Long-run Impacts of Forced Labor Migration on Fertility Behaviors: Evidence from Colonial West Africa*

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Abstract

Is the persistently high fertility in West Africa today rooted in the decades of forced labor migration under colonial rule? We study the case of Burkina Faso, considered the largest labor reservoir in West Africa by the French colonial authorities. Hundreds of thousands of young men were forcibly recruited and sent to work in neighboring colonies for multiple years. The practice started in the late 1910s and lasted until the late 1940s, when forced labor was replaced with voluntary wage employment. We digitize historical maps, combine data from multiple surveys, and exploit the historical, temporary partition of colonial Burkina Faso (and, more specifically, the historical land of the Mossi ethnic group) into three zones with different needs for labor to implement a spatial regression discontinuity design analysis. We find that, on the side where Mossi villages were more exposed to forced labor historically, there is more temporary male migration to Côte d'Ivoire *up to today*, and lower realized and desired fertility *today*. We show evidence suggesting that the inherited pattern of low-skill circular migration for adult men reduced the reliance on subsistence farming and the accompanying need for child labor. We can rule out women's empowerment or improvements in human and physical capital as pathways for the fertility decline. These findings contribute to the debate on the origins of family institutions and preferences, often mentioned to explain West Africa's exceptional fertility trends, showing that fertility choices respond to changes in modes of production.

Keywords: Fertility, Colonial origins, Forced labor, Migration, Africa

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> "*In Africa, the century prior to the 1960s was marked by colonial rule, and the current reproductive systems were shaped in response to that rule. Colonization increased the pressure for high fertility by, among other things, introducing cash crops in African agriculture and imposing forced labor upon rural populations who had to meet the demands of the metropolis while continuing production of staple foods. This increased the need for labor, placing an additional upward pressure on fertility.*" Mbacké (1994)

1 Introduction

Average fertility in Sub-Saharan Africa remains relatively high: in 2019, the total fertility rate was 4.6 children per woman compared to a world average of 2.5 (United Nations, 2020). One prominent, though debated, explanation is that cultural norms, rooted in traditional beliefs, strongly value large families (Casterline, 2017). The literature on precolonial origins of family systems in Sub-Saharan Africa has long been interested in variations across ethnic groups and relates these variations to differences in traditional modes of production (Lesthaeghe, 1989). Interestingly, the response of family systems to colonial rule has attracted less attention. European colonizers deeply modified the economic and social organization of local communities in order to extract and appropriate more resources, with long-lasting consequences for African economies. This suggests that today's fertility preferences and behaviors may be partly shaped by the disruptions of the organization of production under colonial rule.

We investigate the legacy of a specific policy implemented by colonizers to address the shortage of labor in areas with rich natural resources: forced migration of workers from areas perceived as less economically promising. Coercive movements of labor took place throughout the continent, to supply workers for ambitious infrastructure projects such as railroads linking the inland to major ports, for coffee and cocoa plantations in French Côte d'Ivoire (Cordell and Gregory, 1982), for copper mines in Belgian Congo and in British Northern Rhodesia (Juif and Frankema, 2018), or for sisal plantations in German Tanganyika (Rodney et al., 1983). This external demand for labor was a shock to communities of origin, who relied mainly on subsistence farming. In particular, the organization of food production was affected by the absence of young men.[1] We show that the shock persisted once forced labor was abolished because employers at destination used the same networks to recruit voluntary workers in the

[1] Labor was taxed in multiple ways as described in section 2, including through forced conscription, but forced labor migration was by far the biggest shock in terms of man-days extracted.

post World War II period. In the long run, the impact on "sending" communities is ambiguous. On the one hand, households (whether labor migration was forced as in the past, or voluntary as today) may need to have more children to compensate for the missing male labor on the farm (substitution effect). On the other hand, since today's migration labor is paid, remittances may reduce the reliance on agriculture and the need for family labor (income effect).

The case of Burkina Faso is particularly interesting for two reasons. First, the colony was considered as the largest "labor reservoir" in French West Africa. The Mossi ethnic group, perceived as populous and obedient by French colonizers, was especially targeted (Gregory et al., 1989). Second, we can exploit variation in exposure to forced labor migration within the Mossi ethnic homeland as a natural experiment. In the late 1910s, neighboring colonies started recruiting Mossi labor more or less intensively depending on their needs. This process climaxed between 1932 and 1947, when Burkina Faso was dismantled and split into three parts, which were attached to (i) the southern colony, Côte d'Ivoire, (ii) the northern colony, French Soudan (now Mali), and (iii) the eastern colony, Niger. This division was driven by economic motives in the case of Côte d'Ivoire and French Soudan: the goal was to reallocate the Mossi labor to large public infrastructure projects (railroads, irrigation) and private plantations. Hundreds of thousands of young men participated in forced contract labor for 1 to 2 years, over the 15 years of partition (Bouquet, 2003). On the contrary, political motives prevailed in the case of Niger, where no external labor was needed for any economic activity. After 1947, the colony was reunified, forced labor was abolished, and large public works were completed or abandoned. However, temporary migration flows to private plantations continued until independence in 1960, and intensified afterwards. Migration flows initially oriented to public work in French Soudan were redirected towards private work in Côte d'Ivoire (Cordell et al., 1996).

We build on qualitative and quantitative evidence from colonial archives to argue that the partition boundaries can be used for a spatial regression discontinuity design to study the long-term impact of forced labor migration on fertility. First, we document substantial variation in the incidence of forced contract labor within Burkina Faso. Importantly, the part temporarily attached to Niger was considerably less exposed than the other two parts, both before and during the partition. We also find that, within the part temporarily attached to Côte d'Ivoire, some administrative units were particularly targeted. Second, we exploit historical maps of French West Africa to reconstruct the boundaries at the time of partition.

These boundaries do not correspond to current administrative borders within Burkina Faso nor to historical ethnic homelands. Our main boundary of interest is the one separating the part attached to Côte d'Ivoire and the part attached to Niger during the partition. This boundary is orthogonal to climate zones and there is no substantial discontinuity in terms of elevation, precipitation, suitability for agriculture nor population density in colonial times. Moreover, we use the boundary between the part temporarily attached to Côte d'Ivoire and the part temporarily attached to French Soudan as a placebo, since both parts were exposed to forced labor migration. This allows us to rule out the possibility that the difference between the part temporarily attached to Côte d'Ivoire and that temporarily attached to Niger comes from other factors specific to the Côte d'Ivoire side.[2] Finally, we exploit variation in forced labor migration within the part attached to Côte d'Ivoire as an additional test.

We combine the historical maps with three geo-referenced datasets to compare contemporaneous outcomes on both sides of the boundary, controlling flexibly for the distance to the boundary and ethnicity fixed effects. To estimate the effect on fertility, we use four waves of the Demographic and Health Surveys (DHS) collected between 1993 and 2010. These are nationally representative household surveys collecting fertility history for women between 15 and 49 years old. We focus on rural areas and our sample includes $28,649$ women in 935 clusters of villages. The main disadvantage of DHS is that, for privacy reasons, cluster locations are published with a random noise up to 5 kilometers. To mitigate this issue, we complement our results with first-hand data collected in 2017 in 499 precisely geo-referenced villages as part of the Burkina Families Aspirations and Behaviors (BFAB) project (Dupas et al., 2023). We have information on fertility history for 35,683 married women and on subjective determinants of fertility (e.g., desired fertility, needs for child labor, perceptions of social norms) for 14,704 couples. To investigate the persistence channel, we use the Living Standards Measurement Study (LSMS) collected in 2018-19 and covering 7,010 rural households in 322 villages. The survey provides data on migration and economic activity, in particular remittances, occupation, time use, and productive assets.

We find that, in villages historically more exposed to forced labor migration, fertility is lower today. The difference amounts to 0.5 children at the end of the reproductive life. Desired fertility is also lower, in particular among men. There is more male temporary migration to Côte

[2] We cannot compare French Soudan and Niger due to too few observations along this short boundary.

d'Ivoire, and households are more likely to receive remittances, especially from Côte d'Ivoire. Adults are less likely to work in agriculture, and when they do, they cultivate smaller pieces of land; children spend less time working in the fields; household heads report lower needs for family labor in general and for child labor in particular. Importantly, the effects on fertility are driven by areas where the soil is suited for food crops requiring a lot of labor. This is consistent with the idea that remittances make a difference when family labor is the most important factor of food production. We conclude that, in our context, the income effect—reducing the total level of labor on the farm—dominates the substitution effect—replacing adult labor by child labor. However, we find no difference in terms of education levels, child survival, productive assets or female empowerment, suggesting that the income effect does not operate through a quality-quantity trade-off or a change in household bargaining, but rather through a decrease in the value of high birth order children when subsistence farming becomes less important. Alternative mechanisms, such as abstinence, social norms, age at marriage, or composition effects are not supported by the data.

Our study contributes to a nascent literature on the long-term effects of specific colonial policies on fertility in Africa today. Canning et al. (2020) focus on population policies and find that differences in laws forbidding contraception partly explain why fertility is higher in former French colonies than in former British colonies. However, the difference is no longer detectable in areas with high female opportunity cost of childbearing, suggesting that changes in economic incentives may overcome historical determinants. Okoye and Pongou (2023) and Guirkinger and Villar (2022) study the role of Christian missions (both Catholic and Protestants) in Nigeria and Congo, respectively. They estimate an overall negative effect on fertility in the long run—with the exception of Catholic missions in Congo—that they explain through improvements in education. Our paper shows that even colonial policies that did not directly target fertility may have a long-lasting influence on family structures.

We also contribute to a growing literature quantifying the impact of forced labor on African economies. Some papers estimate the magnitude of the contribution of forced labor to colonial economies (Van Waijenburg, 2018; Archibong and Obikili, 2020; Cogneau and Mo, 2022). Others estimate the long-term impacts on socio-economic development today (Mo et al., 2022; Salem and Seck, 2022). We show that forced labor migration reshaped local economies and this, in turn, impacted fertility decisions. An important additional result is that, in our context, the persistence channel operates through the private sector: migration flows to French Soudan rapidly dropped when public works ceased to be a priority for the authorities, while they persisted to Côte d'Ivoire where private plantations actively sought migrant laborers throughout the 20th century.

A closely related paper is Denton-Schneider (2022), who compares, within Mozambique, areas where the colonial administration facilitated the migration of young men to South African gold mines as well-paid contract workers for periods of up to 12 months, to neighboring areas where young men were forced to provide their labor to local plantations against very low wages and under harsh conditions. This is somewhat the opposite of our setting: Labor migration in the Mozambican context was not coerced, it is the restriction on labor movement that was coercive. Just like we do, Denton-Schneider (2022) finds that colonial rule over how men can use their labor reshaped families, but through a different mechanism. In the Mozambican case, the inability to migrate influenced the *marriage market*, with young men unable to compete for brides against older men, cementing a norm of large age gaps between spouses that helped fuel the HIV epidemic 40 years later.

Our study also contributes to the literature on the long-run effects of temporary labor migration on places of origin. There is a vast literature on migration, and most papers focus on the effect on migrants themselves or on households sending migrants. However, recent papers argue that migration could have macro effects by facilitating the structural transformation of sending economies through increased investments in human and physical capital (Dinkelman and Mariotti, 2016; Dinkelman et al., 2022; Khanna et al., 2022; Libois et al., 2022; Salem and Seck, 2022). In the same vein, we argue that the village is the relevant unit of analysis in our context because households are interconnected and form a bigger unit of production (Remy, 1977). In contrast with much of the migration literature, we find no effect on the accumulation of capital, suggesting that positive dynamics may be specific to migration movements that started without coercion. Some papers have looked at the impact of voluntary labor migration to places with different fertility norms on the fertility behaviors of communities of origin. They find a robust positive relationship between the average family size at destination and changes in family size at origin, in line with the concept of cultural remittances (Beine et al., 2013; Bertoli and Marchetta, 2015; Melki et al., 2023). In our context, norms on family size are similar at destination and at origin.

Finally, beyond economics, there is a vast literature on the supposed "African exceptionalism" in demography. The debate dates back to Caldwell and Caldwell (1987)[3] and can be summarized as follows: there is a near-consensus that the decline in fertility is particularly late and particularly slow in Africa, but there is no consensus on the causes (Casterline, 2017). The main disagreement is about the relative roles of economic factors and cultural factors. Very few studies explicitly relate these factors to colonial policies and establish a direct causal link. We found only one scholar, the demographer Cheikh Mbacké, who hypothesized that preferences for a large family are not an eternal, constant feature of African cultures, but rather a rational response to colonial rule (Mbacké, 1994). We test a specific aspect of colonial rule, forced labor migration, and find a reduction in desired fertility. Even though the sign is not in line with Mbacke's specific conjecture, our results support the more general idea that fertility preferences respond to changes in economic factors.

The outline of the paper is as follows. Section 2 introduces the historical context and Section 3 describes the evidence on forced labor migration from colonial archives. Section 4 presents the data and important descriptive statistics. Section 5 sets up the empirical strategy. Section 6 reports the results and the robustness tests. Section 7 discusses the persistence channel and proposes a theory of change to rationalize the effects we observe in the data on some intermediate variables and the lack of effects on others. Section 8 concludes.

2 Historical Background

This section provides a rapid overview of Burkina Faso's colonial history, based on Cordell et al. (1996, Chapter 2).

The Mossi Empire From the 11th to the 19th century, a large part of the territory that is present-day Burkina Faso was controlled by Mossi Kingdoms. The Mossi are by far the largest ethnic group in Burkina Faso, constituting 52% of the population today. The second largest ethnic group in the country, the Fulani, comprises only 8.4% of the population.

The Mossi are considered unique in the region's history for their highly centralized governing body. They established a prosperous and stable empire, whose expansion was stopped when

[3] Important references include Caldwell and Caldwell (1988); Lesthaeghe (1989); Caldwell et al. (1992); Bledsoe et al. (1998); Bongaarts and Casterline (2013); Casterline and El-Zeini (2022).

France started actively expanding its colonization effort in West Africa in the late 19th century, moving eastward from Senegal. The Mossi fought against the French invasion, but ultimately lost. Ouagadougou, the capital of the most important Mossi Kingdom and home to the Mossi emperor, Mogho Naba Wobgho, fell to French forces in 1896. The Mogho Naba fled into exile into neighboring Ghana in 1897. France replaced him with Naba Sighiri, who signed a treaty in 1897 accepting the French protectorate.

The AOF and Haute Volta French West Africa (in French: Afrique-Occidentale française, hereafter AOF) was a federation of French colonial territories in West Africa that existed from 1895 until 1958. At its peak it included 8 territories, among them French Soudan (now Mali), Côte d'Ivoire, Niger, and Haute Volta (now Burkina Faso). Haute Volta, with in it the entirety of the former Mossi empire, was established in 1919. Haute Volta attained independence from France in 1960, and changed its name to Burkina Faso in 1984.

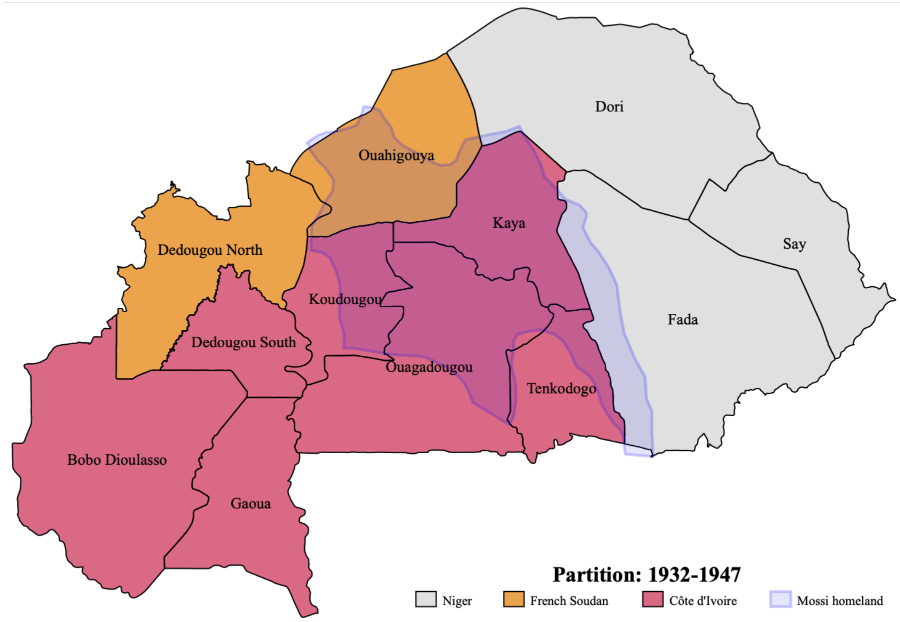
Indigénat Legally, Africans in Haute Volta and most other colonies of the AOF were considered French "subjects" and not citizens. They were excluded from most rights, including the right to own and the right to vote. The Indigénat legal code of 1885, which prevailed until its abolition in 1946, gave colonial authorities (and in practice, any European) the rights to arbitrarily arrest, try, punish and/or imprison subjects (Mann, 2009). It also gave them the right to requisition forced labor.

Colonial administration Each colony of the AOF was administered by a Lieutenant Governor, who reported to the Governor General headquartered in Senegal. The Governor-General received orders from the Minister of Colonies in France. Internally, each colony was divided into "cercles". Figure 1 shows the boundaries and names of colonial cercles in present-day Burkina Faso, the focus of this paper. (We explain how we reconstructed this map in section 4.)

Each cercle was headed by a French officer ("commandant de cercle"). At the local level, the administration relied on African chiefs for collecting taxes, recruiting forced labor, and enforcing customary law. Chiefs were either traditional chiefs co-opted by the colonial administration, or African bureaucrats trained in French school and appointed as *de facto* administrators.

Given the very low number of French citizens physically present in the colonies, chiefs loyalty was crucial to the colonial administration. For this reason, the colonial administrators monitored carefully chiefs' ability to control their population. For example, the 1926 annual

Figure 1: Colonial Burkina Faso: cercle boundaries and partition



Note: This is a map of the colony of Burkina Faso (Haute-Volta). The colony was split into 12 administrative units called "cercles", represented on the map with black lines. We digitized cercles' boundaries using a historical 1924-1926 atlas available on Gallica. At the time of the atlas and until the partition in 1932, Dedougou was one cercle until it was divided in two along the Black Volta River. We added this border using the River bed. See Appendix D for details on sources and methodology. Between 1932 and 1947, the colony was dismantled and cercles were attached to neighboring colonies: Niger (in light grey), French Soudan (in orange), and Côte d'Ivoire (in pink). The area shaded in light purple represents the ancestral homeland of the Mossi ethnic group (Murdock, 1959).

report sent by the Lieutenant Governor of Haute Volta to the AOF Governor General, which we were able to access in the AOF Archives in Dakar (Sous-serie 1K-K19-57), describes how chiefs from the Ouattara dynasty had lost all authority and should not remain in power nor ever be reappointed. Instead, those areas with Ouattara chiefs would be consolidated into larger administrative units led by educated African civil servants. In contrast, the same report highlights how Mossi chiefs had uncontested authority over their own people and were considered "docile and compliant" towards the colonial administration.

3 Forced labor

3.1 Overview

Under the Indigénat rule, colonial administrators were empowered to requisition labor through many channels: the "corvée" or "prestations" (taxes paid in forced labor on specific, local projects, see Van Waijenburg (2018)), forced conscription (Cogneau and Mo, 2022; Salem and Seck, 2022), as well as forced contract labor for periods of one to two years (Suret-Canale, 1971). Many major projects in the AOF in this period were performed by forced labor, most notably, the Abidjan-Ouagadougou railroad constructed from 1904 to 1955 and the ambitious irrigation system in present-day Mali launched under the name "Office du Niger" in 1932 and gradually abandoned after 1945.

French administrators considered Haute Volta as a major source of human labor for other colonies of the AOF because it was more densely populated than other colonies, but with a much lower agricultural potential.[4] Workers from Haute Volta were forcibly sent to public works in nearby colonies as well as to settler-owned cotton plantations and timber companies in Côte d'Ivoire. The external demand for labor, and resulting forced labor migration, were highest during the interwar period. This is what we refer to as "forced labor migration" and focus on in this paper.

The travel conditions to those remote locations as well as the working conditions once there were extremely poor. Official reports by work inspectors reveal lack of access to proper clothing and bedding, food rations "insufficient for an adult man engaged in hard labor", lack of access to health care, and abnormally high death rates.[5] Employers themselves at times complained to

[4]For example, here is a quote from the AOF Governor-General in 1927, as quoted in Cordell and Gregory (1982, p. 206): "*I am unable to share [the] point of view that Upper Volta should not become the reservoir of human energy for the other colonies of the group. [The] colony has more than 3 million inhabitants, one-fourth of the total population of French West Africa... it is therefore normal that this population be called upon to participate in works of a general interest to the federation.*" In contrast, here is a quote about the mismatch between Côte d'Ivoire's natural potential and its manpower: "*Côte d'Ivoire, with its innumerable and still poorly known resources, will not achieve the peak of its prosperity until the growth of its population will have allowed it to exploit the natural resources with which it abounds.*" (Chef du service des douanes, June 1926, Rapport Economique d'ensemble sur le commerce de la colonie (Côte d'Ivoire). AOF Archives Dakar Série G Sous-série 2 Côte d'Ivoire: 2 G 25-16).

[5]See for example the 1927 report on the cotton company Cicconie in Diré, and the August 1927 letter sent from the commandant for Dedougou cercle to the Haute Volta administrator, mentioning that, out of 450 workers sent to the Cicconie company in Spring 1927, 19 had died by August, despite the workers having been chosen "among the most vigorous" and screened by a medical doctor at origin. (Abidjan archives, Serie Haute

the colonial administration that the workers they had been sent were gravely sick upon arrival and completely unable to work (see previous footnote).

International calls for the end of forced labor, such as the 1926 League of Nations Slavery Convention and the Labor Convention of 1930, which France did not ratify until 1937, were ineffective against economic motives (Cooper, 1996). Only in 1937 was a serious effort undertaken to "humanize" the recruitment process. An official report describing the 1937 changes states: "It was now well understood that the representatives of the administrative authority should no longer be the providers of labor that they may have been in the past, but it was also clear that everyone had to induce the natives to work, in their own interest, by advising them and persuading them...".[6] This effort led to the creation of 'placement agencies' supposed to help employers find workers, and to efforts to improve working conditions and increase payments to workers. However, the documentation we consulted in the AOF archives did not indicate any concrete changes in how laborers were recruited in practice, nor any evidence of improvements in their material conditions, for at least another decade.

3.2 Heterogeneity in exposure to forced labor migration

Our study design relies on the fact that exposure to forced labor migration was heterogeneous across areas of present-day Burkina Faso. In this section, we describe the sources of this heterogeneity, and which components are arguably exogenous.

While "corvée" was imposed uniformly, not all ethnic groups were equally targeted by migrant labor recruiters. The Mossi were particularly affected. Cordell et al. (1996, p. 190) write: "As Mossi societies were the most centralized in Burkina Faso, the recruitment of Mossi migrant laborers was facilitated by the cooperation of their chiefs". We found numerous evidence corroborating this narrative in official reports, such as the 1926 annual report mentioned above. The 1930 annual report for the cercle of Bobo-Dialousso bemoans the difficulties in recruiting from other ethnic groups compared to the Mossis due to differences in organization. Private companies also had a preference for Mossi labor.[7]

Volta, Sous-Serie SS Main d'Oeuvre, 29126-1927).

[6] AOF Archives, Dakar, Serie 2G Rapports Periodiques, 1937 report, Cote 2G/37/40/CI.

[7] A letter sent to the colonial administration by a cotton company stated "The Mossi workforce gave us complete satisfaction, it is much superior to that of the Timbuktu region." Abidjan archives, Serie Haute Volta, Sous-Serie SS Main d'Oeuvre, 29126-1927).

Moreover, even within the Mossi land, not all areas were equally affected. Areas closer to French Soudan were targeted for public works in French Soudan, and areas closer to Côte d'Ivoire were targeted for public works and private companies in Côte d'Ivoire. Areas closer to Niger indirectly benefited from the differential treatment applied to this colony, where the exploitation of human labor was hindered by the mobility of the population, consisting mostly of nomadic, pastoral groups.

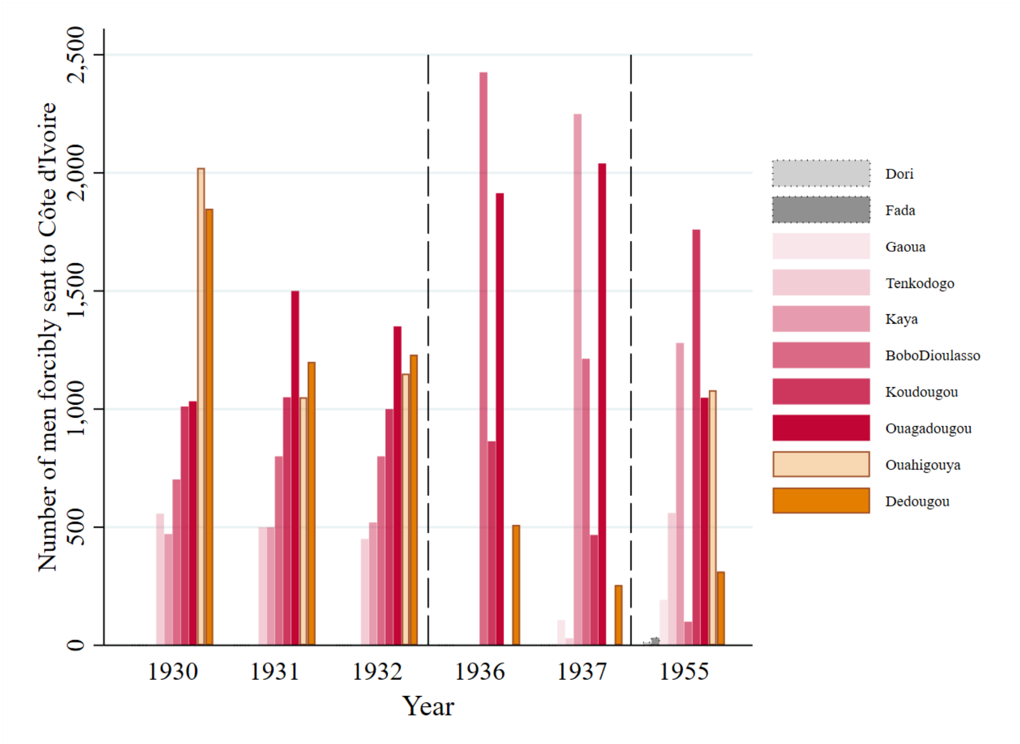
The Partition. These differences in exposure to forced labor migration across parts of Haute Volta culminated with the "partition": In September 1932, Haute Volta was dissolved as a colony, and partitioned into three parts reallocated to the colonies of Côte d'Ivoire (South), French Soudan (West) and Niger (East). Specifically, the cercles of Dori, Fada, and Say were attached to the colony of Niger (see Figure 1, light grey area); those of Dedougou North and Ouahigouya to the colony of French Soudan (orange); and the remaining 7 cercles to the colony of Côte d'Ivoire (pink).

Historians have provided both economic and political reasons for the split. On the economic side, unifying parts of Haute Volta to French Soudan and Côte d'Ivoire was a way to reallocate labor to more "profitable" colonies and save on administrative costs (Beucher, 2010). On the political side, unifying the eastern side with Niger was a way to shift Niger's center of gravity from Zinder—under the influence of Northern Nigeria—to Niamey (Sidikou, 1975). Haute Volta was reinstated with its pre-1932 boundaries in 1947. Historians discuss how this reinstatement, which was demanded by Mossi ruling class, was the result of an alliance between the French colonial administration and "traditional African leaders" made to both (a) undermine the young, European-educated African nationalists (such as Houphouet-Boigny in Côte d'Ivoire) and (b) ensure Mossi chiefs continued assisting in the recruitment of labor for both public and private works (Cordell et al., 1996).

The purple line on Figure 1 represents the boundaries of the area historically inhabited by the Mossi ethnic group taken from the map drawn by the anthropologist Murdock (1959) and digitized by Nunn (2008). The partition cuts through the Mossi ancestral homeland, which allows us to identify the effect of forced labor migration within Mossi land.

Figure 2 and Table 1 show statistics compiled from the national archives of the AOF. We compiled these data from various annual reports, some found in the Dakar archives and some

Figure 2: Heterogeneity in exposure to forced labor migration



Note: This figure shows the number of men recruited for work in Côte d'Ivoire, by cercle of origin, for 6 years for which we were able to find administrative records in the AOF archives. Between 1932 and 1947, the colony was dismantled and cercles were attached to neighboring colonies: Niger (in light grey), French Soudan (in orange), and Côte d'Ivoire (in pink). Archival sources: For 1930 to 1937: Dakar AOF archives, Sous-Series 2G (Periodiques) and 1K (Travail et Main d'Oeuvre), last physically consulted by the authors in Dakar, Senegal, in July 2022. For 1955: the source is EAP462/1/34/5 at the Centre National des Archives (CNA) in Ouagadougou found here: `https://eap.bl.uk/archive-file/EAP462-1-34-5` (last accessed September 2023). Data for Kaya is missing in 1936. The values are zeroes for Dori for all years; for Gaoua in 1930, 1931, 1932, and 1936; for Fada in 1930, 1931, 1932, 1936, and 1937; and for Ouahigouya during the partition (1932 to 1947). See Table 1 for breakdown by work location for the year 1930, and for population size for each cercle.

found in the Abidjan archives. Figure 2 compiles summary information across 6 years spanning the period 1930 to 1955, while Table 1 shows a detailed example for a specific year (1930). The outcome of interest is the number of men forcibly sent to Côte d'Ivoire in a given year, by cercle of origin. We were unable to obtain comprehensive data for every year, but for the years that have information for all cercles, a clear pattern emerge: some cercles were taxed considerably more heavily than others.[8] Notably, both before and during the partition, the two cercles that were attached to Niger (Fada and Dori) at the time of partition were completely unaffected by

[8]We include 1926 population estimates as recorded in the AOF archives, though, as discussed in Frankema and Jerven (2014) among others, colonial census counts may not have been reliable and may be serious underestimates.

forced migration to Côte d'Ivoire. There was heavy recruitment in the two northern cercles, Dedougou and Ouahigouya, with workers sent to Côte d'Ivoire both before the partition and after it, but less so during the partition, when recruits were instead sent to French Soudan.[9]

Table 1: Heterogeneity in exposure to forced labor (pre-partition)

Zone	Cercle	Contract labor, 1930			Army, 1926	Labor tax, 1926	Population, 1926
		Railroad (1)	Public (2)	Private (3)	Head (4)	Days (5)	Head (6)
Niger	Dori	0	0	0	165	95,000	143,308
	Fada	0	0	0	240	80,000	179,837
Côte d'Ivoire	Kaya	471	0	0	270	369,500	249,145
	Tenkodogo	557	0	0	285	241,038	255,187
	Ouagadougou	993	696	40	660	905,576	580,210
	Bobo-Dioulasso	641	53	61	385	346,410	312,235
	Gaoua	0	0	0	190	39,129	231,930
	Koudougou	431	286	100-580	400	364,000	331,366
	Dedougou	1,069	418	129-779	490	613,366	433,682
French Soudan	Ouahigouya	1,813	0	206	400	319,000	362,148

Note: Source: Dakar AOF archives, Sous-Series 2G (Périodiques) and 1K (Travail et Main d'Oeuvre) (years 1930 to 1937), last physically consulted by the authors in Dakar, Senegal, in July 2022. This table shows the incidence of different types of forced labor by cercle. Columns (1) to (3) show the number of men recruited for infrastructure, public, and private work in Côte d'Ivoire, by cercle of origin, for the year 1930. Columns (4) and (5) show the number of men enrolled in the army and the number of forced labor days, by cercle, for the year 1926. Column (6) shows estimates of the population by cercle for the year 1926.

Heterogeneity in exposure to forced labor migration is summarized in Figure A1, in which we categorize cercles as having experienced "high", "medium", or "low" exposure.

3.3 From forced labor to circular migration

The transition between forced labor and voluntary migration was gradual and started after the World War II. After forced labor was officially abolished in 1946 and Burkina Faso was reunified in 1947, employers in Côte d'Ivoire, in particular private firms, set up a syndicate to keep attracting workers: the SIAMO (Syndicat Interprofessionnel d'Acheminement de la Main d'Oeuvre). Employers improved working conditions, raised wages, but often used some forms of coercion as well: Cordell et al. (1996, p. 163) state that "*some forced migration continued, particularly in 1947-1959 [...] This persistence of forced labor suggests that it took some time for official policy to become effective.*" Employers took advantage of the networks built during

[9] The data we compiled is consistent with the following statement found in a 1931 report from the Haute Volta Lieutenant Governor to the AOF General Governor: "[...] five cercles currently supply almost all the workers hired by public and private companies inside and outside the Colony: cercles de Ouagadougou, Bobo-Dioulasso, Dédougou, Koudougou, and Ouahigouya." Original text in french: "[...] cinq cercles fournissent actuellement la quasi-totalité des travailleurs engagés par les entreprises publiques et privées a l'intérieur et à l'extérieur de la Colonie : cercles de Ouagadougou, Bobo-Dioulasso, Dédougou, Koudougou, et Ouahigouya." (Dakar Archives, K-26-121, p. 22.). Unfortunately we were unable to access the AOF archives in Mali so we do not have data to compile statistics on the number of workers forcibly taken to French Soudan.

the partition period and already oriented towards Côte d'Ivoire. Moreover, they redirected the labor flows that were initially going to French Soudan but were no longer needed there because public work programs had been abandoned. Approximately 265,000 people participated in this system between 1947 and 1959 (Bouquet, 2003).

After independence, there was a real boom in temporary migration to Côte d'Ivoire. In the Ivorian census, the number of Burkinabe increases from 100,000 in 1960 to 2.2 million in 1998 (Kabbanji and Piché, 2006). Most of them are employed as unskilled workers in agricultural companies producing cash crops like cocoa or coffee (Boutillier et al., 1977a). Demographers coined the term "circular migration" to describe the large labor migration flows from Burkina Faso to Côte d'Ivoire and back that still characterize the country today. Cordell et al. (1996, p. 164), analyzing data from the National Migration Survey of 1974-1975 in Burkina Faso, write that "*migration is a collective household economic strategy, which designates some members for migrant labor and others to stay home to work the fields and take care of the family.*" Migrants are almost exclusively unmarried young men who travel from Burkina Faso to Côte d'Ivoire in small groups of two or three, going to seek work from the same employers that earlier cohorts in their village worked for. Family networks did not initially play a crucial role at destination, however, as 84% of Mossi migrants to Côte d'Ivoire were lodged by employers in the 1960-1973 period (Cordell et al., 1996, Table 4.10b, p. 209). The modal circular migrant stays abroad for periods of less than two years: 24.1% stayed less than a year and 57.9% stayed between 1 and 2 years (Cordell et al., 1996, Table 4.7b, p. 203).

4 Data

Our analyses combine the historical data on exposure to forced labor migration described in subsection 3.2 with contemporary data on relevant outcomes drawn from three datasets. In this section, we describe each dataset and present descriptive statistics of the main outcomes of interest. Appendix Tables B1 to B3 provide statistics on all variables used in the analysis.

4.1 Historical Boundaries

Our estimation strategy relies on regression discontinuities (RD) at the historical cercle boundaries within present-day Burkina Faso. The first step in this analysis was to compile historical cercles' boundaries from historical archives. To this end, we obtained scanned maps by the AOF from a 1924-1926 atlas available on Gallica, the digital repository of the French National Library.[10] We georeferenced and digitized the maps using their coordinates. We then created a Python code to extract the boundaries automatically, with only a few manual corrections. Our methodology, presented in detail in Appendix D, can potentially be applied to extract information from other digitized maps.[11] The result is shown in Figure 1.[12]

4.2 Contemporary Data

Fertility Outcomes Our empirical analysis is built primarily on multiple rounds of the Burkina Faso Demographic and Health Survey (DHS) conducted in 1993, 1999, 2003, and 2010 (Konaté et al., 1994; INSD, 2000, 2004, 2012). The DHS is a nationally representative household survey collecting comprehensive information on socio-demographic characteristics, including fertility history for women aged 15 to 49 years and desired fertility for men and women. In our analysis, we focus on women living in rural areas.[13] Overall, we have information on $28,649$ women across 935 clusters—i.e., villages or groups of villages. Each survey wave includes clusters' georeferenced locations. We match them with our map of colonial Burkina Faso and obtain Figure A2a. This allows us to assign households to a side of the partition boundary and to define their ancestors' exposure to colonial forced labor migration.

A limitation of the DHS is that, to protect respondents' privacy, GPS coordinates of clusters

[10] The 1924-1926 atlas only features 11 cercles as, until the partition, Dedougou was one cercle, later divided in two along the Black Volta river. To fill in the missing boundary between Dedougou North and South, we use the Black Volta river bed. See Appendix D for further details.

[11] We provide a replication folder including the raw maps, the codes and methodology, and the final shapefiles.

[12] Note that cercle boundaries shifted slightly during colonial times. For instance, Huillery (2009) uses a 1925 atlas in which the boundary between Fada N'Gourma and Kaya slightly differs from ours. Historical maps from 1926 to 1929 show that the boundary likely shifted in late 1925 to the one we use, and remained stable until the partition. In addition, Say and a part of Dori were integrated to Niger in 1926. This has no bearing for our analysis since the affected areas fall outside the bandwidth of our analysis.

[13] We restrict the sample to rural areas because Burkina Faso is almost entirely rural: along the boundaries we consider in our analysis, 82% of people are rural, and the fraction jumps to 93% within the historical Mossi homeland, our area of focus. In section 7 we discuss and rule out the possibility of endogenous urbanization. All our results are robust to keeping urban residents in the sample.

are randomly displaced by up to $5km$ for 99% of rural clusters and up to $10km$ for 1% of rural clusters. This jittering induces a classical measurement error which would bias our estimates toward zero if we assigned villages to the wrong side of the historical boundary. We partially address this issue in our empirical analysis by excluding DHS clusters close to the boundary and varying the size of this "donut" hole.[14]

To further address this limitation of the DHS data, we complement the DHS analysis with data from the precisely geo-referenced Burkina Families Aspirations and Behaviors (BFAB) survey. BFAB is a cross-sectional baseline survey conducted in 2017 as part of a randomized control trial of family planning interventions in Burkina Faso (Dupas et al., 2023). The survey was administered in 499 villages across 20 provinces. It contains fertility and child mortality information on a sample of 35,683 married women older than 17 years old as well as detailed information on determinants of desired fertility for a subsample of 14,704 couples. Importantly, BFAB provides the exact geographic location of villages. In comparison to the DHS, BFAB is not a nationally representative survey and only covers half of Burkina Faso.[15] However, there are enough BFAB villages along partition boundaries for an RD analysis (see Figure A2b).

We use DHS and BFAB to compute annual birth rates in the 10 years preceding the surveys, total number of children ever born for women of different age groups, and ideal number of children for both men and women. *Completed fertility*, defined as the total number of children ever born for women older than 45 years old, is only available in BFAB, due to the small number of observations in that age group in DHS.

Other Outcomes We use the Living Standards Measurement Study (LSMS) to study the persistence of migration. The LSMS is a nationally representative household survey collected in Burkina Faso in two waves, 2018 and 2019, covering 7,010 rural households in 322 geo-referenced villages (INSD, 2018). The LSMS contains information on migration history of current household members and on remittances. As shown in Figure A2c, there are very few

[14]The displacement is not perfectly random because the displaced clusters are maintained in their subnational administrative unit (district). If a cluster close to today's administrative border is displaced to the other side of the border, there is a new draw. We thank Denis Cogneau for alerting us of this issue, and of the fact that it could create a downward bias in the estimation of the distance-to-the-boundary gradient and hence an upward bias in the regression discontinuity estimate if the historical boundaries coincided with today's administrative borders, which fortunately is not the case.

[15]The sampling procedure had two steps: (i) select health centers and (ii) select villages in the catchment area of each health center. Centers and villages were selected to maximize the minimum distance between any two centers and between any two villages belonging to the same center. See details in Dupas et al. (2023).

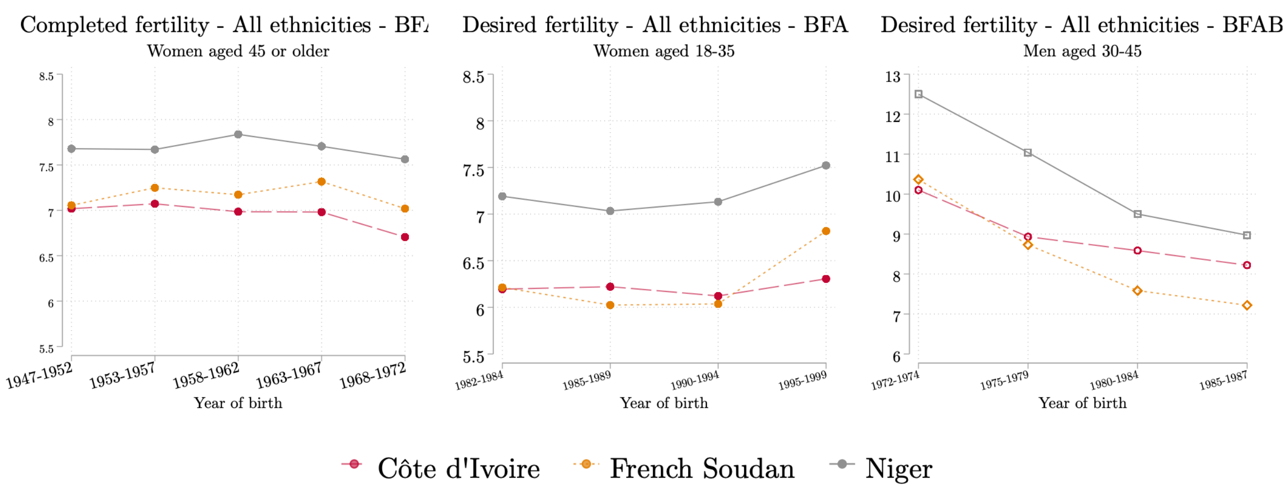
LSMS villages on the Niger side, which does not allow a full RD estimation using this dataset.

To explore mechanisms, we use information on economic activity, specifically occupation, time use, productive assets, and needs for child labor, as well as information on other potential mediators, such as education, health, wealth, female empowerment, marriage, and contraception. These outcomes are drawn from DHS, BFAB and/or LSMS depending on availability.

4.3 Descriptive Motivating Evidence

Using BFAB data, Figure 3 plots the trend in women's completed fertility, women's desired fertility, and men's desired fertility. Each figure shows the evolution across different cohorts of birth, separately for areas exposed to forced labor migration (cercles historically allocated to the colonies of Côte d'Ivoire and French Soudan) and areas not exposed to forced labor migration (cercles historically allocated to the colony of Niger).

Figure 3: Descriptive statistics



Note: Source: BFAB. We use the map in Figure A2b and compute average fertility statistics for the three areas of today's Burkina Faso historically partitioned between Niger (in light grey), French Soudan (in orange), and Côte d'Ivoire (in pink), by 5-year cohort. The graphs on the left plot completed fertility (total number of children ever born) for women older than 45 y.o. ; the graphs in the middle plot ideal family size for women aged 18 to 35 y.o.; the graphs on the right plot ideal family size for men aged 30 to 45 y.o.

Completed fertility is high, between 7 and 8 children, on average, and quite stable over time. The oldest cohort of women was born in 1947, just after the reunification, and there was little change in the subsequent 25 years. Similarly, the desired fertility of younger women, born between 1982 and 1999, ranges between 6 and 7 children and shows no sign of decline. In contrast, men's desired fertility has decreased substantially over time, from $10-12$ children for cohorts born in the early $1970s$ to $7-9$ for cohorts born in the late $1980s$.

Strikingly, both completed and desired fertility are persistently higher in areas not exposed to forced labor migration, by an order of magnitude of roughly one child. These descriptive results are not driven by differences in ethnic group composition because we observe similar patterns within the ancestral homeland of the Mossi ethnic group (see Figure A3).

5 Empirical Strategy

To investigate the long-term causal impacts of colonial forced labor migration on fertility, our empirical strategy takes advantage of the spatial variation in exposure within the colony. The temporary dislocation of colonial Burkina Faso was the epitome of the differential exposure across cercles. As discussed in section 2, the vast majority of men forcibly sent to work abroad were taken from cercles assigned to the colonies of Côte d'Ivoire and French Soudan during the partition. In contrast, cercles temporarily allocated to the colony of Niger were spared this type of forced labor migration, while—importantly—they were equally exposed to other forms of forced labor: military conscription and *corvée*. This allows us to use a spatial Regression Discontinuity (RD) design, relying primarily on the historical Côte d'Ivoire-Niger boundary (solid dark pink line on Figure A2).

We estimate the following spatial RD specification:

$$Y_{ivet} = \alpha + \beta Exposed_v + f(distance_v) + Z_i'\mu + X_v'\sigma + \Delta_e + \Phi_{b(v)} + \theta_t + \varepsilon_{ivet} \tag{1}$$

where Y_{ivet} is the outcome of interest for individual i from ethnic group e, interviewed at time t in village/cluster v. $Exposed_v$ is an indicator equal to 1 if village v is inside the portion of Burkina Faso temporarily attached to the colony of Côte d'Ivoire and equal to 0 if village v belongs to the portion of Burkina Faso temporarily attached to the colony of Niger during the partition. $f(distance_v)$ is the RD polynomial which controls for smooth functions of the distance between village v and the Côte d'Ivoire-Niger partition boundary. Following Calonico et al. (2014); Gelman and Imbens (2019); Cattaneo et al. (2019), our baseline specification is a local linear polynomial estimated separately on each side of the partition boundary. We consider higher-order polynomials in robustness checks. Z_i' is a vector of individual-level covariates including age and age squared, and X_v' is a vector of village-level covariates including distance from village v to the capital city, Ouagadougou. Both vectors help reduce the variance of the error term; we consider the inclusion of alternative controls in robustness checks. Δ_e is a vector of ethnic group fixed effects which ensures that we are comparing individuals from the same ethnicity who are residing on different sides of the partition boundary. $\Phi_{b(v)}$ is a vector of boundary segment fixed effects, obtained by splitting the boundary into six segments of equal length and indicating which one is the closest to village v. This is important because, in map projection terms, climate zones are "horizontal" (see Figure A4) and segment fixed effects ensure that, on the "vertical" portion of the boundary, we compare villages in the same latitude. Moreover, we restrict the sample to villages on the Niger side for which we can find a counterfactual village at the same latitude on the Côte d'Ivoire side. We show in robustness tests that the results remain stable if we remove this restriction and keep the northern villages on the Niger side. Lastly, θ_t includes survey year fixed effects. We cluster standard errors at the village level to account for the sampling design of the surveys and because *Exposed* varies at the village level. We check for robustness to spatial correlation using Conley (1999).

In the main analysis, we estimate Equation 1 using the sample of villages within $70km$ of the boundary. The bandwidth is represented by the black dotted lines on Figure A2. In practice, this means that we compare villages in the exposed cercles of Kaya and Tenkodogo to the non-exposed cercles of Fada and Dori. Our main results are robust to alternative bandwidths.[16] Furthermore, to account for potential measurement errors arising from the jittering of DHS clusters as well as the imprecise location of the boundary, we exclude villages which are within $5km$ of the boundary in DHS or within $1km$ of the boundary in other datasets. We test for robustness with respect to these choices.

The RD specification in Equation 1 can be implemented with DHS and BFAB data. For LSMS outcomes, there are too few observations to adequately estimate a polynomial in the running variable and obtain stable RD estimates. Instead, we simply compare means across the two sides of the boundary, using the same bandwidth on either side as in the RD and controlling

[16]We have several outcomes measured in several datasets so the data-driven "optimal" bandwidth changes in each regression. In the main specification, we opted for setting a fixed bandwidth to estimate all regressions on the same set of villages. $70km$ is a rough average of "optimal" bandwidths for fertility outcomes in DHS (see details in the robustness section Appendix B.2).

for survey year fixed effects. In practice, this amounts to estimating the following equation:

$$Y_{ivet} = \alpha' + \beta' Exposed_v + \theta'_t + \varepsilon'_{ivet} \tag{2}$$

6 Results

This section presents the estimated effects on contemporary fertility behaviors and preferences. We first provide a graphical illustration of the discontinuity at the boundary, then turn to the regression estimates and the robustness tests, and finally discuss the identification assumptions.

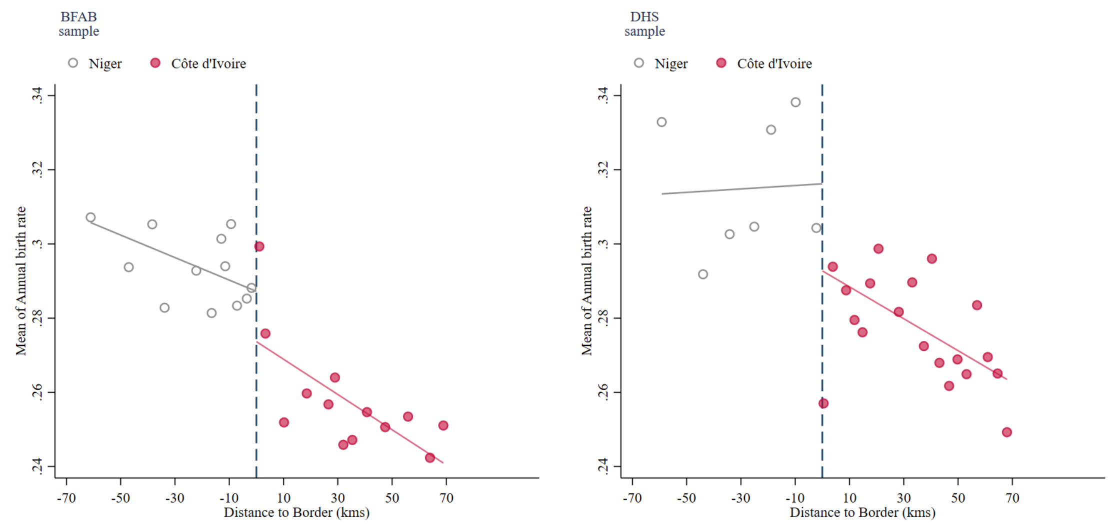
6.1 RD Graphs

Our main RD graph is Figure 4, plotting the mean value of the annual birth rate (y-axis) against the distance to the Côte d'Ivoire-Niger partition boundary (x-axis) using BFAB (on the left) and DHS (on the right). The vertical dashed line marks the Côte d'Ivoire-Niger partition boundary separating areas exposed (Côte d'Ivoire side in pink) from areas not exposed (Niger side in light grey). The dots represent binned scatterplots drawn separately on each side of the partition boundary and show the average annual birth rate within equal-sized bins. Overlaid on the scatterplots is a local linear trend, fitted separately on each side of the partition boundary.

Both graphs exhibit a discontinuity at the partition boundary. Specifically, relative to women residing in areas not exposed to forced labor migration, women from villages historically exposed have a lower annual birth rate. Note that some dots located exactly at the partition boundary are far from their linear fit: the pink dot at the partition boundary in BFAB is closer to the light grey linear fit, and the light grey dot at the partition boundary in DHS is closer to the pink linear fit. Remember that we have some imprecision in the exact location of the partition boundary and in the exact location of DHS villages, so some villages at the partition boundary might be allocated to the wrong side. We think that these measurement errors are mitigated by the fact the we observe a very similar pattern in both datasets if we ignore the dots located at the partition boundary. If there were no true discontinuity, it would be very implausible to observe these patterns in two independent datasets.

Similar graphs for number of births, completed fertility, and both female and male desired fertility are shown in Figures A5 and A6. While noisier, they also tend to exhibit a discontinuity

Figure 4: RD graph: Annual birth rate



Note: Source: BFAB (left) and DHS (right). The figure plots the average annual birth rate (y-axis) against the distance to the Côte d'Ivoire-Niger boundary (x-axis). The analysis is restricted to observations within our main bandwidth ($70km$). The vertical dashed line marks the boundary separating areas exposed to forced labor migration (Côte d'Ivoire in pink) from areas not exposed (Niger in light grey). Villages are grouped in equal-sized bins on each side of the boundary and each bin is represented by a dot. The lines overlaid on the dot represent the best linear fit on each side of the boundary.

at the partition boundary, except for female desired fertility. In the next subsection, we test for a discontinuity formally using regression analysis.

6.2 RD Regressions

Estimates of β in Equation 1 are presented in Table 2. We report the analysis using BFAB (Panel A) and DHS (Panel B). Odd-numbered columns report the estimates for all ethnicities while even-numbered columns report those for the sample in Mossi land.[17]

In both datasets, all estimates show a significant, negative effect on fertility behaviors. Specifically, columns (1) and (2) show that in areas exposed to forced labor migration during colonial times, the annual probability of giving birth is reduced by about 0.01 to 0.03 percentage points relative to areas not exposed (with p-values below 0.1 in all 4 specifications and below

[17] We use a dummy for *residing in historical Mossi homeland* rather than self-reported ethnicity to identify populations most affected, but our results are robust to using self-reported Mossi ethnicity instead, as shown in Appendix B.

Table 2: Effects on fertility

	Annual birth rate		Total births		Completed fertility		Desired fertility (Men)		Desired fertility (Women)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
Panel A: BFAB sample										
Exposed (CIV)	-0.011*	-0.016**	-0.209***	-0.234**	-0.491**	-0.640***	-1.280**	-1.441**	-0.260	-0.221
	(0.006)	(0.008)	(0.079)	(0.093)	(0.202)	(0.236)	(0.520)	(0.638)	(0.330)	(0.359)
Mean DV (Control)	0.294	0.290	4.819	4.790	7.512	7.334	10.493	10.298	7.511	7.154
Observations	81,022	59,395	13,278	9,771	3,164	2,480	2,251	1,614	5,481	4,113
Clusters	140	107	140	107	140	107	140	107	140	107
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: DHS sample										
Exposed (CIV)	-0.023**	-0.029***	-0.206*	-0.303**			-0.425	-1.405*	-0.255	-0.496
	(0.010)	(0.011)	(0.111)	(0.134)			(0.580)	(0.717)	(0.249)	(0.304)
Mean DV (Control)	0.315	0.327	4.172	4.156			7.932	7.756	6.944	6.660
Observations	33,842	20,796	5,440	3,373			1,603	906	4,915	2,991
Clusters	186	108	186	108			185	108	186	108
Bandwidth	70.00	70.00	70.00	70.00			70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: BFAB (Panel A) and DHS (Panel B). The table reports the estimates of β in Equation 1, i.e. RD estimates of the effects of exposure to colonial forced labor migration using a pre-determined bandwidth of $70km$ around the boundary Côte d'Ivoire-Niger. Each cell corresponds to a separate regression and shows the coefficient on a dummy equal to 1 if the respondent lives in the portion of Burkina Faso historically assigned to Côte d'Ivoire (exposed to forced labor migration) and equal to 0 if the respondent lives in the portion of Burkina Faso historically assigned to Niger (less exposed to forced labor migration). All regressions include a local linear specification estimated separately on each side of the boundary. Controls include the respondent's age, age squared, and the distance between the respondent's village and the capital city (Ouagadougou). In even-numbered columns, the analysis is restricted to the ancestral ethnic homeland of the Mossi group. Panel A reports coefficients using BFAB with a donut specification that excludes observations within $1km$ of the boundary. Panel B reports coefficients using DHS with a donut specification that excludes observations within $5km$ of the boundary. The dependent variables are realized and desired fertility, defined as follows. In columns (1) and (2): annual birth rate of women aged $18 - 40$ is reconstructed for every year in the last 10 years preceding the survey using retrospective birth histories. In columns (3) and (4): total births measures the total number of children ever born at the time of the survey for all women. In columns (5) and (6): completed fertility is the total number of children ever born for women older than 45 y.o. We cannot study this outcome using DHS data because there are too few women in this age category. Desired fertility measures the ideal number of children reported by men in columns (7) and (8) and by women in columns (9) and (10). The unit of analysis is woman × year in columns (1) and (2) and the individual in columns (3) to (10). The mean dependent variable (DV) shows the average on the Niger side of the boundary, within the bandwidth. Standard errors clustered at the village level are reported in parentheses. ****p<0.01, **p<0.05, *p<0.1.*

0.05 in three of them). This represents a decrease by 4 to 10% relative to the control mean, which is equal to 0.3 (one birth every 3.5 years). After 10 years of reproductive life, which is the average in the sample of columns (3) and (4), the difference cumulates to 0.2 to 0.3 births. At the end of their reproductive lives, exposed women have 0.5 to 0.6 fewer children, as shown in columns (5) and (6), compared to a mean of 7.5 children among women not exposed.

Columns (7) to (10) consider fertility preferences. The signs of the estimates are consistent with a reduction in desired fertility, with both men and women from exposed villages preferring to have fewer children, though the effect is only statistically significant for men in Mossi areas: men in Mossi land report wanting 1.4 fewer children, from a base of 10.3 in BFAB and 7.8 in

DHS. For women, the magnitude of the drop in family size is a bit smaller than the effect on realized fertility itself (between 0.2 and 0.5 children) but imprecisely estimated. This suggests that the decline in actual fertility is most likely driven by a change in men's preferences.

Estimates tend to be larger when we restrict the sample to the Mossi land. But they are never significantly different from estimates in the whole sample. This indicates that the identification in the specification with all ethnic groups and ethnicity fixed effects mainly comes from variations within the Mossi land, as intended. The estimates are consistent in sign and within each other's confidence intervals across the two datasets, BFAB and DHS. This is remarkable given that the two datasets were collected at different time periods, covered different areas, and used different sampling strategies.[18]

Appendix B.2 presents and discusses robustness with respect to (i) alternative RD parameters (bandwidths, polynomials, controls, sample selections, estimation methods) and (ii) spatial autocorrelation. We also show how stable the results are across DHS survey waves (see Figure B1) and how the results are unchanged when using actual mossi ethnicity instead of mossi homeland residence. Overall, the finding that fertility is *lower* on the side of Burkina Faso historically more exposed to forced labor migration is extraordinarily robust. This was quite surprising to us, as we went in this research project with the prior, just like Mbacké, that we may find a positive, not negative, effect on fertility.

6.3 Additional evidence using other partition boundaries

To rule out any specificity of the Côte d'Ivoire side (stemming, e.g., from differences in other colonial policies across partitioned areas), this subsection exploits additional natural experiments using other cercle boundaries.

Placebo analysis. We start with a placebo test at the Côte d'Ivoire–French Soudan partition boundary (the dashed brown line in Figure A2). Both areas were similarly exposed to forced labor migration during colonial times, and migration flows oriented to French Soudan during the partition were redirected towards Côte d'Ivoire after the partition. Therefore, any long-run impact of forced labor migration on today's fertility should be at play in the same way on the

[18] These differences can explain why the control mean is not always the same across the two datasets. In particular, the desired fertility question is asked to all men in DHS and only to married men in BFAB. Married men tend to report much higher desired fertility than unmarried ones.

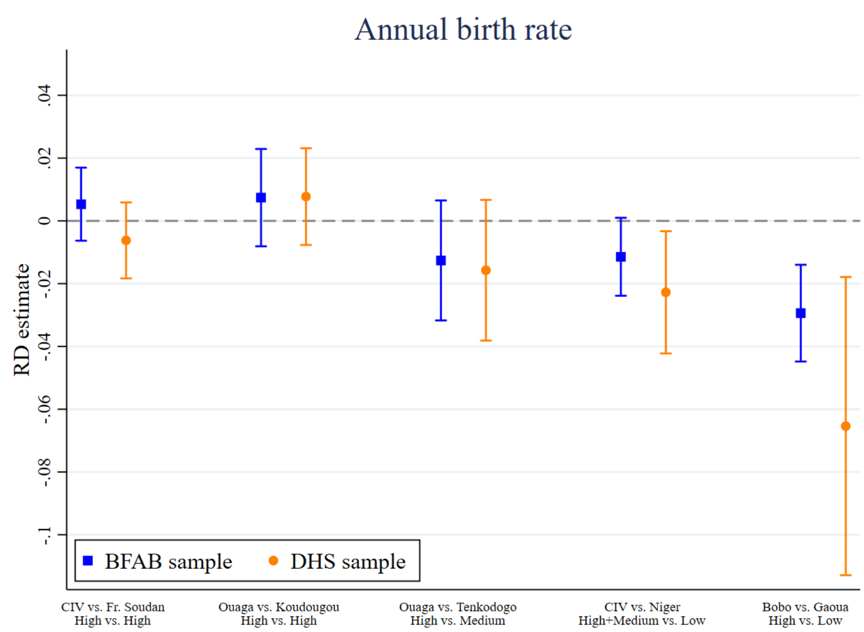
French Soudan side as on the Côte d'Ivoire side, and we expect no discontinuity in fertility outcomes at this historical boundary. On the contrary, if the discontinuity at the historical Côte d'Ivoire–Niger boundary is driven by other policies specific to cercles assigned to Côte d'Ivoire during the partition, we should observe the same discontinuity in fertility outcomes at the Côte d'Ivoire–French Soudan boundary.

Figure A7 plots the same graph as Figure 4 but using the placebo Côte d'Ivoire-French Soudan partition boundary. The graph shows no discontinuity. This is confirmed in the regression analysis in Table A2, which estimates a version of Equation 1 where the dummy *Exposed* is equal to 1 for villages inside the portion of Burkina Faso temporarily assigned to Côte d'Ivoire and equal to 0 for villages inside the portion temporarily assigned to French Soudan during the partition. Distance variables, fixed effects, and bandwidths are defined with respect to the Côte d'Ivoire-French Soudan boundary. The estimated effects at the placebo boundary show no systematic pattern—they are typically small and not significant (with 2 exceptions out of 18), of varying sign depending on the outcome, and not always consistent between the two datasets, even though we have more observations and therefore more power to detect an effect at this placebo boundary. This strongly suggests that the discontinuity at the Côte d'Ivoire-Niger partition boundary cannot be explained by a "Côte d'Ivoire effect".

Variations across cercles within the Côte d'Ivoire side of the partition. We also exploit the variation across cercles *within* the Côte d'Ivoire side of the partition. Our classification (summarized in Figure A1) generates three possible natural experiments within Côte d'Ivoire: (i) high-low boundary (Bobo Dioulasso vs. Gaoua) where we expect a large effect on fertility; (ii) high-medium boundary (Ouagadougou vs. Tenkodogo) where we expect a smaller effect; and (iii) high-high boundary (Ouagadougou vs. Koudougou) where we expect no effect. If we find that the magnitude of discontinuities in fertility outcomes is systematically related to differences in exposure to forced labor migration across several cercles, this is evidence against a confounding policy at the cercle level.

The estimated effects on annual birth rates using these different natural experiments are shown in Figure 5. Estimates using BFAB are shown in blue while estimates using DHS are shown in orange. For ease of comparison, we also plot the estimates previously obtained using the main partition boundary of interest between Côte d'Ivoire and Niger (high/medium vs low exposure) and the placebo partition boundary between Côte d'Ivoire and French Soudan (high vs high exposure). Within the portion of Burkina Faso assigned to the colony of Côte d'Ivoire, the patterns of the estimates are broadly in line with what we expect: zero effect in the high versus high boundary, a large negative effect in the high versus low boundary, and something in-between in the high versus medium boundary. We conclude that there is a systematic negative relationship between exposure to forced labor migration in the past and fertility today.

Figure 5: Effects on fertility exploiting multiple historical boundaries



Note: Source: BFAB (blue) and DHS (orange). The figure shows the estimates of β and their 95% confidence intervals in a generalized version of Equation 1 using various historical boundaries. The dummy *Exposed* now indicates the side of the boundary with the highest exposure to forced labor migration. We order the estimates on the x-axis depending on the difference in exposure to forced labor migration on both sides. On the left, both sides at the boundary between Côte d'Ivoire (CIV) and French Soudan (our main placebo boundary) and at the boundary between Ouagadougou and Koudougou (both within Côte d'Ivoire) had high exposure. In the middle, one side at the boundary between Ouagadougou and Tenkodogo (both within Côte d'Ivoire) had a high exposure and the other had a medium exposure; one side at the boundary between Côte d'Ivoire and Niger (our main boundary of interest) had a medium exposure and the other had a low exposure. On the right, one side at the boundary between Bobodioulasso and Gaoua (both within Côte d'Ivoire) had a high exposure and the other had a low exposure.

6.4 Validity of the RD design

The coefficient β in Equation 1, estimated at -0.5 children for women with completed fertility (Table 2), captures the local average effect of exposure to colonial forced labor migration under the assumption that potential outcomes are continuous at the boundary. In this subsection, we discuss potential violations related to events occurring before, during, and after colonial times.

Before the colonial period. An important concern relates to the potential endogenous placement of the boundary. The continuity assumption would be violated if the Côte d'Ivoire–Niger partition boundary was drawn according to characteristics that matter for outcomes today. Qualitative evidence from history scholars suggests that borders of colonial Burkina Faso and the subdivisions in cercles were decided on a military basis, following the conquests of various army officers (Royer, 2021). Importantly, they do not coincide with ethnic homelands, as shown in Figure 1. Moreover, the boundary consists of several straight line segments, suggesting that the boundary was, to some extent, artificially drawn on a map without taking into account realities on the ground.

To further rule out the threat of endogenous placement of the boundary, we test for discontinuities in precolonial factors that could potentially affect contemporaneous fertility outcomes. To this end, we augment our data with geographical and environmental information measured at a fine level. We divide Burkina Faso into pixel units of $12km \times 12km$. For each pixel, we rely on various sources described in Appendix C to collect information on the following variables: elevation, precipitation, soil suitability for agriculture, and population density in $1924 - 26$. In Table A1, we estimate a variant of Equation 1 with this pixel-level dataset, re-weighting each pixel according to the number of observations in BFAB (Panel A) and in DHS (Panel B).[19] First, in columns (1) to (6), we look at geographical and environmental variables such as elevation, precipitation, and soil suitability for agriculture. We find no systematic, substantial discontinuities at the border. The coefficient on elevation is statistically significant with the DHS sampling weights but the magnitude is small (20 meters or 7% of the control mean). Burkina Faso is a flat country and most environmental differences are driven by latitude, which is why we control for boundary segment fixed effects. Second, we look at population density at the time when cercles boundaries were drawn.[20] We construct a proxy of population density using the AOF maps from 1924-1926: we divided the maps into pixels and counted the number of cities per pixel. The assumption is that cities on colonial maps indicate relatively dense

[19]See notes below Table A1 for more details on the specification.

[20]De la Croix and Gobbi (2017) show that population density is related to fertility in Sub-Saharan Africa today. In terms of magnitude, our fertility effect (0.5 children) would be associated with a rise in density at the boundary from 10 to 700 inhabitants per square kilometer. We do not observe such ample variations within our bandwidth; the only outlier in terms of population density is the central province (around Ouagadougou) which is beyond the $70km$ buffer.

places. As shown in columns (7) and (8), we find no significant discontinuity at the boundary.

During the colonial period. There are two potential concerns: selective sorting around the boundary and other policies defined at the cercle level.

First, selective sorting could be a threat in our context if (i) there were permanent migratory movements out of the cercles on the Côte d'Ivoire side of the boundary (Kaya and Tenkodogo) to the cercles on the Niger side (Fada and Dori) or to neighboring Ghana, in order to escape forced labor migration; (ii) migrants were selected in the sense that they had higher desired fertility than non-migrants; (iii) these fertility preferences were transmitted across generations and persisted until today. Annual reports by colonial administrators document that Burkinabe households indeed tried to relocate to cercles with lower rates of forced labor. However, these movements were limited because administrators claim they were able to identify defectors (since every adult had to pay a head tax every year) and return them to their cercle of origin. We found some estimates suggesting that the magnitude of successful relocations was small. For example, the 1930 annual report for the cercle of Kaya lists $2,544$ adults (out of a total population of over $250,000$) as having relocated permanently to a new cercle, $1,911$ of which had relocated to Fada or Dori, two cercles not subject to recruitment for Côte d'Ivoire.[21] Given these small magnitudes, we consider that the selection on fertility preferences would have to be implausibly high, and the persistence over time implausibly strong, to generate a difference of 0.5 children several decades later.

Nevertheless, there was some form of out-migration from the areas more exposed to forced labor migration (especially Tenkodogo): young men fled to present-day Ghana, Gold Coast at the time, under British colonial rule (see Asiwaju (1976) for a discussion of "migration as revolt"). In contrast with the French colonial administration, the British did not impose much forced labor in its African colonies, and they abolished it completely in 1927. The head tax was also lower in Ghana, and thanks to the rapidly growing cocoa, forests, and gold mining industries, the demand for labor was high. Young Burkinabe men were thus both pushed away from Burkina Faso by the threat of coerced, poorly paid labor with bad working conditions; and pulled towards wage employment in Ghana.[22] This exodus to Ghana potentially reinforces

[21] Abidjan Archives, Serie Haute Volta #5069. While it is possible that French administrators chose to downplay this issue in reports, it seems unlikely since they had no qualms admitting defections to Ghana were very common as we discuss below.

[22] In a 1931 report to the Governor-General on the "depopulation of the Mossi", the administrator for Haute

the mechanism proposed in section 7: a change in the economic activity of young men.[23]

Second, in order to isolate the effect of forced labor migration, we need to assume that there was no other colonial policy which (i) would be differently implemented in Kaya and Tenkodogo (Côte d'Ivoire side) on the one hand, and in Fada and Dori (Niger side) on the other hand, and (ii) would have a persistent effect on fertility. We already noted that other forms of forced labor (military conscription and *corvées*) were similarly implemented across cercles (see Table 1). Another important confounder could be missionary activities since a recent literature has documented the long-term effect of exposure to Christian missions on fertility outcomes (Guirkinger and Villar, 2022; Okoye and Pongou, 2023). In the case of Burkina Faso, missionary activities were extremely limited compared to coastal areas of Africa or the Democratic Republic of Congo. We found no Christian missions on the $1924-1926$ maps of colonial Burkina Faso. In 1955, the directory of Catholic missions in French African colonies indicates that only a few basic and temporary juridictions were operating in Haute Volta.[24] One way to test for differential exposure to missions is to look at religion. In Table A3, we show that the proportion of Muslims is not significantly different across sides of the partition boundary. Finally, a potential channel of persistence is that former missions were later used as health centers providing reproductive health services (Guirkinger and Villar, 2022). If our negative effect on fertility was confounded by exposure to missions, we would expect to observe an increase in contraceptive use. Table A7 shows this not the case, as discussed in section 7.

After the colonial period. The concern is that current administrative units may coincide with the former cercles and implement different policies susceptible to affect fertility. This concern is mitigated by the fact that administrative units changed after independence. On Figure A8, we show the borders of current provinces and boundaries of historical cercles. The number

Volta Fournier noted: "[...] in areas closer to the boundaries of the Tenkodogo and Ouagadougou cercles, any recruitment attempt leads to migrations, at least temporary, to the Gold Coast. [...] The seasonal movement to the Gold Coast would therefore absorb 55 to 60,000 Mossis each year." Archives Nationales de l'OAF a Dakar, côte K-26-121.

[23] As discussed in subsection 7.1, we do not see any persistence of circular migration to Ghana in present day. However, it seems plausible that the flows were partly redirected to Côte d'Ivoire. As noted by de Haas and Travieso (2022, p.233), "During the 1960s, the center of cocoa production and labor migration shifted from Ghana to southern Côte d'Ivoire". They document that, in Ghana's regions growing cash crops, the number of African migrants coming from outside the British empire decreased from 133,654 in 1931 to 54,939 in 1948. This is partly explained by the fact that the wage gap relative to Burkina Faso vanished in Ghana after 1945 whereas it persisted in Côte d'Ivoire.

[24] Four *vicariats apostoliques* and one *préfecture apostolique*. We thank Catherine Guirkinger for sharing the directory with us.

of provinces is much higher than the number of cercles: 45 against 12. The historical cercle boundaries tend to cut through provinces. Moreover, Burkina Faso has a centralized governance and most policies are implemented at the national level.

To check whether the *de facto* implementation of policies is differential across administrative units in a way that would confound historical legacies of forced labor migration, we show on Figure A8.A the number of technical services and public projects and programs established between 2017 and 2019 at the province level. The historical cercles boundaries are overlaid in red. The map shows heterogeneity across areas of Burkina Faso, but this heterogeneity appears orthogonal to historical boundaries. Figure A8.B shows data on the onset of a free family planning policy across health facilities, as measured in the BFAB data.[25] Again, there is no clear relationship between today's speed of implementation and historical boundaries.

Finally, as described in section 7, we find very peculiar empirical patterns. There is an effect on some variables typically associated with structural change, like family size and occupation, but no effect on others like human and physical capital. Any potential omitted variable should explain both sets of results.

7 Mechanisms

In this section, we provide an explanation for the systematic negative relationship between exposure to forced labor migration in colonial times and fertility today. First, we present evidence that the spatial variation in temporary male labor migration persisted over time. Second, we describe the contextually most plausible causal chain from labor migration to lower desired fertility. Third, we provide empirical support for each step in the causal chain. Fourth, we discuss potential alternative mechanisms relating temporary male migration and fertility.

7.1 Persistence channel: temporary male migration

We argue that the main persistence channel is temporary male migration. The transition from forced labor to circular migration has been described by demographers. Using a national migration survey conducted in $1974-75$, Coulibaly et al. (1980, p. 35) estimate that 17.1% of

[25]Due to the insecurity in Burkina Faso from 2019 onward, the BFAB project was unable to collect this information from all facilities, hence the paucity of points along the Kaya-Fada boundary.

males are reported as temporary emigrants in Mossi rural areas. The fraction is only 6.7% in rural areas located east of the Mossi land. This difference is consistent with the Mossi's strong exposure to forced labor migration discussed in section 2.

In Table 3, columns (1) and (2), we use the DHS question *"How many times have you been away from home in the past 12 months?"*. On the Niger side of the boundary, the average among men older than 15 years old is 1.5. The RD coefficient is equal to 1.4, significant at 5%, implying that temporary migration is close to twice as frequent on the Côte d'Ivoire side of the partition boundary (column 1). The coefficient remains stable in magnitude and precision when we restrict the sample to the Mossi (column 2). We can also use the LSMS data to know where

Table 3: Effects on temporary migration

	Time away from home (DHS)		Lived in CIV (LSMS)		Lived outside BF and CIV (LSMS)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)
Exposed (CIV)	1.359**	1.261***	0.088***	0.154***	0.004	-0.004
	(0.611)	(0.454)	(0.026)	(0.030)	(0.007)	(0.007)
Mean DV (Control)	1.534	0.685	0.062	0.036	0.011	0.007
Observations	1,181	617	1,117	644	1,117	644
Clusters	129	71	60	34	60	34
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓				
Ethnicity FE	✓	✓				
Year FE	✓	✓	✓	✓	✓	✓
Controls	✓	✓				

Note: Source: DHS (columns 1 and 2) and LSMS (columns 3 to 6). Columns (1) and (2) report the estimates of β in Equation 1 (see Table 2 notes for more details on the specification). Columns (3) to (6) report the estimates of β' in Equation 2. β' represents the difference in the mean dependent variable between the two sides of the boundary, within the bandwidth, controlling for the wave of the LSMS survey (2018 or 2019); we cannot estimate Equation 1 due to the small number of clusters in the LSMS data. The dependent variable is temporary migration, measured for men older than 15 y.o., defined as follows. In DHS data, columns (1) and (2): *"How many times have you been away from home in the past 12 months?"*. In LSMS data: in columns (3) and (4), probability that the respondent has ever lived in Côte d'Ivoire; in columns (5) and (6), probability that the respondent has ever lived outside Burkina Faso but not in Côte d'Ivoire.

these men go. Men surveyed on the Côte d'Ivoire side of the boundary are significantly more likely to have lived in Côte d'Ivoire at some point, by 9 percentage points (Table 3 column 3). The gap increases to 15 percentage points and remains significant at 1% when we look within the Mossi homeland (column 4). There is no significant difference in the probability to have lived somewhere else. Columns (5) and (6) look at the probability to have lived outside Burkina Faso but not in Côte d'Ivoire: the control means and the coefficients are all very small. Thus, foreign migration in this context boils down to migration to Côte d'Ivoire.

Each data set has its limitations. However, taken together, the results strongly suggest that forced labor migration in colonial times led to circular migration today. Each outcome comes from a different survey and measures migration in a different way; and yet, they all point to the same conclusion, in line with accounts from historians and demographers.

7.2 Theory of change

Circular migration can lead to lower fertility through several paths. Our preferred explanation focuses on child labor. The theory we propose is consistent with the effects on remittances, occupation, and needs for family labor, as well as *the lack of* effects on human and physical capital that we document in the next sections.

The traditional Mossi household consists of a male head, his wife or wives and their children, as well as single male relatives. These men are typically younger brothers or nephews, who act as "family helpers" until they get married and start their own household (Remy, 1977, p. 12-14). In economies based on subsistence farming, they work on the fields controlled by the household head. Livestock activities are limited to small animals reared on the family concession. Very few people sell their labor on the market in these villages, farming is done within the family. When external employment opportunities arise, family helpers go and work outside the village for some time, send part of their income to the household head, and later return to get married. Those individuals who participate in circular migration belong for the most part to the social group of family helpers.

We hypothesize that remittances inflows reduce the reliance on agriculture for households in the village. Their food consumption is no longer limited to what they produce. This, in turn, reduces the marginal value of farm labor in general and child labor in particular. When weighting the costs and benefits of having another child, couples are more likely to stop. To sum up, we argue that couples have incentives for large families when (i) subsistence farming is the main economic activity, (ii) labor is the main factor of production, and (iii) farming is done by family members, including children.[26]

Formally, we can model our intuition as follows. The household head maximizes the utility of the couple in a unitary framework. The utility has two parts: food consumption and health costs of bearing children. The head chooses the number of children n to maximize:

$$u(n) = log(A + bn) - cn$$

Where b is the monetary benefit per child and c is the non-monetary (health) cost per child. A is the adult income controlled by the head. In economies based on subsistence farming, $f = A + bn$ represents how much food is produced by family members and children, net of what they consume. In this toy model, at very low levels of adult income (as long as $A < \frac{b}{c}$), the optimal number of children is $n^* = \frac{1}{c} - \frac{A}{b}$ and the optimal food consumption is $f^* = \frac{b}{c}$. An increase in A reduces the optimal number of children and leaves food consumption unchanged.

In this set-up, couples have children in order to reach a given level of food consumption. Each pregnancy is costly due to high maternal mortality and morbidity. People are willing to incur these health costs because, at very low levels of food consumption, the marginal utility of consumption is extremely high. When paid work opportunities raise adult income, couples need fewer children to reach subsistence levels.

Our argument is similar in spirit to Basu and Van (1998) who explain that parents send their children to work out of necessity, not out of greed. When adult income is very low, parents alone cannot feed the family; they need children's wages. When adult income increases, the main response is reducing child labor rather than increasing consumption. In their framework, the number of children is exogenous and parents choose whether children work. In our framework, parents have no incentives to have children if they do not work; this is obviously a simplification to focus on the core argument.

Our model considers that children provide a monetary gain to their parents at a non-monetary cost. This stands in contrast with standard family economics models, which assume that children provide a non-monetary gain to their parents at the expense of a monetary cost. To get a negative correlation between fertility and income, these models incorporate a quality-quantity tradeoff and/or female opportunity cost of time. They are a powerful tool to account for empirical regularities in rich countries in the twentieth century (Doepke et al., 2022). However,

[26] This argument has been extensively developed by Singh (1988).

they are not suitable in our context. First, the exogenous shock we are considering is on male work opportunities, not on female ones, so the female opportunity cost of time is not at play. Second, we find no evidence that the reduction in the number of children is associated with an increase in the “quality”, proxied by education and health.

7.3 Empirical evidence

Our theory of change can be summarized by the following causal chain: exposure to forced labor leads to (a) temporary male migration, (b) remittances inflows, (c) less reliance on agriculture, (d) lower needs for child and family labor, and ultimately (e) smaller optimal family size. We showed evidence for link (a) in subsection 7.1. In this subsection, we describe a series of empirical tests supporting links (b), (c), and (d).

Remittances. Table 4 uses LSMS data and shows that households exposed to forced labor migration receive more international remittances today.

Table 4: Effects on international remittances

	Total remittances		Received remittances dummy		Log total remittances		Sender lives in CIV	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)
				LSMS sample				
Exposed (CIV)	26.497***	15.889**	0.184***	0.185***	0.257	-0.571**	0.127***	0.177***
	(6.212)	(6.760)	(0.036)	(0.051)	(0.343)	(0.256)	(0.035)	(0.055)
Mean DV (Control)	5.219	8.393	0.066	0.083	10.879	11.275	0.061	0.071
Observations	720	408	720	408	131	82	720	408
Clusters	60	34	60	34	43	27	60	34
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE Ethnicity FE Year FE Controls	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: LSMS. This table reports the estimates of β' in Equation 2. β' represents the difference in the mean dependent variable between the two sides of the boundary, within the bandwidth, controlling for the wave of the LSMS survey (2018 or 2019); we cannot estimate Equation 1 due to the small number of clusters in the LSMS data. The dependent variables are international remittances, measured at the household level, defined as follows. In columns (1) and (2): total amount of remittances received last year, expressed in thousands of francs CFA (FCFA, 1 euro=656 FCFA). In columns (3) and (4): a dummy for receiving remittances last year. In columns (5) and (6): the log of total amount of remittances received last year. In columns (7) and (8): a dummy indicating whether at least one sender of remittances lives in Côte d'Ivoire.

Households on the Côte d'Ivoire side receive an extra 26K FCFA per year compared to an average of 5K on the Niger side (column 1). The coefficient is significant at 1%. The magnitude is smaller for the Mossi: an extra 16k FCFA from a mean of 8K (column 2). The difference between the two sides of the boundary comes entirely from the extensive margin: households are 18 percentage points more likely to receive at least one transfer (columns 3 and 4). Conditional on receiving a transfer, the amount is no larger (column 5) and even significantly smaller when we focus on the Mossi (column 6). Therefore, the possibility to send someone abroad seems to matter more than the quality of the move. Consistently with the hypothesis of persistent migration networks, the vast majority of the additional senders live in Côte d'Ivoire: we get very similar estimates for international remittances (columns 3 and 4) and remittances *from Côte d'Ivoire* (columns 7 and 8).

Do these magnitudes make sense? Households in villages exposed to forced labor migration receive 26K FCFA more every year. This is equivalent to roughly 40 euros. Remember that these households also have, on average, 0.5 fewer children. Using the toy model above, we can recover the monetary benefit that parents derive from a child: $b = \frac{A_{CI} - A_{Niger}}{n_{CI} - n_{Niger}} = \frac{40}{0.5} = 80$ euros per year. We believe that the order of magnitude is plausible compared to an annual GDP per capita of roughly 800 euros. The benefit should be (i) large enough to matter in couples' fertility decisions and (ii) an order of magnitude smaller than the average income given that b captures the *net* monetary benefits to parents.

Reliance on agriculture. The second series of tests focuses on the modes of production in the LSMS data. Results are presented in Table 5. Adults on the side temporarily assigned to Côte d'Ivoire are not significantly less likely to report agriculture as their main occupation (this is a predominantly rural area with a mean of 82% on the Niger side, column 1), but they are 8 percentage points more likely (p-value $\leq$.05) to spend some time doing trade or market services compared to a mean of 8% (column 3). As for children, while 60% of those aged 5 to 17 years old are working in the fields on the Niger side, the fraction is 13 percentage points lower on the Côte d'Ivoire side (column 5, p-value$\leq$.05). When we restrict to the Mossi land (columns 2, 4, and 6), coefficients are less precisely estimated but are not significantly different from those in the main sample.

When we look at land-related activities, we see that households are 9 percentage points less likely to cultivate some land (column 7) whereas cultivating is quasi-universal on the Niger side. Conditional on cultivating, households cultivate smaller areas in per capita terms (column

9). Magnitudes are similar in the Mossi land and all coefficients are significant at conventional levels. All these results point to the fact that agriculture has a less crucial role in the rural economy on the Côte d'Ivoire side.

Table 5: Effects on reliance on agriculture

	Main occupation is agriculture (18-64)		Work for at least an hour in... Trade or market service (18-64)		Work for at least an hour in... Field (5-17)		Cultivated land		Log of p.c. cultivated land size	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
					LSMS sample					
Exposed (CIV)	-0.063	-0.040	0.081**	0.085	-0.133**	-0.088	-0.090**	-0.131*	-0.366***	-0.364**
	(0.045)	(0.077)	(0.033)	(0.057)	(0.055)	(0.071)	(0.040)	(0.072)	(0.108)	(0.154)
Mean DV (Control)	0.819	0.809	0.082	0.100	0.591	0.493	0.939	0.929	-1.016	-1.134
Observations	2,119	1,242	2,119	1,242	2,078	1,256	720	408	633	349
Clusters	60	34	60	34	60	34	60	34	59	33
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE										
Ethnicity FE										
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls										

Note: Source: LSMS. This table reports the estimates of β' in Equation 2. β' represents the difference in the mean dependent variable between the two sides of the boundary, within the bandwidth, controlling for the wave of the LSMS survey (2018 or 2019); we cannot estimate Equation 1 due to the small number of clusters in the LSMS data. The dependent variables are reliance on agriculture, defined as follows. In columns (1) and (2): whether the main occupation of the individual (men and women aged 18-64) is in agriculture. In columns (3) and (4): whether the individual (men and women aged 18-64) worked for at least one hour in trade or market services in the past week. In columns (5) and (6): whether the individual (boys and girls aged 5-17) worked for at least one hour in the fields. In columns (7) and (8): whether a member of the household has cultivated land in the previous year. In columns (9) and (10): log of total land size cultivated divided by total number of household members (sample restricted to households who cultivated some land in the previous year).

Need for child and family labor. The final link in the causal chain deals with the needs for family labor. Table 6 provides support in three ways. First, we use a question in BFAB eliciting the reasons behind people's fertility preferences. We asked: *"What would happen if you had fewer children than what you desire?"* The only significant differences in answers between the Côte d'Ivoire and the Niger sides of the temporary partition boundary are related to child labor: "*I would not have enough people to help on the farm*" and "*I would not have enough people to help at home*". Both men (columns 1-4) and women (columns 5-8) are less likely to give these answers on the side temporarily assigned to Côte d'Ivoire, by an order of magnitude of 6 to 16 percentage points. Magnitudes are very stable when we restrict to the Mossi land. This is consistent with the idea that adults spend less time in agriculture; they need less help from children in the fields and less help from children at home to substitute for adults working in the fields.

Second, in BFAB, we inferred the needs for family labor by asking the household heads whether they would have enough people in their current household to farm more land if they were suddenly given additional plots. If the answer is no, we consider that all household members are already working at full capacity, meaning that the labor constraint is binding. In columns (9) and (10), we show that households on the Côte d'Ivoire side are 10 to 11 percentage points less likely to be labor constrained (though the result is not significant when restricting to the Mossi land). In other words, they have more idle labor. This is consistent with the idea that the size of the household is less driven by productive motives.

Third, another way to look at this question is to study polygamy. In our context, women contribute substantially to agricultural activities. The main reason why men want to marry another wife is to help work the land (52% percent of male BFAB respondents say so).[27] If the needs for family labor on the farm are lower on the Côte d'Ivoire side, there should be less demand for second wives and therefore less polygamy. This is indeed what we find: men in the traditional Mossi areas are much less likely to be polygamous (column 12).

Note that the order of magnitude of the effect is remarkably consistent across Tables 3 to 6. When we look at extensive margins, we systematically find that exposure to forced labor migration raised the fraction of households who (a) have a migrant, (b) receive remittances, (c) move out of agriculture, and (d) need little family labor, by 8 to 20 percentage points. Let us suppose that 15% of the households are directly affected by our causal chain. The average reduction in completed fertility is equal to 0.5 child. This implies that "compliers" reduced their fertility by roughly 3 children, from 7.5 to 4.5, which is quite plausible (e.g., it is in line with the magnitude of fertility reductions observed in East Africa over the past two or three decades). Though this is likely an upper bound because, in practice, other households may be indirectly affected. Indeed, in our context, households in a village are interconnected. Some of them are part of the same extended family and form large units of production. They may share part of the remittances or take turn in sending migrants. Therefore, the share of compliers is probably larger than 8-20%.

[27] See also Singh (1988, p. 18): "The demand for the number of wives is essentially a derived demand from a) the household's demand for wife's own labour services as farmworker, and b) the household's demand for child quantity which eventually provides another valuable source of labor."

Table 6: Effects on needs for child and family labor

	I would not have enough people to...											
	Help on the farm (BFAB Men)		Help at home (BFAB Men)		Help on the farm (BFAB Women)		Help at home (BFAB Women)		Labor constrained to expand farm (BFAB)		Man is polygamous (DHS)	
	All	Mossi land	All	Mossi land	All	Mossi land	All	Mossi land	All	Mossi land	All	Mossi land
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Exposed (CIV)	-0.056**	-0.056*	-0.082**	-0.084*	-0.108***	-0.114***	-0.148***	-0.161***	-0.104*	-0.115	-0.080	-0.217**
	(0.027)	(0.032)	(0.038)	(0.048)	(0.028)	(0.030)	(0.027)	(0.025)	(0.055)	(0.076)	(0.062)	(0.090)
Mean DV (Control)	0.112	0.112	0.181	0.204	0.140	0.148	0.225	0.240	0.404	0.418	0.290	0.343
Observations	1,990	1,457	1,990	1,457	3,856	2,878	3,856	2,878	20,631	15,174	1,177	697
Clusters	140	107	140	107	140	107	140	107	140	107	185	107
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: BFAB (columns 1 to 10) and DHS (columns 11 and 12). See Table 2 notes for more details on the specification. The dependent variables are needs for child and family labor, defined as follows. In columns (1) to (8): we use the question in BFAB *"What would happen if you have fewer children than what you desire?"*. Columns (1) to (4) report answers by husbands and columns (5) to (8) report answers by wives. In columns (9) and (10): we use the question in BFAB *"If your farm was bigger, would your family have enough labor available?"*. If the answer is negative, we define the household as labor-constrained to expand farm activity. In columns (11) and (12): we use a dummy indicating whether the household head is polygamous.

Heterogeneity by labor intensity of food production. If our theory of change is correct, the effect should be larger when labor is initially the main factor of production. We use the measure developed by Fontenay et al. (2023) to determine the relative importance of labor and land in food production, depending on the type of soil. The idea is that soil characteristics determine the type of crops that farmers can cultivate, and different crops require different hours of work in order to yield the same calories per hectare. In particular, cereals, such as sorghum, have higher labor input requirements than roots and tubers, such as yam. Fontenay et al. (2023) create an index summarizing the difference in potential yields of cereals vs. roots and tubers in Africa.[28] In Table A4, we split the DHS sample at the median value of this index in Burkina Faso and we estimate the RD coefficient separately in areas where the soil is relatively better suited for crops with low labor requirements (Panel A) and for crops with high labor requirements (Panel B). The discontinuity in fertility outcomes is only detected in high labor areas. In areas where labor is less vital for food production, the inflow of remittances has no effect on fertility.[29]

7.4 Alternative mechanisms

The vast literature on migration has proposed several mechanisms that could potentially lead to lower fertility. In this section, we consider them one by one and show they are rejected by the data.

Human capital. In other contexts, temporary labor migration has been shown to increase education in communities of origin (e.g., Yang (2008) in the Philippines and Dinkelman and Mariotti (2016) in Malawi). This could affect fertility through the quality-quantity tradeoff or through changes in mothers' preferences. However, we find no evidence supporting an increase in education in our context (see Table A5). The vast majority of respondents have never attended a formal school: this is the case for 92% of adult women, 89% of adult men,and 60% of children aged 6 to 15 years old in the BFAB sample. Proportions are very similar in the DHS sample, except for children (82%) because this sample also includes less recent waves. Importantly, there is no significant difference across the two sides of the boundary; the magnitudes are small

[28] We are very grateful to Paula Gobbi and her co-authors for sharing their methodology and data with us.

[29] Note that the average fertility is slightly lower in high labor areas than in low labor areas. We would expect the opposite if the need for child labor was the only difference between the two groups. This is not the case: the suitability index is positively correlated with other measures of development, such as road density and access to hospitals, which are themselves correlated with lower fertility.

and the signs vary across samples.

One explanation for the lack of effect is that circular migration to Côte d'Ivoire did not change the returns to education. Migrants typically perform low-skilled agricultural tasks. Education is not a requirement to participate in migration flows and does not raise income at destination (Wouterse and Taylor, 2008). In columns (1) to (4) in Table A6, we study health outcomes. We find no effect on child mortality. There is a small effect on the food insecurity score: households on the Côte d'Ivoire side are less likely to be classified as severely food insecure, and more likely to be classified as food secure (columns 5 and 6). We interpret this as evidence that remittances are primarily spent on food.

Physical capital. Recent studies have also argued that temporary labor migration can lead to the structural transformation of sending economies in the long run (e.g., Khanna et al. (2022) in the Philippines and Dinkelman et al. (2022) in Malawi). In particular, they show that the initial inflows of remittances can trigger the rise of high-skill and capital-intensive sectors, which contribute to substantial improvements in domestic income. In our context, even though we find that some households move out of farming, these sectoral shifts have a limited impact on the accumulation of capital. We create an asset index using a principal component analysis in the DHS data. Columns (7) and (8) in Table A6 show that households on the Côte d'Ivoire side do not own more productive assets; if anything, the coefficient are negative and imprecise. When we look at cattle, which can be considered as a form of savings in rural economies, we find no effect either (columns 9 to 12). The finding that temporary labor migration in West Africa is *not* associated with strong improvements in sending economies is consistent with earlier evidence (see review by Azam and Gubert (2006)).

Female empowerment. In the literature, temporary labor male migration has also been associated with female empowerment, in particular with the uptake of health care services and contraception (e.g., West et al. (2021) in Bangladesh and Libois et al. (2022) in Nepal). The idea is that the wives of migrants have more financial resources and more agency in the absence of their husbands. This could lead to a reduction in fertility through an improvement in women's ability to control births.

While *a priori* very plausible, this mechanism appears unlikely in our context for several reasons (see Table A7). First, most of the men participating in circular migration are not married yet. Once they get married, they become household heads and spend less time away. Around 6% of the households are headed by a woman and this share is not significantly higher on the side more exposed to forced migration (columns 1 and 2). Second, there is no evidence that migration is associated with higher contraceptive use; the coefficient is either zero or negative (columns 3 and 4). Third, we constructed standard indices of female participation in decision-making (columns 5 and 6), acceptance of domestic violence (columns 7 and 8), and experience of domestic violence (columns 9 and 10) using DHS questions. We systematically reject the hypothesis that women are more empowered in areas more exposed to forced migration.

Abstinence. Male temporary migration could lead to lower fertility through reduced female exposure to pregnancy risk, either by postponing the age at marriage or by lengthening abstinence periods for married couples. In Table A8 columns (1) and (2), we show that there is no systematic effect on age at first marriage for women. On both sides of the historical boundary, women are married at age 17 or 18 to older men, who have already spent some years working abroad or on the farm of their relatives. Next, we look at the effect on birth spacing, by birth rank. Participation in temporary migration decreases with age: Ouédraogo and Piché (2007, chapter 4, p.87-90) estimate that annual foreign emigration rates are equal to 4.9% between ages 15 and 29, 2.4% between ages 30 and 44, and 0.6% between ages 45 and 64. Therefore, the abstinence channel would predict a strong effect at the beginning of the marriage that would gradually disappear over time. We find, if anything, the opposite: In Figure A9, we plot the estimates of Equation 1 using the duration between (i) marriage and first birth, (ii) first and second birth, (iii) second and third birth, and (iv) third and fourth birth. If anything, the interval between marriage and first birth seems shorter on the Côte d'Ivoire side. Intervals become longer only after the first birth, and even more after the second birth (the only difference significant at 5%).

Marriage Market. Wage employment opportunities for young men may affect marriage markets, by allowing men to become economically independent at a younger age. This may change the pool of potential male partners in ethnic groups practicing bride prices. In Mozambique, Denton-Schneider (2022) finds that, in areas where men were historically allowed to migrate for work, men married earlier and fertility was *higher* in the following decades. We do not observe the same patterns in our context: Table A8 columns (3) and (4) show that, if anything, men's age at first marriage is higher on the Côte d'Ivoire side. This is consistent with historians' argument that the Mossi society remains dominated by elders, who control social relationships, in particular the organization of marriage (Remy, 1977; Boutillier et al., 1977b). Younger men are allowed to get married once they have sufficiently contributed to the lineage economy, either by supplying labor in the fields or by sharing their wage earnings.

Social norms. The literature on cultural remittances argues that migrants influence fertility preferences in their communities of origin by transmitting ideas and values that prevail in their communities of destination (see Beine et al. (2013) for cross-country evidence, Bertoli and Marchetta (2015) for a case study of contemporary Egypt, and Melki et al. (2023) for the diffusion of the fertility transition in the late 19th century in Europe). In our context, desired and realized fertility in Côte d'Ivoire are not very different from Burkina Faso: the average desired fertility for women aged 18 to 35 is close to 6 children and the average completed fertility for women older than 45 years old is close to 7 children. Moreover, an analysis of the distributions does not support the cultural remittances hypothesis. Figure A10 compares the distributions of desired and realized fertility in the community of destination (Côte d'Ivoire) and in the community of origin (the part of Burkina Faso temporarily attached to Côte d'Ivoire during the partition). The distributions are widespread in the community of destination and concentrated in the community of origin. In presence of cultural remittances, we would have expected the opposite: (i) homogeneous preferences and behaviors in the community of destination, indicating a strong social norm easy to observe for newcomers; and (ii) heterogeneous preferences and behaviors, possibly a bimodal distribution, in the community of origin, indicating the erosion of the previous norm and the gradual transition to a new ideal family size.

Composition effects. Even though most migrants return to their village of origin to marry and settle down at some point, some of them stay permanently in Côte d'Ivoire (Cordell et al., 1996). Composition effects may therefore generate a difference between the two sides of the boundary if two conditions are met: (1) the fraction of permanent migrants should be different; (2) permanent migrants should be systematically different from those who return and those who never leave. To test the first condition, we would need to follow migrants for a long time to observe whether they return or not. We have no data to do that.[30] It seems however plausible

[30] In Ivoirian censuses, there is no information on birth place of foreigners. In our datasets, there is no information on members who permanently migrated out of the household.

that the fraction of men who have permanently left the village is higher on the Côte d'Ivoire side, given that more men are migrating to start with.[31] The second condition cannot be tested because we would need to observe the counterfactual migrant if he had stayed/returned. We can only conjecture that individuals who choose to migrate permanently have a weaker preference for the traditional, rural lifestyle and a weaker bond with their kin. Therefore, the selection into permanent emigration would play against our results: on the Côte d'Ivoire side, only those with a taste for agricultural work and large families would choose to stay or return.

Finally, permanent emigration would imply less pressure on resources in the village. We would therefore expect to observe more land per capita and more women per man on the Côte d'Ivoire side. This is inconsistent with our results on cultivated land and polygamy.

Endogenous urbanization. Our analysis has focused on *rural* households. This is primarily due to a data constraint: the BFAB sample excluded urban areas by design. But if areas urbanized at a different rate across the two sides of the boundary, focusing on rural households could be misleading. If the mechanism we put forward (reduced reliance on agriculture thanks to remittances) led more households to urbanize, and fertility tends to be lower in urban areas, by focusing on rural households we may be *underestimating* the legacy of forced labor migration. On the other hand, if reliance on remittances from abroad desincentivized permanent migration to urban areas, then we may be overestimating the legacy of forced labor migration in rural areas. We test for this in two ways. First, in Figure A11, we test for any discontinuity at the historical partition boundary in terms of markers of urbanization: night light density and road density. This analysis is at the $6.2km$ x $6.2km$ pixel level. We do not see any discontinuity here either. What's more, the figure makes it clear that the boundary we are focused on is extremely rural. Second, we look at potential migration to pre-existing urban areas in Table A9. We see a positive, economically large but statistically imprecise impact of historical exposure to forced labor on urban residence, especially for the Mossi areas (columns 9 and 10). When re-estimating Equation 1 on the *full sample*, i.e., including urban respondents, we see patterns identical to those for the rural sample (columns 1-8 of Table A9)—if anything, they are somewhat stronger, suggesting that by focusing on rural areas we, if anything, underestimate the legacy of forced labor migration on fertility because we ignore one of the channels of impact.

[31] In East Africa, de Haas (2019) shows how circular migration of men from Ruanda-Urundi to Buganda eventually led to permanent migration of entire families.

8 Conclusion

This study presents evidence consistent with a reversal of fortune for the Mossi land.[32] Densely populated, the Mossi kingdoms drew the attention of French colonizers, who turned them into a major labor reservoir in West Africa. Hundreds of thousands of young, single, rural men were forced into temporary work for public or private entities in neighboring colonies. After independence, coffee and cocoa farm companies in Côte d'Ivoire kept exploiting migration networks to attract workers. Circular migration flows between rural areas historically exposed to forced labor and Côte d'Ivoire have persisted until today. The private sector played a key role in perpetuating these movements of labor, which suggests that focusing on the use of coerced labor in the public sector may underestimate the long-run impacts. Even though migrants send remittances, they do not seem to generate substantial economic improvements in villages of origin. This is different from what has been documented in other contexts, where migration started without coercion (Dinkelman et al., 2022; Khanna et al., 2022). An important avenue for future research is to understand how adverse initial conditions can trap individuals in low-return circular migration flows.

Despite limited impacts on human and physical capital, we find that circular migration leads to a decrease in family size. We argue that the diversification of income reduces the importance of family agriculture in ensuring food security, which in turn lowers the needs for child labor and the incentives for high fertility. We draw two conclusions. First, decisions on family formation can change if modes of production change. This suggests that differences in family types can at least partially be explained by differences in the economic environment–they are not merely the reflection of permanent cultural differences. Second, fertility in Africa today is influenced by complex, long-term processes shaped by colonial rule. So far, only a handful of studies have investigated the colonial origins of fertility behaviors (Canning et al., 2020; Okoye and Pongou, 2023; Guirkinger and Villar, 2022). We believe that this is a promising research avenue to advance our understanding of demographic transitions in Africa.

[32] In a recent paper focused on Morocco, Salem (2022) also finds evidence of a reversal of fortune for the colonized, but through a different channel: dispossession of fertile land due to colonial settlements, which prevented local populations from benefiting from the technological innovations and trade opportunities that settlers brought with them.

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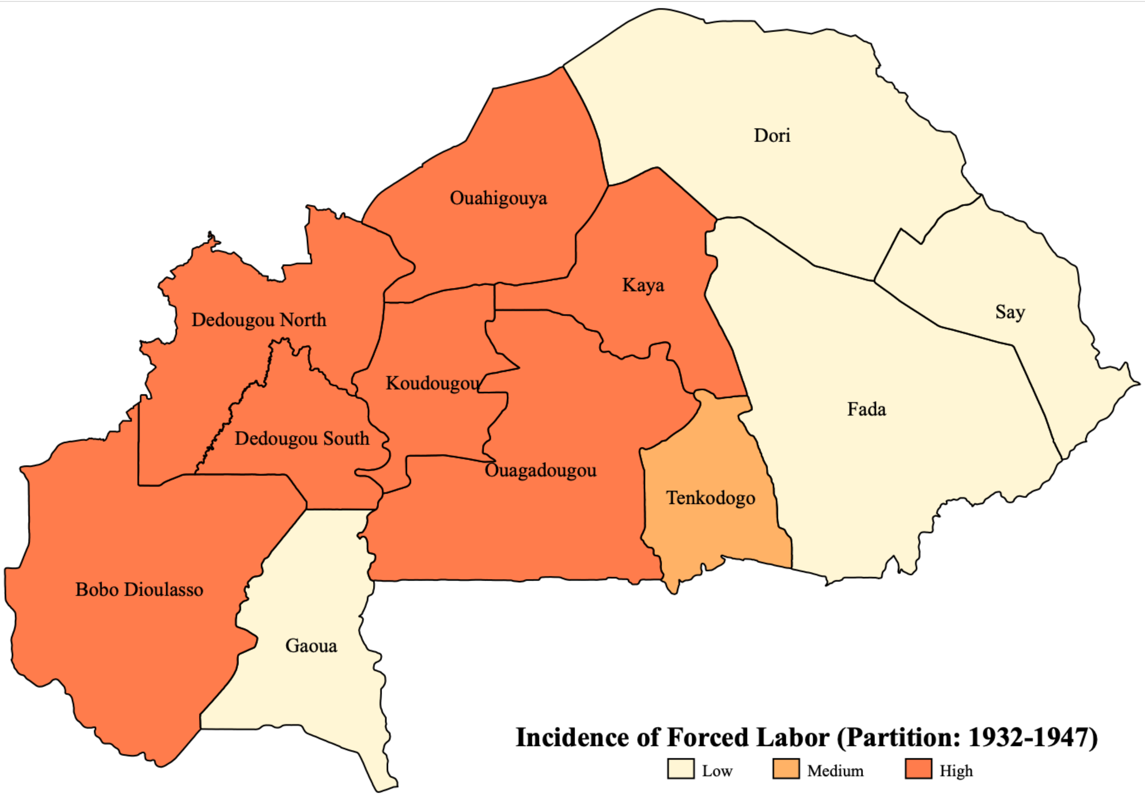
Online Appendix

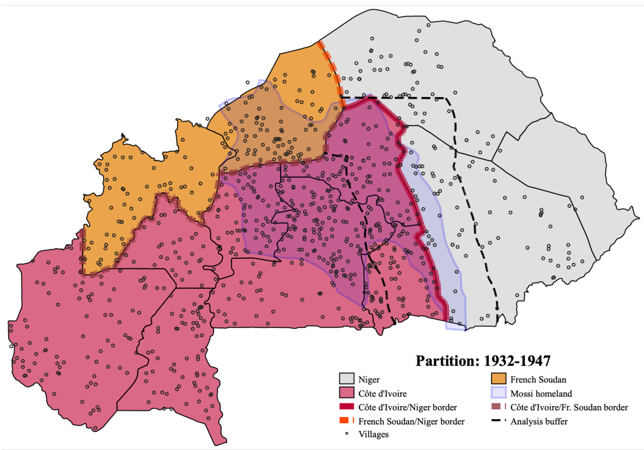
Appendix A Additional Maps, Figures, and Tables

Figure A1: Heterogeneity in historical exposure to forced labor migration within present-day Burkina Faso

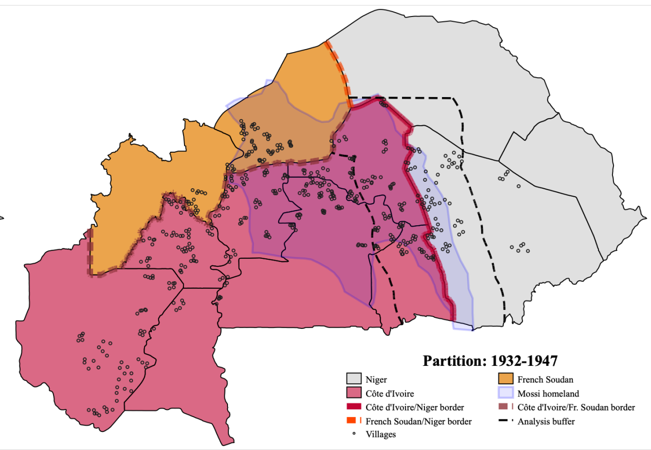


Note: Source: The map combines archival information from Figure 1 and Figure 2 to show the spatial variation in exposure to forced labor migration in colonial times. Darker colors indicate higher incidence.

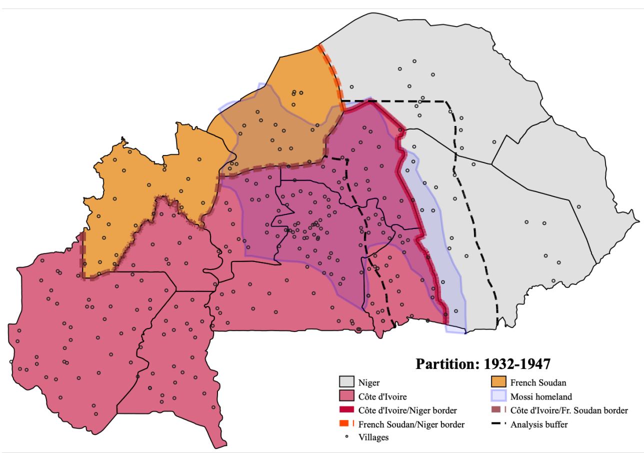
Figure A2: Map of partition, clusters, and main bandwidth



(a) DHS clusters



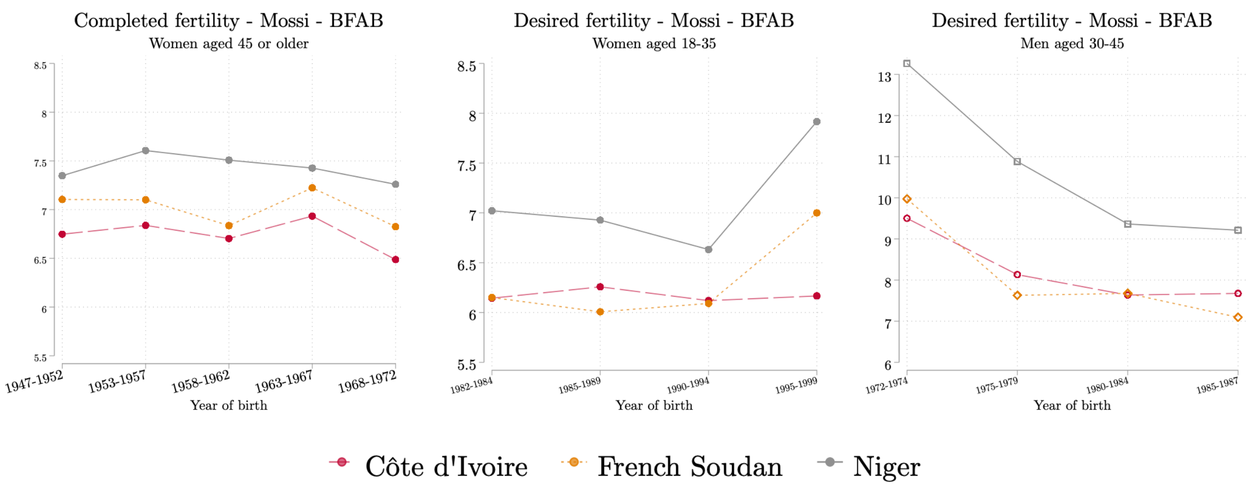
(b) BFAB villages



(c) LSMS clusters

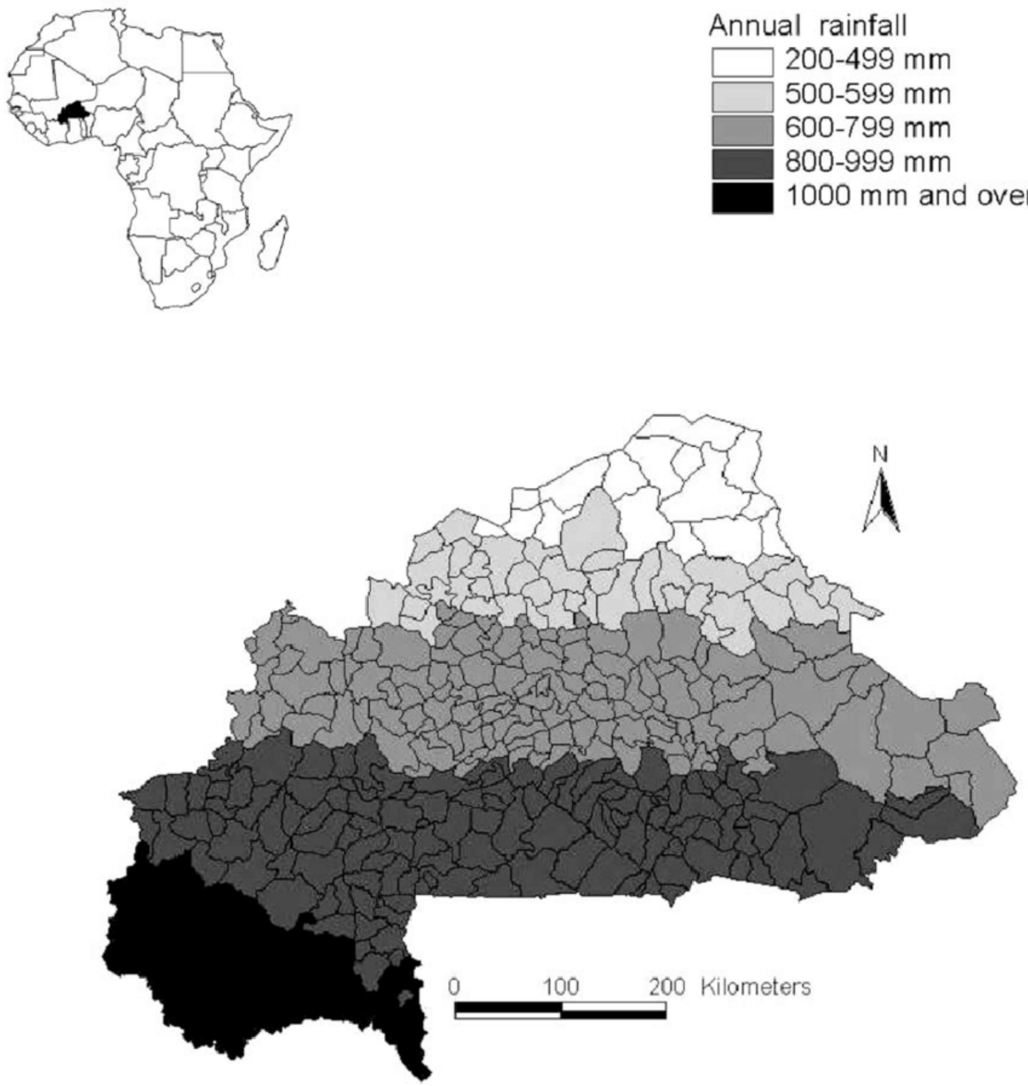
Note: We overlay on top of Figure 1 the GPS coordinates provided in our main datasets for (a) clusters in the DHS sample ; (b) villages in the BFAB sample; and (c) clusters in the LSMS sample. The dashed line represents the bandwidth used in our main analysis. It shows the sample of villages within $70km$ of the Côte d'Ivoire-Niger boundary which have a counterfactual at the same latitude on the opposite side of the boundary.

Figure A3: Descriptive statistics for villages in the Mossi ethnic homeland



Note: Source: BFAB. Sample is restricted to villages in the ancestral homeland of the Mossi ethnic group. We use the map in Figure A2b and compute average fertility statistics for the three areas of today's Burkina Faso historically partitioned between Niger (in light grey), French Soudan (in orange), and Côte d'Ivoire (in pink), by 5-year cohort. The graphs on the left plot completed fertility (total number of children ever born) for women older than 45 y.o. ; the graphs in the middle plot ideal family size for women aged 18 to 35 y.o.; the graphs on the right plot ideal family size for men aged 30 to 45 y.o.

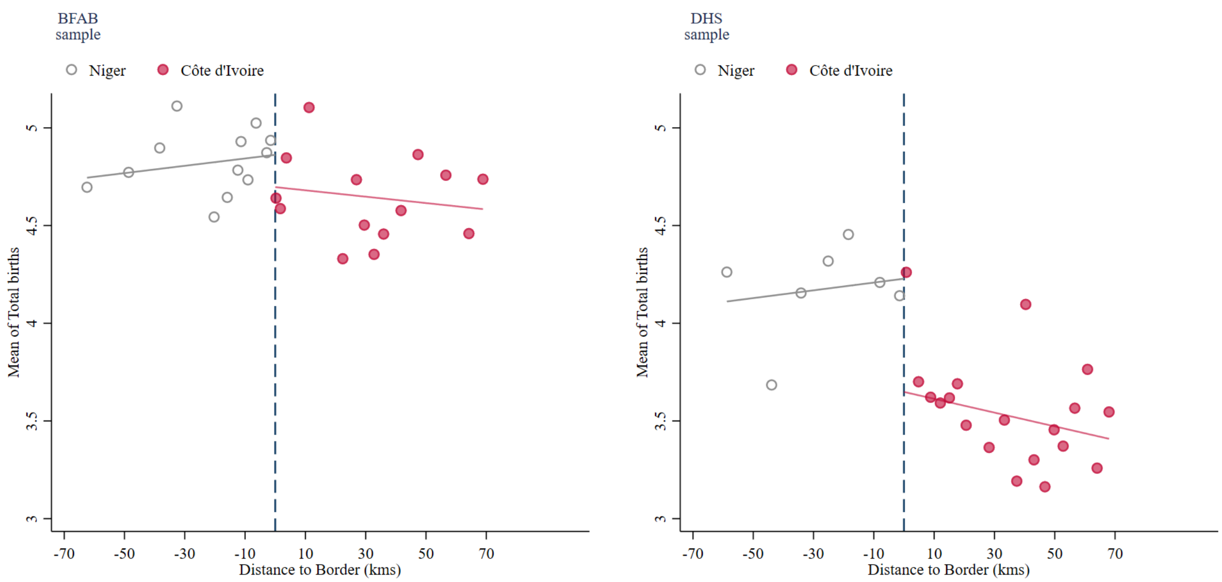
Figure A4: Mean annual rainfall at the department level, 1960-98



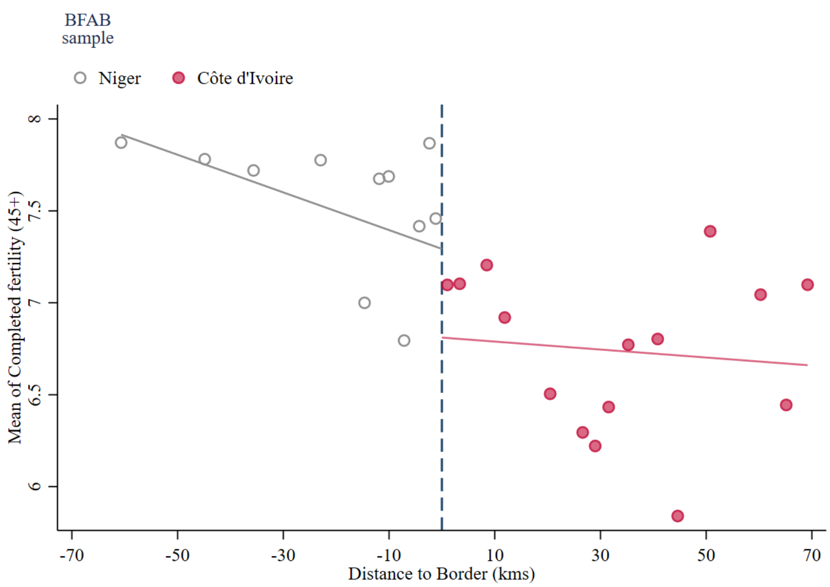
Note: Source: Henry et al. (2004)

Figure A5: RD graphs - Fertility

Panel A: Total births



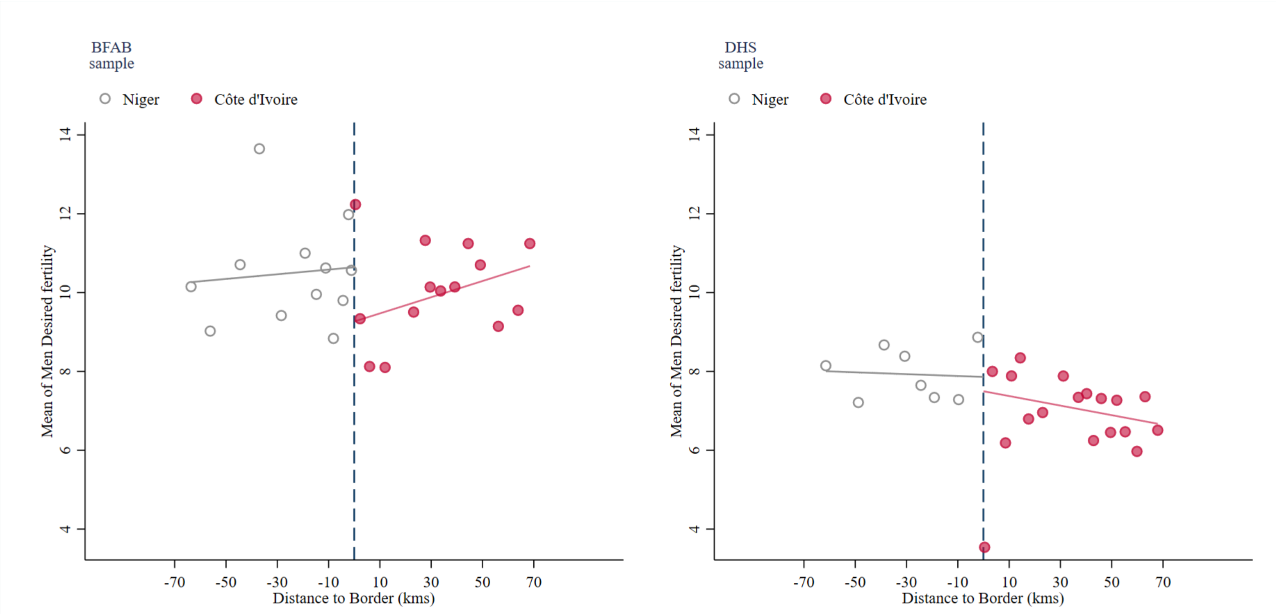
Panel B: Completed Fertility



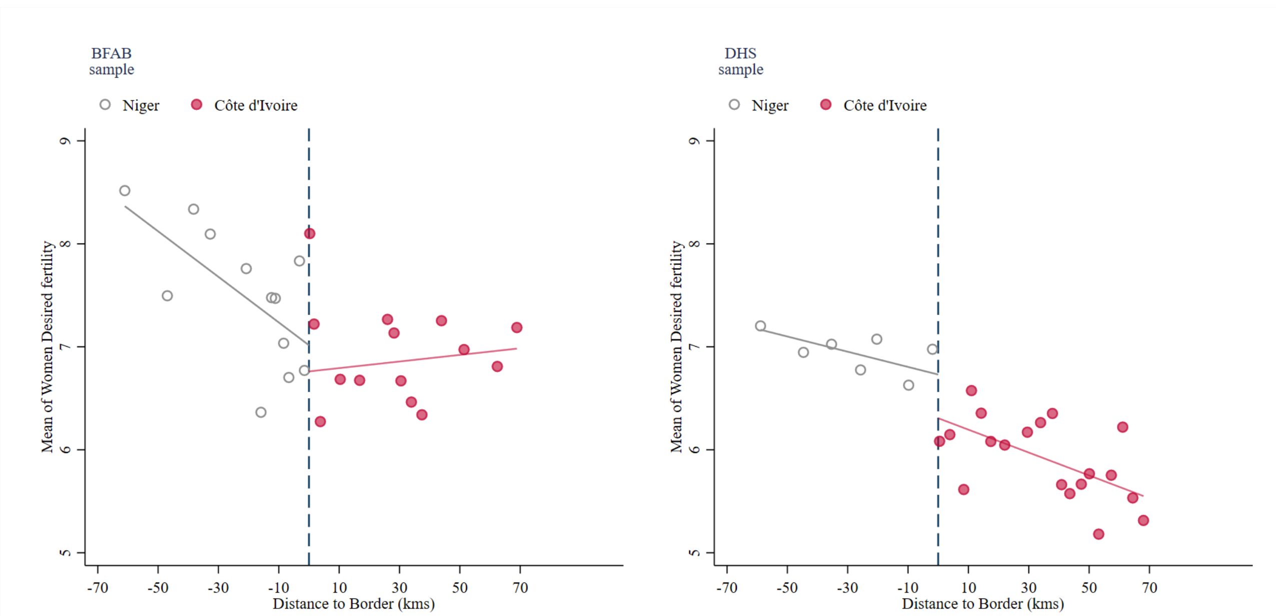
Note: Source: BFAB (left) and DHS (right). The figure plots the average total number of children ever born at the time of the survey for all women (y-axis Panel A) and the average total number of children ever born for women older than 45 y.o (y-axis Panel B) against the distance to the Côte d'Ivoire-Niger boundary (x-axis) within our main bandwidth (70km). The vertical dashed line marks the boundary separating areas exposed to forced labor migration (Côte d'Ivoire in pink) from areas not exposed (Niger in light grey). Villages are grouped in equal-sized bins on each side of the boundary and each bin is represented by a dot. The lines overlaid on the dot represent the best linear fit on each side of the boundary.

Figure A6: RD graphs - Desired fertility

Panel A: Men

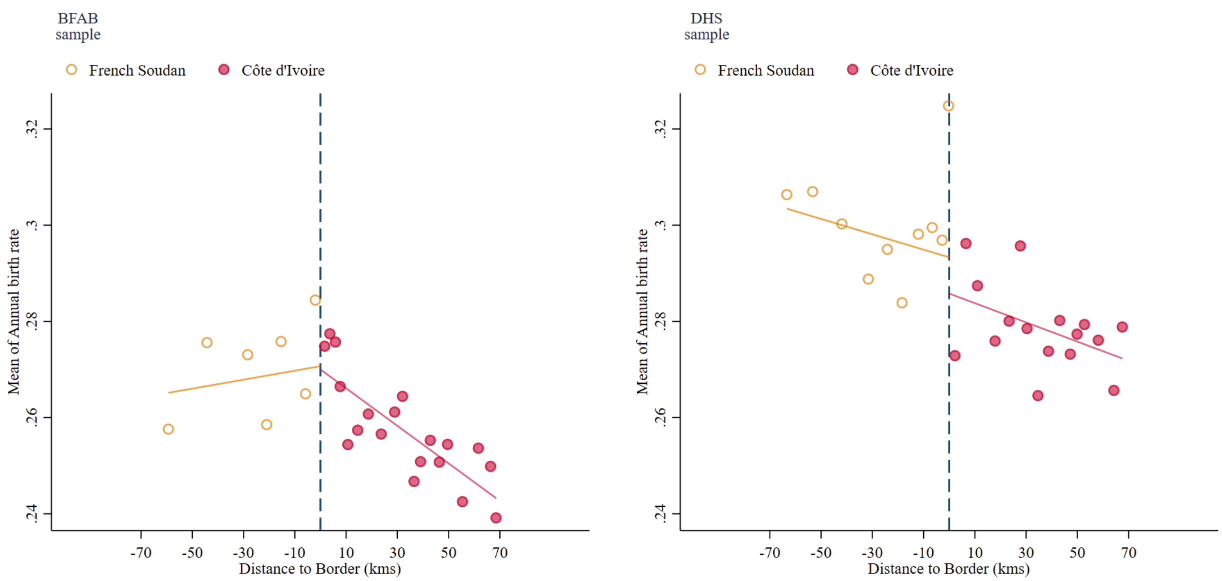


Panel B: Women



Note: Source: BFAB (left) and DHS (right). The figure plots the average ideal number of children reported by men (y-axis in Panel A) and by women (y-axis in Panel B) against the distance to the Côte d'Ivoire-Niger partition boundary (x-axis) within our main bandwidth ($70km$). The vertical dashed line marks the boundary separating areas exposed to forced labor migration (Côte d'Ivoire side in pink) from areas not exposed (Niger side in light grey). Villages are grouped in equal-sized bins on each side of the boundary and each bin is represented by a dot. The lines overlaid on the dot represent the best linear fit on each side of the boundary.

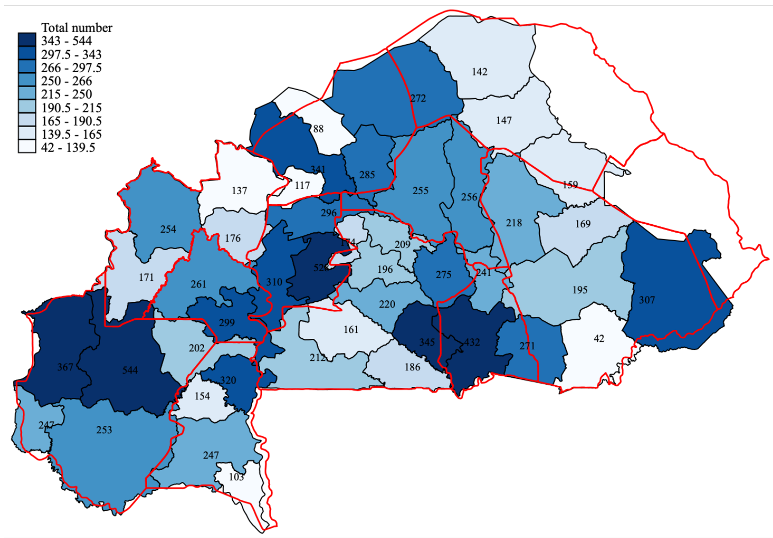
Figure A7: RD graph: Annual birth rate with placebo border - Côte d'Ivoire/French Soudan



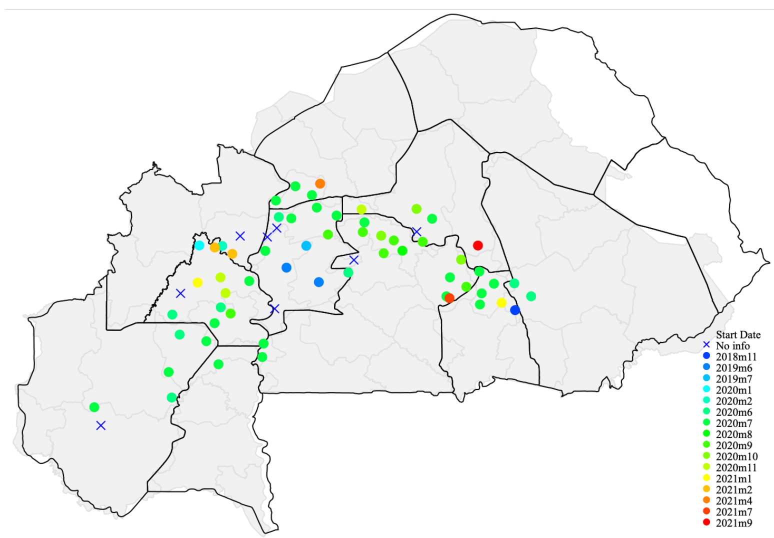
Note: Source: BFAB (left) and DHS (right). The figure plots the average annual birth rate (y-axis) against the distance to the Côte d'Ivoire-French Soudan boundary (x-axis). This is the same plot as Figure 4 but using the placebo Côte d'Ivoire-French Soudan partition boundary. The analysis is restricted to observations within our main bandwidth ($70km$). The vertical dashed line marks the boundary separating two areas exposed to forced labor migration (Côte d'Ivoire in pink and French Soudan in orange). Villages are grouped in equal-sized bins on each side of the boundary and each bin is represented by a dot. The lines overlaid on the dot represent the best linear fit on each side of the boundary.

Figure A8: Recent public projects and programs at the province level

Panel A: Number of decentralized technical services* and public projects and programs established at the departmental level per province (2017 to 2019)



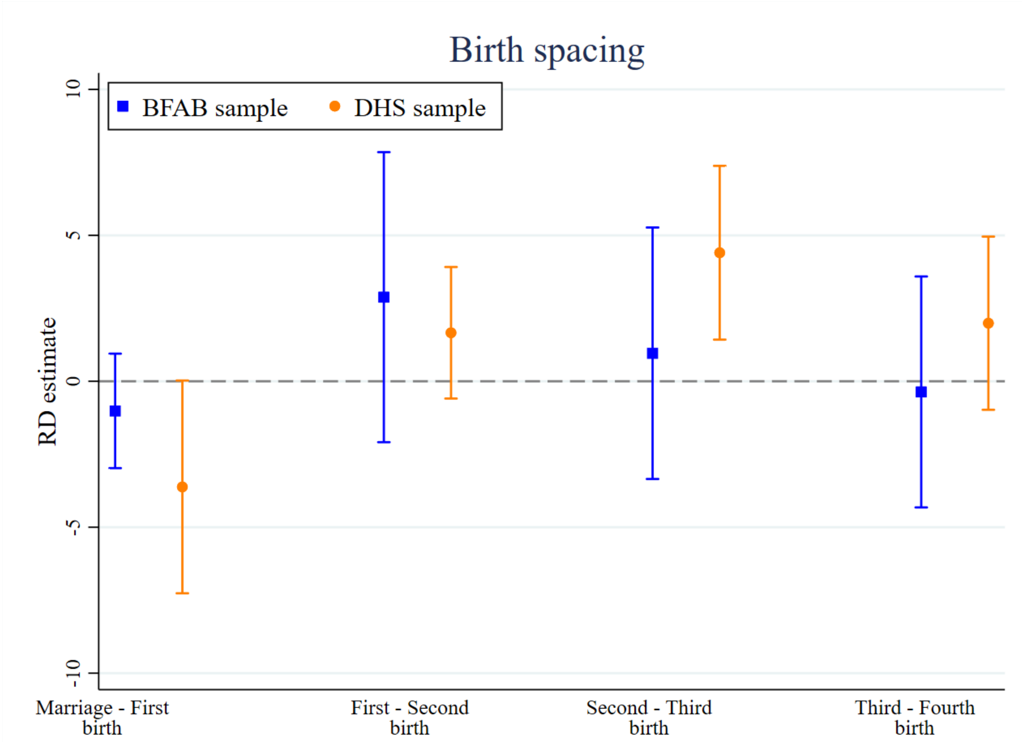
Panel B: Free family planning policy start date per health facility agent report



Note: We overlay cercle boundaries of colonial Burkina Faso (in red, see Figure 1 for details) on present-day administrative provinces of Burkina Faso, as accessed on September 13, 2023 from OCHA ROWCA at https://energydata.info/dataset/burkina-faso-administrative-boundaries-2017. Panel A: data was taken from Ministère de l'Administration Territoriale et de la Décentralisation du Burkina Faso (2021, Table 6). Panel B: In 2019, Burkina Faso introduced a free family planning (FP) policy in certain regions, which was scaled up to the whole country in 2020. Data was collected from interviews with agents from 67 Centres de Santé et Promotion Sociale (CSPS) that were visited for Dupas et al. (2023) in 2021. CSPS for which the start date of free FP is missing had agents who reported FP started in their CSPS but could not recall/did not know when (N=8).

* Excluding schools and healthcare facilities.

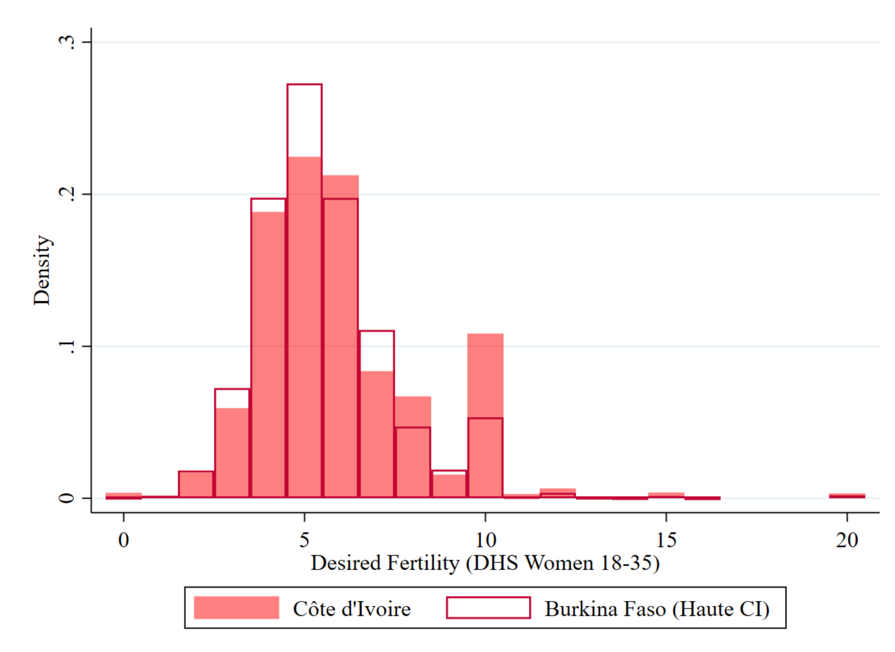
Figure A9: Birth spacing - All ethnic groups



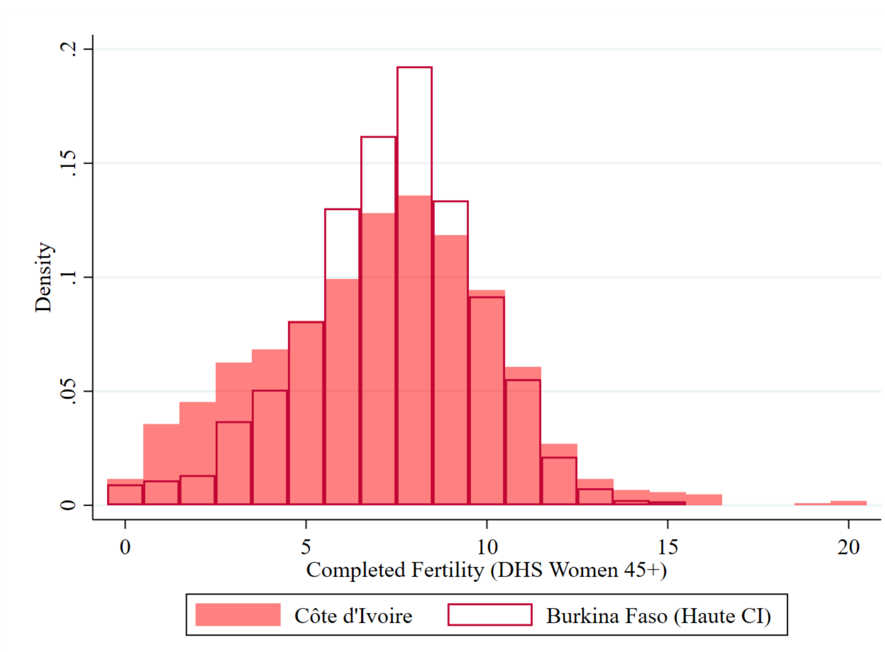
Note: Source: BFAB (blue) and DHS (orange). The figure shows the estimates of β and their 95% confidence intervals in a generalized version of Equation 1 using different measures of birth spacing. We order the estimates on the x-axis depending on the birth order. From the left, the first outcome is the duration between marriage and first birth, the second outcome is the duration between the first and second birth, the third outcome is the duration between the second and third birth, and the fourth outcome is the duration between the third and fourth birth.

Figure A10: Distribution of fertility in communities of origin and destination

A: Desired fertility



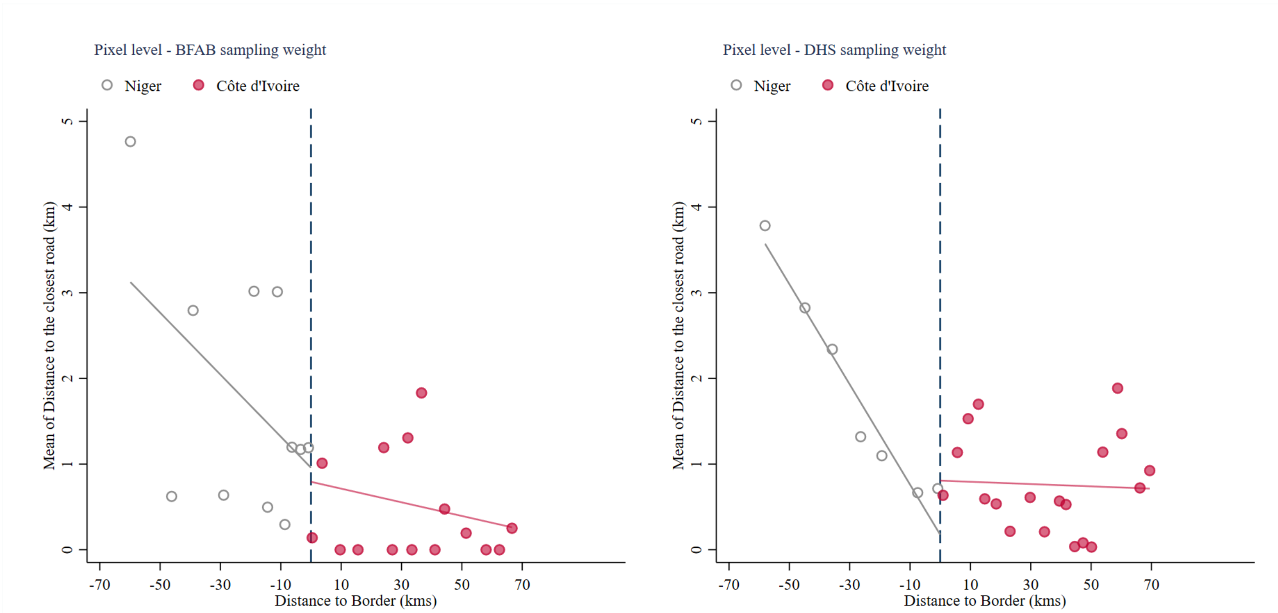
B: Completed fertility



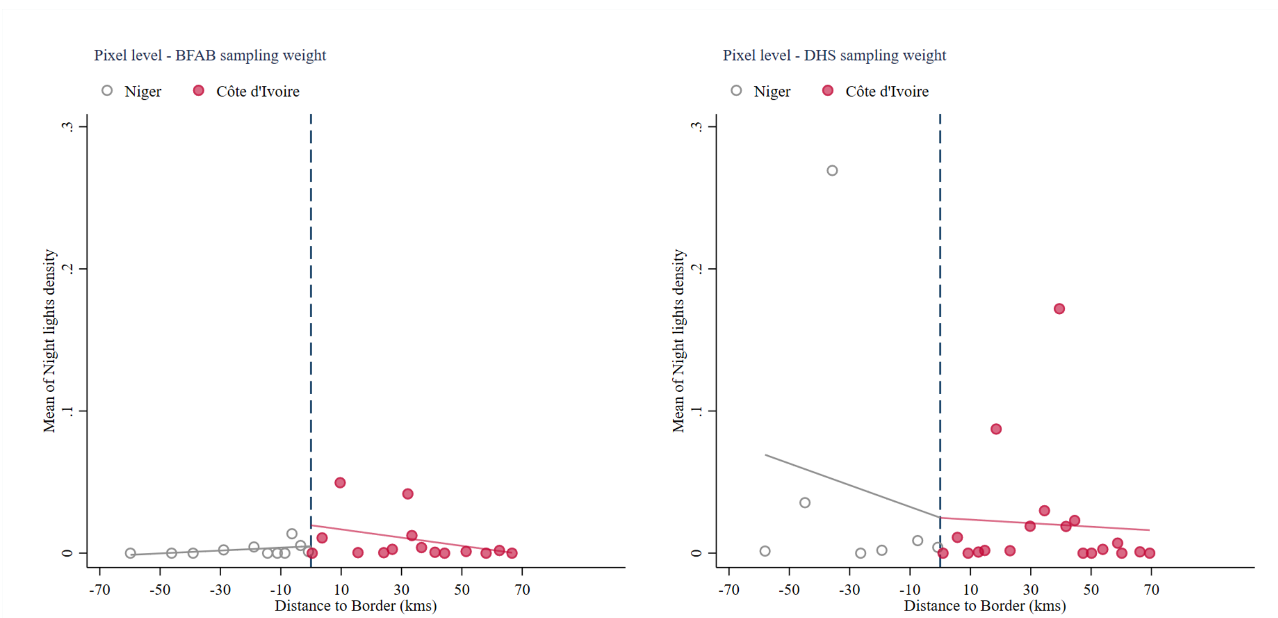
Note: Source: DHS. The community of destination is Côte d'Ivoire and the community of origin is the part of Burkina Faso formerly attached to Côte d'Ivoire (Haute CI). The average desired fertility is equal to 5.97 children in Côte d'Ivoire and 5.58 in Haute CI. The average completed fertility is equal to 7.04 children in Côte d'Ivoire and 7.35 in Haute CI.

Figure A11: RD Graphs - Road and night light density

Panel A: Distance to the closest road



Panel B: Night light density



Note: Source: BFAB (left) and DHS (right). The figure plots the average distance to the closest road (Panel A, y-axis) and the average night light density (Panel B, y-axis) against the distance to the Côte d'Ivoire-Niger partition boundary (x-axis) within our main bandwidth ($70km$). The vertical dashed line marks the boundary separating areas exposed to forced labor migration (Côte d'Ivoire side in pink) from areas not exposed (Niger side in light grey). Pixels are grouped in equal-sized bins on each side of the boundary and each bin is represented by a dot. The lines overlaid on the dot represent the best linear fit on each side of the boundary.

Table A1: Balance checks

	Elevation		Precipitation		Soil suitability		Population density	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)
Panel A: Pixel level - BFAB sampling weight								
Exposed (CIV)	10.343	9.356	2.458*	2.524	-0.018	-0.010	0.134	0.105
	(8.239)	(7.787)	(1.250)	(1.548)	(0.018)	(0.022)	(0.379)	(0.412)
Mean DV (Control)	292.962	294.489	54.132	55.954	0.282	0.312	0.350	0.507
Observations	79	57	79	57	79	57	79	57
Clusters	79	57	79	57	79	57	79	57
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: Pixel level - DHS sampling weight								
Exposed (CIV)	19.933**	21.262***	0.958	-0.348	0.016	0.002	0.267	0.209
	(8.289)	(7.715)	(1.058)	(1.309)	(0.019)	(0.024)	(0.333)	(0.391)
Mean DV (Control)	282.768	271.054	57.272	62.665	0.303	0.331	0.153	0.274
Observations	146	86	146	86	146	86	146	86
Clusters	146	86	146	86	146	86	146	86
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE								
Year FE								
Controls								

Note: Source: BFAB and DHS. The table reports the estimates of γ in the following equation: $Y_p = \alpha + \gamma Exposed_p + f(distance_p) + \Phi_{b(p)} + \varepsilon_p$. The unit of analysis is a $12km \times 12km$ pixel p (or grid cell). $Exposed_p$ is an indicator equal to 1 if pixel p is inside the portion of Burkina Faso historically assigned to Côte d'Ivoire and equal to 0 if pixel p belongs to the portion of Burkina Faso historically assigned to Niger. $f(distance_p)$ is the RD polynomial which controls for the distance between the centroid of pixel p and the Côte d'Ivoire-Niger partition boundary. Like in Equation 1, we use a local linear polynomial estimated separately on each side of the partition boundary, the vector of partition boundary segment fixed effects Φ_b, and a $70km$ bandwidth. Y_p is the average elevation (columns 1 and 2), the average monthly precipitation (columns 3 and 4), an index of the soil suitability for agriculture (columns 5 and 6) and the average population density in 1924-26 (columns 7 and 8) in pixel p. See Appendix C for more details on these variables. In even-numbered columns, the analysis is restricted to the Mossi ethnic homeland. The mean dependent variable shows the average on the Niger side of the partition boundary, within the bandwidth. Each pixel is re-weighted according to the number of observations used in the BFAB sample (Panel A) and in the DHS sample (Panel B). This is equivalent to estimating Equation 1 at the individual level without the controls and clustering standard errors at the pixel level. ****p<0.01, **p<0.05, *p<0.1.*

Table A2: Placebo test: effects of French Soudan – Côte d'Ivoire partition boundary on fertility

	Annual birth rate		Total births		Completed fertility		Desired fertility (Men)		Desired fertility (Women)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
Panel A: BFAB sample										
Exposed (CIV)	0.005	-0.000	0.035	-0.043	0.178	0.168	-0.099	-1.213**	0.070	-0.285
	(0.006)	(0.009)	(0.079)	(0.126)	(0.184)	(0.265)	(0.428)	(0.513)	(0.173)	(0.243)
Mean DV (Control)	0.268	0.272	4.908	4.809	7.153	7.010	8.624	8.245	6.236	6.294
Observations	106,644	57,826	17,944	9,845	5,065	2,866	4,416	2,076	8,726	4,651
Clusters	260	154	260	154	260	154	260	154	260	154
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: DHS sample										
Exposed (CIV)	-0.006	-0.013	-0.132*	-0.164			-0.445	-0.468	-0.134	-0.097
	(0.006)	(0.009)	(0.070)	(0.101)			(0.334)	(0.435)	(0.138)	(0.202)
Mean DV (Control)	0.298	0.295	3.896	3.818			7.320	7.497	5.917	5.856
Observations	68,723	36,498	11,082	5,887			3,345	1,681	9,806	5,360
Clusters	341	180	341	180			341	180	341	180
Bandwidth	70.00	70.00	70.00	70.00			70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: BFAB and DHS. The table reports the estimates of β in a modified version of Equation 1 in which the partition boundary of interest is Côte d'Ivoire-French Soudan. Each cell corresponds to a separate regression and shows the coefficient on a dummy equal to 1 if the respondent lives in the portion of Burkina Faso historically assigned to Côte d'Ivoire and equal to 0 if the respondent lives in the portion of Burkina Faso historically assigned to French Soudan. This is a placebo test as both portions were equally exposed to forced labor migration. See notes below Table 2 for more details on the dependent variables and the specification.

Table A3: Effects on Religion

	Muslim (women)		Muslim (men)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)
Panel A: BFAB sample				
Exposed (CIV)	0.065	0.048	0.020	0.045
	(0.061)	(0.067)	(0.068)	(0.086)
Mean DV (Control)	0.285	0.292	0.388	0.382
Observations	4,164	3,159	2,851	2,124
Clusters	140	107	140	107
Bandwidth	70.00	70.00	70.00	70.00
Panel B: DHS sample				
Exposed (CIV)	-0.110	-0.083	-0.098	-0.123
	(0.083)	(0.107)	(0.088)	(0.113)
Mean DV (Control)	0.406	0.436	0.478	0.453
Observations	5,427	3,365	1,741	1,006
Clusters	186	108	186	108
Bandwidth	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Note: Source: BFAB and DHS. See Table 2 notes for more details on the specification. The dependent variable is a dummy indicating whether the respondent is muslim for women (columns 1 and 2) and for men (columns 3 and 4).

Table A4: Heterogeneity by labor intensity of food production

	Annual birth rate		Total births		Desired fertility (Men)		Desired fertility (Women)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)
Panel A: Suitable for low-labor roots and tubers (< $Q50$)								
Exposed (CIV)	0.001	-0.009	0.116	-0.069	-0.397	-0.493	0.205	0.157
	(0.015)	(0.015)	(0.181)	(0.197)	(0.723)	(0.923)	(0.390)	(0.442)
Mean DV (Control)	0.312	0.330	4.245	4.293	8.229	8.213	7.093	7.005
Observations	18,007	13,025	2,873	2,098	817	537	2,608	1,858
Clusters	98	67	98	67	92	63	98	67
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: Suitable for high-labor cereals (> $Q50$)								
Exposed (CIV)	-0.044***	-0.047***	-0.318**	-0.359**	-0.950	-1.259	-0.397	-1.042***
	(0.013)	(0.017)	(0.131)	(0.149)	(0.814)	(0.948)	(0.322)	(0.336)
Mean DV (Control)	0.321	0.324	4.044	4.061	7.304	7.495	6.687	6.460
Observations	15,835	7,771	2,567	1,275	786	369	2,307	1,133
Clusters	88	41	88	41	93	45	88	41
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: DHS and Fontenay et al. (2023), who developed an index of soil suitability for labor intensive crops. Cereals typically require more labor than roots and tubers; therefore, areas where the soil characteristics are suitable for cultivating cereals rather than roots and tubers have a higher index of labor intensity. We split the DHS sample at the index median value in Burkina Faso and we report the estimates of β in Equation 1 for both subsamples: individuals living in areas where the soil is relatively better suited for low labor crops (Panel A) and those in areas where the soil is relatively better suited for high labor crops (Panel B). See notes below Table 2 for more details on the specification.

Table A5: Effects on education

	No education (women)		No education (men)		No education (Children 6-15 y.o)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)
Panel A: BFAB sample						
Exposed (CIV)	-0.000	0.026	0.000	-0.024	-0.045	-0.013
	(0.022)	(0.026)	(0.033)	(0.044)	(0.068)	(0.079)
Mean DV (Control)	0.920	0.909	0.890	0.869	0.603	0.544
Observations	43,991	32,939	2,852	2,124	1,854	1,402
Clusters	140	107	140	107	140	107
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: DHS sample						
Exposed (CIV)	-0.027	-0.026	0.023	0.074	-0.071	0.001
	(0.023)	(0.024)	(0.049)	(0.051)	(0.045)	(0.047)
Mean DV (Control)	0.952	0.955	0.857	0.868	0.821	0.806
Observations	5,439	3,372	1,744	1,006	8,830	5,392
Clusters	186	108	186	108	186	108
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓

Note: Source: BFAB and DHS. See Table 2 notes for more details on the specification. The dependent variable is a dummy for having at least one year of formal education for women older than 15 y.o. (columns 1 and 2), for men older than 15 y.o. (columns 3 and 4) and for children aged 6 to 15 y.o. (columns 5 and 6).

Table A6: Effects on health and assets

	Child mortality (BFAB)		Child mortality (DHS)		Food insecurity (LSMS)		Assets (DHS)		Own cattle (BFAB)		Own cattle (DHS)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)	All (11)	Mossi land (12)
Exposed (CIV)	-0.008	-0.014	-0.024	-0.032	-0.174*	-0.197*	-0.058	-0.020	0.021	-0.003	-0.022	-0.016
	(0.011)	(0.014)	(0.025)	(0.030)	(0.092)	(0.116)	(0.045)	(0.050)	(0.041)	(0.053)	(0.017)	(0.014)
Mean DV (Control)	0.152	0.156	0.242	0.229	1.447	1.405	-0.735	-0.735	0.766	0.747	0.440	0.410
Observations	47,359	35,227	14,908	9,175	719	408	4,345	2,589	4,165	3,159	4,361	2,601
Clusters	140	107	186	108	60	34	186	108	140	107	186	108
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓

Note: Source: BFAB, DHS, and LSMS. See Table 2 and Table 4 notes for more details on the specification. In columns (1) to (4), child mortality is a dummy indicating whether the child died before age 5. The unit of observation is a child (alive or dead) born more than 5 years before the survey. The dependent variable in columns (5) and (6) is a four-scale index for food insecurity derived from the Food Insecurity Experience Scale; it indicates whether a household is food secure (index=0), mildly food insecure (index=1), moderately food insecure (index=2) or severely food insecure (index=4). The dependent variable in columns (7) and (8) is an asset index computed using a Principal Component Analysis. Assets include electricity, radio, TV, refrigerator, bicycle, motorcycle, and car. Note that the mean dependent variable in columns (7) and (8) is not zero because the index is constructed using the whole DHS dataset. The mean dependent variable shows the average on the Niger side of the partition boundary, within the analysis bandwidth.

Table A7: Effects on women empowerment

	Household head is a woman		Contraceptive use (women)		Participation in decision making		Acceptance of domestic violence		Experience domestic violence	
	All	Mossi land	All	Mossi land	All	Mossi land	All	Mossi land	All	Mossi land
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: BFAB sample										
Exposed (CIV)	-0.027	-0.049*	0.006	-0.008						
	(0.025)	(0.028)	(0.029)	(0.042)						
Mean DV (Control)	0.059	0.069	0.270	0.246						
Observations	20,850	15,360	4,163	3,158						
Clusters	140	107	140	107						
Bandwidth	70.00	70.00	70.00	70.00						
Panel B: DHS sample										
Exposed (CIV)	0.018	0.032	-0.033**	-0.022	-0.275	-0.411*	-0.254	0.100	0.092	-0.072
	(0.022)	(0.025)	(0.016)	(0.017)	(0.200)	(0.246)	(0.244)	(0.283)	(0.239)	(0.268)
Mean DV (Control)	0.057	0.062	0.058	0.039	0.092	0.194	-0.601	-0.512	-0.064	-0.203
Observations	4,360	2,600	5,438	3,373	3,449	1,967	3,497	1,971	1,240	651
Clusters	186	108	186	108	129	71	129	71	69	35
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: DHS. See Table 2 notes for more details on the specification. Columns (5) to (8) only use DHS waves 2003 and 2010. Columns (9) to (10) only use DHS wave 2010. In columns (1) and (2), the dependent variable is a dummy for whether the household head is a woman. In columns (3) to (10), the sample is restricted to women. In columns (3) and (4), the dependent variable is a dummy for whether the respondent indicates using a modern method of birth control (modern methods include: pill, IUD, injection, diaphragm, condom, female sterilization, male sterilization, lactational amenorrhea, implants/norplant, female condom, and foam/jelly). In columns (5) to (10), each outcome represents an index computed using Principal Component Analysis. Participation in decision-making (columns 5 and 6) reflects whether the respondent is involved in decisions related to healthcare, household purchase, and visit to relatives. Acceptance of domestic violence (columns 7 and 8) indicates whether the respondent tolerates violence within the household. Experience of domestic violence (columns 9 and 10) indicates whether the respondent experienced different types of physical and/or sexual violence in the year before the survey. The mean dependent variable shows the average on the Niger side of the partition boundary, within the analysis bandwidth. It is often not zero because each index is constructed using the whole DHS dataset.

Table A8: Effects on Marriage

	Age at first marriage (women)		Age at first marriage (men)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)
	Panel A: BFAB sample			
Exposed (CIV)	0.026	0.066	0.524	0.969**
	(0.158)	(0.206)	(0.433)	(0.452)
Mean DV (Control)	17.534	17.799	23.178	23.338
Observations	4,165	3,159	2,852	2,124
Clusters	140	107	140	107
Bandwidth	70.00	70.00	70.00	70.00
	Panel B: DHS sample			
Exposed (CIV)	0.385*	0.190	0.432	1.540
	(0.208)	(0.240)	(0.844)	(1.105)
Mean DV (Control)	16.549	16.985	23.228	22.863
Observations	4,640	2,867	1,051	594
Clusters	186	108	162	91
Bandwidth	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Note: Source: BFAB and DHS. See Table 2 notes for more details on the specification. The dependent variable is the age at first marriage for women (columns 1 and 2) and men (columns 3 and 4).

Table A9: Urbanization

	Annual birth rate		Total births		Desired fertility (Men)		Desired fertility (Women)		Urban residence	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
	DHS sample - Urban and rural areas									
Exposed (CIV)	-0.027**	-0.036**	-0.249*	-0.366**	-0.392	-1.629**	-0.193	-0.541	0.035	0.074
	(0.013)	(0.014)	(0.143)	(0.175)	(0.628)	(0.797)	(0.284)	(0.332)	(0.086)	(0.082)
Mean DV (Control)	0.299	0.318	3.906	4.053	7.148	7.392	6.554	6.536	0.185	0.074
Observations	40,703	24,071	6,629	3,945	2,061	1,133	6,028	3,542	33,698	19,920
Clusters	229	128	229	128	228	128	229	128	229	128
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: DHS. The table reports the estimates of β in Equation 1 for the *full* sample, i.e. including urban individuals (which are otherwise excluded from the main analysis). The dependent variable in columns (9) and (10) is a dummy equal to 1 if the respondent lives in an urban area and 0 if they live in a rural area. See Table 2 notes for more details on dependent variables and specifications.

Appendix B Descriptive Statistics and Robustness checks

Appendix B.1 Descriptive Statistics

Table B1: Descriptive statistics - DHS sample

	Whole sample		Côte Ivoire		Niger		T-test
	Mean	Obs.	Mean	Obs.	Mean	Obs.	P-value
Fertility							
Annual birth rate	0.288	33,842	0.277	24,392	0.315	9,450	0.000
Total births	3.699	5,440	3.522	3,957	4.172	1,483	0.000
Men Desired fertility	7.334	1,603	7.061	1,101	7.932	502	0.000
Women Desired fertility	6.191	4,915	5.900	3,546	6.944	1,369	0.000
Migration							
Time away from home	1.522	1,181	1.515	782	1.534	399	0.940
Child and family labor							
Man is polygamous	0.321	1,177	0.336	794	0.290	383	0.110
Education							
Women have no education	0.923	5,439	0.912	3,956	0.952	1,483	0.000
Men have no education	0.825	1,744	0.810	1,205	0.857	539	0.017
Children (6-15 y.o) have no education	0.739	8,837	0.706	6,287	0.821	2,550	0.000
Health and nutrition							
Child mortality	0.214	14,998	0.202	10,391	0.242	4,607	0.000
Physical capital							
Assets	-0.658	4,347	-0.625	3,057	-0.735	1,290	0.000
Own cattle	0.349	4,363	0.311	3,069	0.440	1,294	0.000
Women empowerment							
Household head is a woman	0.079	4,362	0.088	3,069	0.057	1,293	0.001
Contraceptive use - women	0.053	5,438	0.051	3,957	0.058	1,481	0.286
Index of participation in decision making	-0.004	3,449	-0.045	2,420	0.092	1,029	0.004
Index of acceptance of domestic violence	-0.151	3,497	0.045	2,435	-0.601	1,062	0.000
Index of experience of domestic violence	-0.211	1,240	-0.296	785	-0.064	455	0.015
Marriage							
Women age at first marriage	17.230	4,640	17.502	3,315	16.549	1,325	0.000
Men age at first marriage	24.280	1,051	24.819	695	23.228	356	0.000
Birth spacing							
Marriage-first birth interval	21.180	4,437	20.938	3,166	21.782	1,271	0.285
First-second birth interval	33.807	3,835	35.086	2,713	30.714	1,122	0.000
Second-third birth interval	34.245	3,209	35.067	2,255	32.301	954	0.000
Third-fourth birth interval	34.558	2,618	35.497	1,806	32.469	812	0.000
Religion							
Women religion: Muslim	0.559	5,427	0.616	3,951	0.406	1,476	0.000
Men religion: Muslim	0.569	1,741	0.609	1,203	0.478	538	0.000

Note: Source: DHS (1993, 1999, 2003, and 2010). Table shows summary statistics of various outcomes using observations falling within the $70km$-bandwidth around the Côte d'Ivoire - Niger border. Variables are constructed as described in the text. The sample excludes observations within $5km$ of the boundary. Côte d'Ivoire and Niger indicate whether observations are within areas of Burkina Faso historically allocated to the colonies of Côte d'Ivoire and Niger. Columns (1), (3), and (5) give the mean of the corresponding variable. Column (7) shows the p-value of the difference in mean across the border.

Table B2: Descriptive statistics - BFAB sample

	Whole sample		Côte Ivoire		Niger		T-test
	Mean	Obs.	Mean	Obs.	Mean	Obs.	P-value
Fertility							
Annual birth rate	0.275	81,022	0.258	42,031	0.294	38,991	0.000
Total births	4.726	13,278	4.643	7,001	4.819	6,277	0.000
Completed fertility (45+)	7.061	3,164	6.738	1,843	7.512	1,321	0.000
Men Desired fertility	10.218	2,251	9.971	1,187	10.493	1,064	0.060
Women Desired fertility	7.172	5,481	6.862	2,860	7.511	2,621	0.000
Child and family labor							
Men: I would not have enough people to help on the farm	0.087	1,990	0.067	1,079	0.112	911	0.000
Men: I would not have enough people to help at home	0.127	1,990	0.081	1,079	0.181	911	0.000
Women: I would not have enough people to help on the farm	0.099	3,857	0.070	2,266	0.140	1,591	0.000
Women: I would not have enough people to help at home	0.151	3,857	0.099	2,266	0.225	1,591	0.000
Labor constrained to expand farm activity	0.378	20,946	0.358	11,867	0.405	9,079	0.000
Education							
Women have no education	0.898	44,525	0.882	26,233	0.920	18,292	0.000
Men have no education	0.892	2,852	0.894	1,686	0.890	1,166	0.760
Children (6-15 y.o) have no education	0.524	1,855	0.472	1,122	0.603	733	0.000
Health and nutrition							
Child mortality	0.133	47,594	0.116	24,948	0.151	22,646	0.000
Physical capital							
Own cattle	0.624	5,080	0.627	3,061	0.621	2,019	0.649
Women empowerment							
Household head is a woman	0.085	21,177	0.106	12,074	0.058	9,103	0.000
Contraceptive use - women	0.235	4,164	0.212	2,530	0.270	1,634	0.000
Marriage							
Women age at first marriage	17.786	4,166	17.949	2,531	17.534	1,635	0.000
Men age at first marriage	24.273	2,852	25.031	1,686	23.178	1,166	0.000
Birth spacing							
Marriage-first birth interval	12.352	4,022	12.493	2,433	12.136	1,589	0.509
First-second birth interval	33.824	1,071	34.522	638	32.797	433	0.153
Second-third birth interval	36.090	987	37.363	590	34.199	397	0.008
Third-fourth birth interval	35.517	844	36.940	496	33.489	348	0.004
Religion							
Women religion: Muslim	0.530	4,165	0.689	2,531	0.285	1,634	0.000
Men religion: Muslim	0.561	2,851	0.680	1,686	0.388	1,165	0.000

Note: Source: BFAB (2017). Table shows summary statistics of various outcomes using observations falling within the $70km$-bandwidth around the Côte d'Ivoire - Niger border. The sample excludes observations within $1km$ of the boundary. Variables are constructed as described in the text. Côte d'Ivoire and Niger indicate whether observations are within areas of Burkina Faso historically allocated to the colonies of Côte d'Ivoire and Niger. Columns (1), (3), and (5) give the mean of the corresponding variable. Column (7) shows the p-value of the difference in mean across the border.

Table B3: Descriptive statistics - LSMS sample

	Whole sample		Côte Ivoire		Niger		T-test
	Mean	Obs.	Mean	Obs.	Mean	Obs.	P-value
Migration							
Probability that a men has lived in CIV	0.125	1,117	0.154	764	0.062	353	0.000
Probability that a men has lived outside BF and CIV	0.014	1,117	0.016	764	0.011	353	0.568
Remittances							
Total amount of international transfers	22.446	720	30.429	492	5.219	228	0.000
Probability of receiving atleast one international remittance	0.182	720	0.236	492	0.066	228	0.000
Total amount of international transfers in log	11.118	131	11.149	116	10.879	15	0.390
Atleast one sender lives in CIV	0.140	720	0.177	492	0.061	228	0.000
Reliance on agriculture							
Main occupation is agriculture (18-64)	0.779	2,119	0.763	1,507	0.819	612	0.005
Worked for at least one hour in trade or market service (18-64)	0.136	2,119	0.158	1,507	0.082	612	0.000
Worked for at least one hour in a field or garden (5-17)	0.499	2,078	0.464	1,518	0.591	560	0.000
Cultivated land	0.879	720	0.852	492	0.939	228	0.001
Log of per capita cultivated land size	-1.258	633	-1.382	419	-1.016	214	0.000
Health and nutrition							
Food insecurity	1.337	719	1.285	491	1.447	228	0.025

Note: Source: LSMS (2018 and 2019). Table shows summary statistics of various outcomes using observations falling within the $70km$-bandwidth around the Côte d'Ivoire - Niger border. Variables are constructed as described in the text. The sample excludes observations within $1km$ of the boundary. Côte d'Ivoire and Niger indicate whether observations are within areas of Burkina Faso historically allocated to the colonies of Côte d'Ivoire and French Soudan. Columns (1), (3), and (5) give the mean of the corresponding variable. Column (7) shows the p-value of the difference in mean across the border.

Appendix B.2 Robustness checks

Choice of control variables. In the main equation, we include distance to the capital city as a control variable and we use "donut holes" of $5km$ in DHS and $1km$ in BFAB. In Table B4 we present regressions including the distance to the national border as an additional control in columns (1) and (2); removing the distance to the capital city in columns (3) and (4); including the geographical and population density variables described in Table A1 as additional controls in columns (5) and (6); removing donut holes, that is keeping all villages, in columns (7) and (8); and increasing the donut holes to $10km$ in DHS and $5km$ in BFAB in columns (9) and (10). Coefficients remain stable and significant across the board, except when we keep DHS villages located less than $5km$ of the border. In this case, estimates decrease and become insignificant, as expected since the risk of classical measurement errors, and hence attenuation bias, increased.

Bandwidth. Our main strategy uses a $70km$ bandwidth with a linear RD polynomial. In Table B5, we re-estimate Equation 1 using a narrower bandwidth of $60km$ in columns (1) and (2); a larger bandwidth of $80km$ in columns (3) and (4); the optimal bandwidth according to the MSE-minimizing procedure suggested by Cattaneo et al. (2019) in columns (5) and (6);[33] a second-order RD polynomial in columns (7) and (8); and we keep northern villages on the Niger side in columns (9) and (10). DHS estimates are very stable in magnitude and significance. BFAB estimates are more sensitive to the inclusion of a second-order polynomial, which seems to be driven by the pink dot right at the border in Figure 4. There is no specification in which coefficients are small and insignificant for both outcomes in both datasets.

Spatial correlation. We present the results with Conley standard errors, considering two cut-offs: $40km$ and $80Km$. Table B6 confirms that most estimates remain significant at conventional levels.

Ethnic boundaries. Exact boundaries for precolonial homelands are imprecise, as the Murdock atlas was only a rough sketch. We do not look for discontinuities at ethnic boundaries, but we do use the Mossi homeland boundary to restrict the sample to Mossi homeland. We check whether the results are changed when we use reported ethnicity. Table B7 replicates the results in Table 2 for the subset of Mossi respondents. We can only do this for DHS because the BFAB dataset does not contain ethnicity. For each outcome, the first column estimates Equation 1 for all Mossis, and the second column estimates Equation 1 for all Mossis *within the Mossi homeland boundary*. The results are unchanged.

Stability of effects across DHS rounds. Figure B1 shows the estimated effect on the annual birth rate when we estimate Equation 1 separately for the four waves of DHS surveys available. The effect is quite stable across rounds, especially for the Mossi areas.

[33] The RD treatment effect is estimated using two different MSE-optimal bandwidth on each side of the border

Table B4: Alternative controls and sample selection

	Distance to nat. border		No location controls		All Geo + Pop Density		No Donut		Change Donut size	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
Panel A: BFAB sample										
Annual birth rate										
Exposed (CIV)	-0.012*	-0.014*	-0.012*	-0.017**	-0.011*	-0.013*	-0.013*	-0.018**	-0.028***	-0.028***
	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
Mean DV (Control)	0.294	0.290	0.294	0.290	0.294	0.290	0.295	0.291	0.296	0.290
Observations	81,022	59,395	81,022	59,395	81,022	59,395	81,964	60,337	71,795	50,281
Clusters	140	107	140	107	140	107	141	108	127	94
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Total births										
Exposed (CIV)	-0.235***	-0.241**	-0.182**	-0.192**	-0.215**	-0.223**	-0.221***	-0.268***	-0.180	-0.164
	(0.080)	(0.098)	(0.078)	(0.090)	(0.083)	(0.098)	(0.075)	(0.089)	(0.134)	(0.142)
Mean DV (Control)	4.819	4.790	4.819	4.790	4.819	4.790	4.818	4.791	4.821	4.750
Observations	13,278	9,771	13,278	9,771	13,278	9,771	13,402	9,895	11,781	8,304
Clusters	140	107	140	107	140	107	141	108	127	94
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Panel B: DHS sample										
Annual birth rate										
Exposed (CIV)	-0.022**	-0.028***	-0.022**	-0.029***	-0.021**	-0.026**	-0.012	-0.001	-0.025**	-0.054***
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)	(0.009)	(0.012)	(0.011)	(0.013)
Mean DV (Control)	0.315	0.327	0.315	0.327	0.315	0.327	0.310	0.316	0.316	0.337
Observations	33,842	20,796	33,842	20,796	33,842	20,796	34,848	22,374	34,079	20,353
Clusters	186	108	186	108	186	108	197	120	188	105
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Total births										
Exposed (CIV)	-0.178	-0.294**	-0.185*	-0.276**	-0.196*	-0.329***	-0.100	0.006	-0.232*	-0.455***
	(0.114)	(0.133)	(0.106)	(0.121)	(0.111)	(0.122)	(0.097)	(0.112)	(0.125)	(0.152)
Mean DV (Control)	4.172	4.156	4.172	4.156	4.172	4.156	4.067	3.996	4.152	4.153
Observations	5,440	3,373	5,440	3,373	5,440	3,373	5,635	3,637	5,489	3,298
Clusters	186	108	186	108	186	108	197	120	188	105
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: The table shows RD estimates of variants of the main specification (see Table 2 notes for more details). We included the distance to the national border as an additional control in columns (1) and (2). We removed the control for distance to the capital city in columns (3) and (4). We included the geographical and population density variables described in Table A1 as additional controls in columns (5) and (6). We removed donut holes, meaning that we kept all villages close to the border, in columns (7) and (8). We increased the size of the donut holes from $5km$ to $10km$ in DHS and from $1km$ to $5km$ in BFAB in columns (9) and (10).

Table B5: Alternative bandwidths and polynomials

	Bandwidth of 60km		Bandwidth of 80km		Optimal bandwidth + non-parametric specif.		Second order poly		Keep northern villages	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)	All (9)	Mossi land (10)
Panel A: BFAB sample										
Annual birth rate										
Exposed (CIV)	-0.011*	-0.015*	-0.010*	-0.013*	-0.009	-0.005	-0.005	-0.001	-0.011*	-0.013*
	(0.007)	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)	(0.008)	(0.010)	(0.006)	(0.007)
Mean DV (Control)	0.293	0.290	0.295	0.290	0.295	0.290	0.294	0.290	0.294	0.290
Observations	72,919	55,019	86,274	63,469	78,867	51,807	81,022	59,395	81,022	59,395
Clusters	125	99	152	117	106	58	140	107	140	107
Bandwidth Niger	60.00	60.00	80.00	80.00	37.01	24.24	70.00	70.00	70.00	70.00
Bandwidth CIV	60.00	60.00	80.00	80.00	105.38	52.25	70.00	70.00	70.00	70.00
Total births										
Exposed (CIV)	-0.204**	-0.250**	-0.168**	-0.200**	-0.178**	-0.124	-0.103	-0.159	-0.216***	-0.217**
	(0.086)	(0.098)	(0.078)	(0.091)	(0.078)	(0.115)	(0.099)	(0.127)	(0.082)	(0.097)
Mean DV (Control)	4.827	4.790	4.832	4.790	4.832	4.790	4.819	4.790	4.819	4.790
Observations	11,883	9,025	14,152	10,461	13,783	7,930	13,278	9,771	13,278	9,771
Clusters	125	99	152	117	124	58	140	107	140	107
Bandwidth Niger	60.00	60.00	80.00	80.00	54.43	24.24	70.00	70.00	70.00	70.00
Bandwidth CIV	60.00	60.00	80.00	80.00	87.57	44.24	70.00	70.00	70.00	70.00
Panel B: DHS sample										
Annual birth rate										
Exposed (CIV)	-0.027**	-0.027**	-0.025**	-0.031***	-0.036***	-0.011	-0.032**	-0.048***	-0.023**	-0.026**
	(0.011)	(0.011)	(0.010)	(0.011)	(0.009)	(0.010)	(0.014)	(0.017)	(0.010)	(0.011)
Mean DV (Control)	0.312	0.327	0.315	0.327	0.314	0.327	0.315	0.327	0.299	0.327
Observations	29,274	18,042	39,464	24,801	40,520	15,614	33,842	20,796	38,670	20,796
Clusters	163	95	217	128	166	57	186	108	218	108
Bandwidth Niger	60.00	60.00	80.00	80.00	54.81	25.15	70.00	70.00	70.00	70.00
Bandwidth CIV	60.00	60.00	80.00	80.00	89.59	48.33	70.00	70.00	70.00	70.00
Total births										
Exposed (CIV)	-0.275**	-0.295**	-0.274**	-0.347**	-0.466***	-0.316***	-0.300**	-0.253	-0.269**	-0.331***
	(0.115)	(0.137)	(0.110)	(0.135)	(0.090)	(0.089)	(0.151)	(0.196)	(0.108)	(0.122)
Mean DV (Control)	4.141	4.156	4.153	4.156	4.098	4.156	4.172	4.156	3.962	4.156
Observations	4,718	2,934	6,346	4,009	7,566	2,503	5,440	3,373	6,250	3,373
Clusters	163	95	217	128	149	57	186	108	218	108
Bandwidth Niger	60.00	60.00	80.00	80.00	44.49	25.15	70.00	70.00	70.00	70.00
Bandwidth CIV	60.00	60.00	80.00	80.00	108.08	45.79	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note: The table shows RD estimates of variants of the main specification (see Table 2 notes for more details). We replaced the 70km bandwidth by a 60km bandwidth in columns (1) and (2); by a 80km bandwidth in columns (3) and (4); and by the optimal bandwidth defined using the data-driven local-polynomial estimation and inference procedures discussed in Cattaneo et al. (2019) in columns (5) and (6). We replaced the linear polynomial by a second-order polynomial in columns (7) and (8). We removed the restriction on the latitude, that is we kept all villages on the Niger side including those located north of the border in columns (9) and (10).

Table B6: Conley standard errors

	Conley cut-off:					
	40km		85km		100km	
	All	Mossi land	All	Mossi land	All	Mossi land
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: BFAB sample			
			Annual birth rate			
Exposed (CIV)	-0.011*	-0.016***	-0.011**	-0.016***	-0.011**	-0.016***
	(0.007)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)
Mean DV (Control)	0.294	0.290	0.294	0.290	0.294	0.290
Observations	81,022	59,395	81,022	59,395	81,022	59,395
Optimal Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
			Total births			
Exposed (CIV)	-0.209***	-0.234**	-0.209***	-0.234***	-0.209***	-0.234***
	(0.062)	(0.091)	(0.014)	(0.048)	(0.013)	(0.022)
Mean DV (Control)	4.819	4.790	4.819	4.790	4.819	4.790
Observations	13,278	9,771	13,278	9,771	13,278	9,771
Optimal Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
			Panel B: DHS sample			
			Annual birth rate			
Exposed (CIV)	-0.023*	-0.029**	-0.023**	-0.029***	-0.023**	-0.029***
	(0.013)	(0.013)	(0.012)	(0.009)	(0.012)	(0.009)
Mean DV (Control)	0.315	0.327	0.315	0.327	0.315	0.327
Observations	33,842	20,796	33,842	20,796	33,842	20,796
Optimal Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
			Total births			
Exposed (CIV)	-0.206	-0.303**	-0.206	-0.303**	-0.206	-0.303*
	(0.144)	(0.154)	(0.178)	(0.153)	(0.175)	(0.159)
Mean DV (Control)	4.172	4.156	4.172	4.156	4.172	4.156
Observations	5,440	3,373	5,440	3,373	5,440	3,373
Optimal Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓

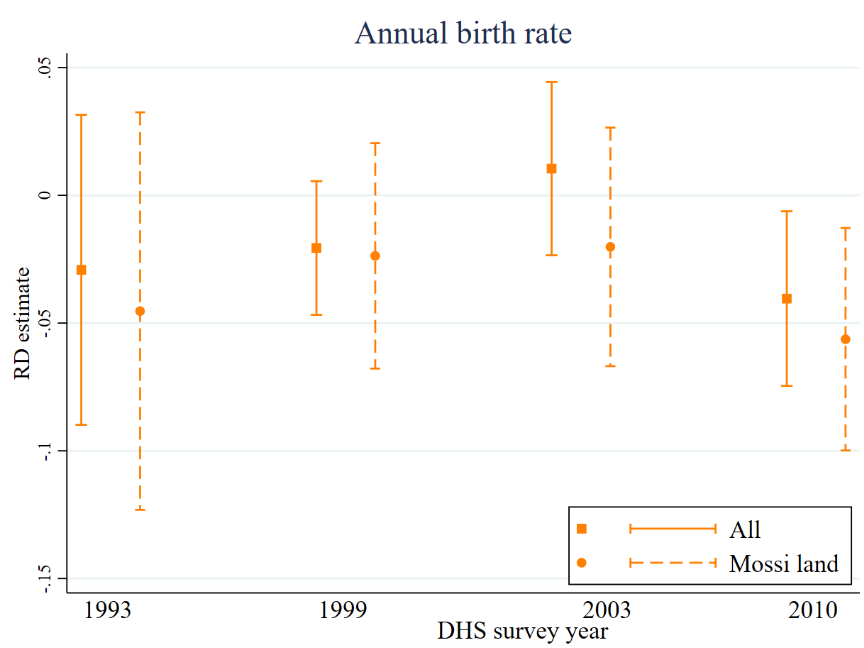
Note: The table shows RD estimates of variants of the main specification (see Table 2 notes for more details). Instead of clustering standard errors at the village level, we allow for spatial auto-correlation in the error terms using Conley standard errors. We use a cut-off radius of 40kms in columns (1) and (2); 85kms in columns(3) and (4); and 100kms in columns (5) and (6). The cut-off radius is the distance after which we assume that the spatial correlation disappears. Conley standard errors are reported in parentheses. ****p<0.01, **p<0.05, *p<0.1*

Table B7: Robustness to Mossi Ethnics only

	Annual birth rate		Total births		Desired fertility (Men)		Desired fertility (Women)	
	All (1)	Mossi land (2)	All (3)	Mossi land (4)	All (5)	Mossi land (6)	All (7)	Mossi land (8)
				DHS sample - Mossi ethnic only				
Exposed (CIV)	-0.055***	-0.051***	-0.400***	-0.441***	-1.332	-1.888	-0.358	-0.821**
	(0.014)	(0.015)	(0.141)	(0.165)	(0.889)	(1.235)	(0.317)	(0.348)
Mean DV (Control)	0.312	0.329	3.970	4.124	7.832	8.155	6.412	6.283
Observations	21,105	16,858	3,472	2,769	954	739	3,085	2,454
Clusters	150	103	150	103	135	96	149	103
Bandwidth	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
Border FE	✓	✓	✓	✓	✓	✓	✓	✓
Ethnicity FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓

Note: Source: DHS. The table reports the estimates of β in Equation 1 for the subsample of individuals who report being from the Mossi Ethnic group. The analysis in odd-numbered columns includes all Mossis. In even-numbered columns, the analysis is restricted to Mossis living within the historical Mossi homeland. See Table 2 notes for more details on the specification.

Figure B1: Effect on fertility by survey year



Note: Source: DHS. The figure shows the estimates of β and their 95% confidence intervals in a generalized version of Equation 1 for different years of the DHS survey. The dependent variable is annual birth rate of women aged $18-40$. We order the estimates on the x-axis depending on the DHS survey year. The dashed line shows estimates when we restrict the analysis to the ancestral ethnic homeland of the Mossi.

Supplement to Long-run Impacts of Forced Labor Migration on Fertility Behaviors: Evidence from West Africa

In this appendix, we (i) detail the sources we used for our geographical variables (ii) present our methodology to digitize cercles' boundaries from the scanned historical maps.

Appendix C Geographic Data Sources

Elevation: The elevation data is provided by the National Oceanic and Atmospheric Administration (NOAA) and U.S. National Geophysical Data Center, TerrainBase, release 1.0 (CD-ROM), Boulder, Colo. and available at https://sage.nelson.wisc.edu/data-and-models/atlas-of-the-biosphere/mapping-the-biosphere/ecosystems/topography/. This data provides elevation information in meters at the 30 arc-second resolution (approximately at the $1km^2$ level near the equator). Our paper's elevation variable calculates the mean elevation for each $12km$ by $12km$ grid cell in meters.

Precipitation: Precipitation data is provided by the Global Climate Database created by Hijmans et al. (2005) and available at http://www.worldclim.org/. This data contains average monthly rainfall in millimeters covering the years 1970-2000. We calculate the mean of the average monthly rainfall within each $12km$ by $12km$ grid-cell. For each pixel, we then calculate the average over the twelve months to obtain our grid-cell level measure of precipitation.

Soil Suitability for agriculture: Soil suitability is the soil component of the land quality index created by the Atlas of the Biosphere available at https://sage.nelson.wisc.edu/data-and-models/atlas-of-the-biosphere/mapping-the-biosphere/land-use/. This data uses soil characteristics (namely soil carbon density and the acidity or alkalinity of soil) and combines them using the best functional form to match known actual cropland area and interpolates this measure to be available for most of the world at the 0.5 degree in latitude by longitude level. This measure is normalized to be between 0 and 1, where higher values indicate higher soil suitability for agriculture. Our Soil Suitability variable measures the average soil suitability in each $12km$ by $12km$ grid cell to provide a measure of soil suitability that also ranges between 0 and 1, with higher values indicating higher soil suitability for agriculture.

Population density: For a given pixel, we define population density as the number of cities in that pixel. Cities were georeferenced using A.O.F historical maps from 1924-1926. Following the map legend, we included as cities: "Capitale d'Etat ou de Colonie", "Ville importante", and "Ville".

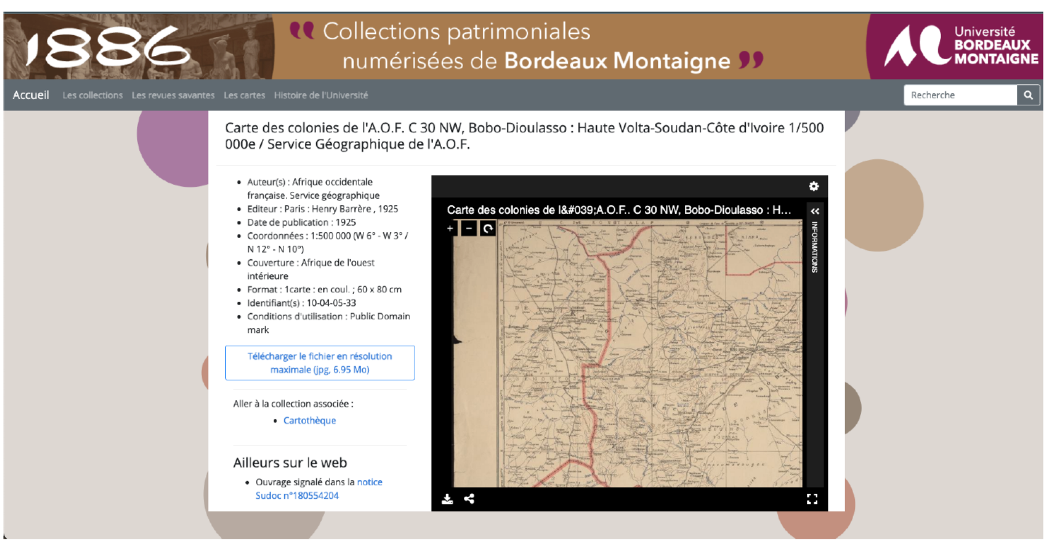
Appendix D Methodology to Digitize Maps

In this appendix, we describe the procedure to georeference scanned historical maps and extract their administrative boundaries. We also provide a replication folder including the raw maps, code, and our final output. It is important to note that our methodology involves some manual steps (e.g. georeferencing coordinate points, manual corrections, etc.). Those are indicated in the document.

1. Tools needed. The following softwares and applications: QGIS; ArcGIS; Python; Adobe Photoshop.

2. Source and Original Maps We used Cercle and colony administrative boundaries from historical maps by the Afrique Occidentale Française (A.O.F) Service Géographique published between 1924 and 1926. Scanned versions of the maps were available on the numerical Carthothèque from Université Bordeaux Montaigne. 10 maps cover Haute-Volta (see table below for details). Maps were downloaded in June 2021. Figure D1 below presents one of those maps and its associated description from the online Carthothèque.

Figure D1: Screenshot of Scanned Map on Carthotèque of Université Bordeaux Montaigne



Note: Auteur(s): Afrique occidentale française. Service géographique. Date de publication: 1926. Description En marge : tableau d'assemblage des feuilles voisines. Coordonnées 1:500 000 (E 0° - E 3° / N 12° - N 10°). Couverture Afrique de l'ouest : golfe de Guinée. Format 1carte ; en coul. ; 60 x 80 cm.Accessed on Nov 20th, 2023

Table D1: List of Historical Scanned Maps Used

Map Name and Link to Carthothèque	File (replication package)
Carte des colonies de l'A.O.F. C 30 NW, Bobo-Dioulasso : Haute Volta -Soudan-Côte d'Ivoire 1/500 000e / Service Géographique de l'A.O.F. 1925 https://1886.u-bordeaux-montaigne.fr/s/1886/item/203868	1925_C30NW_CI_HV_S.jpeg
Carte des colonies de l'A.O.F. C 30 SW, Dabakala : Côte d'Ivoire- Haute Volta 1/500 000e / Service Géographique de l'A.O.F. 1924 https://1886.u-bordeaux-montaigne.fr/s/1886/item/203870	1924_C30SW_CI_HV.jpeg
Carte des colonies de l'A.O.F. C 30 NE, Tenkodogo : Haute - Volta 1/500 000e / Service Géographique de l'A.O.F. 1925 https://1886.u-bordeaux-montaigne.fr/s/1886/item/168697	1925_C30NE_HV.jpeg
Carte des colonies de l'A.O.F. C 30 SE, Bondoukou : Côte d'Ivoire- Haute Volta / Service Géographique de l'A.O.F. 1924 https://1886.u-bordeaux-montaigne.fr/s/1886/item/168698	1924_C30SE_CI_HV.jpeg
Carte des colonies de l'A.O.F. D 30 NE, Hombori : Soudan-Haute Volta 1/500 000e / Service Géographique de l'A.O.F. 1925 https://1886.u-bordeaux-montaigne.fr/s/1886/item/168718	1925_D30NE_HV_S.jpeg
Carte des colonies de l'A.O.F. D 30 SE, Ouagadougou : Haute Volta -Soudan français 1/500 000e / Service Géographique de l'A.O.F. 1925 https://1886.u-bordeaux-montaigne.fr/s/1886/item/203855	1925_D30SE_HV_S.jpeg
Carte des colonies de l'A.O.F. C 31 NW, Kandi : Dahomey-Haute Volta -Togo / Service Géographique de l'A.O.F. 1926 https://1886.u-bordeaux-montaigne.fr/s/1886/item/168699	1926_C31NW_HV.jpeg
Carte des colonies de l'A.O.F. D 31 SW, Niamey : Haute Volta -Niger-Dahomey 1/500 000e / Service Géographique de l'A.O.F. 1926 https://1886.u-bordeaux-montaigne.fr/s/1886/item/168721	1926_D31SW_HV.jpeg
Link Missing (contacted library)	1926_D30SW.jpeg
Link Missing (contacted library)	1926_D31NW.jpeg

3. **Methodology.** The following methodology draws on/uses:

- Peichel (2020): *(Semi-)Automatic Vector Extraction of Administrative Borders from Historical Raster Maps.*
- University of Texas Libraries Raster Data Georeferencing Guide: "*Georeference By Map Corners: Process Overview*" (link accessed in 2021 https://guides.lib.utexas.edu/georeference-raster-data/qgis-georeference-by-map-corners)
- Cheng (2023): Python code written by Shirley Cheng who provided invaluable help for

this exercise. Code is available in the replication folder.

Step 1: Georeferencing maps.

We georeferenced the scanned maps using the coordinate points displayed on the maps. We adapted the methodology from the University of Texas Libraries, following their online guide *Georeference By Map Corners: Process Overview.* For replicability purposes, we write down again the steps we followed based on their guide as well as the settings we used.

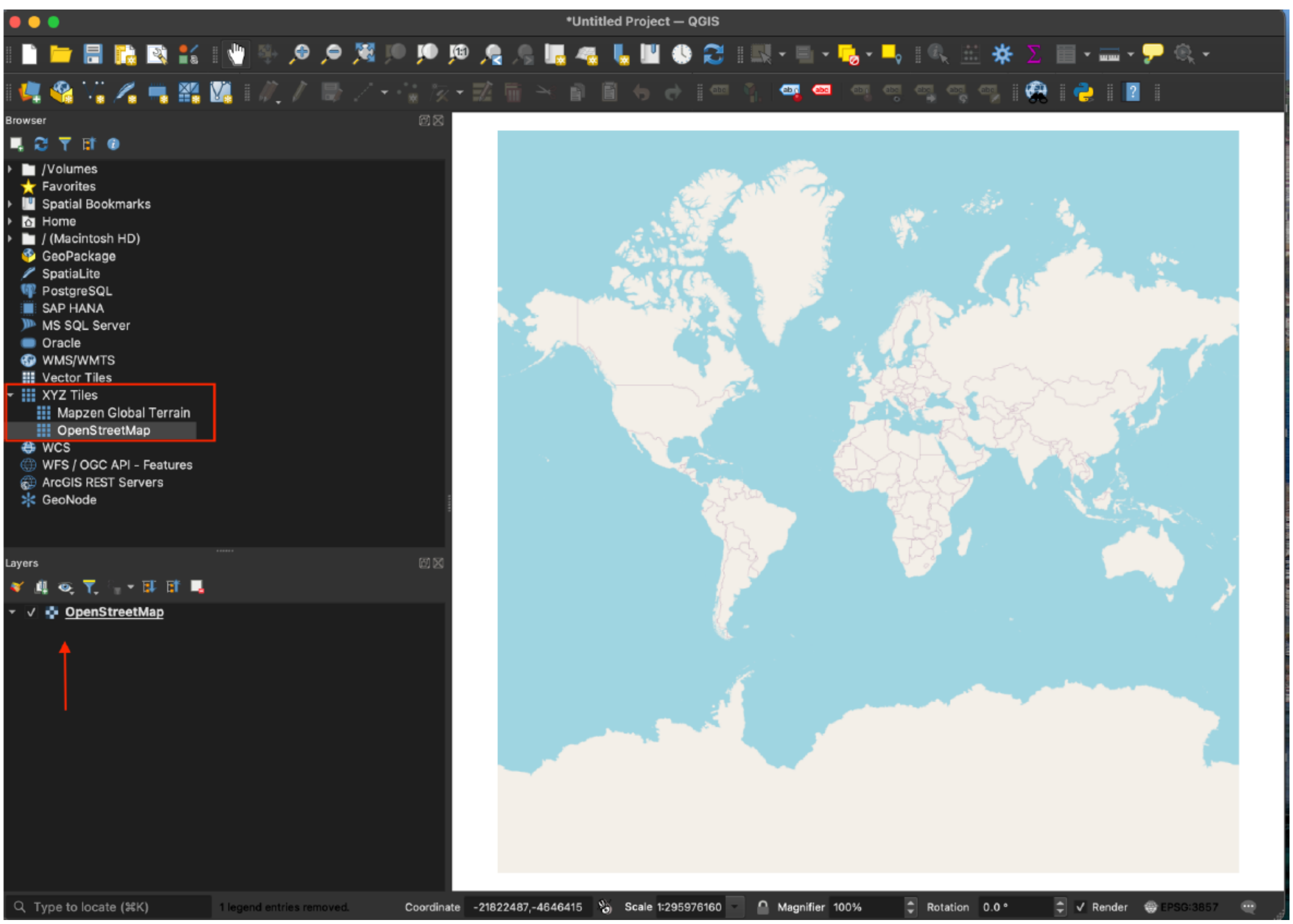
Application: QGIS.

1.1) Basemap choice:

a) Load OpenStreetMap by clicking on the left hand panel "XYZ Tiles > OpenStreetMap" or on the top "Layer > Add Layer > Add XYZ Layer".

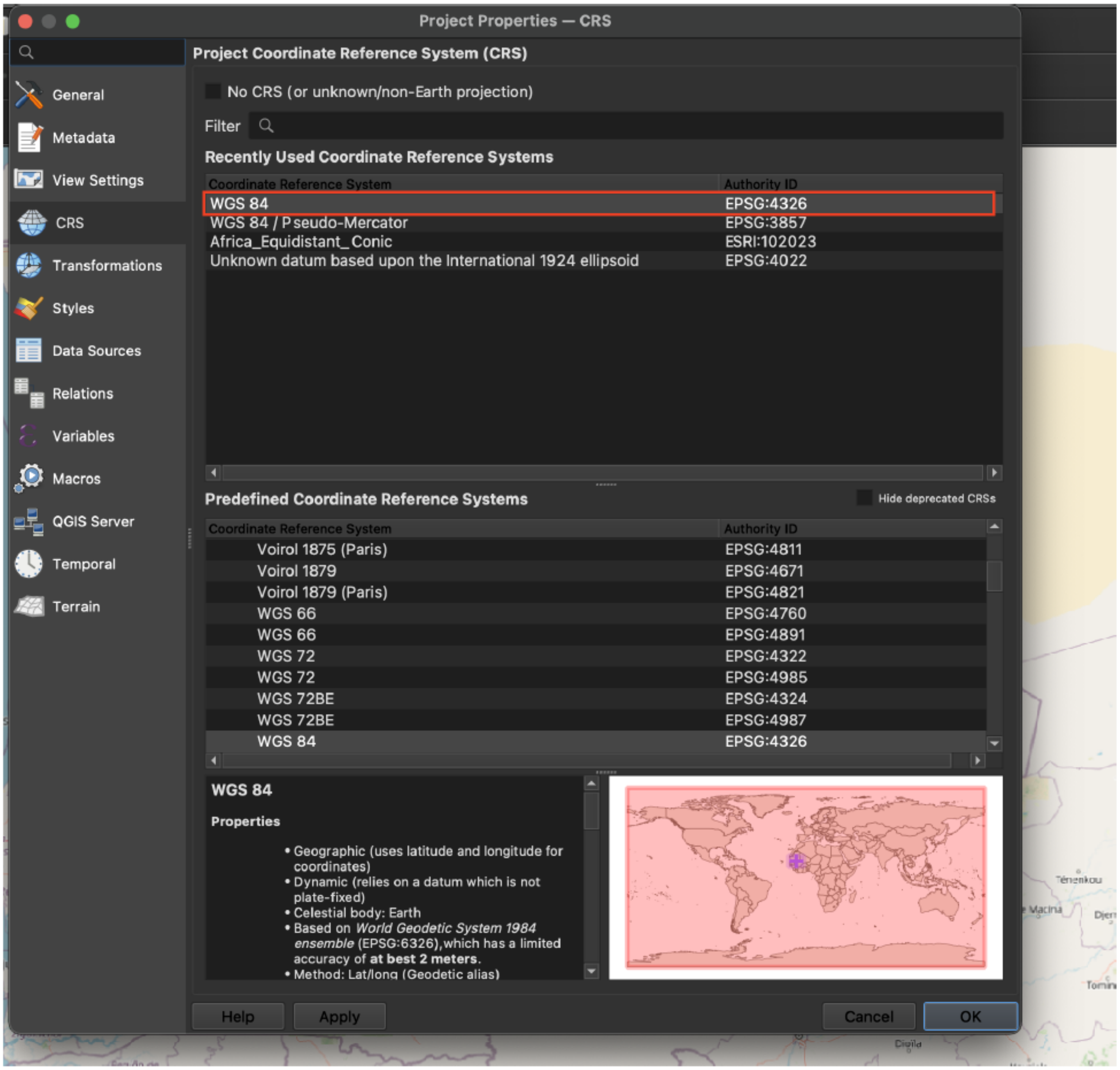
b) Select "OpenStreetMap" from the drop down menu then click "Add"

c) A new layer will appear on the right hand side. From now on, click on the checked square in the panel "Layers" (see the arrow) to make the OpenStreetMap layer disappear or appear.



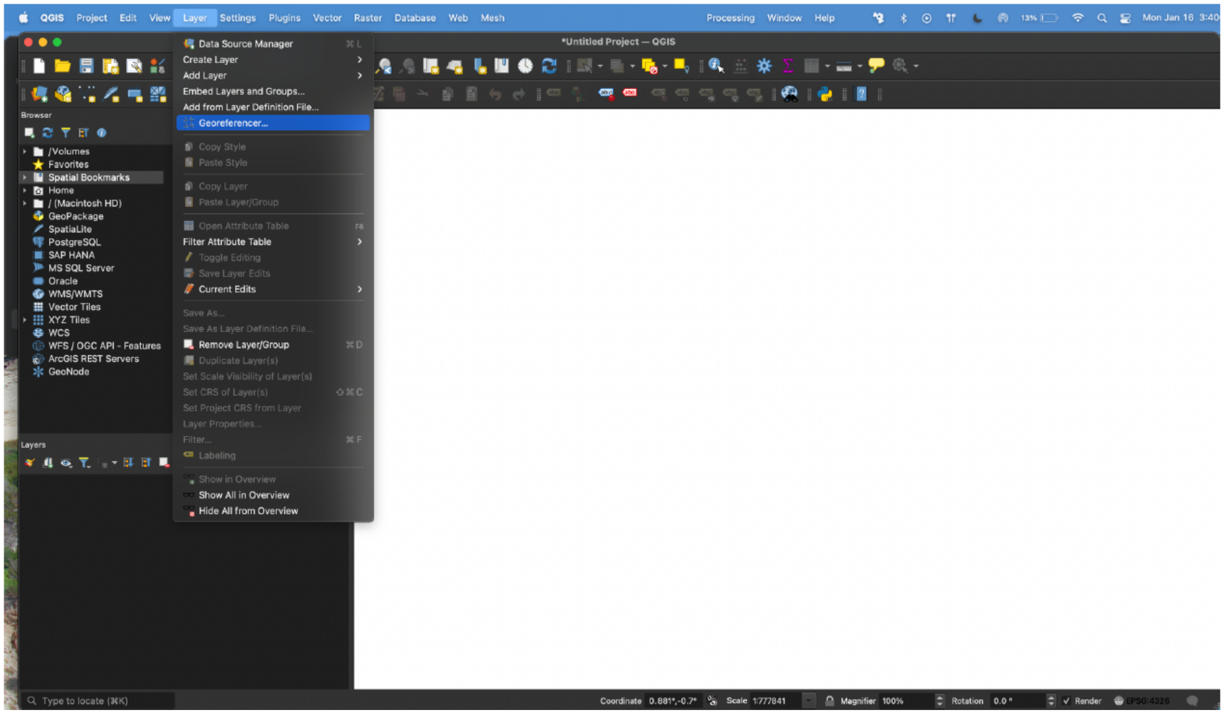
1.2) Set Project Coordinate Reference System (CRS)

a) Click **Project** at the top of the QGIS screen. Select **Properties** from the menu that appears. In the Project Properties window, click on CRS in the left hand column and then select the desired CRS for the project and georeferenced layers. We used the CRS WGS84 (**EPSG:4326**)



1.3) Georeference Raster: Load the scanned map on QGIS

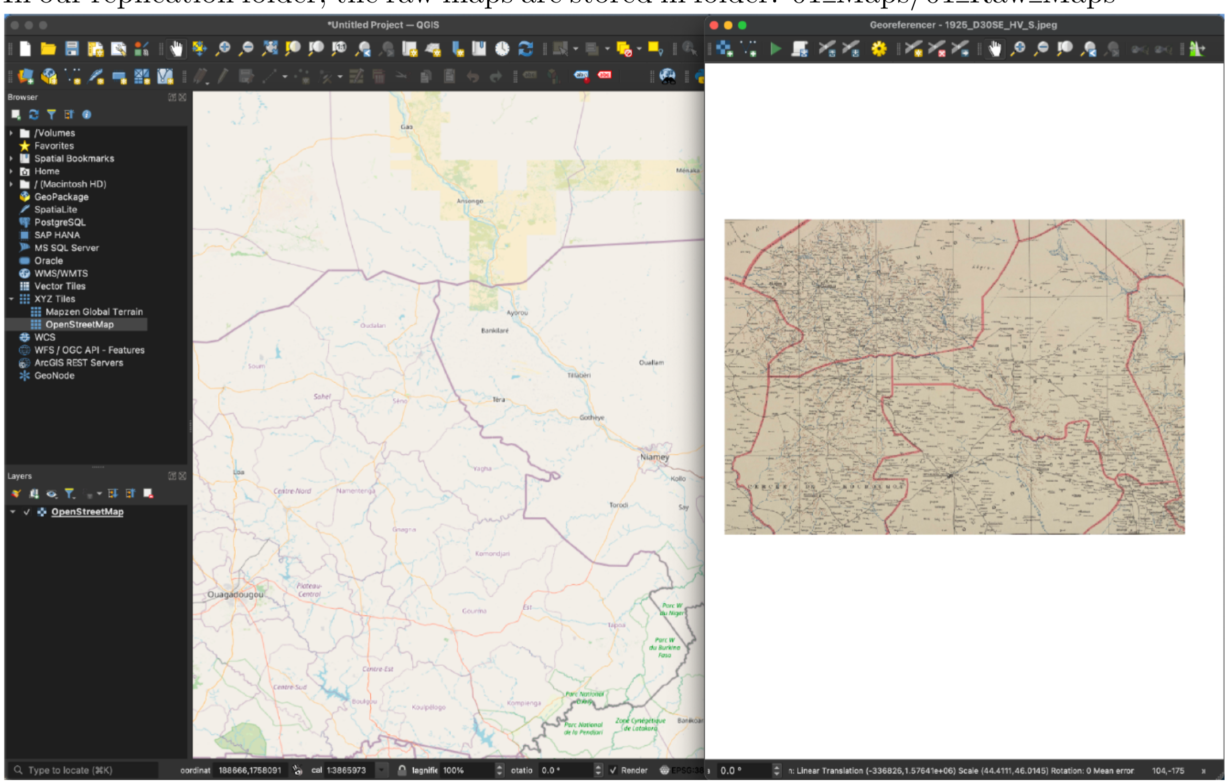
a) To start georeferencing click on Layer > Georeferencer



b) Click in the new window on "Open Raster" 

c) Select the map in JPEG format to georeference

d) In our replication folder, the raw maps are stored in folder: 01_Maps/01_Raw_Maps

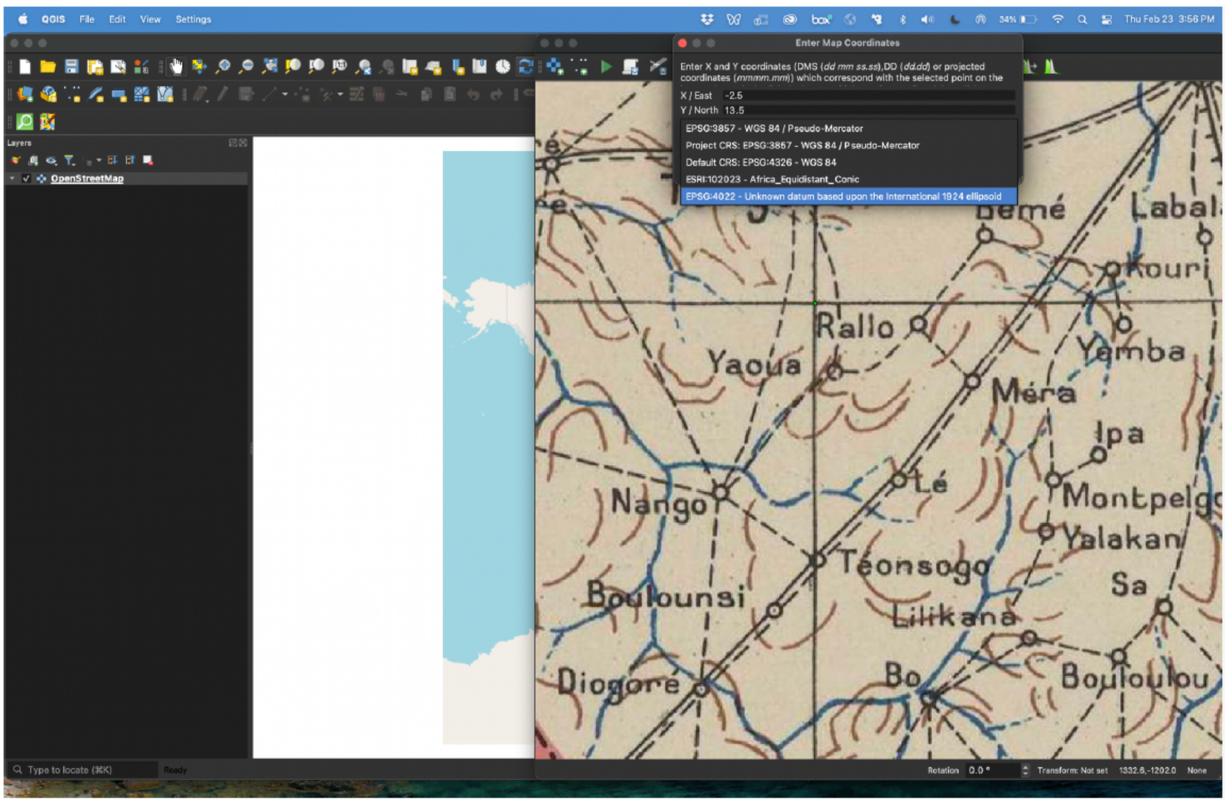


1.4) Add Ground Control Points (GCP)

a) To add GCP points, click on “Add point” 

b) Click on a coordinate intersect from the grid displayed on the map. A box “Enter Map Coordinates” will open.

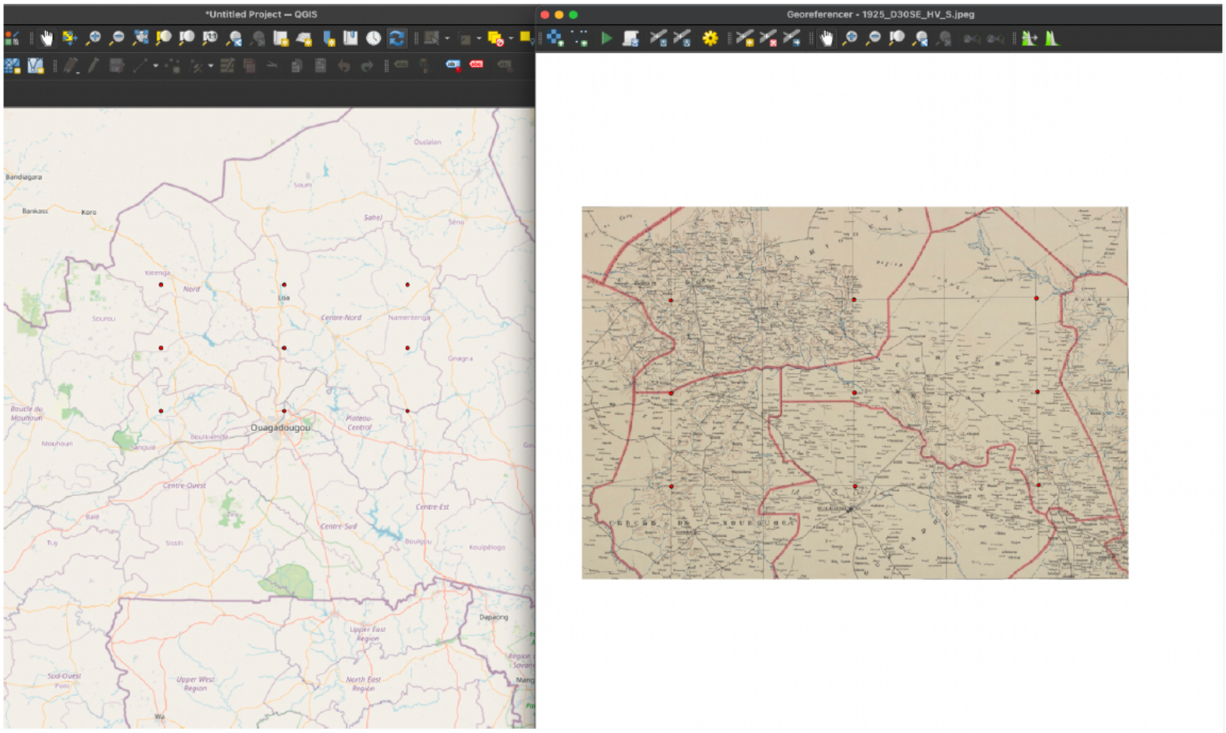
c) Enter the X/East coordinate and Y/North coordinate of the point (in degrees). *Careful, West is entered as a negative number. E.g. 3W = -3.00.*



d) Select the Coordinate Reference System: EPSG:4022 (CRS is in degrees).

e) Click “ok”

f) After referencing a couple of GCP, the map will appear as follows:



1.5) Transformation

a) After georeferencing at least 3 points (we did 12 per map), click on the "*Transformation Settings*" button 

b) Set the parameters to (*following University of Texas Libraries guide except for Target CRS*):

   i) Transformation type: Polynomial 1

   ii) Target CRS (same as project): EPSG:4326 (degrees)

   iii) Resampling method: Cubic

   iv) Compression: LZW

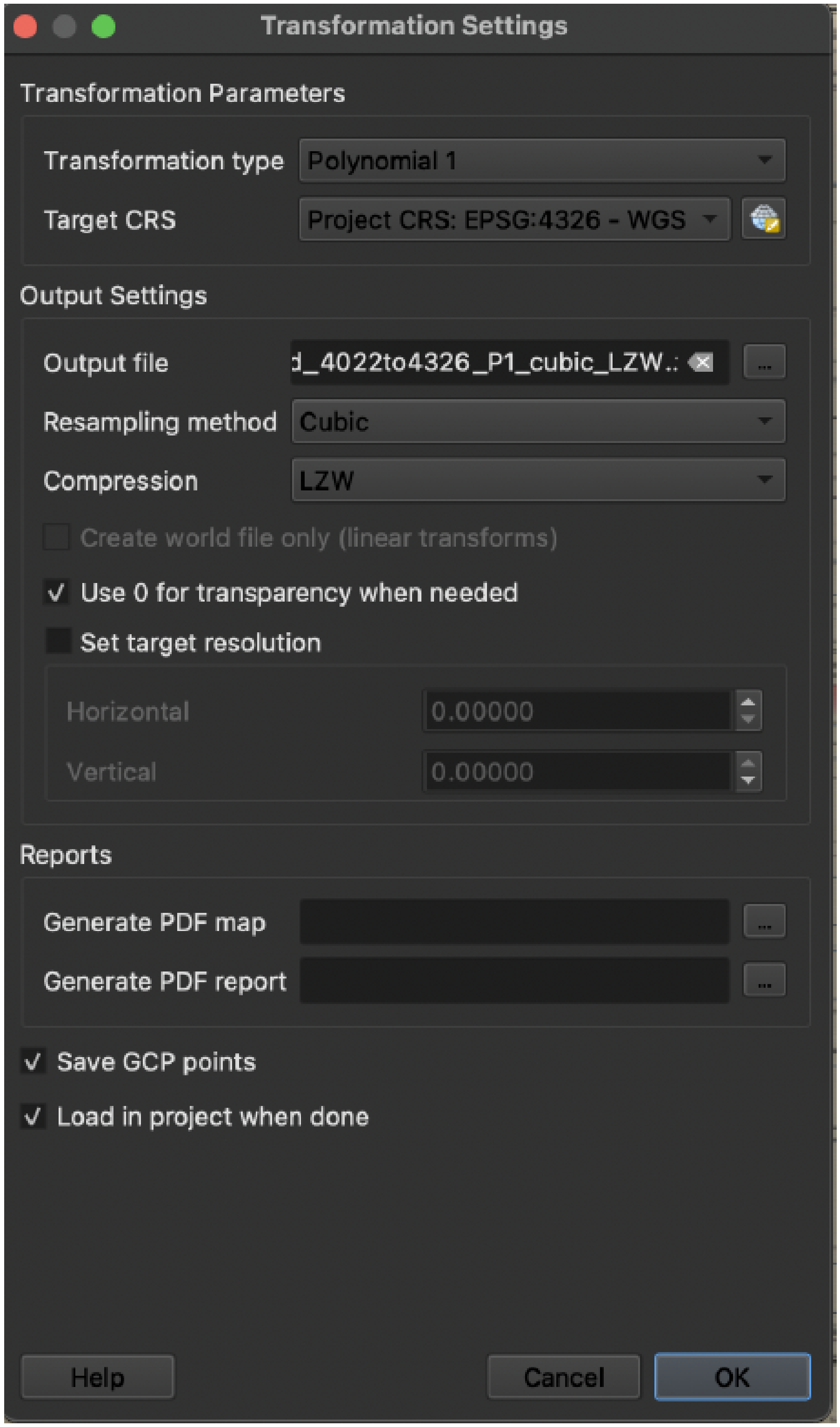
   v) Tick "Use 0 for transparency when needed"

   vi) Untick "Set target resolution"

   vii) Tick "Save GCP points"

   viii) Tick "Load in project when done"

   iX) Save output in the desired folder. Follow the naming convention: *originalname_EPSGsourcetoEPSGtarget_transformationtype_resamplingmethod_compr*



c) The new map should automatically load in QGIS in the correct position.

d) In our replication folder, georeferenced maps and GCP are in the folder: 01_Maps/01_Georeferen

Once all maps have been georeferenced, the final result should look like below.

Step 2: (Mostly) automatically extracting boundaries.

Cercles and colony borders are indicated in red on the maps. In this section, we semi-automatically extract the boundaries from the georeferenced maps (raw jpeg images) and geo-reference the output.

Applications: Python, QGIS, ArcGIS, Adobe Photoshop.

2.1) Processing the map images to extract boundaries:

The replication folder contains a Python code written by Shirley Cheng (2023) to extract the boundaries: 02_Code/process_image.py The code does the following for each map:

a) Extract the "red" of the administrative boundary line

   i) The code takes the RGB value of the "red" line and extracts only pixels within +/- 30 of that value. (Note, for some maps, it is better to use +/- 15 RGB instead of +/-30 because of the difference in tones, but it should be visually obvious when +/-15 is better. This can be changed in line 63-65.)

ii) In our replication folder, extracted borders (png format) can be found in 01_Maps/02_Extracted_Boundaries.

b) Greyscale and remove noise

i) Greyscaling the image is necessary to use other functions in later steps. Noise removal removes all the fuzzy bits of red that we can see present in the previous image. These functions are done with Python's OpenCV library.

c) Erode the border

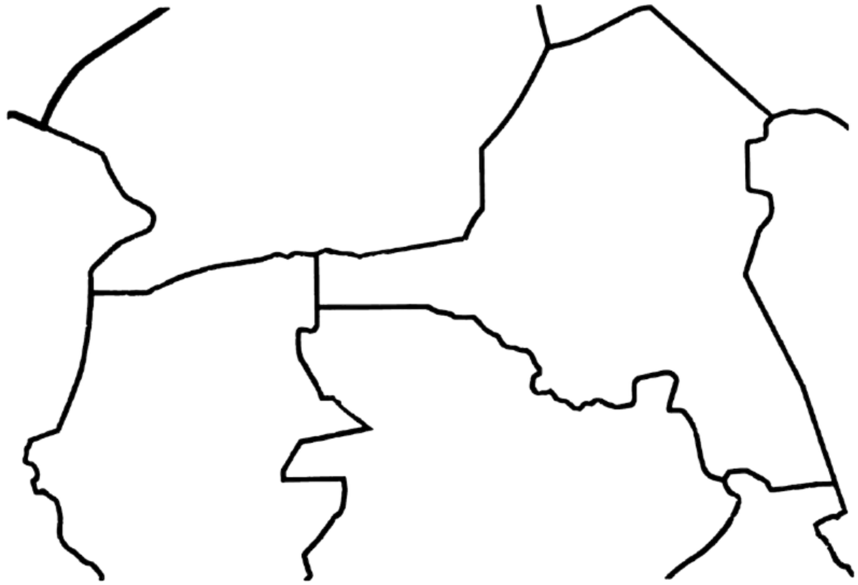
i) This increases the size of the border. The documentation for erosion is on the page "Eroding and Dilating" on OpenCV (link https://docs.opencv.org/3.4/db/df6/tutorial_erosion_dilatation.html)

d) Blur the borders very slightly

   i) This will make the borders smoother

e) Threshold the image

   i) This takes all pixel values above 127 (grey color) and sets them to be 255 (black), and all pixel values below to be 0. This has the effect of removing the blur and turning the image into a black and white image which is necessary to later skeletonize the image.



f) Skeletonize the image

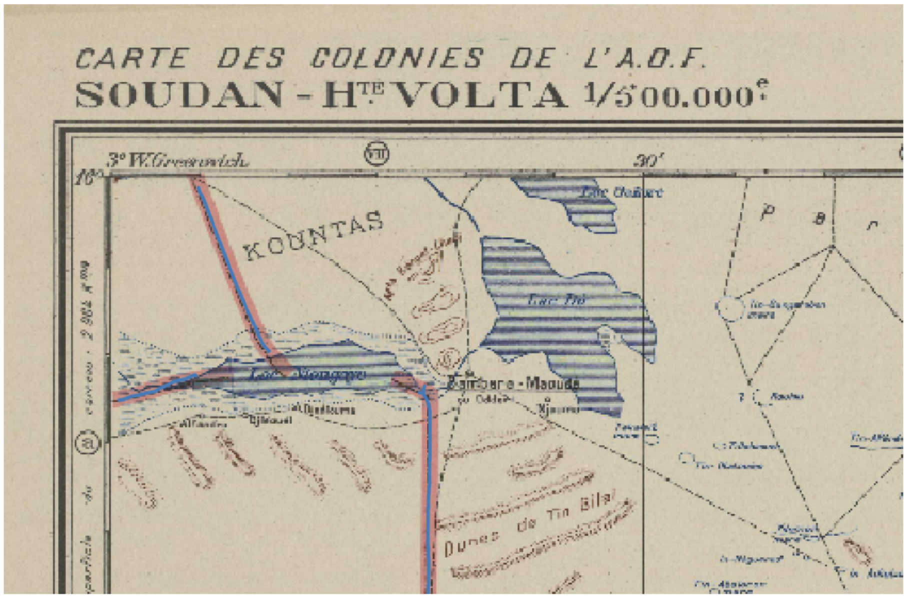
i) The skeletoning of the image is done using Python's morphology library. The documentation can be found here: https://scikit-image.org/docs/stable/auto_examples/edges/plot_skeleton.html

ii) In our replication folder, skeletonized borders (png format) can be found in 01_Maps/03_Skeletonized_Boundaries.

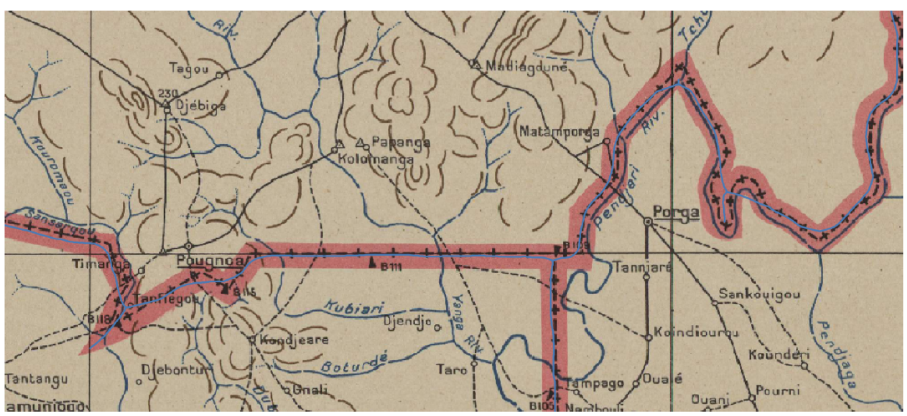
2.2) Manual corrections:

a) At this stage, the automatically extracted borders may display discontinuities or extra lines. To correct for those, we make a few manual corrections. Below are examples of imprecisions that we came across and manually corrected.

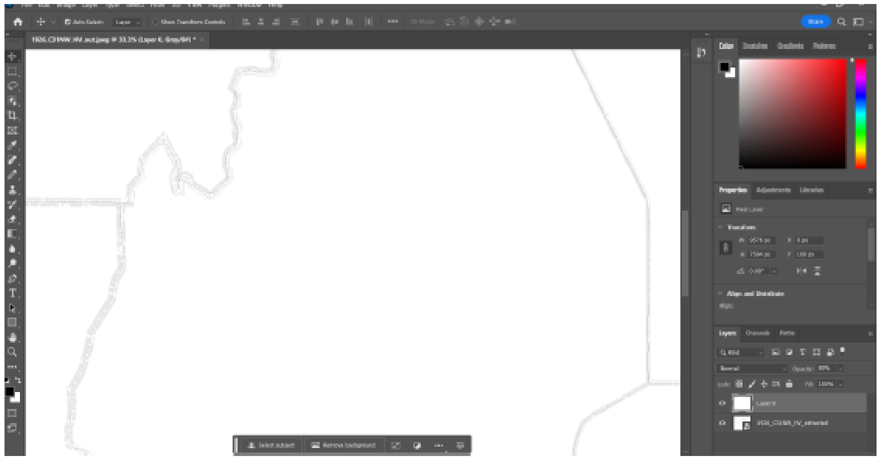
i) Here, there is a lake which we cannot automatically detect the border for.



ii) The python skeletonize library can have difficulty with triangular borders.



b) To make manual adjustments, we used Adobe Photoshop. To ensure accuracy, import the skeletonized border (files in 01_Maps/03_Skeletonized_Boundaries) and overlay it on top of the red extracted border (from the first step of image processing, files in 01_Maps/02_Extracted_Boundaries). Set the skeletonized image as the top layer at 80% opacity to see both borders.



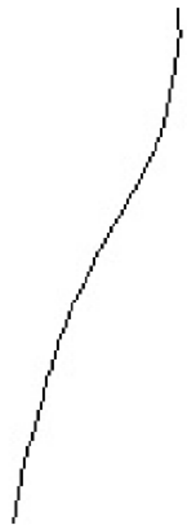
i) Use the erase tool to remove any extra details.

ii) To draw new lines, use the pencil tool with a width of 1px.

iii) In our replication folder, the modified borders can be found in 01_Maps/04_Edited.

2.3) Converting into lines:

The python skeletonize library converts all lines to be only one pixel thick, but the output will not make neat lines when we put it into a mapping software, as it will look like this:

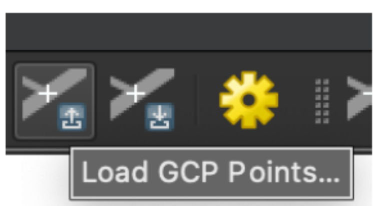


So, we go through the following steps for each edited image in 01_Maps/04_Edited using

a) Georeference the image

   i) We follow the same steps as in step 1 to georeference the images using QGIS. Follow steps 1-2-3 but instead of loading raw maps as rasters, load the images with the edited borders.

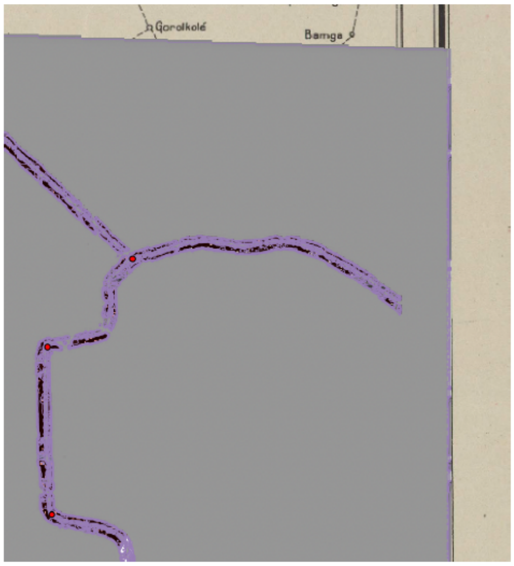
   ii) Instead of adding GCP, click on "Load GCP Points" to load the GCP previously outputted in step 1 (and saved in 01_Maps/01_Georeferenced_Maps/GCP). Points will be loaded on the raster and the basemap.



   iii) Use the same settings as in Step 1.

b) Contour and buffer the image: Contouring and buffering the image allows to make the lines (that we have already extracted) continuous.

   i) For contouring: use the tool "contour" from the GDAL plugin. We have found that it does not matter what you set the value of the contour and buffer to be at, because we have already processed the image down into a one pixel line. We used "Band 1 (Red)" for Band number and 50 for "Interval between contour lines". We obtain something like below:

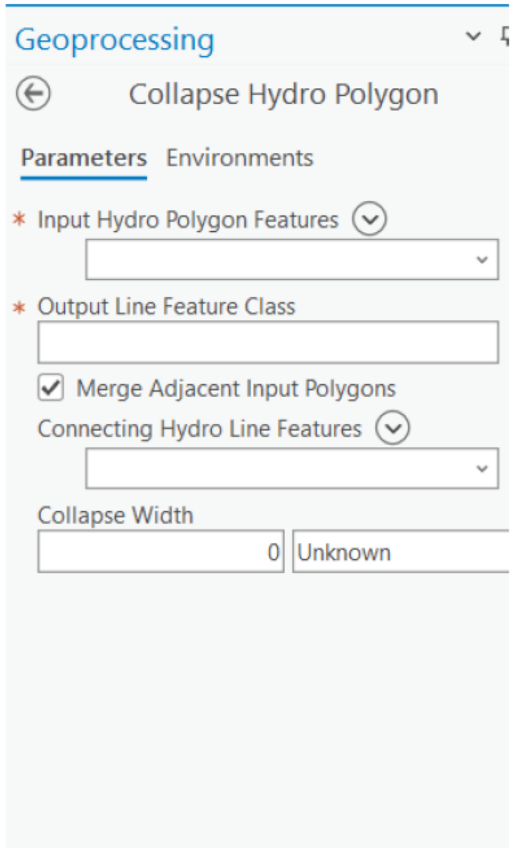


ii) In case of unwanted geometries (e.g. in the picture above, the boundaries of the raster), they can be removed clicking on "toggle editing" and selecting the hammer tool. Select pixels you want to remove and press delete.

c) Export the output into a shapefile

d) Convert buffered line into centerline

i) Import shapefiles into ArcGIS. Use ArcGIS's Collapse Hydro Polygon to convert the buffered lines into one centerline.



ii) The specifications of the fields are very simple. You only need to specify the input as the map vector and give an output name.

iii) It should be possible to do all steps in ArcGIS. The only thing is ArcGIS does not accept .points as inputs for georeferencing, so it can be more straightforward to do steps a) and b) in QGIS).

iv) In our replication folder, the boundaries are stored in: 01_Maps/06_Final_Shapefiles.

2.4) Missing boundary:

The 1924—1926 atlas only features 11 Cercles instead of the 12 we exploit. Indeed, Dedougou was one cercle until the 1932 partition when it was divided in two (North and South) along the Black Volta River. The boundary between Dedougou North and Dedougou South, which followed the Black Volta River as a natural boundary. We used the historical Black Volta River bed as depicted in the atlas for the boundary between Dedougou North and South. We used QGIS to manually draw the boundary[34].

[34]Our automatic python code extract features based on their color (e.g. cercle borders are red, the code

2.5) Extra Steps:

a) To connect the lines across multiple maps, load all the individual line-shapefiles in ArcGIS (semi-automatically extracted and manually drawn for the missing one). Use ArcGIS's line intersection tool, or the "continue feature" then "trim" tool.

b) In our replication folder, the final shapefile is stored in folder: 01_Maps/06_Final_Shapefiles.

attempts to only extract pixel of that color). Unfortunately, our "border" of interest here, the Black Volta River, is blue like many other features in the map. Hence, it was easier to manually draw the map instead of relying on the python code.

References:

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