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The fertility transition in Sub-Saharan Africa: The role of structural change

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Abstract: Despite relatively sustained economic growth in at least parts of Sub-Saharan Africa over the past twenty years, the fertility transition has not much advanced in most countries in that region. We explore whether the lack of structural change can explain this slow transition. For this end, we analyze the determinants of fertility transitions across the developing world using a novel regional level panel dataset created by matching Demographic and Health Surveys and Household Income Surveys from 60 countries over three decades. Our key hypothesis is that structural change, i.e. a shift of employment from subsistence agriculture to more skill-intensive services, accompanied by an increase in human capital accumulation, is a key driver of the fertility transition. Our results indicate that higher education of women, female employment in non-agricultural formal jobs and industrialization as measured by an increase in nighttime light intensity are indeed important determinants of the fertility transition. We also find suggestive evidence for a complementary role of access to health insurance. Simulations show that if high-fertility countries in Sub-Saharan Africa had experienced the same structural change as the most demographically advanced regions in our sample over the last twenty years, fertility levels would be up to 40% lower.

Key Words: Demographic transition; Fertility; Structural change; Human capital; Sub-Saharan Africa.

JEL-Codes: D13, J11, J13, J22, O12.

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1 Introduction

Whereas the total fertility rate for the world as a whole fell from around five live births per woman in 1950 to 2.5 births in 2015, fertility rates in most countries in Sub-Saharan Africa are still at a very high level (United Nations DESA, 2020). In Sub-Saharan Africa (excluding Southern Africa), women give on average birth to more than 4.6 children during their fertile age (United Nations DESA, 2020). None of the Sub-Saharan African countries has completed the fertility transition, except South Africa and Mauritius, but even in these two countries fertility varies greatly across socio-economic groups (Bruni, Rigolini and Troiano, 2016). While some countries have not even started their transition, others have seen declines in fertility, but often these have not been lasting and ended in some cases in so-called fertility stalls (Bongaarts, 2008; Garenne, 2008; Schoumaker, 2009, 2019).[1]

Since most countries have, however, entered their health transition and experienced a significant increase in life expectancy thanks to a substantial decline in child mortality, population growth rates are at very high levels, much higher of what the today developed countries experienced historically during their transition (Lee, 2003). Indeed, the under-five mortality rate declined from 151 deaths per 1,000 live births in 2000 to less than 76 deaths per 1,000 live births in 2019.[2] This is by historical standards a very rapid and sharp decline. Over the same period, life expectancy at birth increased, despite the HIV/AIDS pandemic, from 50 years to almost 62 years.[3]

These high levels of fertility persist despite a relatively sustained economic growth and even remarkable poverty reduction in most parts of Sub-Saharan Africa. On average, since the early 2000's, GDP per capita has increased in Sub-Saharan Africa by about 3% on an annual basis (Rodrik, 2018). In some countries, such as Côte d'Ivoire, Ethiopia and Tanzania, per capita growth has in the recent past even exceeded 7% annually. The poverty head count index declined from 59.4% in 1999 to about 40.2% in 2018 (World Bank, 2020).

In Western countries, East and Southeast Asia and most parts of Latin America, such sustained rates of income growth and mortality reductions have been accompanied by significant declines in fertility. This is well documented in the literature. Jones and Tertilt (2006), for example,

[1] A fertility stall occurs when the fertility transition has (temporarily) stopped or at least markedly slowed down. Schoumaker (2009), for example, operationalizes this concept by considering two consecutive surveys. If in the more recent survey the TFR is at least as high as in the previous survey a country or region is said to have experienced a fertility stall.
[2] https://data.worldbank.org/indicator/SH.DYN.MORT?end=2019&locations=ZG&start=2000.
[3] https://data.worldbank.org/indicator/SP.DYN.LE00.IN?end=2019&locations=ZG&start=2000.

show that in the US the number of children ever born per woman declined between 1850 and 1950 from about 5.5 to 2.1, while average occupational income was multiplied by eight. In East Asia and Southeast Asia, birth rates fell by about 45% and 20%, respectively, over the period 1960 to 1980, while labor force participation and human capital accumulation substantially increased. Bloom and Williamson (1998) show that both forces mutually reinforced each other. In Brazil, the total fertility rate fell from 6.3 in 1960 to 2.0 in 2005. This time span included several periods of rapid economic growth. Potter, Schmertmann and Cavenaghi (2002) find a strong and consistent relationship between the decline in fertility and changes in economic circumstances.

Yet, the growth trajectory of countries in Asia, Europe and Latin America was quite different of what has been observed on the African continent until now. Whereas in the former economic growth came along with substantial structural change, i.e. a massive migration of labor from agriculture to industry, especially manufacturing, in the latter it has been largely based on an extension of agriculture, natural resource extraction, and the informal sector (McMillan and Harttgen, 2014; de Vries, Timmer and de Vries, 2015; Diao, Harttgen and McMillan, 2017; Rodrik, 2018). In non-African countries, this shift in the labor composition implied increasing returns to education, a constant need to adapt to new technologies, increasing labor market opportunities for women, and reduced returns to child labor. Moreover, industrialization was typically also accompanied by a formalization of the economy and hence increased social protection, including old age security and health insurance. In a Beckerian fertility demand framework, such shifts from agriculture to industry are sought to reduce the returns to the quantity of children and increase the returns to quality, i.e. parents tend to have fewer, but better educated children (Becker and Lewis, 1973; Becker, 1981). Hence, if economic development, i.e. income growth and reduction in mortality, arises without such structural change, this substitution may not take place and parents may continue to have many children with rather low levels of education.

In this paper, we analyze to what extent the slower fertility transition in Sub-Saharan Africa can be explained by sluggish structural change. We use a novel data set covering 60 low- and middle-income countries over the period 1986 to 2019, which we constructed by merging Demographic and Health Surveys and Living Standard Measurement Surveys (or analog), enriched with data on global nighttime lights from 1992 to 2018. We merged these data at the first level of administrative units (regions), which provides us with a regional (albeit unbalanced) panel for in total 543 regions from 60 countries over a period of 34 years. This data gives us variation in fertility and indicators of structural change within countries and over time that we use to test whether there is a statistically and economically significant relationship between the advancement of the fertility transition and the degree of structural change, while controlling for indicators that reflect rather general economic development, such as income growth, urbanization, mortality, and primary education. To our knowledge, our study is the first to look at the link between fertility and structural change in low- and middle-income countries at the subnational level. This level of disaggregation allows for a more precise identification of relevant channels that typically get blurred when country averages are used.

Policymakers should be interested in the understanding of fertility trends in Sub-Saharan Africa, since under the current fertility trends its population will grow over the next 30 years by another 1.2 billion, from 1.3 billion today to 2.5 billion in 2050. This will be by far the highest population spurt worldwide and in history. Much of Africa's population boom will come from Nigeria, currently the world's 7th most populous country and ranked 158th out of 189 countries in UNDP's "Human Development Index".[4] Without reductions in population growth, Africa's population may face an insurmountable 'demographic burden' with millions of young people without jobs and an economic and social perspective and with a serious pressure on public resources, especially on health and education infrastructure. If, in turn, this trend can be stopped and fertility rates can be significantly reduced, it may, to the contrary, turn into a 'demographic gift', which could perpetuate and further enhance economic development (Bloom, Canning and Sevilla, 2003; Bloom et al., 2009; Bloom, Kuhn and Prettner, 2017).

This paper contributes to different strands of the literature. First, it adds to the general debate about the fertility transition in Sub-Saharan Africa. Recent influential research includes for example Bongaarts (2017), who stresses the role of slow socio-economic development, poor governance and the exposure to risk of households as some of the key drivers. Yet, he adds that Sub-Saharan Africa has, compared to other regions, even controlling for socio-economic development in terms of mortality, income per capita, urbanization, and education, still a higher fertility on average. Bongaarts refers to this as the 'Africa effect.' Casterline and Agyei-Mensah (2017) and Hertrich (2017) focus on the role of intermediate factors that stand between more general socio-economic forces and fertility decisions, such as fertility desires and nuptiality. Singh, Bankole and Darroch (2017) argue that although desired fertility is high, it is still exceeded by actual fertility, so that there is scope to reduce fertility to some extent by promoting family planning (see also Günther and Harttgen, 2016; May, 2017; Tsui, Brown and Li, 2017).

[4] http://hdr.undp.org/en/countries/profiles/NGA.

Cohen (1998), Bongaarts (2010), Bongaarts and Casterline (2013) and Bloom, Kuhn and Prettner (2017) provide additional interesting insights on this topic. There are also a series of papers that focus specifically on 'fertility stalls' in Sub-Saharan Africa (Bongaarts, 2006; 2008; Shapiro and Gebreselassi, 2008; Garenne, 2008; 2011; Ezeh, Mberu and Emina, 2009; Shoumaker, 2009; 2019; Goujon, Lutz and Samir, 2015).

Our analysis also provides an empirical basis regarding the relevance of unified growth models in the African context, as we focus in our analysis on some of the key drivers that are stressed by this literature (Galor and Weil, 1996; 2000; Galor and Moav, 2002; Doepke, 2004; Cervellati and Sunde, 2005; Strulik and Weisdorf, 2008; Galor, 2011). Unified growth theory emphasizes the increasing role of human capital and technological progress in the production process that enhances the demographic transition. Finally, we contribute to the literature on structural change in Sub-Saharan Africa, as we document that it is slow and different as compared to other regions in the world and very heterogenous even within countries. Influential research on structural change in Sub-Saharan Africa includes McMillan and Harttgen (2014), de Vries, Timmer and de Vries (2015), Barret et al. (2017), Diao, Harttgen and McMillan (2017), Rodrik (2018), and Diao, McMillan and Rodrik (2019).

The remainder of this paper is structured as follows. In Section 2, we present our dataset, introduce our key variables and show some basic descriptive statistics. In Section 3, we lay out our empirical specifications. In Section 4, we discuss our results. In Section 5, we conclude.

2 Data

2.1 Data sources and merging

We created a novel dataset by combining 289 Demographic and Health Surveys (DHS) from 60 countries over a time period of 34 years.[5] These surveys include individual and household level information with respect to fertility, demographics, health, education, occupation, and other socio-economic characteristics. Despite frequent adjustments over time, the questionnaires of DHS are largely harmonized across countries and survey years with respect to the key variables of interest; hence, they allow to construct consistent measures across time and space. We enrich this dataset by adding information on nighttime light intensity as a proxy for modern economic development at the local level. Specifically, we use a harmonized annual

[5] Appendix A provides an overview of all included DHS by country and year.

time series dataset on global nighttime light intensity based on weather satellite recordings covering the period 1992 to 2018, constructed by Li et al. (2020).

Before merging, all data was aggregated at the level of regions (first level administrative units) in each survey year. A substantial share of the sampled countries experienced changes with respect to boundaries of their administrative regions during the period of observation, mostly in the form of a region being split into two or more smaller regions at some point during our observation period. This does not present a problem for an analysis based on pooled observations, however, fixed effects estimations require consistent boundaries over time. We thus adjusted the region variable following the dual objective of ensuring boundary consistency over time and maximizing the number of regions included in the dataset.[6]

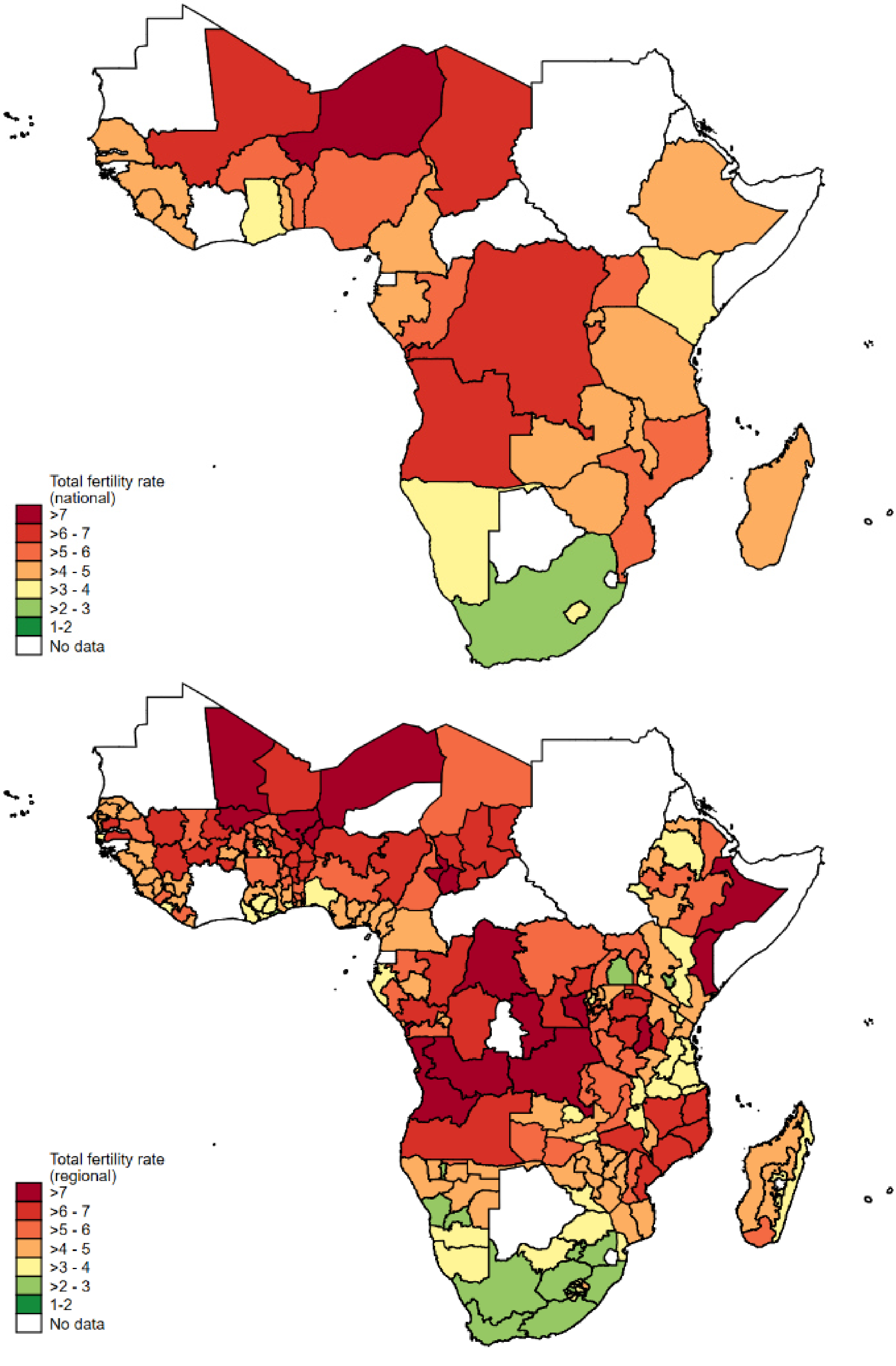
The merged dataset is a regional, unbalanced panel covering 543 regions stemming from 60 low- and middle-income countries over a period of 34 years (1986-2019), providing 2,447 region-by-year observations.

2.2 Measurement of fertility

The main outcome variable of interest is the total fertility rate (TFR). The TFR is derived by calculating the average number of births a woman would have during her reproductive age if she had experienced the age-specific fertility rates observed in a specific calendar year. Instead of country means, we use year-specific regional means of the TFR to explore the relationship between the advancement of the fertility transition and the degree of structural change. This within-country heterogeneity is typically ignored in macro-economic country-level studies which may blur the relationship between fertility and structural change. Figure 1 on the next page demonstrates, for the example of Sub-Saharan Africa, that most countries indeed show quite strong heterogeneity with respect to the TFR across administrative regions.

[6] Appendix B provides a detailed illustration of the regional boundaries' adjustment process.

Figure 1: A comparison of national and regional total fertility rates in Sub-Saharan Africa



Note: The map on top shows the national TFR and the map below the regional TFR for the Sub-Saharan African countries in our sample in the respective latest available survey year. The redder the area, the higher the TFR, the greener the area, the lower the TFR. Countries/regions without fertility data are left blank.
Source: Own calculations using data from DHS.

2.3 Indicators of structural change

We capture the degree of structural change through the following five dimensions: Female educational attainment, female occupational structure, nighttime light intensity, social security coverage and, supplementary, relative female wages.

Female educational attainment is measured by the shares of women aged 15 to 59 in a region that fall into the categories ‘no education’, ‘primary school education’, and ‘secondary or higher education’. We consider an increase in the share of women with secondary or higher education as a reflection of structural change that is relevant for parents’ fertility decisions. Secondary or higher education offers the opportunity to take a job in the public sector or the private formal sector and therefore offers higher earnings opportunities, which, in turn, increases the time costs of women. In the regression analysis, we exclude ‘no education’ as the reference category and include ‘primary school education’ as a control variable. The latter serves to captures a range of effects on fertility which are not directly related to structural change, such as better investment decisions in health and better knowledge about contraception. Primary school education cannot be considered an indicator of structural change, but it is likely to decrease fertility through, for example, better investment decisions in health and better knowledge about contraception.

The female occupational structure is measured by the shares of women aged 15 to 59 in a region that fall into the categories ‘agriculture’ (employed, self-employed), ‘not working’, ‘non-agricultural informal jobs’ (unskilled industry workers, sales, services, domestic workers), and ‘non-agricultural formal jobs’ (skilled industry workers, professionals, clerical staff). Here, we consider an increase in the share of women with jobs in the non-agricultural formal sector as a reflection of structural change. Again, we assume that the higher time costs that come with such jobs may reduce fertility. Such jobs typically also offer a less flexible time schedule and hence are less compatible with having many children. In the regression analysis, we exclude ‘agriculture’ as the reference category and include ‘not working’ and ‘non-agricultural informal jobs’ as control variables. Hence, we measure the effect on fertility of women leaving the agricultural sector and entering the non-agricultural formal sector. Obviously, it is not always easy to make a sharp distinction between formal and informal jobs in the non-agricultural sector. However, we allocated the different occupations based on whether they are typically carried out in a formal or in an informal setting.[7] Moreover, we cannot rule out that the category

[7] For example, if the occupation of the respondent is household work or domestic work, it is reasonable to assume that this is an informal occupation, whereas if the respondent is employed or is working in the

‘not working’ may also capture some income-generating activities, e.g. subsistence agriculture or small-scale sales or services (e.g. selling food, washing cars on the street), especially given the high share of women that report to be ‘not working’ (see Table 2).

Third, we include nighttime light intensity as a proxy of structural change. Electrification allows for industrial activities, especially manufacturing. It is therefore an important driver of employment in the private formal sector and may especially enhance female labor market participation. For each year from 1992 to 2018, Li et al. (2020) provide a gridded dataset covering the entire globe comprised of more than 725 million pixels sized 30x30 arc seconds, where one pixel corresponds to less than one square kilometer at the equator. Each pixel reports annual average nighttime light intensity as a number ranging from 0 to 63, with higher numbers indicating higher nighttime light intensity. In combination with a shape file of all 543 regions, we calculated the mean nighttime light intensity for each region in each year as the unweighted average of the numbers reported by all pixels within the region boundaries. Since the distribution of the obtained variable is heavily right-skewed, we apply a log-transformation before using it in regressions.

Gibson, Olivia and Boe-Gibson (2020) stress that the nighttime light intensity that is recorded by satellites in poorer countries easily captures urban activity, but misses most lights that can usually be found in rural areas, also because many lights available in rural areas are turned off at 1.30 a.m. when satellites take their pictures from space. In rural areas, only very bright lights, such as lights emitted from a high density of street lamps, large car parks and enclave mining and industrial facilities can be detected.[8] Consistently, Keola, Andersson and Hall (2015) also report that the elasticity of the light intensity with respect to GDP is positive for countries where the share of agriculture in GDP is less than 20%, but turns negative when the share of agriculture in GDP is greater than 20%. They further show that it is even possible for agriculture’s value-added to increase without seeing any increase in the light intensity detected from space. All this suggests that nighttime lights are well-suited for our purpose, as they seem to be a good proxy for activities correlated with structural change because they do not simply capture any economic

government sector, we assume that we can consider this as a formal occupation. In other cases, such a self-employment in the service sector, it is not possible to clearly differentiate between the formal and informal sector.

[8] The inability of satellites to detect small, low density, settlements is also seen in Andersson, Hall and Archila (2019); out of 147 geo-referenced cities and towns in Burkina Faso, ranging in population from 7000 to 1.6 million, 83 of these communities (the largest of which had a population of 32,000) went undetected over the entire 21 years of satellite recordings.

activity such as traditional farming, small rural shops and markets, but rather larger-scale modern industrial and service activities.

We consider health insurance coverage as a further important dimension of structural change, as it allows households to reduce precautionary savings, to invest more and to focus on specialization rather than diversification. It should also reduce the need to have many grown-up children to be insured in bad times and in old-age. We use as a measure the share of households in a specific region that are covered by a health insurance scheme. This includes Community Based Health Insurance (CBHI), public health insurance schemes and private insurances, including those offered by private formal and public employers. Obviously, this does only capture part of all the risks households are exposed to, but data on other insurance types is scarce and hence we have to assume that other types of insurance, including live, accident and old-age insurance are correlated with the access to health insurance.

Lastly, we consider relative female wages as a relevant aspect of structural change. Specifically, an increase of female wages in absolute terms as well as relative to male wages may be a sign of the emergence of higher-productivity employment opportunities for women. These will again imply an increase in the opportunity costs of women's time and hence potentially the cost of having children. We use the log of the average monthly female wage in a certain region while controlling for the log of the average monthly male wage. Alternatively, we calculate the male to female wage ratio, i.e. mean male wage divided by mean female wage, also controlling for the log of the average male wage. Mean wages are based on wages of persons aged between 15 and 59 in dependent employment, that live in urban areas and work at least 20 hours in non-agricultural jobs.

As the DHS do not contain wage data, we rely on Living Standard Measurements Surveys (LSMS) and similar surveys to create variables of relative female wages and merge them to our main dataset. Yet, the number of available LSMS is much smaller than the number of DHS, not all LSMS can be matched to a DHS (due to severe differences in regional boundaries or survey years), and not all LSMS contain (suitable) wage data.[9] As a consequence, the analysis of relative female wages can only be carried out for very small sub-samples (271 obs. globally / 197 obs. in Sub-Saharan Africa) and has to be interpreted with caution. This analysis is thus only presented in Appendix D.

[9] Appendix A provides an overview of all included LSMS by country and year.

We can of course think of many other dimensions of structural change that are relevant for parents' fertility decisions, such as the share of employment and valued added in manufacturing, but the available survey data is relatively limited in that respect. National accounts data does typically provide additional useful information, such as sectoral value added, but this does in most cases not exist on a disaggregated level by regions. There is also no suitable remotely sensed data beyond the satellite data we already use that could be used for that purpose. Nevertheless, we believe that our measures capture a good portion of those dimensions of structural change that are relevant for our purpose. Obviously, we cannot claim to offer a strictly causal analysis and of course our proxies leave also room for alternative transmission channels, but we believe that we expand the available literature considerably, both in terms of the level of disaggregation and in terms of the range of economic determinants considered.

2.4 Indicators of general development and control variables

As mentioned above, we control for those categories of female educational attainment and occupational structure that do not reflect structural change. In addition, we control for child mortality, urbanization and household wealth, as these factors have been established as important determinants of fertility in the literature on fertility transitions (see e.g. Bongaarts, 2017). Obviously, all three might themselves partly be reflections and consequences of structural change, but because they clearly have also drivers that cannot be subsumed under structural change, but rather general economic development, we include them as controls.

We measure child mortality as the number of children that died between birth and their 5th birthday per 1,000 live births in a specific region. Urbanization is measured as the share of households that live in an urban area. Lastly, we built an asset index as a proxy for household wealth. The list of assets considered for this index is consistent across all years and regions.[10] First, for each household in each region and year, we count the number of assets owned by the household. Then, we calculate the mean of the index per region and year using survey-specific household weights.

We do explicitly not control for indicators such as nuptiality, the age at marriage, the use of contraception or desired family size as all these behaviors are endogenous in our model, i.e.

[10] To calculate the asset index, we used the following household characteristics: Radio, TV, motorized transport (car or motorcycle), electricity, quality of drinking water, quality of floor material, quality of sanitation.

they are jointly determined with the level of fertility and hence depend, at least partly, on the same set of determinants.

2.5 A description of the sample

Our dataset contains a total of 2,447 region-by-year observations. However, given the broad temporal and spatial coverage, not every single DHS contains information about every single variable of interest. For example, while female education data is available for all regions in all years, we have 351 missing records of female occupation. In addition, while the dataset on nighttime light intensity has global coverage, it only contains records from 1992 to 2018, leading to 159 missing records in our dataset. Data on social security coverage is much scarcer and even more so is wage data.

Table 1: Information on samples: included variables, regional coverage, and sample size

Variables with non-missing information in sample	Regional and temporal coverage of samples	
	All regions	Only SSA
TFR, all controls, female educational attainment, female occupational structure, nighttime light intensity	<u>*Sample 1a:*</u> − 2,012 observations − 59 countries − 1992 – 2018	<u>*Sample 1b:*</u> − 1,011 observations − 32 countries − 1992 – 2018
TFR, all controls, female educational attainment, female occupational structure, nighttime light intensity, social security coverage	<u>*Sample 2a:*</u> − 801 observations − 48 countries − 2006 – 2018	<u>*Sample 2b:*</u> − 427 observations − 31 countries − 2006 – 2018
TFR, all controls, female educational attainment, female occupational structure, nighttime light intensity, relative female wages	<u>*Sample 3a:*</u> − 271 observations − 18 countries − 1993 – 2018	<u>*Sample 3b:*</u> − 197 observations − 11 countries − 1993 – 2018

Source: Own calculations using data from DHS, LSMS (and similar surveys), and Li et al. (2020).

In order to mitigate sample selection bias, we construct three different samples. Sample 1a contains all observations that have non-missing data on the regional TFR, all control variables, female educational attainment, female occupational structure, and nighttime light intensity, leading to 2,012 observations stemming from 59 countries. Sample 2a contains all observations that have in addition non-missing data on social security coverage, leading to 801 observations. Sample 3a contains all observations that have also non-missing data on relative female wages, leading to 271 observations. Additionally, we construct for each of these three samples sub-samples, 1b, 2b and 3b, that only include observations from Sub-Saharan Africa (SSA), leading to sample sizes of 1,011, 427 and 197 observations, respectively. Table 1 summarizes the composition of each sample.

Table 2: Summary statistics

	Non-SSA		SSA	
	Obs.	Mean	Obs.	Mean
Fertility				
Regional total fertility rate (TFR)	1,001	3.220	1,011	5.223
Indicators of structural change				
Share of women with secondary or higher education	1,001	0.537	1,011	0.278
Share of women working in non-agricultural formal jobs	1,001	0.138	1,011	0.086
Mean nighttime light intensity	1,001	3.995	1,011	2.636
Share of households with social security	374	0.329	427	0.082
Average male wage	74	995.610	197	429.942
Average female wage	74	769.270	197	309.248
Male to female wage ratio	74	1.555	197	1.845
Control variables				
Child mortality rate	1,001	76.120	1,011	132.044
Urbanization rate	1,001	0.457	1,011	0.352
Asset index	1,001	1.195	1,011	0.137
Share of women with no education	1,001	0.147	1,011	0.342
Share of women with primary school education	1,001	0.316	1,011	0.380
Share of women working in agriculture	1,001	0.170	1,011	0.313
Share of women working in non-agricultural informal jobs	1,001	0.209	1,011	0.244
Share of women not working	1,001	0.483	1,011	0.358

Notes: Summary statistics are calculated using the largest possible sample for each variable, i.e. Sample 1a, 2a and 3a (excluding all observations from SSA) for the Non-SSA columns and Sample 1b, 2b and 3b for the SSA Columns. Specifically, summary statistics regarding social security coverage are obtained from Samples 2a and 2b and regarding wages from Samples 3a and 3b. For all other variables, summary statistics are calculated using Samples 1a and 1b. Nighttime light intensity is measured on a continuous scale from 0 to 63 with higher values corresponding to higher nighttime light intensity. Wages are monthly wages in 2011 intl. $ PPP.
Source: Own calculations using data from DHS, LSMS (and similar surveys), and Li et al. (2020).

In Table 2, we provide summary statistics that illustrate the systematic differences between regions in low- and middle-income countries outside and inside SSA with regards to fertility levels, the degree of structural change and the general development indicators that we use as controls.[11] With around 5.2 children per woman, the average regional TFR in SSA exceeds that of regions outside SSA by two children. Both the average share of women with secondary or higher education and the average share of women working in non-agricultural formal jobs is much lower in SSA regions (48% and 38% lower than outside SSA, respectively), and so is the average intensity of nighttime lights (a third lower). Social security coverage in SSA regions corresponds to only a quarter of that outside SSA and wage levels in general, and even more so for women, are significantly lower. SSA regions also lag behind in terms of household wealth and child mortality and, to a lesser extent, urbanization.

3 Empirical specification

To explore the link between women's fertility and structural change, we use alternatively the samples presented above. In each case, we regress the region- and year-specific total fertility rates (TFR) on several indicators of structural change and the control variables introduced in section 2. We rely on the following four specifications:

$$TFR_{rct} = D'_{rct}\alpha_1 + \alpha_2(I_c \times T_t) + \varepsilon_{rct} \text{ (I)}$$

$$TFR_{rct} = X'_{rct}\beta_1 + D'_{rct}\beta_2 + C'_{rct}\beta_3 + \beta_4(I_c \times T_t) + \varepsilon_{rct} \text{ (II)}$$

$$TFR_{rct} = \rho WTFR_{rct} + X'_{rct}\gamma_1 + D'_{rct}\gamma_2 + C'_{rct}\gamma_3 + \gamma_4(I_c \times T_t) + \varepsilon_{rct} \text{ (III)}$$

$$TFR_{rct} = \rho WTFR_{rct} + X'_{rct}\delta_1 + D'_{rct}\delta_2 + C'_{rct}\delta_3 + \delta_4(I_c \times T_t) + \upsilon_{rc} + \varepsilon_{rct} \text{ (IV),}$$

where TFR is the total fertility rate in region r and country c at time t, X is a vector with indicators of structural change, D is a vector including the child mortality rate, the urbanization rate and the asset index, and C is a vector including additional controls, i.e. the control categories of female education attainment and female occupational structure. Hence, Model I can be considered a baseline regression that illustrates the correlations between fertility and general indicators of development. In the subsequent models, we then add our main explanatory variables, i.e. the different indicators of structural change, and the additional controls.

We model time effects and spatial correlations in different ways. In model I and II, we account for country-specific time-effects ($I \times T$). In Model III, we additionally control for the spatial correlation of fertility, i.e. we add the spatially lagged regional TFR, $WTFR$, as a control. To

[11] Statistics for all sub-samples are provided in Appendix C.

do so, we first estimate a spatial weight matrix using the geographical information of latitude and longitude (Kondo, 2021). This matrix is then used to compute a region-specific spatially lagged variable that accounts for spatial dependencies across regions within a specific country. Finally, model IV makes use of the panel structure of the dataset and includes in addition region-fixed effects (υ). While adding region-fixed effects allows in principle to control for a sizeable portion of unobserved heterogeneity, our preferred specification is specification III and we see specification IV rather as a robustness check. The reason is that we still have a substantial portion of regions for which we have only one observation, for many we have only two.[12] Regions with one observation do not enter our region-fixed effects estimation which means we lose power and may get biased estimates. Regions with only two observations do also only provide limited variation for a within-estimator.

It must also be noted that our approach is not fully immune to reverse causality. A high TFR indicates that women not only have more children, but also start childbearing early. This is likely to decrease their level of education and hence also to influence their occupational choice and wage. Hence, we won't make any causal claims, but we will provide a sufficient number of alternative estimates and specifications to show that our results are relatively robust to the remaining sources of bias.

4 Results

4.1 Main results

This section presents our findings regarding the relationship between the regional TFR and various indicators of structural change. Tables 3 and 4 show the corresponding regression results. In both tables, each column refers to one regression. The first four columns refer to the global samples (Sample 1a and 2a, respectively) and the second four columns to the SSA samples (Sample 1b and 2b, respectively). Table 4 serves mainly to present the results regarding social security coverage, for which we had to use the smaller samples 2a and 2b. For the sake of simplicity, we will thus generally refer to Table 3, except when the effects of social security coverage are concerned.[13] In both tables, columns (1) and (5) correspond to Model I, columns

[12] Regions with only one observation: Sample 1a: 13, Sample 1b: 4, Sample 2a: 176, Sample 2b: 97, Sample 3a: 56, Sample 3b: 24 Regions with only two observations: Sample 1a: 332, Sample 1b: 156, Sample 2a: 340, Sample 2b: 192, Sample 3a: 124, Sample 3b: 82

[13] For all regressors, coefficient sizes are very similar between Sample 1a and 2a respectively 1b and 2b. Due to the smaller sample sizes, coefficients are sometimes of less statistical significance in Sample 2a and 2b.

(2) and (6) to Model II, columns (3) and (7) to model III and columns (4) and (8) to Model IV. For the reasons illustrated above, columns (3) and (7) represent our preferred estimates.

Before discussing in detail the effects of the various indicators of structural change, we provide a brief overview of the associations of our measures of general development with the regional TFR. As expected, the coefficient of child mortality is positive and highly statistically significant throughout all samples and specifications, while the coefficient of the asset index is generally negative and also statistically highly significant. The coefficient associated with urbanization is generally statistically insignificant and more often negative, but especially in the smaller samples also often positive. Lower child mortality rates and increased household wealth thus come with lower fertility; however, the additional effect of urbanization is less clear. These results are coherent with findings from cross-country regressions in the literature. Bongaarts (2017), for example, uses a sample of 71 low- and middle-income countries and finds a significant negative effect associated with GDP per capita and the population share with primary education, a negative effect (though not significant) with life expectancy, and no effect associated with urbanization.

If we introduce our set of indicators of structural change, it can be noted that the coefficients of all three variables reflecting general development decrease quite markedly in size, suggesting a quite strong correlation between structural change and general determinants of development. We now discuss the role of the various features of structural change one by one.

Female educational attainment

The estimated effects associated with the share of women with secondary or higher education are, throughout all samples and specifications, negative and statistically highly significant. The smallest coefficients correspond to an effect of about 0.14 less children per women as the share of women with completed secondary of higher education increases by ten percentage points (see columns (2) and (3), Table 3). The coefficient is around a third larger for SSA and almost doubles when using the fixed effects specification. While the effects may look rather small, it is important to keep in mind that the corresponding regressions include not only the full set of controls, including the general indicators of development, but also primary education as a separate category, which also has a significant negative effect, and the other indicators of structural change.

Table 3: Regressions of the TFR on female educational attainment, female occupational structure, and nighttime light intensity

	Sample 1a				Sample 1b			
Independent variables	Spec. I	Spec. II	Spec. III	Spec. IV	Spec. I	Spec. II	Spec. III	Spec. IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Indicators of structural change								
Share of women with secondary or higher education		-1.357*** (0.4760)	-1.360*** (0.4441)	-2.638*** (0.6557)		-1.865** (0.7738)	-1.854** (0.7213)	-2.119** (0.8274)
Share of women working in non-agricultural formal jobs		-1.141 (0.8561)	-1.096 (0.7949)	-0.861 (0.5283)		-2.689** (1.2761)	-2.566** (1.0977)	-1.526* (0.8716)
Log of mean nighttime light intensity		-0.068*** (0.0251)	-0.067*** (0.0239)	-0.020 (0.0204)		-0.017 (0.0239)	-0.017 (0.0225)	-0.002 (0.0229)
Indicators of general development								
Child mortality rate	0.005*** (0.0013)	0.003*** (0.0011)	0.003*** (0.0011)	0.005*** (0.0009)	0.005*** (0.0016)	0.003** (0.0013)	0.003** (0.0013)	0.004*** (0.0009)
Urbanization rate	-0.174 (0.2326)	-0.031 (0.2622)	-0.064 (0.2716)	0.818* (0.4353)	-0.405 (0.4427)	-0.201 (0.4208)	-0.333 (0.5070)	0.693 (0.6163)
Asset index	-0.818*** (0.0694)	-0.639*** (0.0772)	-0.631*** (0.0666)	-0.322** (0.1520)	-0.780*** (0.1161)	-0.596*** (0.1180)	-0.564*** (0.0924)	-0.315** (0.1283)
Share of women with primary school education		-1.493** (0.7119)	-1.502** (0.6740)	-0.815 (0.6804)		-1.950* (0.9969)	-1.984** (0.9384)	-0.904 (0.6431)
Share of women working in non-agricultural informal jobs		0.575** (0.2751)	0.578** (0.2566)	0.226 (0.2049)		0.590 (0.3984)	0.629 (0.3827)	0.157 (0.2433)
Share of women not working		0.045 (0.2222)	0.049 (0.2075)	-0.006 (0.1296)		-0.164 (0.2114)	-0.157 (0.1954)	-0.089 (0.1917)
Country-specific time-effects	yes	yes	yes	yes	yes	yes	yes	yes
Spatial lag	no	no	yes	yes	no	no	yes	yes
Region-fixed effects	no	no	no	yes	no	no	no	yes
R-Squared	0.866	0.875	0.877	0.687	0.761	0.785	0.793	0.641
Observations	2,012	2,012	2,012	2,012	1,011	1,011	1,011	1,011

Region groups	528	528	528	528	259	259	259	259

Notes: Each column refers to one regression. 13 regions in Sample 1a and 4 regions in Sample1b have information on fertility, indicators of structural change and indicators of general development for only one survey year and thus do not contribute to the fixed-effects regressions in Columns (4) resp. (8). Robust standard errors clustered at the country level in parentheses. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Source: Own calculations using data from DHS and Li et al. (2020).

Female occupational structure

We consistently find negative effects associated with the share of women working in non-agricultural formal jobs. While they are of modest size and statistically insignificant in Sample 1a, they are quite large and statistically highly significant in the SSA sub-sample (Sample1b). Considering our preferred specification (column (7), Table 3), the total fertility rate decreases by 0.26 children per woman if this share goes up by ten percentage points. Overall, a shift in the female occupational structure from the agricultural sector towards the non-agricultural formal sector is associated with a reduction in fertility, and this effect is driven by a particularly strong association in Sub-Saharan African regions. For a reduced sample for which this data is available, we also find some suggestive evidence that higher female wages are associated with lower fertility (see Appendix D).

Electrification - nighttime light intensity

The association between nighttime light intensity and the regional TFR is negative and statistically significant in the global samples without region-fixed effects. When using the SSA samples the coefficients stay negative but lose significance and magnitude. In our largest sample, the effect size is in the order of -0.07 children for a doubling of nighttime light intensity (columns (2) and (3), Table 3). The smaller and non-significant effect in the SSA samples might be due to the fact that the level and variation of nighttime lights in this region is markedly lower than in other regions. Still, the results suggest, that there is a non-negligible effect that can be attributed to nighttime light intensity, which we believe is a good indicator of industrialization, and an expansion of formal large-scale activities.

Social security – health insurance coverage

Next, we discuss the effects associated with health insurance coverage. Since information on this aspect is not available in all DHS, this can only be explored for a reduced sample of 801 region-year observations in the general sample or 427 region-year observations in the SSA sample. The information on health insurance has mostly been collected in more recent years so that these samples do not mirror relationships in earlier years (1990's). The effect of health insurance coverage is always negative and mostly significant. Using our preferred specification, for the global sample, the estimates suggest that a ten percentage-point increase in health insurance coverage reduces the TFR by about 0.07 children per women, again controlling for conventional determinants of fertility and all the other features of structural change discussed

Table 4: Regressions of the TFR on female educational attainment, female occupational structure, nighttime light intensity, and social security coverage

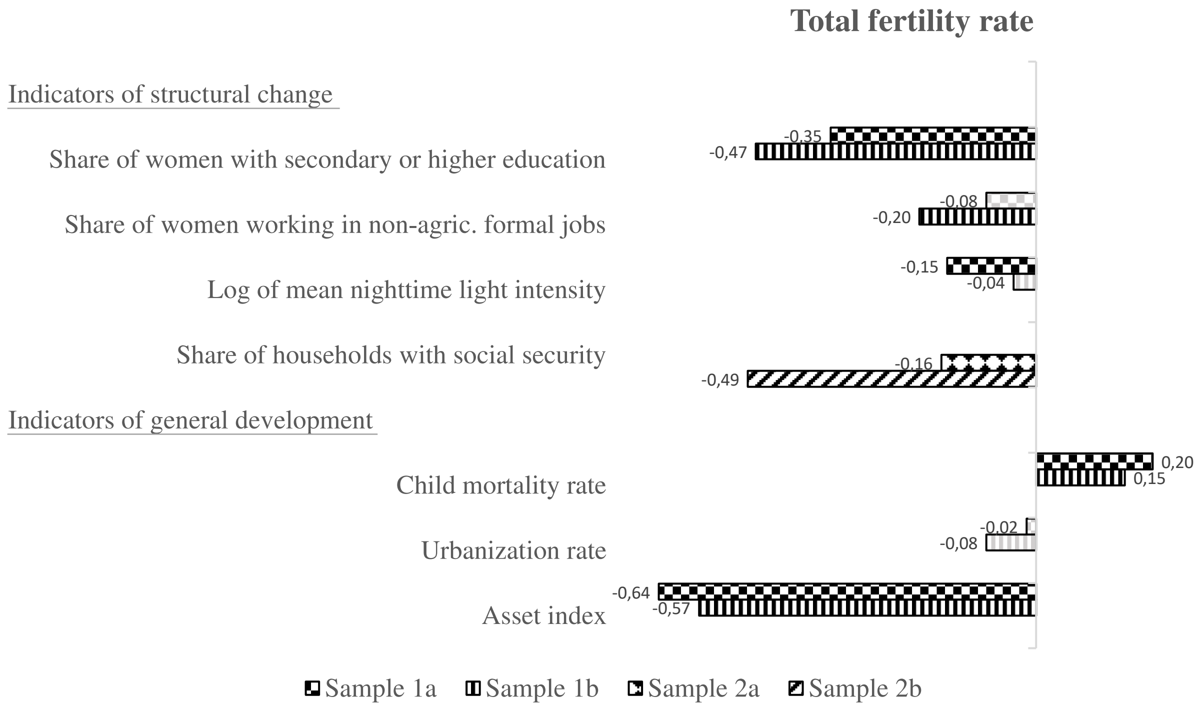
	Sample 2a				Sample 2b			
Independent variables	Spec. I (1)	Spec. II (2)	Spec. III (3)	Spec. IV (4)	Spec. I (5)	Spec. II (6)	Spec. III (7)	Spec. IV (8)
Indicators of structural change								
Share of women with secondary or higher education		-1.498*** (0.4817)	-1.487*** (0.4576)	-3.011** (1.2258)		-1.732** (0.8049)	-1.698** (0.7221)	-2.909* (1.6099)
Share of women working in non-agricultural formal jobs		-0.916 (1.0808)	-0.819 (0.9190)	-0.483 (0.4616)		-2.497 (1.8790)	-2.157* (1.2408)	0.084 (0.4619)
Log of mean nighttime light intensity		-0.089** (0.0398)	-0.088** (0.0376)	0.002 (0.0216)		-0.018 (0.0501)	-0.025 (0.0456)	-0.003 (0.0183)
Share of households with social security		-0.645* (0.3799)	-0.663* (0.3551)	-0.335 (0.2726)		-1.990** (0.8932)	-2.016** (0.8941)	-1.903*** (0.6020)
Indicators of general development								
Child mortality rate	0.009*** (0.0015)	0.007*** (0.0016)	0.007*** (0.0011)	0.006*** (0.0012)	0.010*** (0.0015)	0.008*** (0.0017)	0.007*** (0.0010)	0.006*** (0.0014)
Urbanization rate	0.189 (0.2863)	0.276 (0.2500)	0.187 (0.2833)	0.484 (0.3565)	0.047 (0.4220)	0.191 (0.2925)	-0.115 (0.4023)	0.123 (0.5604)
Asset index	-0.927*** (0.1081)	-0.693*** (0.1210)	-0.671*** (0.1076)	0.113 (0.1636)	-0.897*** (0.1407)	-0.602*** (0.2078)	-0.516*** (0.1707)	0.293 (0.2703)
Share of women with primary school education		-1.626** (0.7309)	-1.635** (0.6852)	-0.396 (1.0004)		-1.989** (0.9436)	-2.046** (0.8694)	-0.305 (1.2426)
Share of women working in non-agricultural informal jobs		0.507 (0.4181)	0.530 (0.3882)	-0.461** (0.2245)		-0.127 (0.4735)	-0.022 (0.4549)	-0.279 (0.2845)
Share of women not working		0.098 (0.2252)	0.112 (0.2026)	-0.244** (0.1127)		-0.206 (0.2250)	-0.221 (0.2037)	-0.520** (0.2152)
Country-specific time-effects	yes	yes	yes	yes	yes	yes	yes	yes
Spatial lag	no	no	yes	yes	no	no	yes	yes

Region-fixed effects	no	no	no	yes	no	no	no	yes
R-Squared	0.873	0.887	0.891	0.747	0.781	0.807	0.825	0.804
Observations	801	801	801	801	427	427	427	427
Region groups	425	425	425	425	239	239	239	239

Notes: Each column refers to one regression. 176 regions in Sample 2a and 97 regions in Sample2b have information on fertility, indicators of structural change and indicators of general development for only one survey year and thus do not contribute to the fixed-effects regressions in Columns (4) resp. (8). Robust standard errors clustered at the country level in parentheses. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Source: Own calculations using data from DHS and Li et al. (2020).

above (column (3), Table 4). The coefficient remains negative, but turns insignificant in the fixed effects specification, but again, this is not our preferred specification. For the SSA sample, the effect is more than twice as large. This effect also remains statistically significant to the introduction of region-fixed effects and barely changes in magnitude. Health insurance thus further reduces fertility on top of female secondary or higher education, female non-agricultural formal employment and industrialization as proxied by nighttime light intensity, especially in the Sub-Saharan African context.

Figure 2: Determinants of fertility – overview of the associated effect sizes



Notes: All coefficients were obtained from regressions using Specification III, but with standardized regressors. Bars with checkered pattern are based on Sample1a, bars with vertical stripes on Sample 1b, bars with diamonds pattern on Sample 2a, bars with diagonal stripes on Sample 2b. Black filling indicates significant coefficients and light-grey filling indicates non-significant coefficients (p>0.1).
Source: Own calculations using data from DHS and Li et al. (2020).

Figure 2 provides an overview of the effect sizes of the various indicators of structural change, as well as the conventional determinants of fertility. The coefficients are obtained from OLS regressions with country-specific time-effects and the spatial lag of the TFR, using the full list of covariates (Spec. III). For better comparability of the effect sizes, all regressors have been standardized by expressing them in units of their standard deviation.[14] Light-grey bars indicate

[14] Not all regressors follow a normal distribution; hence, comparability is restricted even with standardized coefficients.

insignificant effects. With a reduction of around 0.6 children for a one standard deviation increase in the asset index, household wealth is the most important determinant of fertility among all regressors considered. Among the various indicators of structural change, female secondary and higher education is an especially important contributor to fertility reductions, with a standardized coefficient of -0.35 in Sample 1a and even -0.47 in Sample 1b. In SSA, health insurance coverage seems to be an equally important aspect of structural change. Even though of less robustness and smaller magnitude, both female employment in non-agricultural formal jobs and industrialization as proxied by nighttime light intensity can further reduce regional fertility rates.

4.2 Interaction effects

To see how the effects associated with structural transformation change with the level of general development, we also estimated regressions where we include interactions of both. Table A5 in Appendix E shows the results. The interactions with child mortality (column (1)) suggest that the fertility-reducing effect of a shift of women from agriculture to formal jobs is stronger the higher the level of child mortality. This may reflect the fact that child labor is more important in the agricultural sector and that parents tend to have many children if mortality is high to ensure that they have enough surviving children that can contribute to household income. If in such a situation, opportunities in the formal labor market emerge, there is a potentially strong negative effect on fertility. The effect would be lower, if mortality was also lower and hence risk-averse parents would not have to engage in ‘hoarding’. We do not find any significant interaction effect between child mortality and secondary education and nighttime light intensity. In column (2), we explore interactions with urbanization. None of the interactions is significant. In column (3), we check interactions between structural change and income as proxied by the asset index. Here, we find a positive coefficient when we interact with the share of women working in non-agricultural formal jobs. We believe this reflects a similar phenomenon than the negative interaction with child mortality. If in very poor economies, where children typically contribute a lot to household income, suddenly labor market opportunities in the formal sector arise, the return to children decreases strongly and hence fertility is reduced by more than if this happens in an economy that is already richer.

4.3 The unlocked potential of industrialization and structural change

Some illustrative simulations

To put into perspective the magnitude with which structural change transports the fertility transition, we performed some illustrative simulations. In a nutshell, we simulate regional fertility levels for the least advanced (in terms of the fertility transition) countries in SSA, had they been exposed to the same degree of structural change as the most advanced regions outside SSA.

For this, we first identify all regions outside SSA with a TFR below 2.5 in recent survey years (no older than 2010) and then select from each available country the region with the lowest TFR.[15] This selection process leads to 16 regions from 16 different countries: Albania (Central), Armenia (Gegharkunik), Bangladesh (Khulna), Cambodia (Phnom Penh), Colombia (Central), Dominican Republic (Region 3), Guatemala (Metropolitan), Haiti (Metropolitan Area/West), Honduras (Francisco Morazan), India (Sikkim), Indonesia (Yogyakarta), Jordan (Balqa/Amman/Madaba), Nepal (Far Western), Peru (Tacna), Philippines (National Capital Region), and Turkey (Central). For these 16 regions, we then compute the means for all variables capturing structural change included in our regression models, i.e. female educational attainment, female occupational structure, nighttime lights, and social security coverage. We then identify those countries in SSA that are the least advanced in their fertility transition, specifically, all countries with a national TFR higher than 5 in their most recent survey year. This leads to the selection of the following nine countries: Angola, Benin, Burundi, Chad, Congo, Congo DR, Mali, Niger, Nigeria.[16] We then impute for all regions in each of these nine countries, for all variables measuring structural change, the averages from the 16 regions outside SSA. Importantly, we do not impute the values for child mortality, urbanization, and household wealth. Using the estimated regression coefficients from our empirical analysis, we then predict the hypothetical TFR for each region in each country. For better comparison, we also predict the TFR using the actual levels of the structural change variables.

In total, we run four different predictions, two specifications for each of the two sub-samples for SSA (countries with and without information on health insurance coverage), given that we are interested in predictions specifically for countries in SSA. We always use specification II,

[15] For the sake of generalizability, we excluded regions from Maldives despite fulfilling the selection criteria, as it is a very small island with a population of only around half a million.

[16] Burkina Faso, Mozambique and Uganda also have a TFR higher than 5, but are excluded because of incomplete data for the indicators of structural change.

i.e. we accounted for country-specific time-effects.[17] However, the predictions differ regarding the following parameters. In approach 1, we only impute the values of the indicators of structural change, but we leave the values of child mortality, urbanization and asset index unchanged. Hence, this approach implies that structural change does not impact these factors. However, it is likely that structural change comes along, at least to some extent, with an improvement in terms of general development, and especially in household wealth. Approach 1 thus presents lower boundary estimates. In approach 2, we also impute the value of the asset index in order to account for the wealth effects of structural change. One might consider this an upper boundary estimate; however, note that we still do not impute the values for urbanization or child mortality, which might of course also improve along with advanced structural change. We apply both approaches to Sample 1b and Sample 2b. When using Sample 1b, the indicators of structural change are restricted to female educational attainment, female occupational structure and nighttime light intensity, and when using Sample 2b, we also include health insurance coverage.

Table 5: The effect of structural change on fertility, results from simulations

Simulation results (mean values)	Simulation approach 1		Simulation approach 2	
	Sample 1b	Sample 2b	Sample 1b	Sample 2b
Observed TFR – w/o structural change	6.15	6.15	6.15	6.15
Predicted TFR – w/o structural change	6.13	6.12	6.13	6.12
Predicted TFR – w/ structural change	5.07	4.54	4.10	3.56
Total difference	1.06	1.58	2.03	2.56
Relative difference	0.17	0.25	0.32	0.40

Notes: Each column refers to one prediction. All predictions are based on specification II. Predictions using Sample 1b imputes female educational attainment, female occupation structure and nighttime light intensity as indicators of structural change. Predictions using Sample 1b additionally imputes social security coverage. Simulation approach 2 extends the imputations beyond structural change and additionally imputes the asset index. Line 1 contains the mean TFR as observed in the dataset. Line 2 contains the mean predicted TFR based on the actual values of all regressors as observed in the dataset. Line 3 contains the mean predicted TFR based on the imputed values of the indicators of structural change (and the asset index) and the actual values of the control variables.
Source: Own calculations using data from DHS and Li et al. (2020).

[17] We decided against (our generally preferred) specification III, as the inclusion of spatial lags of the TFR is not feasible in the simulation. The reason is that we simulate the TFR for all regions in a country, and the spatial lag only considers the TFR of other regions within country borders, i.e. the spatial lag would be based on simulated values itself.

The results from these predictions are summarized in Table 5 and suggest that if the regions in the nine selected lagging countries had experienced the same structural change as the 16 most advanced regions outside SSA, their TFR would be markedly lower. Based on the conservative simulation approach, the mean regional TFR would be around 5.1 (or 4.5 when also considering health insurance coverage) instead of around 6.1. Using the more optimistic approach, these values further decrease leading to a simulated mean regional TFR of only 4.1 (or 3.6). Overall, the scope of fertility reductions ranges from 17% (most conservative) to 40% (most optimistic). As we argued above, there are good reasons to believe that, considering all indirect effects of structural change, the true potential might be closer to the optimistic scenarios. Overall, these simulations support the hypothesis that the absence of substantial structural change accounts for a sizeable share of the high levels of fertility observed in most countries of Sub-Saharan Africa.

Shorrocks decomposition

The results from the main analysis revealed a strong and robust negative relationship between the total fertility rate of a region and its advancement in the structural transformation. To further explore the relative contribution of structural change to the fertility transition, especially in comparison to determinants of fertility that we would rather attribute to general economic development, we used a Shorrocks decomposition (Shorrocks, 1982). Originally developed to decompose the factors contributing to income inequality, this method can also be applied more generally to estimate the relative contribution of different independent variables to a dependent variable's variance. The results from this analysis can for example help to prioritize alternative interventions in order to direct financial resources and efforts towards those areas where the impact on fertility is the highest; yet, this decomposition is of course first of all of descriptive nature, and the results should not be seen as stemming from a causal identification, also because the different components are correlated with each other.

We apply the Shorrocks decomposition to our preferred regressions from the main analysis, using all four samples, i.e. columns (3) and (7) from Tables 3 and 4. Table 6 on the next page presents the relative contribution of the explanatory variables to the R-squared. Not surprisingly, the largest contribution to the R-squared comes from the indicators of general development and the country-specific time-effects. Each of these two sets accounts for about 30% of the R-squared. The spatial lag of the regional TFR contributes to around 17% to 20%

of the R-squared, showing again the importance of accounting for these spatial dependencies in the regression analysis. Yet, our quite small set of structural change variables account for 21% to 23% of the total variance. We see this as rather a lower bound, as we can capture only some features of structural change. Other features are still in the residual or captured by our general indicators of structural change. Yet, the contribution is consistent with the fertility gap observed between countries that have and have not started to experience structural change. When breaking the total contribution down to the individual indicators, female secondary and higher education account with 10% for almost half of this contribution. Hence, overall, the Shorrocks decomposition confirms the findings from the simulations above, i.e. that structural change does indeed provide significant scope for fertility reductions.

Table 6: Results from a Shorrocks decomposition: contribution of structural change to the fertility transition

	Sample 1a	Sample 1b	Sample 2a	Sample 2b
Indicators of structural change	*21.17%*	*22.48%*	*23.06%*	*21.52%*
Share of women with secondary or higher education	9.62%	10.27%	10.24%	9.60%
Share of women working in non-agricultural formal jobs	5.48%	6.77%	5.42%	7.58%
Log of mean nighttime light intensity	6.06%	5.45%	3.76%	2.36%
Share of households with social security			3.64%	1.98%
Indicators of general development	*28.46%*	*31.42%*	*29.19%*	*31.30%*
Child mortality rate	10.52%	10.23%	11.82%	11.56%
Urbanization rate	4.09%	6.99%	3.98%	5.76%
Asset index	11.72%	10.31%	12.28%	9.68%
Share of women with primary school education	0.90%	2.10%	1.22%	1.96%
Share of women working in non-agricultural informal jobs	0.49%	1.54%	0.35%	1.91%
Share of women not working	0.75%	0.25%	0.58%	0.43%
Spatial lag of TFR	*20.37%*	*17.19%*	*19.48%*	*18.89%*
Country-specific time-effects	*30.50%*	*30.14%*	*27.60%*	*28.78%*
Total R-squared	0.88	0.79	0.89	0.82

Note: Each column refers to one regression decomposition. All regressions are based on specification III. Samples 1a and 1b include the share of women with secondary or higher education, the share of women working in non-agricultural formal jobs, and nighttime light intensity as indicators of structural change. Samples 2a and 2b additionally include social security coverage.
Source: Own calculations using data from DHS and Li et al. (2020).

5 Conclusion

We built a unique data set of matched Demographic and Health Surveys and Household Income Surveys, enriched with nighttime light intensity data, from a large sample of low- and middle-income countries, including many countries in Sub-Saharan Africa. The data was matched at the regional level. To our knowledge, these data sources have never been matched before for such a large sample of countries at this level.

We use this rich dataset to explore the determinants of the fertility transition across the developing world and to identify in particular the role of structural change. Our key hypothesis is that structural change is, together with child mortality and income, a key driver of the demographic transition.

Our regression analysis shows that post-primary female education, female employment in non-agricultural formal jobs, and industrialization as proxied by nighttime light intensity, and to a lower extent, health insurance coverage, are indeed important drivers of the fertility transition. This seems to confirm that slow structural change is in many regions indeed a key obstacle to the fertility transition. Our simulations show that if countries in Sub-Saharan Africa with the highest fertility levels had experienced the same structural change as the most demographically advanced regions in our sample, fertility levels would be 17% to 40% lower of what they are now. A Shorrocks decomposition quantifies the share of the variance in regional fertility levels that can be explained by our set of variables related to structural change with 21% to 23%.

Hence, our results suggest that policies that enhance structural change could be a very effective trigger of the fertility transition in the Sub-Saharan African context. Thinking about the type of policies that could enhance such a transition is clearly beyond the scope of this paper, but it may include classical industrialization based on manufacturing as well as other industries and services, like agrobusiness and the e-economy. Enhanced investment in education may accompany this process. Finally, access to formal insurance, which reduces the need for many children, can probably further push this transition. Family planning may help parents to achieve lower fertility goals, but we believe family planning alone is unlikely to play an important role in the absence of structural change, as the demand for children would still be high.

Structural change needs to accelerate soon in Sub-Saharan Africa in order to turn the demographic burden that many countries increasingly experience into a demographic gift. The demographic gift could arise if fertility rates eventually decline and hence a large work force coincides with a low dependency ratio. Bloom and Williamson (1998) have shown that this has been a substantial driver of the economic miracle in emerging Asia. Fertility rates that finally decline in a sustained way could further boost economic development and structural change through various channels so that the process could become self-perpetuating.

References

Andersson, M., O. Hall and M. Archila (2019), How data-poor countries remain data poor: Underestimation of human settlements in Burkina Faso as observed from nighttime light data, *ISPRS International Journal of Geo-Information*, 8(11): 498.

Barret, C. B., L. Christiaensen, M. Sheahan and A. Shimeles (2017), On the structural transformation of rural Africa, *Journal of African Economies*, 26(suppl_1): i11-i35.

Becker, G. S. (1981), *A treatise on the family,* Harvard University Press, Cambridge, MA.

Becker, G. S. and H. G. Lewis (1973), On the interaction between the quantity and quality of children, *Journal of Political Economy*, 81(2), p.2: S279-S288.

Bloom, D. E., D. Canning, G. Fink and J. E. Finlay (2009), Fertility, female labor force participation, and the demographic dividend, *Journal of Economic Growth*, 14(2): 79-101.

Bloom, D. E., D. Canning and J. Sevilla (2003), *The demographic dividend: A new perspective on the economic consequences of population change*, RAND, Santa Monica.

Bloom, D. E., M. Kuhn and K. Prettner (2017), Africa's prospects for enjoying a demographic dividend, *Journal of Demographic Economics*, 83: 63-76.

Bloom, D.E and J.G. Williamson (1998), Demographic transitions and economic miracles in emerging Asia, *World Bank Economic Review*, 12(3): 419-455.

Bongaarts, J. (2006), The causes of stalling fertility transitions, *Studies in Family Planning*, 37(16): 1-16.

Bongaarts, J. (2008), Fertility transitions in developing countries: Progress or stagnation?, *Studies in Family Planning*, 39(2): 105-110.

Bongaarts, J. (2010), The causes of educational differences in fertility in Sub-Saharan Africa, *Vienna Yearbook of Population Research*, 8(1):31-50, Vienna Institute of Demography (VID) of the Austrian Academy of Sciences in Vienna, Vienna.

Bongaarts, J. (2017), Africa's unique fertility transition, *Population and Development Review*, 43(S1): 39-58.

Bongaarts, J. and J. Casterline (2013), Fertility transition: Is Sub-Saharan Africa different?, *Population and Development Review*, 38(S1): 153-168.

Bruni, L. M., J. Rigolini and S. Troiano (2016), *Forever young? Social policies for a changing population in Southern Africa*, World Bank, Washington, DC.

Casterline, J. and S. Agyei-Mensah (2017), Fertility desires and the course of fertility decline in Sub-Saharan Africa, *Population and Development Review*, 43(S1): 84-111.

Cervellati, M. and U. Sunde (2005), Human capital, life expectancy, and the process of development, *American Economic Review*, 95(5): 1653-1672.

Cohen, B. (1998), The emerging fertility transition in Sub-Saharan Africa, *World Development*, 26(8): 1431-1461.

de Vries G. J., M. Timmer and K. de Vries (2015), Structural transformation in Africa: Static gains, dynamic losses, *Journal of Development Studies*, 51(6): 674-688.

Diao, X., K. Harttgen and M. McMillan (2017), The changing structure of Africa's economies, *World Bank Economic Review*, 31(2): 412-433.

Diao, X., M. McMillan and D. Rodrik (2019), The recent growth boom in developing economies: A structural-change perspective, in M. Nissanke and J.A. Ocampo (eds.), *The Palgrave Handbook of Development Economics: Critical Reflections on Globalisation and Development*, Palgrave Macmillan, Cham.

Doepke, M. (2004), Accounting for fertility decline during the transition to growth, *Journal of Economic Growth*, 9(3): 347-383.

Ezeh, A. C., B. U. Mberu and J. O. Emina (2009), Stall in fertility decline in Eastern African countries: Regional analysis of patterns, determinants and implications, *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences*, 364(1532): 2991-3007.

Galor, O. (2011), *Unified growth theory*, Princeton University Press, Princeton.

Galor, O. and O. Moav (2002), Natural selection and the origin of economic growth, *Quarterly Journal of Economics*, 117(4): 1133-1192.

Galor, O. and D. N. Weil (1996), The gender gap, fertility, and growth, *American Economic Review*, 86(3): 374-387.

Galor, O. and D. N. Weil (2000), Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond, *American Economic Review,* 90(4): 806-828.

Garenne, M. L. (2008), Situations of fertility stall in sub-Saharan Africa, *African Population Studies*, 23(2).

Garenne, M. L. (2011), Testing for fertility stalls in demographic and health surveys, *Population Health Metrics,* 9(59): 1-8.

Gibson, J., S. Oliveira and G. Boe-Gibson (2020), Nighttime lights in economics: Sources and uses, *Journal of Economic Surveys*, 0(0): 1-26.

Goujon, A., W. Lutz and K. C. Samir (2015), Education stalls and subsequent stalls in African fertility: A descriptive overview, *Demographic Research*, 33(47): 1281-1296.

Günther, I. and K. Harttgen (2016), Desired fertility and number of children born across time and space, *Demography*, 53(1): 55-83.

Hertrich, V. (2017), Trends in age at marriage and the onset of fertility transition in Sub-Saharan Africa, *Population and Development Review*, 43(S1): 112-137.

Jones, L. E. and M. Tertilt (2006), An economic history of fertility in the U.S.: 1826-1960, *NBER Working Paper #12796*, National Bureau of Economic Research, Cambridge, MA.

Keola, S., M. Andersson, and O. Hall (2015), Monitoring economic development from space: Using night time light and land cover data to measure economic growth, *World Development,* 66(1): 322-334.

Kondo, K. (2021), SPGEN: Stata module to generate spatially lagged variables, available at https://EconPapers.repec.org/RePEc:boc:bocode:s458105.

Lee, R. (2003), The demographic transition. Three centuries of demographic change, *Journal of Economic Perspectives*, 17(4): 167-190.

Li, X., Y. Zhou, M. Zhao and X. Zhao (2020), A harmonized global nighttime light dataset 1992–2018, *Scientific Data*, 7(168): 1-9.

May, J. F. (2017), The politics of family planning policies and programs in Sub-Saharan Africa, *Population and Development Review*, 43(S1): 308-329.

McMillan, M. and K. Harttgen (2014), What is driving the 'African Growth Miracle'?, *NBER Working Paper #20077*, National Bureau of Economic Research, Cambridge, MA.

Potter, J. E., C. P. Schmertmann and S. M. Cavenaghi (2002), Fertility and development: Evidence from Brazil, *Demography*, 39(4): 739-761.

Rodrik, D. (2018), An African growth miracle?, *Journal of African Economies*, 27(1): 10-27.

Schoumaker, B. (2009), Stalls in fertility transitions in Sub-Saharan Africa: Real or spurious? *Document de Travail n° 30, Février 2009*, Département des Sciences de la Population et du Développement, Université catholique de Louvain.

Schoumaker, B. (2019), Stalls in fertility transitions in Sub-Saharan Africa: Revisiting the evidence, *Studies in Family Planning*, 50(3): 257-278.

Shapiro, D. and T. Gebreselassi (2008), Fertility transition in Sub-Saharan Africa: falling and stalling, *African Population Studies*, 23(1): 3-23.

Shorrocks, A. F. (1982), Inequality decomposition by factor components, *Econometrica*, 50(1): 193-211.

Singh, S., A. Bankole and J. E. Darroch (2017), The impact of contraceptive use and abortion on fertility in Sub-Saharan Africa: Estimates for 2003–2014, *Population and Development Review*, 43(S1): 141-165.

Strulik, H. and J. Weisdorf (2008), Population, food, and knowledge: a simple unified growth theory, *Journal of Economic Growth*, 13(3): 195-216.

Tsui, A. O., W. Brown and Q. Li (2017), Contraceptive practice in Sub-Saharan Africa, *Population and Development Review*, 43(S1): 166-191.

United Nations DESA (2020), *World Fertility and Family Planning 2020. Highlights*, United Nations, Department of Economic and Social Affairs, Population Division, New York.

World Bank (2020), *Poverty and Shared Prosperity 2020 (Chapter 1: Poverty)*, World Bank, Washington, DC.

Appendix

Appendix A: Overview of included DHS and LSMS/HIS surveys

Table A1 below presents an overview of all included DHS and LSMS/HIS by country and year.

Table A1: List of included DHS and LSMS/HIS, by county and year

	ca. 1992			ca. 1998		ca. 2004		ca. 2010		ca. 2016		
Albania								**2009**		**2018**		
Angola						2007		2011		2016		
Armenia				2000		2005		2010		2016		
Bangladesh	1994			1997	2000	2004	2007	2011		2014	2018	
Benin				1996		2001	2006	2012		2018		
Bolivia	1989	1994		1998		**2003**		2008				
Brazil	1986			1996								
Burkina Faso	**1993**			**1999**		**2003**		**2010**		**2014**	2018	
Burundi								2010	2012	2016		
Cambodia				2000		2005		2010		2014		
Cameroon	1991			**1998**		**2004**		2011		2018		
Chad				1997		2004				2015		
Colombia	1986	1990	1995	2000		**2005**		2010		2015		
Comoros				1996				2012				
Congo, Dem. Rep.						2007				2014		
Congo, Rep.						2005		2012				
Dominican Rep.	1986	1991		1996	1999	2002	2007			2013		
Egypt, Arab Rep.	1988	1992	1995	2000		2003	2005	2008		2014		
Ethiopia				2000		2005		2011		**2016**		
Gabon				2000				2012				
Ghana	**1988**	**1993**		**1998**		2003		**2008**		2014	2016	2019
Guatemala	1987	1995		**1999**						2015		
Guinea				1999		2005		2012		2018		

Guyana					2005		2009										
Haiti	1995		2000		2006		2012				2016						
Honduras					2006		2012										
India	1993		1999		2006						2015						
Indonesia	1991	1994	1997		2003	2007	2012				2017						
Jordan	1990		1997		2002	2007	2009	2012			2018						
Kenya	1989	1993	1998		2003		2009				2014	2015					
Kyrgyz Rep.			**1997**				2012										
Lesotho					2004		2009				2014						
Liberia					2007		2009	2011			2013	2016	2019				
Madagascar	1992		1997		**2004**		2009	2011			2013	2016					
Malawi	1992		2000		**2004**		**2010**	2012			**2014**	2015	**2017**				
Maldives							2009				2017						
Mali	1987		**1996**		2001	2006					2013	**2015**	**2018**				
Morocco	1987	1992			2004												
Mozambique			1997		2003		2011				2015	2018					
Namibia			2000		2007						2013						
Nepal			1996		2001	2006					2016						
Nicaragua			**1998**		**2001**												
Niger	1992		1998		**2006**		**2012**										
Nigeria	1990				2003		2008	**2010**			**2013**	2015	2018				
Pakistan	**1991**				2007						2013	2018					
Peru	**1986**	1992	1996	2000	2006		2009	2010	2011	2012							
Philippines	1993		1998		2003		2008				2013	2017					
Rwanda	1992		2000		2005		2008	2010			2013	2015	2017				
Senegal	1986	1993	1997		2005	2006	2009	2011			2013	2014	2015	2016	2017	2018	2019
Sierra Leone							2008				2013	2016	2019				
South Africa			1998								2016						
Tajikistan							**2012**				2017						
Tanzania	1992		1996	1999	2005		**2008**	**2010**	**2012**		**2015**	2017					

Timor-Leste						2010		2016		
Togo	1988		1998					2014	2017	
Turkey	1993		1998	2003		2008		2013		
Uganda	1989	1995		2001	2006	**2009**	**2011**	**2015**	**2016**	2019
Vietnam			1997	**2002**						
Zambia	1992		1996	2002	2007			2014	2018	
Zimbabwe	1988	1994	1999	2006		2011		2015		

Notes: Normal font means that only DHS is included, bold font means that DHS as well as LSMS/HIS is included. N(DHS)=289, N(LSMS/HIS)=44.
Source: Authors.

Appendix B: Harmonization of regional boundaries across survey years

This section serves to illustrate in detail how we adjusted the region variable in order to obtain a region-level dataset with consistent regional boundaries over time.

Out of 60 countries in our dataset, 38 experienced changes with respect to boundaries of their administrative regions during the period of observation. In most cases, one or several regions where simply split into two or more smaller regions. While in some of these countries, only one or few regions were affected, in other countries the majority or all regions changed their boundaries. In all affected countries, we adjusted the regions while considering two criteria: first, consistency of regional boundaries over time, and second, no unnecessary omission of information. For the recoding, we used two broad approaches of regional adjustment, depending on how regional boundaries changed. The two following examples are used to illustrate this.

Approach 1: Pakistan was divided into four regions (Balochistan, Khyber Pakhtunkhwa, Punjab, Sindhin) in the 1998 and 2007 DHS. Later, the original 'Punjab' region was split into two regions, 'Punjab' and 'Islamabad', leading to five regions (Balochistan, Khyber Pakhtunkhwa, Punjab, Islamabad, Sindhin) in the 2013 and 2017 DHS. Hence, we merged the regions 'Punjab' and 'Islamabad' in 2013 and 2017, resulting in four regions with consistent boundaries in all four survey years. This allows to control for region-fixed effects, while only 'loosing' two observations.[18] In short, for a given country, this approach leads to a consistent set of regions with the same boundaries across our entire study period.

Approach 2: Benin was divided into six regions (Atacora, Borgou, Atlantique, Mono, Oueme, Zou) in the 1996 and 2001 DHS. Later, in the 2006, 2012 and 2018 DHS, each of the six regions was split into two smaller regions, resulting in 12 smaller regions (Atacora / Donga, Borgou / Alibori, Atlantique / Littoral, Mono / Couffo, Oueme / Plateau, Zou / Collines). Here, instead of merging the smaller regions of the later years back to the original regions, we simply renamed the regions in 1996 and 2001 (Atacora_96/01, Borgou_96/01, Atlantique_96/01, Mono_96/01, Oueme_96/01, Zou_96/01). This still allows to control for region-fixed effects, since every region is at least twice in the data and regions are consistent between 1996 and 2001 and between 2006 and 2018. At the same time, we do not lose any variation, as opposed to losing 18 observations (3 x 6) had we decided to merge the 2006-2018 regions back to their original

[18] Sometimes regions were regrouped in a more complicated manner, such that some of the newly formed regions cross boundaries of old regions and thus can't be unambiguously allocated to one specific old region. Whenever these inaccuracies were small, we allocated the new region the old region with the biggest overlap. If this was not feasible, we tried to re-group both old and new regions in order to form consistent boundaries (of fewer but larger regions) over time. If neither was feasible, we excluded the affected DHS from our dataset.

shape. So, for a given country, this approach leads to two different sets of regions, with each set of regions being included at least twice in consecutive survey years.

Table A2 on the next page shows for each country whether it experienced any changes in regional boundaries and, if so, which approach we used to harmonize the region boundaries over time.[19]

[19] See https://spatialdata.dhsprogram.com/boundaries/#view=table&countryId=AF for a detailed illustration of all regional boundary changes for all DHS surveys.

Table A2: Overview of regional boundaries changes

No regional boundaries changes	Regional boundaries changes – Approach 1	Regional boundaries changes – Approach 2
Armenia	Albania	Benin
Colombia	Angola	Bolivia
Comoros	Bangladesh	Burkina Faso
Congo, Dem. Rep.	Brazil	Nigeria
Egypt, Arab Rep.	Burundi	Peru
Ethiopia	Cambodia	Senegal
Guatemala	Cameroon	
Guyana	Chad	
Kenya	Congo, Rep.	
Lesotho	Dominican Republic	
Malawi	Gabon	
Maldives	Ghana	
Mozambique	Guinea	
Namibia	Haiti	
Nepal	Honduras	
Nicaragua	India	
South Africa	Indonesia	
Tajikistan	Jordan	
Timor-Leste	Kyrgyz Republic	
Turkey	Liberia	
Vietnam	Madagascar	
Zimbabwe	Mali	
	Morocco	
	Niger	
	Pakistan	
	Philippines	
	Rwanda	
	Sierra Leone	
	Tanzania	
	Togo	
	Uganda	
	Zambia	

Source: Authors.

Appendix C: Summary statistics for all sub-samples

Table A3 below presents summary statistics for all variables used in the regressions, separately for each sub-sample.

Table A3: Summary statistics by sub-sample

Sub-sample	1a	1b	2a	2b	3a	3b
	Mean	Mean	Mean	Mean	Mean	Mean
Fertility						
Regional total fertility rate (TFR)	4.227	5.223	3.969	4.918	4.664	5.061
Indicators of structural change						
Share of women with secondary or higher education	0.407	0.278	0.482	0.371	0.298	0.227
Share of women working in non-agricultural formal jobs	0.112	0.086	0.122	0.099	0.107	0.093
Mean nighttime light intensity	3.312	2.636	3.785	3.468	2.821	1.896
Share of households with social security	-	-	0.197	0.082	-	-
Average male wage	-	-	-	-	584.405	429.942
Average female wage	-	-	-	-	434.863	309.248
Male to female wage ratio	-	-	-	-	1.766	1.845
Control variables						
Child mortality rate	104.221	132.044	82.655	103.027	116.396	133.297
Urbanization rate	0.405	0.352	0.428	0.376	0.375	0.317
Asset index	0.663	0.137	0.821	0.297	0.350	0.013
Share of women with no education	0.245	0.342	0.183	0.273	0.306	0.371
Share of women with primary school education	0.348	0.380	0.335	0.356	0.397	0.402
Share of women working in agriculture	0.242	0.313	0.217	0.269	0.294	0.382
Share of women working in non-agricultural informal jobs	0.227	0.244	0.248	0.263	0.239	0.237
Share of women not working	0.420	0.358	0.415	0.369	0.360	0.288
Observations	2,012	1,011	801	427	271	197

Notes: Wages are in 2011 intl. $ PPP.
Source: Own calculations using data from DHS, LSMS (and similar surveys), and Li et al. (2020).

Appendix D: Wage regressions

Table A4 below presents the regression results when including relative female wages as indicator of structural change.

Table A4: Regressions of the TFR on female educational attainment, female occupational structure, nighttime light intensity, and relative female wages

	Sample 3a				Sample 3b			
Independent variables	Spec. I	Spec. II	Spec. III	Spec. IV	Spec. I	Spec. II	Spec. III	Spec. IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Indicators of structural change								
Share of women with secondary or higher education		-1.437*	-1.219	-0.282		-1.684*	-1.257	-0.507
		(0.7985)	(0.7608)	(1.9495)		(0.8631)	(0.8428)	(2.3234)
Share of women working in non-agricultural formal jobs		-5.541	-4.403***	-1.667		-5.636	-4.027***	-2.330
		(3.1906)	(1.3164)	(1.5359)		(3.7506)	(1.3133)	(1.8773)
Log of mean nighttime light intensity		0.001	0.012	-0.011		-0.035	-0.025	-0.022
		(0.0643)	(0.0583)	(0.0512)		(0.0871)	(0.0761)	(0.0553)
Ln of mean male wage		0.091	0.119	0.070		0.037	0.077	0.079
		(0.2011)	(0.1542)	(0.1278)		(0.1872)	(0.1334)	(0.1423)
Ln of mean female wage		-0.262***	-0.197***	0.041		-0.261***	-0.175***	0.053
		(0.0599)	(0.0414)	(0.0536)		(0.0670)	(0.0449)	(0.0565)
Indicators of general development								
Child mortality rate	0.008***	0.004**	0.003**	0.005**	0.008***	0.004	0.003*	0.005**
	(0.0007)	(0.0018)	(0.0016)	(0.0022)	(0.0009)	(0.0020)	(0.0016)	(0.0023)
Urbanization rate	-0.606	-0.123	-0.690*	-0.378	-1.002	-0.470	-1.194***	-0.300
	(0.4722)	(0.2889)	(0.3997)	(0.7818)	(0.6085)	(0.4945)	(0.4005)	(1.4841)
Asset index	-0.728***	-0.531**	-0.475***	0.179	-0.553***	-0.287	-0.277	0.345***
	(0.1512)	(0.1941)	(0.1425)	(0.1593)	(0.1690)	(0.2274)	(0.1824)	(0.0490)
Share of women with primary school education		-3.086*	-3.086***	-0.197		-3.261*	-3.191***	-0.275
		(1.5437)	(1.1472)	(2.3701)		(1.5885)	(1.0870)	(2.9084)
Share of women working in non-agricultural informal jobs		0.689	0.642	-0.338		1.010	1.066	-0.769
		(0.9404)	(0.7016)	(1.1380)		(1.1379)	(0.7592)	(1.2904)

Share of women not working		0.316 (0.3334)	0.507 (0.3389)	0.207 (0.5600)		0.062 (0.4821)	0.350 (0.5020)	0.410 (0.6811)
Country-specific time-effects	yes	yes	yes	yes	yes	yes	yes	yes
Spatial lag	no	no	yes	yes	no	no	yes	yes
Region-fixed effects	no	no	no	yes	no	no	no	yes
R-Squared	0.788	0.832	0.863	0.758	0.709	0.774	0.824	0.765
Observations	271	271	271	271	197	197	197	197
Region groups	146	146	146	146	93	93	93	93

Notes: Each column refers to one regression. 56 regions in Sample 3a and 24 regions in Sample 3b have information on fertility, indicators of structural change and indicators of general development for only one survey year and thus do not contribute to the fixed-effects regressions in Columns (4) resp. (8). Robust standard errors clustered at the country level in parentheses. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Source: Own calculations using data from DHS, LSMS (and similar surveys), and Li et al. (2020).

Appendix E: Interaction effects

Table A5 below presents results from regressions with interaction effects.

Table A5: Nonlinear regressions – interactions with child mortality, urbanization, and household wealth

Independent variables	Sample 1a Spec. III (1)	Sample 1a Spec. III (2)	Sample 1a Spec. III (3)
Indicators of structural change			
Share of women with secondary or higher education	-1.739*** (0.5640)	-1.151*** (0.3828)	-1.189*** (0.4455)
Share of women working in non-agricultural formal jobs	0.750 (0.8457)	-1.740 (1.1566)	-1.840* (0.9863)
Log of mean nighttime light intensity	-0.124*** (0.0480)	-0.059 (0.0362)	-0.059** (0.0248)
Interactions	*Child mortality* ×	*Urbanization* ×	*Asset index* ×
… Share of women with secondary or higher education	0.005 (0.0053)	-0.498 (0.4330)	-0.194 (0.1320)
… Share of women working in non-agricultural formal jobs	-0.016*** (0.0056)	1.489 (1.2926)	0.867* (0.4817)
… Log of mean nighttime light intensity	0.000 (0.0004)	-0.016 (0.0538)	-0.014 (0.0132)
Indicators of general development			
Child mortality rate	0.005** (0.0024)	0.003*** (0.0011)	0.004*** (0.0010)
Urbanization rate	-0.052 (0.2803)	-0.015 (0.5578)	-0.066 (0.3145)
Asset index	-0.632*** (0.0685)	-0.626*** (0.0647)	-0.640*** (0.0811)
Share of women with primary school education	-1.640** (0.7479)	-1.566*** (0.5981)	-1.554** (0.6514)
Share of women working in non-agricultural informal jobs	0.472* (0.2428)	0.496* (0.2752)	0.458* (0.2422)
Share of women not working	0.129 (0.1926)	0.049 (0.1973)	0.109 (0.2052)
Country-specific time-effects	yes	yes	yes
Spatial lag	yes	yes	yes
Region-fixed effects	no	no	no
R-Squared	0.880	0.878	0.879
Observations	2,012	2,012	2,012
Region groups	528	528	528

Notes: Each column refers to one regression. Robust standard errors clustered at the country level in parentheses. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.
Source: Own calculations using data from DHS and Li et al. (2020).

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