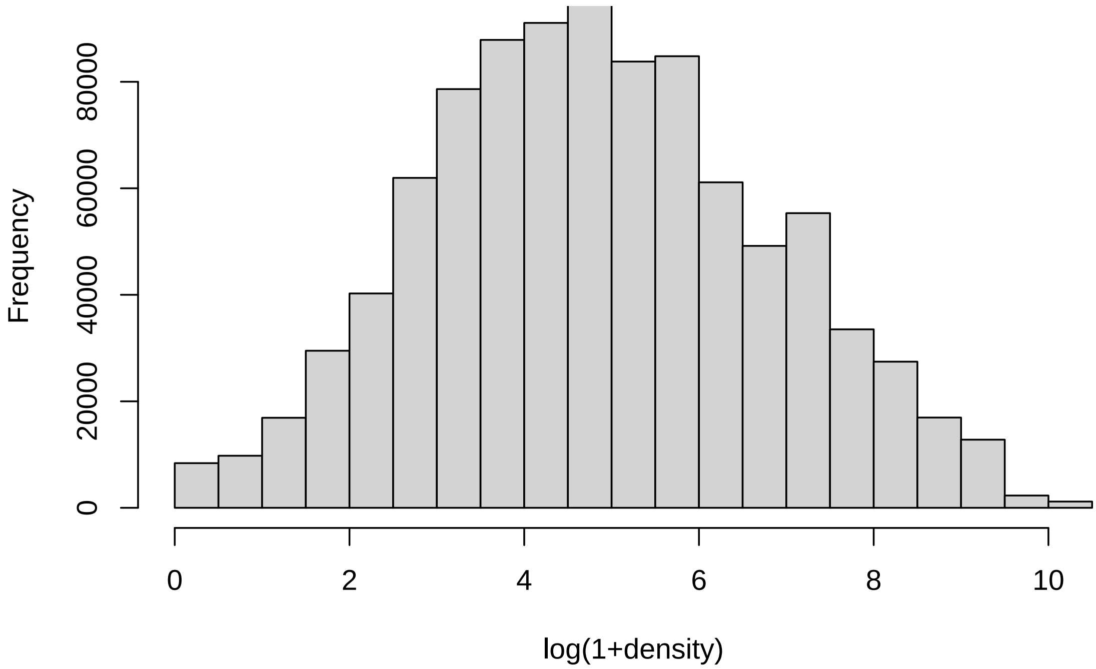

Figure S2: Frequency distribution of $\log(1 + density)$ across women

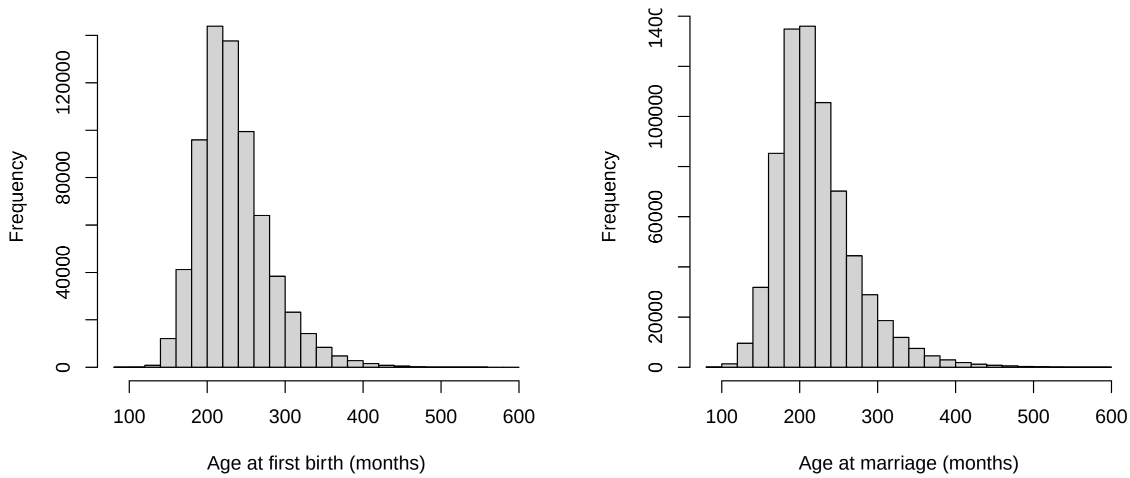

Figure S3: Frequency distribution of the age at first birth and at marriage across women

Robustness (details)

Our benchmark specifications for comparison will be those of column (3) for the age at first birth and those of column (6) for the age at first marriage in our main result Table 1.

Omitted variables

Other variables can affect the age at first birth and the age at first marriage than those included in the benchmark model. Here, we look at the robustness of our findings when adding other possible controls: (1) dummies for the ethnicity of the respondent, (2) the individual's religion, (3) whether the household has electricity or a refrigerator, (4) the education of the spouse, and (5) the average knowledge regarding modern contraception. Through different norms and customs, ethnicity and religion can affect fertility choices in general (De la Croix and Delavallade 2018) and also decisions regarding the timing of marriage and of first birth (Bloom and Reddy 1986; Rindfuss and John 1983). Having electricity or a refrigerator can be seen as a proxy for the overall wealth of the household, which could also affect the timing of the two events studied. A more educated partner might also affect the timing of birth, while the average education of men in a female cluster may affect the age at marriage. Finally, knowledge regarding modern contraception could have an effect on the timing of marriage.

We estimate five different regression models. We do not have information regarding religion, having electricity or a refrigerator, or the education of the spouse for every woman. The sample sizes are therefore different in these specifications. The results are provided in Table S3 for age at first birth and in Table S4 for age at marriage. The column "Benchmark" repeats our estimates of columns (3) and (6), for the age at first birth and the age at first marriage respectively, from Table 1.

The sample in column (2) only includes women in countries where there is information available regarding religion. The reference group includes women whose religion is neither Islam nor Christianity. The findings from Tables S3 and S4 suggest that both the age at first birth and the age at first marriage of Christian women are lower than those of this reference group and than those of Muslim women.

Having electricity/a refrigerator negatively relates to both the age at first marriage and the age at first birth (column (3)). The sign of the relationship between electrification and fertility has been a focus of debate in the past two decades. Our findings are in line with those of Greenwood, Seshadri, and Vandenbroucke (2005) that observe and provide a theoretical explanation for the positive effect of electro-domestics on fertility in the context of the American post-war baby boom. However, other authors suggest a negative (causal) relationship, such as Bailey and Collins (2011) for the Amish in the United States, Grimm, Sparrow, and Tasciotti (2015) for Indonesia, or Akpandjar, Puozaa, and Quartey (2018) for rural Ghana. Peters and Vance (2011) find mixed evidence as they show a positive relationship in urban areas of Côte d'Ivoire and a negative sign for the rural areas.

In column (4), only married women are considered. We find no association between the education of the spouse and the age at first birth. However, the age of the spouse is positively related to a woman's age at first marriage. Knowledge regarding modern contraception is positively related to the age at first birth. We do not find a significant relationship with the age at first marriage (column 5).

	Dependent variable:					
	Probability of becoming a mother					
	Benchmark	(1)	(2)	(3)	(4)	(5)
ln(1+density)	-0.014***	-0.014***	-0.013***	-0.009***	-0.010***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
education	0.052***	0.050***	0.053***	0.050***	0.049***	0.050***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$(\text{education})^2$	-0.008***	-0.007***	-0.008***	-0.007***	-0.007***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
infant mortality	0.583***	0.588***	0.583***	0.578***	0.528***	0.583***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
married	1.268***	1.266***	1.307***	1.245***		1.267***
	(0.007)	(0.007)	(0.008)	(0.007)		(0.007)
calories	0.014***	0.013***	0.014***	0.013***	0.014***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
mean mortality	0.577***	0.395***	0.576***	0.602***	0.511***	0.578***
	(0.036)	(0.036)	(0.037)	(0.037)	(0.038)	(0.036)
log(GDP per capita)	-0.002	0.001	-0.004*	0.004	-0.001	-0.004*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
mean education	-0.011***	-0.011***	-0.010***	-0.008***	-0.013***	-0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Muslim			0.009			
			(0.008)			
Christian			-0.023***			
			(0.007)			
refrigerator				-0.073***		
				(0.005)		
electricity				-0.057***		
				(0.005)		
education of spouse					-0.000	
					(0.000)	
mean contraception						0.185***
						(0.014)
Observations	947,191	947,191	914,851	907,071	635,722	947,191
Ethnicity FE	NO	YES	NO	NO	NO	NO

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level. All specifications include survey fixed effects. Column (3) includes married women only.

Table S3: Cox Model Estimates for Age at First Birth: Robustness

	Dependent variable:					
	Probability of marrying					
	Benchmark	(1)	(2)	(3)	(4)	(5)
ln(1+density)	-0.017***	-0.026***	-0.021***	-0.015***	-0.018***	-0.018***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
education	-0.036***	-0.034***	-0.033***	-0.037***	-0.035***	-0.036***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$(\text{education})^2$	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
infant mortality	0.441***	0.446***	0.444***	0.430***	0.437***	0.441***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
calories	0.007***	0.009***	0.010***	0.007***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
mean mortality	1.249***	0.972***	1.267***	1.282***	1.251***	1.248***
	(0.049)	(0.046)	(0.049)	(0.050)	(0.049)	(0.049)
log(GDP per capita)	-0.010***	-0.008**	-0.013***	-0.003	-0.011***	-0.010***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
mean education	-0.051***	-0.040***	-0.044***	-0.049***	-0.067***	-0.052***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Muslim			0.126***			
			(0.009)			
Christian			-0.043***			
			(0.008)			
refrigerator				-0.060***		
				(0.006)		
electricity				-0.022***		
				(0.006)		
education of spouse					0.016***	
					(0.002)	
mean contraception						0.015
						(0.019)
Observations	947,191	947,191	914,851	907,071	931,154	947,191
Ethnicity FE	NO	YES	NO	NO	NO	NO

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level.
All specifications include survey fixed effects.

Table S4: Cox Model Estimates for Age at First Marriage: Robustness

Selection

Density may be correlated with the age at first birth and the age at first marriage because of a selection problem: women with a lower desire for children/marriage may migrate from areas with low population density to areas with high population density. If our estimates are distorted from such a selection bias, then we cannot conclude that there is a causal relationship between population density and fertility, or a built-in stabilizer for population dynamics.

We look at whether this selection problem biases our results by removing from the sample: (1) those we know have moved (keeping those for whom information on the years lived in the place of residence is not available (NA) in the sample), and (2) everyone but those we know did not migrate (we also exclude those for whom we do not have information on migration). We consider a migrant to be a person who arrived in their place of residence when they were between age 15 and their age at the time of the interview.

The results are shown in columns (1) and (2) in Tables S5 and S6. Comparing these results to the Benchmark column, we see that although the sample size is very much reduced after removing migrants, the effect of population density on either the age at first birth or the age at marriage is still significant.

	Dependent variable:		
	Probability of becoming a mother		
	Benchmark	(1)	(2)
ln(1+density)	-0.014***	-0.012***	-0.013***
	(0.001)	(0.001)	(0.002)
education	0.052***	0.052***	0.053***
	(0.001)	(0.001)	(0.002)
$(\text{education})^2$	-0.008***	-0.008***	-0.008***
	(0.000)	(0.000)	(0.000)
infant mortality	0.583***	0.594***	0.584***
	(0.007)	(0.009)	(0.012)
married	1.268***	1.308***	1.370***
	(0.007)	(0.008)	(0.011)
calories	0.014***	0.016***	0.014***
	(0.001)	(0.001)	(0.001)
mean mortality	0.577***	0.703***	0.595***
	(0.036)	(0.042)	(0.058)
log(GDP per capita)	-0.002	0.003	0.015***
	(0.003)	(0.003)	(0.004)
mean education	-0.011***	-0.011***	-0.006***
	(0.001)	(0.001)	(0.002)
Observations	947,191	702,626	327,632

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level. All specifications include survey fixed effects. Column (1): sample of those who did not migrate, keeping those we do not know. Column (2): sample of those we are sure did not migrate.

Table S5: Cox Model Estimates for Age at First Birth – Selection

	Dependent variable:		
	Probability of marrying		
	Benchmark	(1)	(2)
ln(1+density)	-0.017***	-0.014***	-0.017***
	(0.002)	(0.002)	(0.003)
education	-0.036***	-0.046***	-0.049***
	(0.001)	(0.001)	(0.002)
$(\text{education})^2$	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)
infant mortality	0.441***	0.515***	0.594***
	(0.008)	(0.009)	(0.013)
calories	0.007***	0.010***	0.005***
	(0.001)	(0.001)	(0.002)
mean mortality	1.249***	1.401***	1.239***
	(0.049)	(0.055)	(0.078)
log(GDP per capita)	-0.010***	-0.008*	-0.005
	(0.003)	(0.004)	(0.006)
mean education	-0.051***	-0.052***	-0.052***
	(0.001)	(0.002)	(0.003)
Observations	947,191	702,626	327,632

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level. All specifications include survey fixed effects. Column (1): sample of those who did not migrate, keeping those we do not know. Column (2): sample of those we are sure did not migrate.

Table S6: Cox Model Estimates for Age at First Marriage – Selection

Measurement error

Misreporting the date of birth or underreporting the number of births are common sources of error in surveys that look at birth history (Schoumaker 2014). These errors are very much linked to the low education levels of respondents (Pullum 2006), and can affect age at first birth in three ways. The first is the "Potter effect," when a woman reports that a birth occurred later than it actually did (Potter 1977). This will likely increase the age at first birth for older women. The second source of error is interviewers or respondents adjusting a date of birth in order to avoid completing the health section of the DHS questionnaire (for children younger than 5 or 3). This will cause a reduction in the average age at first birth for younger women. The last problem is the omission of earlier births, which most likely occurs with older respondents and is likely to increase the average age at first birth in a population.

Columns (1) and (2) of Table S7 respectively show the estimates of the effect of population density on the age at first birth and the age at first marriage after removing the countries classified as having "poor quality" data in Schoumaker (2014) (Table 5) from the sample.[15] Specifically, we removed Burkina Faso, Benin, Cameroon, Chad, Ethiopia, Guinea, Madagascar, Mali, Mozambique, Nigeria, Niger, Uganda, Central African Republic, Liberia, and Sierra Leone from the sample.

By doing so, we drop more than half of the observations. Comparing the results, we see that when the analysis is restricted to these countries, the overall impact of population density on the probability of first birth and marriage is stronger. The direction of the effect of the other covariates remains stable.

[15] Schoumaker (2014) explores the quality of the data using three approaches. The first consists in reconstructing trends in the total fertility rate (TFR) using a Poisson regression, and relying on one survey per country (see (Schoumaker 2013b) for details on this method). The second approach consists in pooling all the surveys conducted in the same country and then reconstructing fertility trends from the pooled dataset (Schoumaker 2013a). The third approach aims to correct birth histories by adjusting or adding births.

	Dependent variable:			
	Probability of first birth		Probability of marrying	
	Benchmark	(1)	Benchmark	(2)
ln(1+density)	-0.014***	-0.022***	-0.017***	-0.035***
	(0.001)	(0.002)	(0.002)	(0.002)
education	0.052***	0.064***	-0.036***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.002)
$(\text{education})^2$	-0.008***	-0.009***	-0.003***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)
infant mortality	0.583***	0.523***	0.441***	0.430***
	(0.007)	(0.011)	(0.008)	(0.011)
married	1.268***	1.109***		
	(0.007)	(0.008)		
calories	0.014***	0.013***	0.007***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
mean mortality	0.577***	0.664***	1.249***	1.124***
	(0.036)	(0.056)	(0.049)	(0.068)
log(GDP per capita)	-0.002	0.009***	-0.010***	-0.004
	(0.003)	(0.003)	(0.003)	(0.004)
mean education	-0.011***	-0.004***	-0.051***	-0.032***
	(0.001)	(0.001)	(0.001)	(0.002)
Ethnicity FE	NO	NO	NO	NO
Observations	947,191	487,581	947,191	487,581

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level. All specifications include survey fixed effects.

Table S7: Cox Model Estimates for Age at First birth and Age at First Marriage – Data Quality

Non-linear effects (details)

To test for non-linear effects of population density on the probability of having a first birth and the probability of marrying, we estimate a model in which we replace the log of density by ten dummy variables corresponding to the ten deciles of density. Table S8 shows that population density and these two probabilities are positively related to density for the lowest deciles of the density distribution. The positive relationship is however only significant for the probability of marrying, between the first and the second decile of the population distribution. From this analysis, we conclude that population density only has a stabilization effect once a certain threshold is reached. Moreover, we also observe that the effect of population density is in general stronger for deciles 8, 9 and 10. This suggests that the demographic transition will accelerate once population density is high enough.

	Dependent variable:							
	Probability of first birth				*Probability of marrying*			
	Bench.	(1)	Bench.	(2)	Bench.	(1)	Bench.	(2)
ln(1+density)	-0.099***		-0.014***		-0.136***		-0.018***	
	(0.001)		(0.001)		(0.001)		(0.002)	
Decile 2		0.014		0.002		0.027**		0.026***
		(0.009)		(0.008)		(0.011)		(0.010)
Decile 3		-0.015*		-0.004		-0.047***		-0.008
		(0.009)		(0.008)		(0.011)		(0.010)
Decile 4		-0.036***		0.004		-0.092***		-0.005
		(0.009)		(0.008)		(0.012)		(0.011)
Decile 5		-0.046***		0.018**		-0.118***		-0.002
		(0.009)		(0.008)		(0.012)		(0.011)
Decile 6		-0.117***		0.002		-0.207***		-0.019*
		(0.010)		(0.008)		(0.013)		(0.011)
Decile 7		-0.170***		-0.006		-0.291***		-0.038***
		(0.009)		(0.008)		(0.012)		(0.011)
Decile 8		-0.308***		-0.043***		-0.459***		-0.062***
		(0.009)		(0.008)		(0.012)		(0.011)
Decile 9		-0.460***		-0.059***		-0.647***		-0.060***
		(0.010)		(0.009)		(0.012)		(0.012)
Decile 10		-0.610***		-0.094***		-0.826***		-0.100***
		(0.010)		(0.009)		(0.012)		(0.012)
Controls	NO	NO	YES	YES	NO	NO	YES	YES
Observations	947,191	947,191	947,191	947,191	947,191	947,191	947,191	947,191

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors clustered at the cluster level. All specifications include survey fixed effects. Controls include those of column (3) of Table 1.

Table S8: Cox Model Estimates for Age at First birth and Age at First Marriage with Non-linear Effect of Density