The Negative Impacts of Colonization on the Local Population: Evidence from Morocco

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Abstract

Did colonial farming improve or worsen local welfare? To answer this question, I investigate the health effect of early exposure to French farms in colonial Morocco. If European colonists modernized agriculture in this *colony of settlement*, thereby increasing total productivity, the extractive colonial production took over resources, crowding out local producers. Using a novel indidividual dataset of Moroccan soldiers enrolled in French Morocco, I estimate the effect of being born in proximity to colonial farms on adult height, a proxy for early-life conditions. The results derived from a difference-in-difference strategy indicate that cohorts born near colonial farms grew smaller after the arrival of settlers. This adverse effect on health can be explained by the capture of local factors of production and changes in factor intensity. I highlight two mitigating mechanisms: new trade opportunities and technological spillovers. These results shed new lights on the weight of colonization on development, pinning down the channel of structural change in the rural sector.

JEL: N37; N57; O13; O15.

Keywords: Colonialism, land Concentration, rural Poverty, anthropometry

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1 Introduction

Colonial powers typically implemented extractive institutions to maximize colonial investments with ambiguous effects on local welfare (Bertocchi and Canova, 2002, Allen, 2011). The settlement of colonial farmers gave rise to a dual agricultural system, resulting in increased total production while capturing local resources and surplus (Bernstein, 2010). Did these structural changes in agriculture result in improved life conditions for the local population? The answer boils down to understanding which of the growth or redistributive effect dominated.

I explore this question in colonial Morocco (1912-1956) where the French government and farmers orchestrated a large transformation of the rural sector from subsistence to cash-crop agriculture. Concerned about avoiding reproducing rural mass impoverishment experienced in Algeria (1830) and Tunisia (1881), the French government equation was to transform Morocco into its "granary" while developing local farmers production. By the Independence, European settlers represented a substantial share of cultivated lands and agricultural output in nominal terms (respectively 7% and 15%). Amin (1966) estimates that although agricultural production more than doubled in the last 35 years of Morocco's colonization, production per capita merely rose by 0.4%.

Historical narratives provide an intuition of why the colonized benefited so little of the modernization of agriculture. The dual agricultural system meant a competition for fertile lands and water resource, a change in factor intensity detrimental to rural employment and the construction of new infrastructures (roads, rails, enclosures) hindering traditional rural activities (pasturing and crop rotation). On the distribution side, French suppliers exerted a monopoly on access to international markets, preventing local suppliers to capture part of the trade rent. For all these reasons, one may suspect a transfer of agricultural surplus from local to colonial farmers that would have been reflected in a deprived nutrition and health for colonial subjects. In absence of integrated markets, the effect could have been the most substantial in proximity to colonial farms.

The main objective of this article is to provide a quantitative micro-founded analysis of the short-term health effect of agricultural settlement, using adult height as a proxy for early-life conditions. I construct a novel pseudo-panel dataset of individual anthropometric measures observed at the municipality level. The timing and spatial distribution of colonial farms introduced variation in the exposure to colonial agriculture across birth cohorts born in different municipalities. I compare the height of cohorts born before and after the arrival of settlers across municipalities with and without colonial farms in a difference-in-difference strategy, controlling for municipality time-invariant characteristics and regional time fixed effects. This strategy allows overcoming the issue of selection of colonial farms location on time-invariant (or slowly moving over time) unobservable factors, and singling out the local agricultural shock from simultaneous regional and national health shocks provoked by colonization.

The analysis is based on first-hand individual data, including adult height, compiled from Moroccan soldiers enrollment cards enlisted in the French Army between 1912 and 1956. The geocoding of the dataset allows me to explore granular geographic variation across male cohorts depending on whether they were born in municipality with colonial farm or not. Their adult height is an indicator of the stock of nutrition and health accumulated during their childhood. The assumption is that every shock on the subsistence income of their parents will be reflected in this anthropometric measure through access to nutrition and health.

Anthropometric data are now commonly used in the development and economic history literature (Baten and Maravall, 2021) for their virtue of availability and comparability to proxy for biological standards of living. Adult height specifically is known as a synthetic measure of early life conditions, following well established findings in biology and demography. This retrospective measure allows infering pre-colonial and colonial living standards by comparing cohorts born during colonial settlements and those born before.[1]

The main concern raised by this setting is sample selection. As soldiers were voluntary enrolled, one should insure that variation in height is not due to different selection rules in the army. I first take the naive stand that my results are not driven by selection and than rule out the effect of a differential selection rule across treatment and control municipalities. A related question on selection regards migration. Structural changes in the rural sector may have pushed individuals to the cities, most likely the more productive ones and thus the tallest. Based on historical narratives, I argue that this effect is second order and verify the robustness of the results to the inclusion of the likelihood to migrate.

The strategy assumes the absence of reverse causality and of simultaneous shocks affecting local health. To support this, I bring evidence of the existence of parallel trend under counterfactual or, in other words, that exposed municipalities would have evolved on the same trend as unexposed municipalities in absence of colonial farming. I show that results are not driven by an existing pre-trend, ruling out the possibility of reverse causality, famously known as the "Aschenfelter dip", when units are treated because they experienced a negative shock. I also rule out the effect of alternative factors (crop suitability, trade shock) on the height trend differential.

The strategy also relies on the hypothesis that agriculture is the only channel through which colonial settlement affects health. However colonial settlement is a multi-faceted phenomenon with different potential effects on health. Because colonial farms settlement coincides with public investments flowing in different segments of the local economy (education, health, infrastructure) this bundle effect could undermine the identification of the agricultural channel. I therefore control for colonial investments in roads and railroads to partial out other dimensions of colonial presence.

Colonial settlement, that imposed land dispossession and resource deprivation with military force, encountered large armed resistance[2], so one may be worried that conflict is the underlying determinant of health.[3] I employ a set of strategies to evacuate these potential threats, and rule out the

[1]Several authors sudying standards of living in colonial settings, previoulsly relied on anthropometric data sourced from military archives (Austin *et al.*, 2012, Cogneau and Rouanet, 2011).

[2]The full occupation of Morocco arrived only in 1933.

[3]Morocco is a preferrable case study than the other big settlement colony, Algeria, where the occupation war waged by the French Empire was considerably longer, more deadly and crueler. The Napoleonian Army which would later become the Republican Army extensively applied razzias, earth and village burning and gruesome killings among other terror tactics aimed at civilians. According to certain estimates, population fell from 3 Million to 2.125.000 from 1830 to 1871. The probable direct effects of violence on nutrition would complicate the identification of the colonial economy in Algeria.

effect of confounding shocks.

I find that agricultural settlement caused a height penalty of around 0.4 centimeters for exposed cohorts. This adverse shock is an important finding, highlighting a phenomenon of reversal of fortune for localities directly exposed to colonial agriculture. In terms of magnitude, we can compare the results with the anthropometric effect of one of modern history's deadliest famines associated with the Biafran War between 1967-70: (Akresh *et al.*, 2012) find a heigh penalty of 0.75 centimeters for early child exposure to the war. This finding can also be compared with the gain in stature (+ 1.3 centimeters) due to an important positive productivity shock, the introduction of the potato in France (Nunn and Wantchekon, 2011).

I then examine different mechanisms that could support these results: water diversion, land concentration, productivity spillovers and trade opportunities. Results indicate that factor relocation and changes in factor intensity are the underlying forces behind the negative effect of colonial farms. They offer suggestive evidence that new trade opportunities and technological spillovers could have mitigated the effect, but overall the general welfare effect was negative. I find that a positive rain shock benefits the population living in the control group but not the treatment group. Additionally, the detrimental effect rises with colonial land concentration. I propose suggestive evidence that it is due to the combined effect of crowding out of land and reduction in labour intensity. On the other hand, I show that treated individuals benefited more from new market opportunities. A positive trade shock accrued more to treated individuals than to the untreated, a result that I explain by lowered trade costs in the presence of colonial farms. I also show that city-dwellers face a positive effect of colonial farmings, a result congruent with the explanation of change in terms of exchange between the rural and urban area.

Understanding which mechanisms explain the short-term health penalty can provide potential explanations for regional inequality path dependency, through capital accumulation or spatial diffusion of technology. This paper reveals the detrimental effect of the transformative change of colonial agriculture on factors distribution and local production adaptation leading initial prosperous municipalities to fall behind.

The rest of the paper is organized as follows : section 2 reviews the literature and highlights the main contributions of the paper. Section 3 lays down the historical background of colonial agriculture in Morocco. Section 4 describes the data. Section 5 presents the empirical strategy, discusses findings and examines threats to identification. Section 6 unravels potential mechanisms. Section VI brings concluding remarks.

2 Literature

This paper contributes to a recent body of literature focusing on living standards during the colonial period that generally show a deterioration of colonized conditions (Baten and Maravall, 2021, Baten and Moradi, 2015, Cogneau and Rouanet, 2011, Alvaredo *et al.*, 2020, for a review see Hopkins, 2019). I bring this literature forward by pinning down one aspect of colonialism, transformation in agriculture, through factor relocation. It also talks to the literature on colonial legacy which, under the wake of 'new growth economics' models, focuses on the persistent economic effect of colonial institutions and human capital (see Michalopoulos and Papaioannou, 2020 for a review). Following the pioneering work of (Acemoglu *et al.*, 2001) highlighting the institutional channel, Dell (2010) pins down the role of an extractive economic institution, forced labour, in long-run weak economic performance. Lowes and Montero (2018) highlights the role of another coercive institution, colonial medicine in forging long-term mistrust in modern medicine. On the other hand, growth-inducing economic institutions in another colonial setup would in turn appears beneficial (Dell and Olken, 2020). Authors have emphasized the role of ethnic partitioning and weak state building Michalopoulos and Papaioannou (2016), human capital (Huillery, 2009, Cagé and Rueda, 2016) and infrastructure (Jedwab and Moradi, 2016, Jedwab *et al.*, 2016 and Donaldson, 2018). Bertocchi and Canova (2002) evidence two possible mechanisms, the institutional and economic penetration channel, understood as the output drained from colonies to the metropol. They show that lower economic penetration hindered less post-colonial development. The contribution of this paper is to emphasize the role of production drain by colonial farmers, in the form of appropriation of factors of agricultural production, rather than institutions.

A body of economic history literature gives contrasting evidence on the effect of competition between settlement and local agriculture on local productivity shock. Bertazzini (2021) reveals a downwarding effect of colonial farms on local productivity due to the adoption of land extensive technics and labour drain. Arrighi (1967) and Feinstein (2005) highlight the mechanism of land overuse and soil exhaustion due to most fertile land expropriation leading to loss in local productivity. On the other side of the spectrunm Mosley (1983) and Shutt (2002) show that African farmers were incentized to adopt new technics and commercial crops in response to increased population pressure and market opportunities, stirring their productivity up.

Despite the various qualitative evidence highlighting the role of colonial agriculture in the deterioration of local standards of living, the relation between the both remains under-explored in the economic history literature. Authors questioning the legacy of colonial agriculture for African development took a long-term approach. Dell (2010) shows that a past institution enforcing forced labour in colonial Peru has persistent indirect consequences on the nutrition of the population living in formerly exposed localities, through its redistributive effect on land tenure and education provision. This paper highlights a coercive mechanism through which structural change in agriculture could have a detrimental impact. Alternatively, market forces, such as factor relocation, resource exhaustion or trade barriers, could sustain the negative effect of the dual agriculture inherited from colonialism. A recent work by Baten and Maravall (2021) taking a comparative approach across 47 African countries brings new evidence that the colonized faced overall a reduction of their biological standards of living upon colonization. Building on these studies, I hypothesize that colonization hindered development through large structural market transformations, first and foremost in agriculture, rather than specific coercive institutions. Taking a short-run and within-country perspective allows pinning down the precise mechanisms through which colonial agriculture harmed colonized welfare, while putting aside the role of different institutional setups at the level of the colony.

3 Historical background

3.1 The agricultural objective of French colonization

Since its conquest of Algeria in 1830, France objective was to push the Western border of its empire towards Morocco, where presumably fertile lands promised agricultural abundance at the doorstep of the metropole.

> "The true fortune of Morocco resides in its agriculture. Through export of the fruit of its soil, Morocco will become rich."

The words of Vaffier-Pollet (1906) sum up the ambition of the French government, that pursued a vast campaign of influence among its European neighbors to acquire Morocco. By signing the Treaty of Fes in 1912 that declared a Protectorate over the Cherifian Kingdom, France overcame the last hurdle for a farming settlement.

Land distribution Pre-colonial Morocco was characterized by a predominantly rural subsistence economy. Local farms were most often collectively owned (*bled el jemâa*) with customs tailored for dual agriculture[4] and nomadic husbandry (Karsenty, 1988) regulating land use and distribution across families. The country opened to trade in the late nineteenth century but the insufficient agricultural surplus and the archaism of the transportation system limited commercial transactions.

Land ownership by foreigners was virtually impossible prior to colonization.[5] In 1913 with the removal of legal restrictions, European capital started flowing into the rural land market, but World War I halted the settlement agenda[6]. Land transactions finally gained momentum in 1918 once land titling was fully enforced. 1919 really initiates the European farming rush.

30% of colonial farms were acquired through a public program. From 1919, the colonial administration conducted an interventionist agricultural policy named *"Colonisation officielle"*, with the distribution of public farms to settlers at a subsidized price (in form of conditional sales or long-term rents) as a main instrument. Alloting initially publicly owned plots, the governement started tapping in the collective[7] and religious (*habbous*) domains.[8]

[4] Two growing seasons per year.

[5] European powers obtained from the Moroccan Kingdom legal exceptions allowing land speculation around the principal harbours (Treaty of Madrid in 1880, treaty of Algeciras in 1908). The presence of settlers remained extremely limited though until the start of the colonization.

[6] In 1917, 133,000 hectares are owned by Europeans, of which only 27,640 are cultivated (Coz, 1964).

[7] I am referring here to both collective ownership of land – *bled el jemâa* – and land owned by the Sultan, granted to tribes for exploitation – *guich*. For the latter, the Protectorate faced no legal hindrance to dispossess users and transfer the lands in the domain of *"colonisation officielle"*.

[8] Over the 270,000 ha belonging to the perimeter of *"Colonisation officielle"* 37% came from the Sultan's domain, 26% from collective lands, 15% from *guich* domain, 19% from the private domain

At an early stage of colonization, the powerful Chambers of Agriculture saw in these plots a large reservoir of fertile lands and lobbied the administration to liberalize the land market. By contrast, the colonial administration's concern was to maintain political control in the rural area, and avoid massive land spoliations.[9] These opposing forces are synthesized in the reform of collective land ownership[10], forbidding private appropriation, while giving the government the discretionary power to allote vacant plots to settlers. This allowed the expropriation of large plots against farmholders consent, sometimes with the use of force.

Land transactions appeared as a cheap though sometimes risky investments for settlers[11]. By speculating on unsecured land titles and negotiating directly with tribe's authority rather than the actual farmholder, land price was ridiculously low, and could hardly represent a wealth shock for the local community. This led to a large transfer of land (550,000 ha. or 7% of all cultivable land) to an elite of 6,000 colonial farmers.

In addition to the vast transfer of land, the collective land reform in itself may have contributed to local farmers underdevelopment. The colonial intepretation of this customary institution is criticized (Bouderbala, 1999) for having forced the individual distribution of land across members of the collectivity, irrespectful of economies of scale and distribution of means of production (cattle, plough) and eventually unbundling the organic relationship between tribal demographic growth and land sharing. Additionally, the inalienability of collective land made impossible the use of the plot as a collateral. The weakening of social links and together with the impossibility to access formal credits hindered local farmers' investments.

Was land appropriation violent? One of the mechanisms explaining the adverse health effect of colonial farming could be through violent land appropriation. Whether the region has been previously military occupied is an important determinant of settlement. We should expect that the adverse health effect of violence correlates with the timing of occupation rather than the timing of settlement, an assumption that is tested in section 5.4.3. Anecdotal evidence report however that settlers sometimes relied on the police or the army to enfore a disputed land title (Coz, 1964).

Crops and farming techniques Colonial farms are typically more capital-intensive than local farms. To enter the public program of land distribution and subsidized loans, colonial farmers had to bring in a minimum capital and comply to technical standards.[12] The interventionist agricul-

[9]It is worth noting the clear ambition of the land policy with respect to natives as stated by Colonel Huot, director of the *Indigenous Affairs* :

> «Notre intérêt bien compris nous commande de fixer l'indigène à sa terre (...); ayant fixé l'indigène à son sol, nous devons lui assurer la conservation de son patrimoine par des mesures appropriées et prendre en main la défense de ses intérêts contre sa propre imprévoyance.»

in Karsenty (1988).

[10]Dahir of April $27^{th}1919$

[11]The rush on lands in the colonies is concomitant to the Franc fluctuations, where lands appear as a safe-haven investment.

[12]The administration pursued the goal of populating the rural area with a farming elite that would lead the local farmers to adopt modern inputs and know-hows.

tural policy largely oriented the two historical phases of colonial farming, the specialization in the production of cereals and later of fruits.

From 1919, the "wheat policy" incarnated the first phase of the big agricultural push. Soon after the First World War, the metropole had a dire agricultural deficit. Food prices were on the rise, while sea traffic was expanding. Settlers were encouraged to transform their husbandry activity into large cereal cultures. The government made possible this transformation by subsidizing investments in farming engines. In less than 10 years, the area cultivated in wheat grew by 60% to a total of 3 million hectares, a rapid increase due in part to the introduction of soft wheat, which was adopted by local farmers stimulated by high prices. Expanding wheat cultivation was perceived as a successful achievement by colonial administrators, an evidence of the restoration of the "ancient granary of Rome" after centuries of "Arab neglect" (Swearingen, 1987), despite the fact that Morocco's geography and climate is marginally suited for wheat cultivation. In absence of irrigation, this water-intensive production exhibit high yield-variability according to rain fluctuations. The Moroccan wheat production would have never competed on international markets without public subsidies.[13] In addition, modern wheat production conflicted with traditional farming, by enclosing plots, transforming pasture into planted fields and hindering husbandry. All these contributed to widen the gap between colonial and local producers.

The end of the 1920's marks a turning point in the agricultural policy. With the decline in wheat prices, metropole's farmers raised voice to stop subsidizing settlers. Decision was taken in 1929 to raise import barriers to Moroccan products at the height of a wheat glut. Domestic producers did not survive to the simultaneous increased protectionism, repeated droughts and locusts attack."Colonisation officielle" was completely halted in 1931, as settlers went into foreclosure.

Settler agriculture found a revival in fruit cultivation, more specifically citrus, at the turning point of the agricultural crisis. Inspired by the "Californian dream", where technical improvements allowed growing citrus in arid climate, settlers and wealth local producers sped up the expansion of citrus cultivation in the 1929-1933 period. After 1942, annual citrus exports generally exceeded wheat exports in tonnage, and always greatly in value. This expansion was dependent on government irrigation development, that included the construction of large dams. Compared to the envisioned 1 million hectares of irrigation, the realized 36,000 hectares appeared ludacrious. However almost half of the irrigated lands belonged to settlers though they represented 0.5 percent of Moroccan landowners. French farmers trusted the production of citrus (72% of total nominal output) and of grapes (half of the fertile region of Meknes). The fruit policy, more suitable than wheat to Morocco natural environment, would last until the end of the Protectorate.

Outcomes : shortage of food supply, famines, migration Historical records report multiple episodes of food shortage and famines during the Protectorate, each highlighting the vulnerability of local consumption to climatic misfortune and international price variation (Swearingen, 1987). As an example, during the 1930 record famine, although the country was facing a grain shortage, a large

[13] As Amphoux (1933) says: « The cultivation of cereals for export, particularly wheat, would long ago have been abandoned... without the metropole's protection.. ».

quantity grown by colonial farmers was exported. Contemporary observers pointed the intrication beween colonial farming and local health deterioration. Célérier (1937), a French geograph, wrote:

> *A large part of the population is under-nourrished, its standard of living being just enough not to die.* [...] *Our settlement, instead of mediating, may have worsened the situation. The population used to live from local production and remittences from migrating workers.*

In the words of Mouillier (1952), the strong reliability on international markets made the matter worse.

> «Population growth and rapid increase in internal demand, were unfortunately not joined with a proportional increase in production and the gravity of the nutritional situation in Morocco appeared bluntly during the last war, as the country was found isolated from the Metropol [...]. In 1945, catastrophic in terms of agriculture, we could glimpse the spectre of starvation.[14] »

Among the many pieces of home security information[15] of the colonial administration, one can find several anthropological studies reporting the health situation in rural Morocco, reflecting the occasional concerns that the governement had on local standards of living.

4 Data and summary statistics

The first contribution of this paper is the construction of a novel dataset including individual precolonial and colonial height data, distribution of colonial farms and various historical covariates (infrstructure, agricultural production and military occupation) sourced from various colonial archives.

4.1 Height data

I use adult height as a synthetic measure of early life conditions, following a well established demographics, economic history and economics of development literature. Height is indicative of nutritional and health intakes during childhood. Anthropometric data are reliable indicators of development, enabling regional and time comparisons.[16] Precisely short adult height reflects an accomodation[17] to mal- or undernutrition in childhood, in low and middle-income countries mostly

[14] A finding that is quantified by Amin (1966) who shows that although agricultural GDP rose by 2.6% in 35 years, the per capita only increase by 0.4%.

[15] Centre des archives diplomatiques in Nantes, France.

[16] In the economic literature on colonialism, one can cite several authors who have relied on anthropometric data, especially those from military archives. Austin *et al.* (2012) show that height stature of conscripts increased, during the colonial time in Ghana as cocoa production rose, before reversing during the economic crisis in 1973-1983. Cogneau and Rouanet (2011) show similarly an height increase in Côte d'Ivoire and Ghana between 1925 and 1960 using surveys on living conditions.

[17] Authors prefer using the term accomodation rather than adaptation, as this process impair individual's biological welfare, as reflected by their physical abilities (Stinson, 1992).

(Perkins *et al.*, 2016). The demographic literature evidenced two important growth periods : between 0 and 2, and during adolescence. Age-range 0 to 2 is the most crucial period because it is when nutritional requirements and infectious attacks are high. Health or nutritional deprivation at this age will result in growth retardation, reflected in lower adult height. Adolescence represents a period of catch-up growth, when growth was delayed in early childhood. In the empirical framework, I will consider an individual to be exposed to colonial conditions when he was born after the arrival of settlers. In a robustness specification, I show that the results hold when treating as exposed individuals who were already adolescent when settlers arrived.

Height data were obtained from the digitization of soldier registration cards of the French Army. Colonial infantry and artillery regiments enrolled approximately 350,000 Moroccans between 1912 and 1956, for a service of three or more years. Upon their enlistment in the army, the military administration filled a biographical card consisting of their name and surname, name and surname of the parents, year and place of birth, place of residence, occupation, level of instruction and height. Height was measured during the medical visit. Figure A.1 displays an example of a registration card. I collected a representative 15% sample of these individual files.[18] To my knowledge, this dataset represents the most comprehensive individual dataset for colonial Northern Africa. It allows tracking the evolution of socio-economic conditions as captured by adult height over time at a high spatial resolution.

Selection issue Military enrolment in Morocco was deemed voluntary[19]. There were two ways to join the army: via regional rounds of recruitment or via recruitment centers in cities (Commandement supérieur des Troupes du Maroc, 1952). Most of recruitment is done via recruitment round in tribes, lead either by a French or a Moroccan officer coming with a doctor and translator. Additionally candidates could present to recruitment centers on their individual initiative. In terms of age and height limits, both qualitative and quantitative sources tend to suggest that the army had particularly loose requirements. General instructions on recruitment Commandement supérieur des Troupes du Maroc (1952) report that first recruitment should theoretically occur between age 18 and 23. During wartime, the age limit can be lowered to 17 years old. In the data, we observe soldiers under 17 but they represent less than 1% of the sample. Additionally, the army did not fix a minimum height to be deemed fit for service. Recruitment instructions state that the candidate "should meet necessary physical aptitudes". Specifically the military doctor must evaluate its aptitude to walking, bag carrying and shooting for the Infantry, special aptitude to horse-riding with normal sight for the Cavalry or special aptitude for other corps. In the data, I observe individuals as short as 140 cm[20] and those below 160 cm represent 6 % of the sample. There is thus no regulatory truncation, but

[18]Individual cards are classified in volumes by yearly promotion. Because no geographical classification prevails, I couldn't stratify the sample by territorial representativity. The strategy relies on randomly sampling 1,000 observations for the first year of observation (1912) and then applying the population growth rate. I end up with 50,000 individual cards.

[19]Only in Algeria and French West Africa did the French colonial ruler enforced a military draft.

[20]14 individuals had shorter heights. I consider them as measurement errors and exclude them of the sample.

one may expect that fitness for service is correlated with height. One could therefore assume that this soldier sample represent a taller portion of the population height distribution.

If recruitment was not compulsory enforced through a draft, it is hard to claim that it has always been voluntary. Historians bring evidence that colonial authorities helped by local elites forced the enrollment of farmers and unemployed during the First World War. From the 1920's administrative sources and historic works report that the recruitment was eased by the higher military payoffs. Various colonial notes recount episodes of what were called "recruitment crisis" to describe an excessive supply of military candidates. The fact that recruitment is not a draft can pose threats to the strategy of identification if selection in army conditional on height varies across treatment and control municipalities. I propose an exercise in the spirit of Heckman selection model in section 5 to overrule the possibility that military recruitment responds differently to income incentive across groups of observation.

4.2 Colonial farming

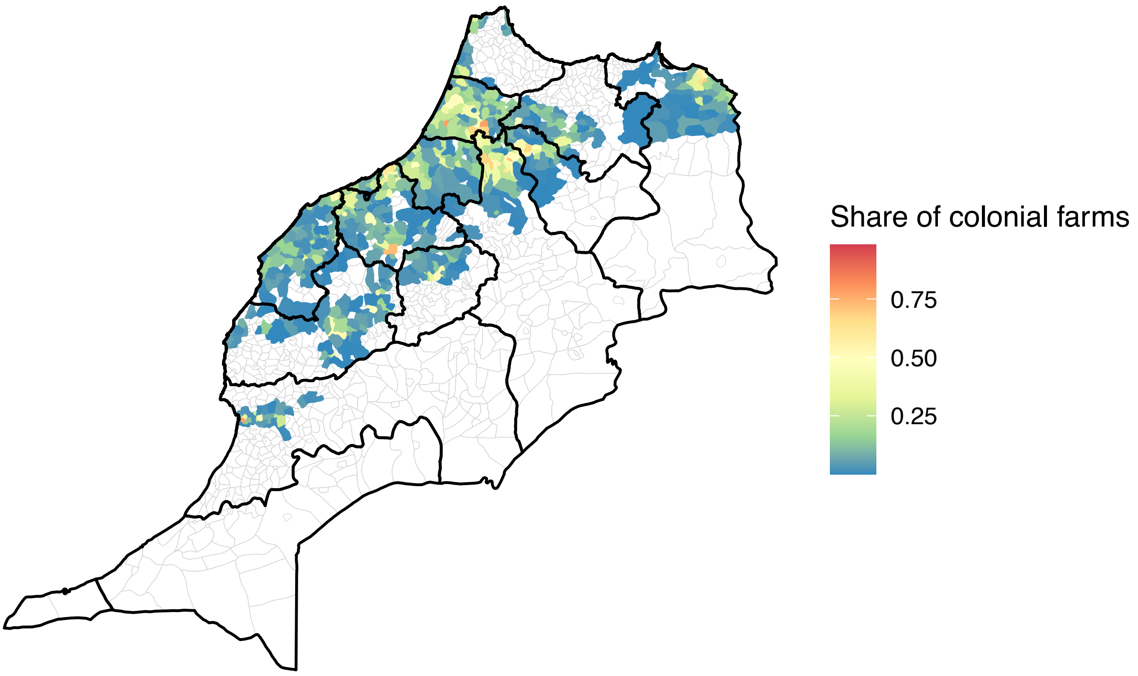
The location of colonial farm plots are derived from a 1955 map, produced by the colonial administration representing all European plots at a high spatial resolution. As far as I know, there is no map with the same level of exhaustivity prior to 1955. The timing of settlers spread is not observed. We know from historical records (Gadille, 1957),[21] that it occurred mostly between 1919 and 1933. We can only infer that what is observed in 1955 corresponds to the full distribution of European lands from 1933 onwards. Between 1919 and 1933, I propose that municipalities that had colonial farms from 1933 are exposed to an intention-to-treat effect. For these cohorts born in this early settlement period, the estimate is therefore likely to be underestimated, as some were not really treated.

I construct a binary variable for whether a municipality is exposed to colonial farms. I apply a minimum spatial threshold corresponding to the median share of colonial farm over municipality surface, conditional on having colonial farms. The reason for this threshold is that the map could be rather imprecise for smaller farms. Additionally, it is unlikely that very small colonial farms fundamentally changed the structure of production in the municipality. To attest the robustness of this strategy, I also test for the effect of the continuous share and the heterogenous effect of different share bins.

Colonial farms are mapped in figure 1. We observe that settlement is concentrated in several regions, on the North Atlantic front (Gharb and Chaouia), inbetween the Rif and Atlas mountains (Meknes and Fes), North-East near The early Algerian settlement (Oriental) and South of the Atlas (Souss). 36% of colonial farms ranges from 125 to 250 hectares, while 26% from 250 to 500 hectares. (Gadille, 1957).

[21]The geographer looks at the general evolution of land sales to determine the period of settlers spread.

Figure 1: Morocco's municipalities and the distribution of colonial farms



Notes: Municipalities with colonial farms are coloured on a scale from blue (lowest share of colonial farms over municipality surface) to red (highest share). The thick black lines correspond to regional boundaries. Municipality boundaries are drawn in light gray. The difference-in-difference strategy absorbs every region-specific and municipality fixed-effects.

4.3 Additional data

I use additional data for covariates and mechanisms exploration. First, to control for other forms of colonial investments, that may have affected local nutrition and health, I have geolocated road and railroad constructions by year. Most of the road and railroad network was established under the Protectorate. Locations were largely determined by economic purpose, firstly to assist settlers and the program of *"Colonisation officielle"*. I compute the time-varying distance from the nearest road or railroad from the municipality centroid. It is therefore important to add these covariates to control for any collinearity between road investments and colonial farm location. I have also geocoded pre-colonial roads from a 1912 map. Because these data are not time-varying, I interact the variable with a time-trend.

I use temperature and rainfall yearly measures obtained from the Global Historical Climatology Network and 19th Century African Instrumental and Documentary and compute the average yearly climatic measure at the municipality level. I derive a yearly weather shock from these data that is the standardized deviation from the period-sample average. The methodology is explained in appendix.

Lastly, I have geocoded maps of the advancement of the military occupation year by year to investigate an alternative channel through the effect of violent conflict on height.

To investigate various mechanisms, I first use GAEZ-FAO crop suitability indices provided at the 5 arc-minute grid cells. I compute the average suitability by crop for rainfed / low input and gravity irrigation / intermediate input (depending on specifications) at the municipality level.

I also synthesize external demand shocks at the municipality level using data on crop suitability and international prices by crop. It is the sum over each crop municipality-specific suitability times world price . World prices are obtained from two sources : Federico and Tena-Junguito (2019) World Trade Historical Database and Blattman *et al.* (2004) database.

Lastly, I collected statistics on production and cultivated surface by crop. These data are obtained from yearly statistical books and are provided at the region and year level. For the end of period (1936-1956), prodcution data are grouped by farmers'origin : European or Moroccan.

4.4 Summary statistics

Table 1 reports the balance of characteristics of soldiers born before 1919, prior the arrival of settlers, across control and treatment municipalities of birth. Cohorts don't differ by height on average. Soldiers in control municipalities are marginally older. Size of recruitment is smaller in control municipalities, possibly because the closest army station or precolonial road is further away. Soldiers born in control municipalities are later military occupied. Over the subsample of individiduals for which we have socio-economic information (17% of the sample), we learn that education characteristics are balanced across groups. Soldiers are massively illiterate and does not speak French. However, occupational distribution varies: soldiers were relatively more working in agriculture and less unemployed in control municipalities.

Table 1: Soldiers characteristics before settlement

	Control	Treatment	Diff
Height	168.01	167.87	0.14
Age	23.50	22.65	0.85***
Year of birth	1907.20	1906.64	0.56***
Speaks French	0.02	0.02	0.00
Illiterate	0.95	0.93	0.01
Works in agriculture	0.83	0.77	0.06***
Unemployed	0.11	0.15	-0.05***
# recruits	11.95	84.76	-72.81***
Distance to army station	8.73	4.88	3.84***
Years of military service	9.50	9.30	0.20*
Distance to trail	6.42	0.96	5.46***
Year of occupation	1917.36	1911.88	5.48***
Observations	15462	7202	22664

Notes: Subsample of soldiers born before 1918, in native sector (no colonial farms) vs. colonial sector (with colonial farms).

Table 2 reports the balance of covariates across municipalities with and without colonial farms, to detect determinants of location choice. Treatment municipalities are earlier occupied, closer precolonial roads, cities, railroads and ports. They displa a higher suitability for the main crops produced in Morocco. They have more rainfall and lower temperature over the post-settlement period. Colonial farms occupy on average 14% of municipalities' surface. Average farming size is near 1700 hectares.

Table 2: Municipalities characteristics across treatment and control groups

	No colonial farm	With colonial farm	Diff
Occupation	1919.97	1912.77	7.21***
Rain intensity	-0.05	0.03	-0.09***
Temperature intensity	-0.10	-0.11	0.01***
Distance to rail	105.99	62.79	43.20***
Distance to road	30.15	32.57	-2.42
Distance to port	151.12	111.90	39.22***
Distance to city	134.05	89.63	44.42***
Wheat suitability	31.60	49.12	-17.53***
Barley suitability	31.61	48.81	-17.20***
Tomato suitability	12.55	23.06	-10.51***
Citrus suitability	12.23	24.53	-12.30***
External demand	3.74	3.77	-0.03
Share of colonial farms		14.31	
Colonial farm size		1679.39	
Observations	893	601	1494

Notes: Balance of covariates across the 1494 municipalities without (column 1) and with (column 2) colonial farms. Rain and temperature intensity are standardized deviation ($\mu = 0$ and $\sigma = 1$) measure from the sample-period. Distances are measured in kilometer. Colonial farm size is measured in hectare. Share of colonial farms is in %. Suitability measure originates from GAEZ low input level rain-fed suitability index (SI). $SI > 25$ indicates moderate suitability, $SI > 40$ medium, $SI > 55$ good.

5 Empirical strategy and findings

5.1 Intuition

The arrival of colonial settlers can be compared to a skilled immigration in the agricultural setor. More productive foreign farmers compete with local producers, crowd out factors of production (land, water, labour) and bring agricultural prices down. Because the local population is composed essentially of producers, some of them are crowded out and lose their means of subsistence. For those remaining, their products are not competitive enough and lose their terms of exchange on local markets. The mechanism could also go through the labour market. Colonial farms being more capital intensive, they hire less local labour, and therefore do not absorb the excess labour supply from local farms. In addition, colonial farms may drain the most high-skilled farmers with the result of lowering productivity on local farms[22].

[22] And inciting children labour on local farms

On the other hand, this immigration could be beneficial to local producers if it brought new market opportunities (higher demand, lower fixed trade cost) or increased local productivity through technological spillovers.

5.2 Baseline framework

The identification of the effect of colonial farming relies on two-way fixed effects regression. I compare the relative change in height between the pre-settlement and settlement period across municipalities with and without colonial farms, controlling for municipality and region-specific time effect. In this setting, all units receive treatment once at the same time[23] The arguably exogeneous variation comes from the interaction of the arrival of colonial farmers cutoff and the location choice of these farms. For the sake of exposition, I will first assume that both selection is not driving the effect. I show in subsection 5.4 what relaxing these assumptions means.

The estimated equation relates one's adult height to the presence of colonial farmers in the municipality and year of birth. It is written as :

$$height_{i,m,t} = \beta(\delta_{t\geq 1919} \times colonial_m) + \alpha_1 age_{i,t} + \alpha_2 age_{i,t}^2 + \Omega'_{m,t}\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \qquad (1)$$

where i, m and t respectively denotes individual, municipality and birthyear. The sample includes all soldiers born in French Morocco[24] from 1890 to 1937, time span for which we have a representative sample and the full set of covariates.

$height_{i,m,t}$ is the individual's anthropometric outcome. $colonial_m$ is a binary variable equal to one for municipality within the colonial sector. The variable $\delta_{t\geq 1919}$ is a binary variable corresponding to the 1919 cutoff[25] after which the individual is exposed. Throughout, I will refer to the composite variable $\delta_{t\geq 1919} \times colonial_m$ as the "settlement effect". Soldier's age[26] denoted $age_{i,t}$ enters the equation in a quadratic form. Both covariates allow to control for height differences due to age.[27]

$\Omega_{m,t}$ is a vector of covariates varying in time and space. It includes the number of soldiers enrolled in municipality m and birthyear t that controls for the relation between number of observations by municipality $\times$ birthyear and mean height.[28] The vector also includes additional colonial investments

[23] Because the treatment is a binary and the design is not a staggered rollout, the regression does not leverage "forbidden comparisons" and therefore the estimand is not suspected to bear negative weights (de Chaisemartin and D'Haultfoeuille, 2020 and Borusyak *et al.*, 2021).

[24] 2% of the sample is born in the former Spanish part of Morocco

[25] I check for the consistency of this date in Appendix A.1, by reestimating the same equation with a different reference category born before 1901. These cohorts were adult when colonial settlement started. I show that the coefficient for cohorts born after 1919 is robust to changing the reference category.

[26] At time of enrollment and measurement

[27] In section 4 I explain why there is significant variation in age.

[28] We may worry that the larger the military cohort, the smaller soldiers average height.

in municipality m, specifically the log inverse distance[29] to the nearest road and railroad (taken at year t-1)[30]. This partials out different dimensions of colonial settlement, including investments in health, education and other amenities. To take into account the diverging trend due to pre-colonial infrastructures, I also add the log inverse distance to non-paved roads[31] interacted with individual's birthyear. Lastly, in the preferred specification, I add weather (temperature and rainfall) shocks at the municipality level reflecting by how much early childhood[32] weather conditions deviated from the sample average measure. μ_m corresponds to a set of municipality fixed-effects filtering out all time-invariant unobserved heterogeneity across municipalities – such as crop suitability, prevalence of disease, topology or water access – which may co-determine height and colonial farms' location. $\nu_{r,t}$ is a vector of regional[33] yearly shocks. It allows to compare treatement and control municipalities within a year and region and to filter out cross-regional economic divergence. Finally, $\epsilon_{i,b,t}$ are idiosynchratic shocks affecting one's height. Standards errors are clustered at the municipality level.

The coefficient of interest β is the estimated average impact of settlers' farming on local height. For clarity, β measures the additional centimeters gained (or lost) from growing near colonial farms under a counterfactual of absence of settlement. It is an average intention-to-treat effect over the period. Because I don't observe the spreading of colonial farms over time, I cannot implement a staggered difference-in-difference. Early exposed cohorts are considered treated if colonial farms are observed in their municipality in the end of period. The coefficient is therefore likely to be underestimated as it averages over cohorts with different treatment intensity. This implies also that by decomposing the effect over cohorts, I should observe that the coefficient increases in magnitude and significativity for later cohorts.

Results of equation 1 are presented in table 3. Column 1 gives the effect of the main treatment variable on height conditioning on a minimal set of covariates (age and number of recruits in municipality at year of birth) and the set of municipality and region-time fixed effects. Column 2 adds a vector of time-varying covariates : the log inverse distance to the closest road, railroad and pre-colonial road (unpaved roads) from the municipality centroid. The last column completes the set of covariates by adding birth weather and trade shocks. Results are consistent throughout the three specifications and colonial farming displays a significantly negative coefficient from -.23 to -.39 from the looser to most stringent specification. This reflects a detrimental effect of colonial farming for cohorts born one year after settlers' arrival compared to the cohorts born just before. The fact that the coefficient is dropping as the model becomes more stringent highlight the fact that colonial farming is encompassing other dimensions of colonial investments that have a developmental effect, such as investments in roads and railroads. The treatment also interesects with a pre-colonial path of development: municipalities closer to the 1912 trail network are engaged on a higher development

[29]From municipality's centroid

[30]I take lag variable to avoid the issue of bad control

[31]This trail network was mapped in 1912 and I assume that it had existed since 1900.

[32]Five years from birthyear.

[33]14 regions

trend as evidenced by the positive coefficient in column 2 and 3. Controlling for this pre-colonial infrastructure increases the settlement effect in absolute terms, suggesting that colonial farmers settled in the most developed municipalities. Weather shocks seem also to be confounders of settlement location. Rain and temperature shocks at an early age have a positive effect on biological welfare. Including them increases the settlement effect in absolute terms. This first set of results demonstrates that agricultural settlement had a negative impact on health and nutrition of young men born in municipalities that attracted settlers.

Table 3: Baseline results

	(1)	(2)	(3)	(4)
Colonial farming * d1919	-0.239*	-0.380**	-0.379**	-0.431***
	(0.135)	(0.156)	(0.157)	(0.158)
Age	0.911***	0.913***	0.913***	0.915***
	(0.085)	(0.085)	(0.084)	(0.084)
Age squared	-0.016***	-0.016***	-0.016***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.002)
# recruits	-0.000	-0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Proximity to road		0.022	0.012	0.019
		(0.088)	(0.090)	(0.085)
Proximity to rail		0.155*	0.151*	0.108
		(0.088)	(0.090)	(0.094)
Pre-treatment infrastructure		0.004	0.004	0.000
		(0.003)	(0.003)	(0.004)
Early child temperature shock			0.263	0.275
			(0.239)	(0.226)
Early child rain shock			0.409***	0.397***
			(0.135)	(0.135)
External demand for top-5 suitable crops			0.346	0.382
			(0.304)	(0.303)
Distance to city				-0.005*
				(0.003)
N	48334	48334	48334	48334
R2	0.07	0.07	0.07	0.07
Mean outcome		167.74		
Std d.		5.58		
Birth commune FE		– Yes –		
Region x year FE		– Yes –		

Notes: Heteroscedasticity-robust p-values in parentheses. $***$, $**$, $*$ denote 1, 5, 10% level of significance. Clustered at the municipality level. Fixed effects: region-specific birthyear and municipality. Height is regressed on a time-variant variable that is the interaction of being born in a municipality with colonial farms after the arrival of settlers. Col. (1) shows an estimation of a simple municipality fixed-effects model with the main treatment, the covariates of age and the size of recruitment in the municipality/birthyear. Col. (2) adds pre-colonial and colonial infrastructures. Col. (3) includes early childhood (first five years) temperature and rainfall shocks and a birth trade shock that is the international demand for crops suitable in the municipality.Col. (4) includes the log distance to the nearest city in km (10,000 pop+ in 1917) from the municipality centroid interacted with a time-trend as a predictor of rural-to-urban migration.

5.3 Timing of farming settlement

The previous model estimates an average effect of agricultural settlement over the entire period of exposure compared to the average pre-exposure height. However there are reasons to believe that the effect of settlement culminated over time.

First of all because settlers took several years to spread over space, from 1919 to 1933. In 1933, agricultural settlement reached its maximum occupancy, date from which we should observe the full effect of colonial farming. Because I don't observe the spreading of settlement across time, I cannot implement a staggered treatment effect. All municipalities within the colonial sector in 1933 are considered treated as soon as 1919. This implies that two cohorts born in 1919, the first one in a municipality where settlement started in 1919 and the second where it started only in 1933, are considered exposed to the same treatment. This – undoubtedly upwarding – bias should dissolve over time, as later born cohorts are more likely to have been exposed since age 1.

Moreover, historians attest that the structural changes brought by colonial farming were incremental. Settlers adapted both tehnics and choices of crop as they were becoming more experienced with Morocco's terrain, soil and climatic conditions. At mid-period, colonial farmers had developped a vast export-oriented agriculture, specialized in high added-value crops. Export data series by crop give evidence that this development was progressive.

All these reasons combined, one may expect that the agricultural settlement had a cumulative effect on native welfare over time. It follows from this that natives born early during the Protectorate should be less impacted than natives born later on and that those born at the very end should be the most impacted.

I can bring this assumption to the data, by discretizing the settlement effect over period and test whether cohorts born in the early Protectorate were less impacted than than cohorts born in mid-period. However I am not able to test the cumulative effect for cohorts born at the end of the colonial period, due to the truncation of the dataset (we do not observe individuals born after 1937 who became adult after Independence and could therefore not be enrolled in the French Army).

I re-estimate the same model as before, allowing the effect of treatment to vary by period. I define 3 periods of 5 years: 1919-1924, 1925-1930 and 1931-1936.

$$height_{i,m,t} = \sum_{\tau \geq 1919}^{1931} \beta_t(\delta_{t=\tau} \times colonial_m) + \alpha_1 age_{i,t} + \alpha_2 age_{i,t}^2 + \Omega'_{m,t}\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \quad (2)$$

where $\delta_{t=\tau}$ is a binary variable for period τ and τ takes three values. Results are given in figure 2 where each β_τ are plotted within their 90% confidence intervals. This period study displays a cumulative pattern of the settlement effect. The first period cohort is not significantly impacted, confirming that the treatment group is likely to be contaminated by untreated observations. The following cohort born between 1925 and 1930 is already significantly different from the pre-exposed cohort. The maximum decline is reached in the period 1931-1936 where the loss in height amounted to approximately -0.6 centimeters compared to the pre-exposed group.

Figure 2: Settlement effect by period of birth

Notes: Coefficients (within their 90% confidence interval) of heterogenous effects of being near colonial farms at different birth period (1919-1924, 1925-1930, 1931-1936). Municipality and region $\times$ Year fixed-effect models with the full set of controls: age, age squarred, size of recruitment in municipality/birthyear, proximity to road, railroad and pre-colonial road, early childhood weather and trade shocks.

5.4 Threats to identification

Although I control for municipality and region specific year fixed-effects, an endogeneity issue remains if the treatment estimate is biased by factors that vary simultaneously by municipality and time period. The difference in outcome observed between cohorts could rather be due to an underlying factor independent of the treatment or to the different assignment rule into control and treatment, rather than to the treatment in itself. The strategy relies on three sets of assumption on the data: (1) absence of selection on the outcome across control and treatment municipalites (2) control and treatment municipalities would have evolved on the same anthropometric trend absent of the treatment (3) the colonial farming shock affects the outcome only via the agricultural channel.

In this subsection, I test these sets of assumption and explore what their violation would imply empirically.

5.4.1 Absence of selection

Migration Selection on height could arise from outmigration of taller individuals in treated municipalities. Pushed out by expropriation of their lands or reduced productivity, families may seek relocation in rural or urban untreated municipalities. A major threat would be that more productive families were more likely to migrate to the cities, because they can face the fixed cost of migrating and their skill is transferrable (Hicks *et al.*, forthcoming). Before addressing this selection issue with an empirical design, one should first relate to historical narratives and figures on migration in colonial Morocco.

Internal migration is a limited phenomenon until the second world war, especially from rural to urban areas. Amin (1966) estimates that the *Muslim* (native) population is only 10% urban in 1939, urbanization being overwhelmingly a European phenomenon. During the second world war and beyond, Moroccan cities (more than 20,000 pop.) face a growing influx of native population. Urban population really surged from the 1930's growing by a yearly average of 5% in the last 25 years of colonization.[34] Therefore, for the period of interest, urban migration is limited to seasonal migration, meaning adult males moving to the cities to find better jobs, especially in the manufacturing sector, and sending remittences to their families. There are abundant descriptive evidence of workers migration. Célérier (1937) describes : *"The population used to live from local production and remittances from migrating workers. Colonial public construction and city development have exacerbated this outmigration."* He later says that this migration fluctuates with the labour demand in public work. The possibility that results are driven by relocation of more productive, taller families to urban settings, is likely to be second-order.

Could taller adults in treated municipalities migrated to cities and would therefore not be observed in the soldier dataset? To rule out this channel, I control for the likelihood to migrate to the city across control and treatment group by adding in the baseline regression the log distance to the nearest city in km (10,000 pop+ in 1917) from the municipality centroid interacted with a time-trend. Distance to the city is a good candidate for predicting rural-to-urban migration and the interaction with a time-trend allows capturing the linear evolution of migration costs. Results are presented in column (4) of table 3. Distance to the city is negatively correlated with height, indicating that more landlock municipalities have shorter population. Because distance to city is corelated with presence of colonial farms, including this regressor improves the significance of the treatment variable. The latter predicts now a height loss by -0.43 cm.

If this result gives reassuring evidence that migration to the city is a second-order phenomenon to explain the main findings, let me also review two other types of migration phenomena. One could assume that individuals sort in international migration based on the outcome. International emigration is quite a rare phenomenon for Moroccan colonized subjects. European emigration started in the 1920's and was only significant for Algerians (Amin, 1966). Additionally, Salem and Seck (2021) highlights that international emigration in colonial Morocco was made possible mostly through the military service.

Lastly, results could reflect movement across treated and untreated rural municipalities. Because land was collectively owned, moving out of tribal land was virtually impossible. Seasonal workers may have been seeking for employment on colonial farms, which is likely to bias the results upward (if taller individuals select in treated municipalities). In the following paragraph, I show that income shock in the agricultural sector is not affecting selection in the army differently across control and

[34]As a comparison, the urban population growth was 2% between 1920 and 1930, and overall population growth was 1.2%.

treatment municipalities.

Selection in the army The validity of the results rely also on the crucial assumption that selection in the army conditional on the outcome does not vary across control and treatment municipalities. The violation of this assumption would mean for instance that the shortest individuals in treatment municipalities enroll in the army, while the tallest enroll in control municipalities. To study this, I look at how treatment and control recruitment outcomes respond to a local income shock.

Prime-age male Moroccans entering the labour market face a set of occupational choices including the decision to join the army. Following Roy's theory, workers strategically select in the occupation with the highest expected income conditional on their skills. Assuming that height is a good proxy of skills for physical jobs, this implies that individuals sort by height into different occupations, the tallest (resp. shortest) sorting in the best-paid (resp. worst-paid) occupation. The causal interpretation of the results relies on the assumption that recruits are pooled from the same moment of the height distribution within the native and colonial sector, which implies in turn that payoffs by occupation are ranked in the same way across treatment and control locations.[35]

Violation of this assumption would arise if the settlement shock brings a change in the labour market affecting the payoff rank. We could argue for instance that settlement farms paid better than the army and that taller individuals selected in farming wage in the colonial sector. Results would be driven by the fact that taller individuals relatively opt out of the army in the colonial sector.

A first answer is brought by historical testimonies from the colonial administration. La *Chambre de l'agriculture*, basically the lobby of colonial farmers in Morocco, complained about the recruitment crisis on colonial farms.[36] Representatives report that agricultural wages were too low compared to wages in the construction and mining sector, or to the army's payoff which included retirement opportunities in the civil administration. Additionally military records report that recruitment campaigns were overwhelmed by the supply of volunteers. These qualitative evidence suggest that the army had the upper hand to pool among the most physically abled and tallest individuals.

Bringing this question to the data, I can estimate how military recruitment responds to a variation in income in competing occupations. I observe two outcomes of military recruitment: the quantity of recruits (number of soldiers per municipality in a given year) and their quality (measured by the average height of recruits). I can therefore test if an income shock in the agricultural sector affects enrollment differently in the colonial and native sector. A positive rainfall shock should increase the expected income in the agricultural sector making jobs in this sector – family farming or agricultural wage – more attractive compared to enrolling in the army. We should observe a different response to a positive shock in the agricultural sector on enrollement outcome between the native and colonial sector if the payoff hierarchy differs across them.

The two response-models read as follows:

[35] The fact that soldiers may be pooled from the top distribution of height does not affect the causal interpretation of the results. The estimate would however be downward biased by the fact that we only observe the tallest individuals, meaning that it lies in the lower band of the true effect of the settlement shock.

[36] *Congrès de la colonisation rurale*, 1932

$$Recruitsize_{m,t} = \beta_1 rainshock * colonial_{m,t-1} + \beta_2 rainshock * native_{m,t-1} + \Omega_{m,t}\Gamma + \mu_m + \mu_{r,t} + \epsilon_{m,t} \quad (3)$$

and

$$Height_{i,m,t} = \beta_1 rainshock * colonial_{m,t-1} + \beta_2 rainshock * native_{m,t-1} + \alpha_1 age_{i,t} + \alpha_2 age^2_{i,t} + \Omega_{v,t}\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \quad (4)$$

Equation 3 estimates the effect of an agricultural shock in year t-1 on the extensive margin of recruitment, the number of soldiers enrolled in municipality m in year t. THe level of observation is thus the municipality. Equation 4 estimates the same effect on the intensive margin of recruitment, soldier i's height enrolled in municipality m in year t. In turn, the level of observation is individual. Both regressions includes muncipality fixed-effect and region-specific enrollment year fixed effects. The rainfall shock is a proxy for the agricultural income shock. A shock in year t is defined as a standardized deviation from the period mean. I first estimate the main effect of a rainfall shock on recruitment and then decompose it between the control and treatment groups. For the assumption of exogeneous enrollment conditional on being treated to hold, one would like to see no difference between the effect of a rainfall shock in the control and treatment group on the intensive margin of recruitment. Results are presented in table 4.

Columns (1) and (2) report the coefficients for the extensive-margin of recruitment, columns (3) and (4) the coefficients for the intensive-margin of recruitment. Columns (1) and (3) report the main effect of the weather shock, when columns (2) and (4) the heterogeneous effect by sectors.

From column (1) we learn that a positive rain shock in t-1 affects the number of recruits in year t on average. In line with the intuition, an income shock in agriculture is crowding out military recruitment, because labour demand in the agricultural sector increases. Turning to the heterogeneous effect across native and colonial sectors, we see that the rain shock is negatively impacting recruitment in the native sector but not in the colonial sector. However the difference between both coefficients is not significant. Now, one would like to see if this differential response – though not statistically significant – of the recruitment process across treatment and control on the extensive margin contaminates the intensive margin.

Turning to column (3) and (4) we observe that a positive variation in the rainfall shock does not affect the average height of soldiers neither for the whole sample nor across control and treatment groups. This means that the reduction in recruitment size in the colonial sector in years of positive rainfall shock does not contaminate the average "quality" of recruits. This is a reassuring evidence that the results are not driven by a different selection process across treatment and control groups.

Table 4: Decision to enroll

	Quantity (size of recruitment)		Quality (recruit's height)	
	(1)	(2)	(3)	(4)
Enrollment rain shock	-0.270**		0.022	
	(0.136)		(0.063)	
By group:				
Rain shock in treatment		0.071		-0.081
		(0.685)		(0.122)
Rain shock in control		-0.284**		0.030
		(0.124)		(0.062)
N	12303	12303	48328	48328
R2	0.52	0.52	0.07	0.07
Rain*treatment-Rain*control p		0.57		0.27
Birth commune FE		– YES –		
region x year FE		– YES –		
Mean outcome	4.35		167.73	

Notes: Heteroscedasticity-robust p-values in parentheses. ∗∗∗, ∗∗, ∗ denote 1, 5, 10% level of significance. Clustered at the municipality level. Fixed effects: region-specific enrollment year and municipality. Full set of municipality (for all columns) and individual controls (for last two columns). Col. (1) and (2) are at the municipality/enrollment year-level and regress number of recruits on a rainfall shock in t-1. Col. (1) regress on the average effect, col (2) on the heterogenous effect across treatment and control groups. Col. (3) and (4) are at the individual/enrollment year level and regress height on a rainfall shock in t-1. Col. (3) regress on the average effect, col (4) on the heterogenous effect across treatment and control groups. P-value of the t-test that the rainfall shock has a differential effect across groups is reported.

5.4.2 Parallel trend under counterfactual

The second proposition assumes the existence of parallel trend under counterfactual. Its violation implies that the treatment group would have diverged from the control in absence of treatment. More specifically, one may be worried that settlers targeted locations where the anthropometric trend was on the decline. This could be the case if settlement correlates with an underlying factor causing the downwarding trend.

Pre-trend test To assess the plausibility of such an assumption, it is common to test for pre-treatment differences in trends. One would like to observe that pre-treatment observations do not exhibit a systematic pattern prior to the treatment, meaning that they are not statistically different from the pre-treatment level.

I conduct an event-study exercise where the settlement shock is discretized for every year of soldiers' birth from 1890 to 1937. Soldiers born in 1918, one year before the settlement is effective, now constitutes the reference category.

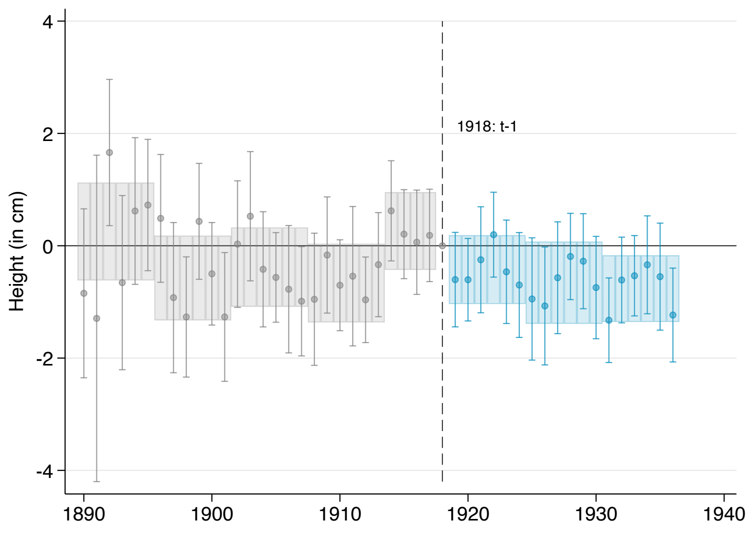
The estimation is of the form :

$$height_{i,m,t} = \sum_{\substack{\tau \geq 1890 \\ \neq 1918}}^{1937} \beta'_t(\delta_{t=\tau} \times colonial_m) + \alpha_1 age_{i,t} + \alpha_2 age^2_{i,t} + \Omega'_{m,t}\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \quad (5)$$

where $\delta_{t=\tau}$ is a binary variable for year τ and τ varies between 1890 and 1937, excluding 1918. β'_t is the point estimate difference in height with respect to height of soldiers born in 1918. It differs from β_t estimated by equation 2 where the reference category is constituted by soldiers born between 1890 and 1918. Results are not therefore comparable between both models. This exercise is meant to detect a divergence in trend anterior to the settlement shock and not estimating the cumulative effect of settlement compared to pre-exposed cohorts. All other variables are the same as those presented in section 5.2. Results are given in figure 3 where each β'_t point estimates are plotted within their 90% confidence intervals (in grey for pre-settlement years, blue for settlement years).

A divergence in trend prior to the settlement shock does not appear in the plot. Most of point estimates prior to 1918 are not significantly different from zero. Some individual estimates and their confidence interval lies above (1892) or below (1912) the zero line, but five-year period joint-significances are never different from zero. Turning to the post-treatment period, we observe the downwarding trend noticed in figure 2. In comparison with cohort born 1918, the cohort born in the last 6 years of the sample period (1931-1937) experiences the highest decrease in height.

Figure 3: Settlement effect by year of birth, pre-trend



Notes: Dots are yearly coefficients (within their 90% confidence interval) of heterogenous effects of being near colonial farms for the pre-treatment period in gray (1890-1917) and post-treatment period in blue (1919-1936). Reference category is 1918. Each coefficient estimates the height difference with a cohort born in 1918 in treatment municipality, compared to the height difference in control municipality. Shaded areas are the estimated coefficients for five-year intervals of birthyear. None are significantly different from zero before treatment, reflecting an absence of pre-trend. Municipality and region × Year fixed-effect models with the full set of controls: age, age squarred, size of recruitment in municipality/birthyear, proximity to road, railroad and pre-colonial road, early childhood weather and trade shocks.

Underlying trend Failure to reject the absence of different pre-trend does not allow to claim the existence of parallel trend under counterfactual. Some unobserved factors across the native and colonial sector could have conducted to the divergence in outcome after 1918. According to table 2, colonial farms settled on average in regions with a higher suitability for a variety of crops. Locations most suitable for a specific crop would have fallen behind for structural reasons independent of colonization, such as modernization of agriculture or trade openness. The effect estimated in equation 1 would then be biased by the underlying variation: the heterogenous effect over time of crop suitability.

I test here the assumption that height difference between pre and post-exposure is not driven neither by crop suitability nor by external demand. This relies on re-estimating equation 1 and adding a crop suitability and external demand shocks, defined as the interaction of the respective continuous measures with the 1919 cut-off. If the settlement effect is channeled by a crop suitability effect or external demand effect, we should observe that (1) cohorts born after 1918 in more suitable municipalities (resp. in municipalities with more external demand) are smaller than pre-exposed cohorts and (2) the settlement effect is null.

Results in table 5 give evidence that neither the suitability nor external demand treatment is driving the settlement effect. Indeed, coefficients for the crop shocks are for most of them statistically not significant. Coefficents for average suitability and tomato suitability display a positive effect significant at the 10% level of confidence for more suitable municipalities after 1918, suggesting that under counterfactual, these municipalities would have grown taller. The coefficient for external demand is not significantly different from zero. In all models, the settlement shock persists with the same magnitude as in the baseline equation (even slightly larger when adding the average suitability and tomato suitability shock). This gives reassuring evidence that the treatment is not encompassing the changing effect of crop suitability or trade exposure.

Table 5: Underlying factor: crop suitability

	(1) Average suitability	(2) Wheat suitability	(3) Citrus suitability	(4) Tomato suitability	(5) Barley suitability	(6) External Demand
Colonial farming * d1919	-0.398**	-0.387**	-0.392**	-0.408**	-0.385**	-0.379**
	(0.160)	(0.162)	(0.157)	(0.160)	(0.163)	(0.157)
Alternative channel * treatment	0.075	0.038	0.033	0.082	0.037	
	(0.067)	(0.036)	(0.057)	(0.067)	(0.036)	
N	48334	48334	48334	48334	48334	48334
R2	0.07	0.07	0.07	0.07	0.07	0.07
Birth commune FE	– Yes –					
Region x year FE	– Yes –					

Notes: The alternative channels are the interaction of a continuous measure of suitability for different categories of crop (resp. average across all crops, wheat, citrus, tomato and barley) or the measure of external demand (international prices for the top 5 suitable crops in the municipality) interacted with the 1919 cut-off. Regressions includes the full vector of covariates and two levels of fixed-effect: municipality and region-specific birthyear.

5.4.3 Confounding shocks

Next, one would like to verify that the arrival of colonial farmers affected the outcome only through agriculture and not through a confounding shock. Here I explore two possible confounding shocks that would lead to inflated estimates of the effect of settlement locations: war of occupation and migration out of the colonial sector after the arrival of settlers.

Conflict Military occupation preceded the phase of civilian settlement. Military campaigns met resistance from Moroccans and were not absent of violence to say the least. An alternative explanation for the results could be that settlers selected into early occupied locations and that the welfare loss observed after 1919 is due to the violence of the occupation rather than the effect of settlement. Going even further, one could argue that the timing of occupation depended on the resistance to occupation, and that early occupied locations were already on a downwarding biological trend. A hypothesis known as the *"Ashenfelter's dip"*, by which the group gets treated because it experiences a negative shock (Ashenfelter, 1978). The estimated effect would then be plagued by reverse causality.

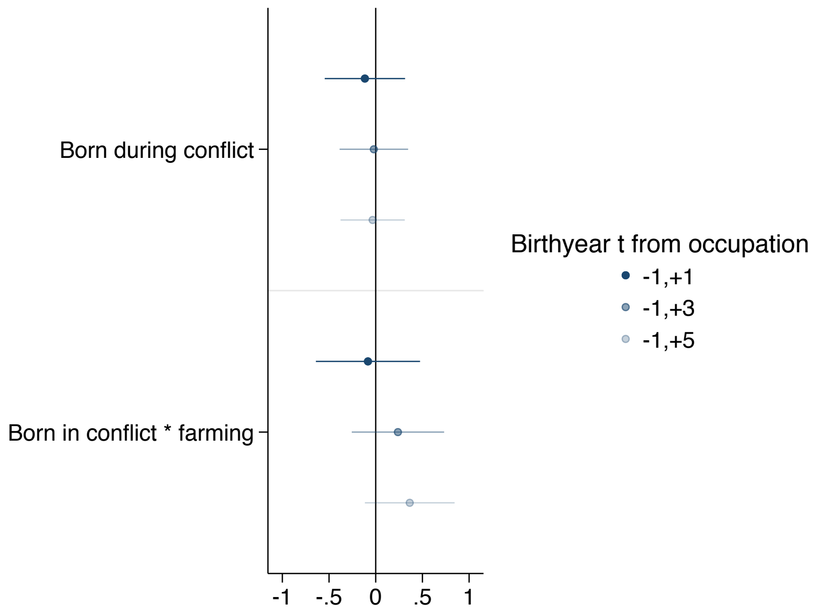
Exploiting the timing of occupation across municipalities, I estimate the height effect of being born during the occupation period across the native and colonial sector. The occupation period is a year window around the date of occupation spanning from one year before to five years. This allows the occupation to have lasting effects on biological welfare. The reference category is composed of individuals born at least two years before the occupation. Individuals born 6 years after the occuption and beyond are excluded. I estimate the main effect of occupation and the interaction with the colonial sector binary.

$$height_{i,m,t} = \beta_1 \delta_{t \geq occupation} + \beta_2 (\delta_{t \geq occupation} \times colonial_m) + \alpha_1 age_{i,t} + \alpha_2 age^2_{i,t} + \Omega'_{m,t}\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \quad (6)$$

$\delta_{,t \geq occupation}$ is the occupation binary variable. α_1 captures the occupation campaign effect for individuals born in the native sector and α_2 the occupation effect for individuals born in the colonial sector. If the colonial farming treatment is channeled by the effect of a violent occupation, α_2 should be negative and of greater magnitude than in the baseline model. Results are presented in figure 4.

Results indicate an interesting pattern. If the coefficient on the occupation time cutoff is non-significantly different from zero, the interaction term with colonial sector is positive. This suggests that in places where colonial farmers settled, the occupation period is associated with a welfare increase. This is not something that can be verified in the data but colonial farmers may have indeed settled in a region even before it was occupied. This positive effect for people born during the occupation period could reflect, for instance the effect of health or nutrition programs by the occupier targeted to regions within the colonial sector to gain population support. However these results does not back up the hypothesis that violent colonial conflict could be the underlying factor

Figure 4: Effect of the occupation war



Notes: Coefficients (within their 90% confidence interval) of the height effect of being born during conflict and the marginal effect of being born near a colonial farm during conflict. Being born during conflict is defined flexibly for different time-windows (-1/+1, -1/+3, -1/+5) The respective samples include all individuals born before or during conflict. Clustered at the municipality level. Fixed effects: region-specific birthyear and municipality. Height is regressed on a time-variant variable that is the interaction of being born in a municipality with colonial farms Regression includes the full vector of covariates presented in table 3.

behind the welfare deterioration due to colonial farming, nor that farming settlers selected into locations on a downwarding trend.

6 Mechanisms

The richness of the data collection allows to extend the general framework by eliciting some mechanisms explaining the relation from farming settlement to height.

There are several qualitative and theoretical explanations for why colonial farming affected the biological welfare of Moroccans. In this section, I explore different reinforcing or mitigating mechanisms, namely exposure to weather variations, land diversion and employability, existence of productivity spillovers and trade opportunities.

6.1 Weather variability and water diversion

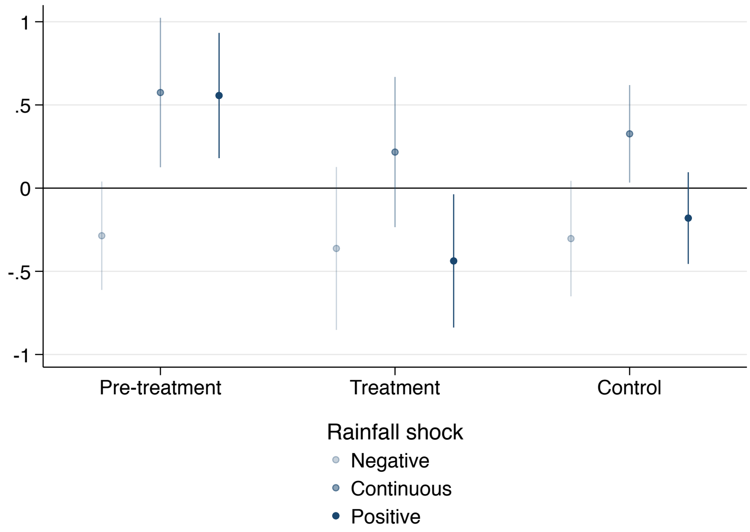
One of the explanations brought by historians for the worsening-off of the native rural population is the combined effect of colonial farms and weather shocks. Swearingen (1987) notably show that colonial farms exerted pressure on the availability of water, an already scarce ressource. The impact of colonial farms on water pressure can be rationalized by a direct and indirect effect. Colonial farms directly diverted water to grow water-intensive export crops. Moreover colonial farming practices contributed to reorganize native agriculture toward crop specialization, thereby moving away from risk diversification strategies. Crop diversification is indeed an insurance mechanism against weather variability. This pressure on water resource was heightened in bad weather years: when precipitation level was low. Adding the fact that market integration is low, agricultural products availability at birth, and thus future height, is more likely to respond to local weather shocks.

To test empirically this prediction, I explore the heterogeneous effect of precipitation variation on the outcome depending on whether it occurs in treatment or control municipalities. I define a precipitation shock in two ways. First I explore the effect of an average precipitation standardized deviation from the sample mean (as defined in section 4). Then I decompose the precipitation shocks into a positive (top quintile of the standardized weather distribution) and negative (bottom quintile of the standardized weather measure distribution) shocks.

Results are summarized in figure 5. Medium blue dots report the estimation for the continuous standardized measure. Light (respectively dark) blue dots report the estimation for the negative (respectively positive) shock.

Results indicate that one rainfall deviation from the mean (5 more milimeters by month over the 5 first years of life) benefits only to untreated municipalities. It indicates that a positive income shock in agriculture is benetial to native's health only in absence of colonial farms. The interpretation is that colonial farms capture the rainfall-induced excess productivity in agriculture. Now the question is whether colonial farms exacerbates an extreme negative shock and/or absorb an extreme positive shock. Decomposing the effect among treated municipalities we see that a positive shock has an adverse effect on height, whereas a negative shock has a non-significant effect. Both extreme shocks has no effect in untreated municipalities. The interpretation that one may have is more complex than the prediction: in presence of colonial farms, native health is deteriorated when a positive agricultural shock hits. The transfer of agricultural income from natives to colons is the largest when municipalities experience the best agricultural conditions. Untreated municipalities do not benefit nor suffer from an extreme rainfall shock. One can compare this result with the positive effect on the continuous standardized measure, and infer that the health response to precipitation is smoother among untreated municipalities and is invariant to extreme rain conditions. The fact that agriculture is organized differently in control and treatment municipalities, that only in untreated municipalities, producers were able to maintain risk mitigation strategies, is a central explanation for these results.

Figure 5: Effect of rainfall in treatment vs. control municipalities



Notes: Coefficients (within their 90% confidence interval) of heterogeneous effects of rainfall shocks across pre-treatment (observed before 1919), treatment and control municipalities. .Heteroscedasticity-robust p-values in parentheses. Medium blue dots report the estimation of a continuous precipitation shock, light blue dots the estimation of extreme negative shocks and dark blue dots the estimation of extreme positive precipitation shocks. Fixed effects: region-specific birthyear and municipality. Regressions include the main treatment variable (being born in a municipality with colonial farms after the arrival of settlers) and the full set of municipality and individual controls. Standard-errors clustered at the municipality level.

6.2 Land Concentration

A second mechanism through which colonial farms transform native agriculture is through the labour market. Colonial farms are typically larger and less labour-intensive. Native farmers have less land to cultivate and face less farm work opportunities with the settlement of colonial farms.

If this is true, we should find that (1) the larger the share of colonial farms in a municipality, the larger the negative effect on biological welfare and (2) the larger the average colonial farm, the more capital-intensive, the scarcer the farm work opportunities, the larger the negative effect on biological welfare. Question 1 investigates the intensive margin of colonial farming and land diversion. Question 2 looks at the channel of change in factor intensity.

I estimate equation 1 on a continuous measure of share of colonial farms in the municipality. I then investigate the heterogeneous effect across four colonial farm share bins. These two models are intended to answer question (1). Lastly, I look at the effect of a variation in the mean size of colonial farms in the municipality conditionnal on the presence of colonial farms. This model is intended to give insights on question (2), the change in the farming labour market and its effect on biological welfare.

Results are presented in table 6. Column 1 reports the coefficient on the continuous treatment effect, that is the share of colonial farming in the municipality, interacted with the arrival of settlers time cutoff. The coefficient is significantly negative at conventional confidence interval. Column 2 gives the estimate for three bins of colonial farm shares in the municipality : $[14, 25\%[$, $[25, 50\%[$ and $[50, 100\%]$. As in the main regression, the control group is characterized by a share of colonial farms

Table 6: Land concentration

	(1) Continuous	(2) Share bins	(3) Farm size
Continuous treatment effect	-0.741		
	(0.503)		
treatment farm $[14, 25[\%$		-0.233	
		(0.161)	
treatment farm $[25, 50[\%$		-0.716**	
		(0.285)	
treatment farm $[50, 100[\%$		0.000	
		(0.347)	
Colonial farm size			-0.110***
			(0.037)
Colonial farming * d1919			-0.321**
			(0.155)
N	48334	48334	48334
R2	0.07	0.07	0.07
Birth commune FE		– Yes –	
region x year FE		– Yes –	

Notes: Heteroscedasticity-robust p-values in parentheses. $***$, $**$, $*$ denote 1, 5, 10% level of significance. Clustered at the municipality level. Fixed effects: region-specific birthyear and municipality. Full set of municipality and individual controls. Height is regressed in col. (1) on a time-variant treatment variable that is the interaction of the continuous measure colonial farm share in the municipality with a binary variable when individual is born after 1919, in col. (2) on the interaction of different share bins of colonial farms with a binary variable when individual is born after 1919, in col. (3) on the main treatment variable that is the interaction of being born near colonial farms with a binary variable when individual is born after 1919 and an interacted term that is the average colonial farm size (in hectare) with a binary variable for being born after 1919.

below 14%. One would expect the effect of colonial farms to increase with the share it occupies in the municipality. Interestingly, only the second bin is significantly different from zero, with a coefficient of -0.8, in other words an adverse effect on height by almost 1 cm. It gives evidence that the transfer of land from the Natives to the colons should be relatively large to alter the health outcome. However above 50%, the effect of settlement is no longer detrimental to native health. Because we are only observing a very small panel of observations with share above 50%, it remains difficult to derive any conclusion from this. Column 3 reports results for the continuous effect of farm size conditional on presence of colonial farming. They show that the larger the average farm size, the more detrimental the effect of colonial farms on native biological welfare. It supports the hypothesis that the main effect is also channeled by a change in the labour market. As farm size increases, the more capital intensive the farming activity, the less farm work opportunities for Natives.

6.3 Productivity spillovers from colonial to native farms

Colonial farming introduced modern agriculture, characterized by the use of fertilizers, motorized engines, intensive cropping and irrigation facilities. In terms of output, colonial farms experienced higher productivity than native farms (25 % more cereal yield on average). Did colonial farms pull native production upward?

I can explore this question with regional production data at the regional level obtained from yearly statistical books that decomposes production and surface cropped between native and European farmers from 1936. I derive correlational evidence of productivity spillovers between colonial and native farms.

One would like to regress Native crop productivity on European crop productivity, controlling for pre-treatment and time-varying determinants. Ideally, one would like to observe Native productivity before the arrival of settlers to estimate the effect of the technological shock, proxied by colonial productivity.

Only a few agricultural regions (7 to 17) are reported by year. Besides their boundaries are not consistent over time. In absence of balanced panel, differencing time-varying measures with their period average (in the spirit of a difference-in-difference) is not possible.

What I do is regressing Native crop productivity on colonial crop productivity, controlling for one lag of native crop productivity. Equation reads as follows :

$$\begin{aligned} nativeyield_{c,a,t} = \beta_1 nativeyield_{c,a,t-1} + \beta_2 colonyield_{c,a,t} \\ + \alpha road_{a,t} + \lambda train_{a,t} + \gamma trail_a + \nu_t + \epsilon_{c,a,t} \end{aligned} \quad (7)$$

where c, a, t respectively denote crop, agricultural region and year of observation. The unit of observation is a region / year. Crop includes durum wheat, tender wheat and barley. $road$, $train$ and $trail$ respectively denotes the log of total length of colonial road, trainrail and pre-colonial trail. Pre-colonial trail is only observed in 1912, whereas road and trainrail are time-varying. The equation includes a vector of year fixed-effect ν_t.

Results are reported in table 7.

Each column reports the model for a different crop. Native yield for each category of crop is positively correlated with colonial crop yield, controlling for past Native productivity. Pre-colonial development and colonial infrastructure do not seem to affect Native productivity, although we can not infer any causal interpretations from these results. What they seem to suggest is that colonial farms may have allowed technological spillover, at least for the end of period that is not observed in individual data. With all the precautions aforementionned, the adverse settlement effect on biological welfare could have effect mediated by technology spillover at the end of the colonial period.

Table 7: Colonial spillover to native production

Native crop yield:	(1) Wheat	(2) Durum	(3) Barley
Colonial crop yield	0.298***	0.174**	0.276**
	(0.057)	(0.073)	(0.131)
Lag crop native yield	0.095***	0.416***	0.356***
	(0.033)	(0.133)	(0.129)
Log sum of pre-colonial trail	5.435	2.722	0.255
	(3.428)	(4.317)	(4.636)
Log sum of road	-4.004	-0.249	1.692
	(3.685)	(5.800)	(6.840)
Log sum of trainroad	-4.346	-3.307	-6.328
	(2.867)	(2.837)	(3.965)
N	85	83	87
R2	0.62	0.76	0.67
Mean outcome	5.22	6.46	7.32

Notes: Heteroscedasticity-robust p-values in parentheses. $***$, $**$, $*$ denote 1, 5, 10% level of significance. Fixed effects: year dummies. Region-level native yield (100 kg/ha) for different types of crop is regressed on colonial crop yield, native crop yield in year t-1, the log sum of pre-colonial roads, colonial roads and railroads. Each column reports different outcome Col. (1) reports the model for wheat yield, col. (2) durum yield and col. (3) barley yield.

6.4 Urban market opportunities

Because colonial farms compete with native farms in rural areas, and sell their products to distant markets at a lower price, one could expect the effect of colonial farms to be different where colonial agricultural products are sold. In cities, the local population typically has access to these products and benefit in addition to non-farm occupations, in the manufacturing or service sectors.

I estimate equation 1 looking only at the urban subsample, namely individuals born in municipalities of more than 10,000 inhabitants in 1917. The estimation compares city-dwellers who live near colonial farms to those who live in cities without colonial farms, before and after 1919. Results are presented in column 1 of table 8. The coefficient on the main regressor is positive at standard confidence level. It indicates that in cities, individuals benefit from the colonial production through the channel of lowered food price. Alternative explanations could be that native producers take profit of productivity spillovers or of access to well-integrated domestic or international markets. In the following subsection, I explore the effect of openness to international trade.

6.5 Trade exposure

Openness to trade may have ambiguous effects on the local population depending on the relative productivity of colonial and native farmers and on the fixed cost to international trade. On the one hand, colonial production being more productive, native producers are crowded out from international markets in a competition effect. On the other hand, the presence of colonial farms may have lowered trade fixed costs, benefitting to local producers. I test the trade channel by computing a municipality specific world demand shock in the spirit of Dube and Vargas (2013). Each municipality faces a specific time-varying mix of world demand $WD_{b,t}$ for the agricultural commodity p it produces.

$$WD_{m,t} = \frac{\sum_p \alpha_{p,m} \times M_{p,t}^W}{P} \tag{8}$$

The world demand shock is the sum of an interaction of the term $\alpha_{p,m}$, a binary variable for whether the cultivation of crop p is suitable in the municipality m, and $M_{p,t}^W$, its world price in year t. A municipality is deemed suitable for a crop if its suitability (in rainfed, low input production) class is intermediate and above.

I can rewrite the baseline equation supplementing the settlement shock by a set of external demand shocks, with different effects accross pre-treatment, treatment and control municipalities.

$$height_{i,m,t} = \gamma_1 WD_{m,t} \times \delta_{t<1919} + \gamma_2 WD_{m,t} \times \delta_{t\geq 1919} \times colonial_m + \gamma_3 WD_{m,t} \times \delta_{t\geq 1919} \times (1 - colonial_m) \\ + \beta\delta_{t\geq 1919} \times colonial_m + \alpha_1 age_{i,t} + \alpha_2 age_{i,t}^2 + \Omega_{m,t}'\Gamma + \mu_m + \nu_{r,t} + \epsilon_{i,m,t} \tag{9}$$

γ_1 captures the effect of a positive variation in external demand in pre-treatment municipalities, γ_2 in treated municipalities and γ_3 in post-treatment control municipalities. Results are presented in column 2 of table 8.

A positive variation in external demand benefits local height only among treated municipalities. A deviation by one unit in external demand leads to an increase height by almost 0.6 cm. This effect is not observed neither before 1919 nor in control municipalities. One can cautiously interpret these results by as the effect of an increased trade oppenness in the presence of colonial farms. Colonial farms lower trade fixed costs benefitting to local producers. The main treatment variable becomes however poorly estimated. This indicates that part of the main effect is explained by this trade channel. Openness to trade exposes local population's to international price fluctuations in municipalities production is mostly export-oriented.

Table 8: Distribution mechanisms

	(1) Urban	(2) Trade
Colonial farming * d1919	0.703*	-1.047
	(0.325)	(0.957)
Trade shock in treatment		0.473
		(0.346)
Trade shock in control		0.317
		(0.314)
Trade shock in pretreatment		0.288
		(0.381)
N	9438	48334
R2	0.08	0.07
Birth commune FE	– Yes –	
Region x year FE	– Yes –	

Notes: Heteroscedasticity-robust p-values in parentheses. $***$, $**$, $*$ denote 1, 5, 10% level of significance. Clustered at the municipality level. Fixed effects: region-specific birthyear and municipality. Height is regressed on a time-variant variable that is the interaction of being born in a municipality with colonial farms after the arrival of settlers. Regressions includes the full vector of covariates presented in table 3. In col. (1) the sample is composed of all individuals born in municipalities of more than 10,000 pop in 1917. Col. (2) includes all units and explore heterogeneous effects of external demand for pre-treatment municipalities (before 1919), control municipalities and treatment municipalities (after 1919). External demand is a municipality level trade shock that a composite index of crop suitability interacted with the year international price for the crop. Mean and standard deviation of external demand is reported at the end of the table.

7 Conclusion

I estimated the height penalty from being exposed to colonial transformative change in the agricultural sector. Cohorts born after the arrival of colonial settlers are up to 0.44 centimeters lower than pre-exposed cohorts compared to unexposed cohorts. I argued that this effect is the consequence of an early life negative shock on nutrition and health. The investigation of the possible mechanisms indicates that colonial farms lead to a relocation of factors from local to colonial farmers. I gave evidence that the local production does not benefit from a precipitation windfall in the presence of colonial farms. Moreover, extreme rainfall impacts negatively early-life conditions suggesting that the reduced availability of land lead to soil exhaustion. I also showed that colonial farms changed factor intensity by adopting land-extensive techniques. Where average colonial farms are the largest, local population's health is worsened, suggesting that land appropriation is not compensated by an increase in employment on colonial farms. Turning to the distribution side, I gave evidence that colonial farms improved integration to international markets, benefitting to local health when prices went up. However, it exposed natives to market fluctuations, worsening their health when prices went down. Lastly, the presence of colonial farms could have had a positive impact in urban settings, where city-dwellers could benefit from colonial products at a lower price. Because the population is in vast majority rural, few benefitted from this mitigating effect.

By singling out one aspect of colonization, the transformation of agriculture, these findings shed a new light on its middle to long-run effects on development and inequalities. They draw two possible channels of path-dependency. First is the direct effect of lower children health on future income. We know that early-life conditions are a specific determinant of future income. By hindering children's health, colonial farms may have affected the income trajectory of several cohorts born under colonisation. The second possible channel is through capital accumulation. After independence, few changes were brought to the colonial agriculture organization. If some of colonial farms were redistributed among small farmers, they mainly accrued to post-colonial elites. The inheritance of these colonial structures could be at the origin of post-colonial wealth inequalities.

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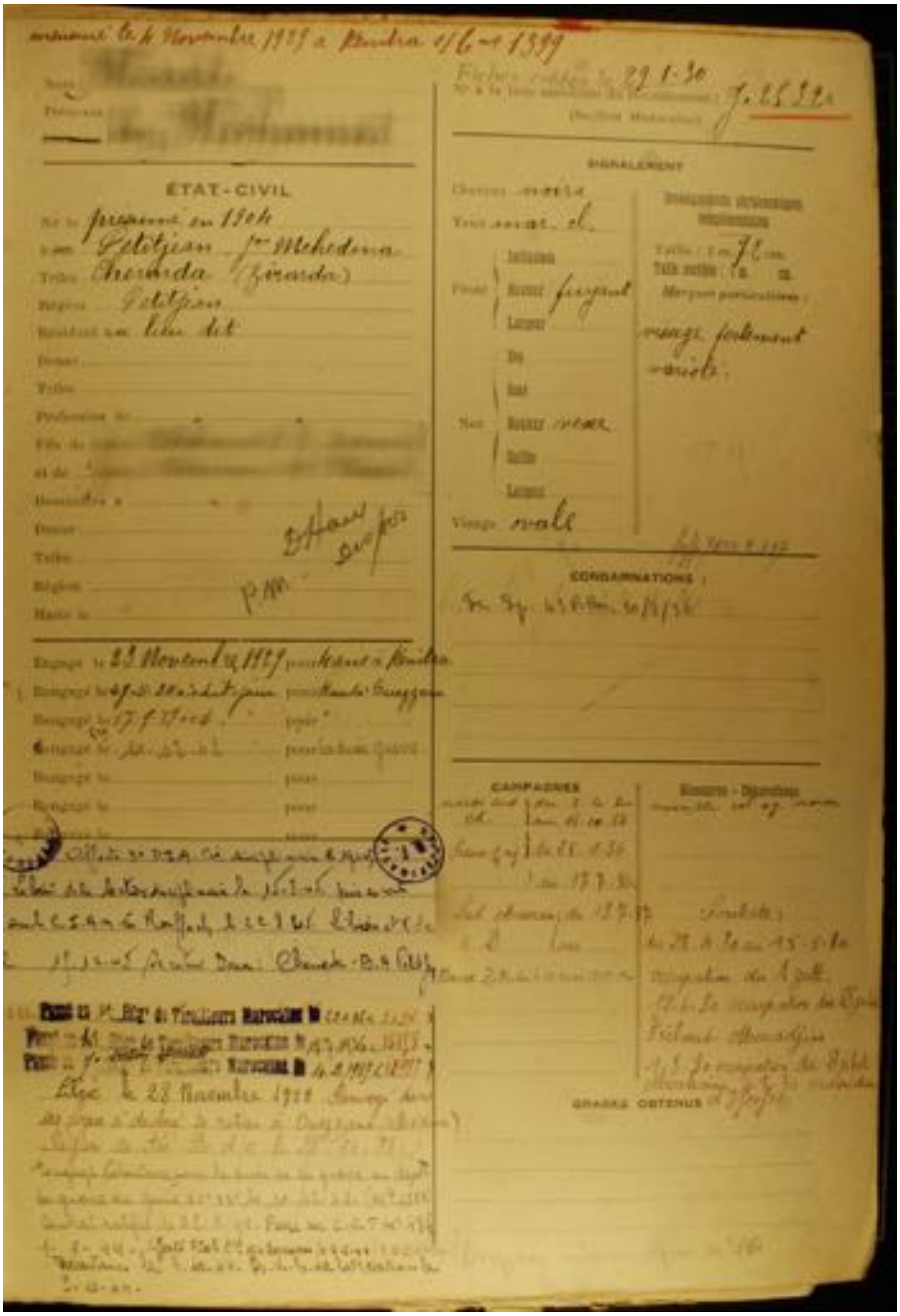
Appendices

A Tables and figures

Figure A.1: Example of registration card



Notes: A registration card of a soldier presumably born in 1904 in Petit-Jean (former Sidi Kacem) and enrolled in 1929. He was therefore 25 years old when he joined the army and measured 175 cm. His name, surname and those of his parents were blurred for privacy rule.

A.1 Balancing tests

The identification relies on the assumption that municipalities, although different along fixed dimensions, did not differ in terms of time-varying characteristics. I test this hypothesis here by estimating mean differences of relevant municipality-specific time-varying characteristics across treatment and control municipalities. Table **??** displays a series of conditional balancing tests which compare characteristics of the municipality between the colonial and native sector before and after the settlement cutoff. The regression equation is given by:

$$municipality_{m,t} = \alpha(\delta_{t\geq 1919} \times colonial_m) + \eta_m + \mu_t + \nu_{r,t} + \epsilon_{m,t} \tag{10}$$

where the unit of observation is a municipality observed at year t. The vector of municipality outcomes comprises road and train investments, precolonial development (existing trails in 1912) interacted with year t, precipitation and temperature shocks, external demand expressed as the most suitable crops interacted with their international price.

A.2 Placebo settlement shock

I conduct here a placebo test where the settlement shock occurs in the period preceding settlement to verify that the native and colonial sector where on a common trend before the arrival of settlers. Table A.1 shows the result of re-estimating equation 1 with a placebo shock occuring between 1912 and 1917. The coefficient on the main variable *pre-settlement treatment* is testing the hypothesis that the locations chosen by settlers were already exhibiting a different trend before settlement due to unobserved factors. Failure to reject the null hypothesis, as shown by the non-significant coefficient on the main variable – is suggestive evidence of the absence of different pre-trend.

Table A.1: Robust reference category

	(1)
Colonial farming * 1901-1918	-0.371*
	(0.203)
Colonial farming * d1919	-0.503***
	(0.124)
N	48447
R2	0.01
Birth commune FE	– YES –
Region x year FE	– YES –

Note: *Pre-settlement period* is the interaction of the presence of colonial farms with a binary variable equals to one in the period 1912 and 1917. The sample includes only indidivuals born before 1918. Cohorts born before 1912 are compared to cohorts born between 1912 and 1917 across the native and pre-colonial sector.

B Matching on correct city names

Procedure City names provided by the soldier files were matched to a predefined list of commune names corresponding to contemporaneous communal boundaries, due to the absence of a historical communal boundary map. I employ a combination of fuzzy merge and hand assignment to geomatch birth communes, following these several steps.

1. I defined a first reference list composed of all administrative communes as existent in 2014 and the list of places referenced in Google maps.

2. I run two fuzzy merge algorithms, respectively based on 3-gram and token matching. Fuzzy-merging is then based on a set of hierarchized rules.

    (a) Soldier's city is assigned to a reference city when the matching score of the city-pair reaches 1 (perfect match) with any of the matching technic.

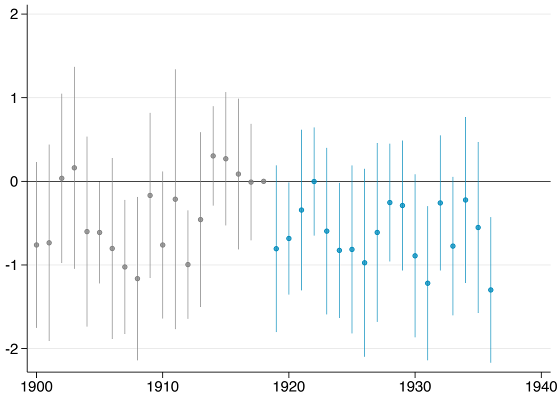
    (b) Soldier's city is assigned to a reference city when the matching score of the city-pair is the highest for both technics.

    (c) Soldier's city is assigned to the reference city corresponding to the higest matching score of both technics. When both technics reach the same higest score, token matching is taken over 3-gram matching.

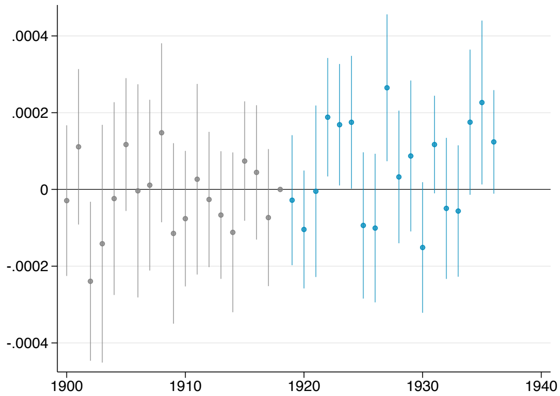
3. I cross-check and complete assignment by hand. Matching with a score below an arbitrary and conservative threshold (.82) were cross-validated. Cities for which the matching algorithm found no correspondence were hand-assigned.

Figure A.2: Settlement and suitability dynamics

(a) Settlement yearly effect



(b) Wheat yearly effect



4. Finally, I hand-assigned cities that were matched to city with synonymous. I exploited the fact that soldiers are assigned a *douar* and *contrôle civil* to determine to which city the synonymous corresponds.

5. Once assignment is completed, I attach the coordinates of the commune's centroid to the assigned city (could be a commune or a place within this commune).

Soldiers' *douar* and *contrôle civil* Soldier files inform two geographic levels of birth place: the *douar* and *contrôle civil*. *Douar* corresponds to the city or village, whereas *contrôle civil* corresponds to a higher administrative-level city, to which the *douar* belongs. I define the *douar* as the commune of birth each time that its geomatching was possible. If not, I defined the *contrôle civil* as the commune of birth, when its geomatching was possible.

C Variable construction

Soldiers Soldiers data are constructed using registration files collected in the Centre des Archives du Personnel Militaire in Pau (France). These files compile information on soldier's birthyear, date of enrollment, place of enrollment, "douar" and "contrôle civil" of birth, height as measured at enrollment, literacy and occupation. The geomatching strategy of soldier's place of birth is described in the subsequent section.

European plots Locations of European farming plots were geocoded from a colonial map published in 1958. It gives the precise location of European farms in 1955 at a 1:1,000,000 scale. The treatment dummy is coded 1 when the share of European farms is over 15% of the total commune surface. It corresponds to the average share of European farming conditional on the presence of European farms.

Occupation Date of French occupation is obtained from yearly maps establishing the military advance of French troops over the territory. Military occupation spans from 1912 to 1933.

Production Time-varying regional production data are obtained from *Annuaires Statistiques du Maroc* that report the quantity of production and cultivated surface per European / native for all crops and per main crop. Data are available from 1915 until 1956. Data broke by origin of owner is missing for the second world war period (1939-1944).

Road and railroad Road and railroad lengths are obtained from historical maps mapping the extent of the network for a given year. Maps exist for the years 1912, 1915, 1916, 1918, 1921, 1924, 1928, 1932, 1934, 1936, 1939, 1941 and 1948. I interpolate the missing years by assuming that the network remained identic since previous observation. According to the maps, first paved roads are built in 1918. First railroads are constructed in 1910. Before these dates, I thus assume that the respective network is inexistent.

Weather Temperature and rainfall data originate from the Global Historical Climatology Network and 19th Century African Instrumental and Documentary. The first source provides world monthly climatic data for the period 1900 onward at the 0.5 degree by 0.5 degree pixel level. I compute the average yearly measure at the municipality level. As the shapefile was not fully covering Morocco (36 pixels are missing over a total of 314), I interpolated the missing pixels employing the same spherical version of Shepard's algorithm, allowing 20 neighbor pixels to influence the grid-node estimate. The second source provides monthly climatic data at the level of historic gauges. I interpolate the weather measure on a 0.5 degree by 0.5 degree latitude/longitude grid employing the same distance-weighting method as for the GHCN data.

I derive a yearly weather shock that is the standardized deviation from the period-sample average. It is constructed as follows:

$$weathershock_{m,t} = \frac{weather_{m,t} - wea\bar{t}her_m}{\sigma weather_m} \tag{11}$$

where m is municipality and t year. $weather_{m,t}$ is the yearly measure of weather (rainfall or temperature), $wea\bar{t}her_m$ denotes the average over the sample-period and $\sigma weather_m$ the standard-deviation over the sample-period.

Trade Commune-level external demand measure is constructed from the interaction of GAEZ crop suitability index for rainfed production with low inputs and world time-series price for major crops. These year series are extracted from two sources : Federico and Tena-Junguito (2019) World Trade Historical Database and Blattman *et al.* (2004) database.