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Laura Maravall Buckwalter

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Keywords: Agriculture, Economic Development, Technological Change, Adaptation, Land Ownership and Tenure, Land Use, North Africa.

JEL Classification: N5 O1 Q15 Q16.

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Abstract

The adaptation of crops, agricultural techniques, and farm size to the new environments ushered in by colonialism help identify the sources of long-term development. This paper is a simplified approach to this adaptation process. It analyzes the relative factor endowments (land and labor) based on the timing of settlement to study the regional differences in the adoption of improved agricultural techniques in Constantine at the beginning of the 1900s. During the colonial years, the Algerian farming system diverged into large estates reliant on indigenous wage labor and sharecropping. As fertile land became increasingly scarce, the ability to participate in the grain export market depended on the capability of engaging in new and non-labor saving agricultural techniques. The results demonstrate that innovation in cash-crop production depended on the abundance of indigenous labor but also required a significant capital investment to offset the worse land quality. Thus, access constraints to agricultural advancement help explain the Algerian origins of colonial land inequality and the failure of colonial institutions to create a small-peasant settler economy.

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The international trade environment evolved rapidly at the turn of the twentieth century. It was a period of world market integration, leading to changing relationships between nations, through shifting specializations and comparative advantages.[1] This phase of world integration was considered to be ``the `golden age' of settler societies;" which comprehended ``the long 19th century (1814-1914) and, particularly, the First Globalization era (1870-1914).”[2] Nevertheless, how these societies performed in the long term was very different and numerous scholars have identified the relative factor endowments - that is, the ratio cultivable land and labor - as the driving force of regional disparities. In the case of Algeria, the settlement process implied a regional integration into the international economy, commercial agriculture boomed, and trade became one of the key drivers of development. As settlers moved into the interior regions, the ratio cultivable land-to-labor changed: the growing land aridity in the later-settled areas required new cultivation techniques that were dependent upon labor availability and required a significant amount of capital to participate in cash-crop production. This paper argues that access to agricultural advancement - namely, changes in crop rotation frequency and more intensive plowing - ultimately shaped Algeria’s pre-independent agrarian society and helps understand the failure of colonial institutions to create a small-scale, family-farm type of settler economy.

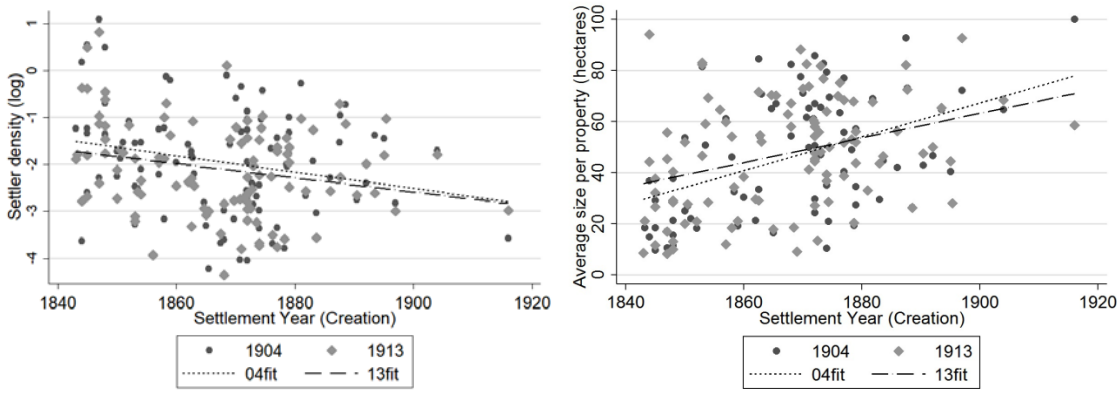
Since occupation in the 1830s, the French government - through official colonization (i.e., organized by the colonial administration) - aspired to expand rural settlement by means of migration waves and granting small plots of land conditional on obligatory residence. Rural settlers were located in territorial units known as “settlement centers” - solely created for agricultural purposes and to provide economic value to the colony and consolidate settlement.[3] The idea was to form a ``peasant's paradise, a prolongation of France across the Mediterranean where *myriads of French settlers* would make the Tell bloom with *small farms* and cosy villages, as in the western provinces of the homeland."[4] Yet, according to numerous historians that study French Algeria, it turned out to be a speculative cash crop producing colony made up of relatively large, export-led, settler-owned estates devoted mainly to cereal and wine, leading to high land inequality levels even prior to Independence in 1962.[5] It is argued that these properties mirrored the French government's institutional failure of creating a family-farm type of economy that would be an integral part of France.[6]

In line with this, the data displayed in Figures 1a and 1b for Constantine (a former French department in the north-eastern part of Algeria) demonstrates that - contrary to this ideal of a ``peasant's paradise" - the institutional goal indeed failed over time: later settlements, proxied by the year of creation of a settlement center (in x-axis), were endowed progressively with *less settlers* and significantly *larger properties*. Hence, one might ask what forces ultimately prevailed over the colonial land-policy and determined the distribution of land. Previous studies on colonial Algeria have indicated that rural colonization was cursed by its natural geography suitability towards large size properties, driving out small-landholding settlers. Thus, Algeria’s case study

[1] Findlay and O’Rourke (2008)
[2] Willebald (2013; p. 106)
[3] As explained by Bellahsene (2006), a settlement center was the final project per se and was not initially intended to become a town or a village devoted to commercial exchange, nor endowed with relevant administrative and economic functions. Before the end of official colonization, territorial expansion by means of establishing new centers was prioritized over the enlargement of centers already built. The basic structure of a settlement center was a ``colonization perimeter" circumscribing a village in the center (to provide accommodation for families) and the to-be-cultivated plots of land were located at a maximum of one-hour walking distance from the village.
[4] Roberts (1963, p. 215). The term ``Tell" refers to a part of a wider mountain chain located between the Mediterranean and the Sahara.
[5] Griffin (1976); Ageron (1991)
[6] In 1848 Algeria was declared as an integral part of France in the French Constitution.

sheds light onto the literature regarding the mechanisms through which colonial institutions are ultimately shaped by the local factor endowments (e.g., geographic conditions) encountered in the colonized regions.

[Figure 1a and 1b; 1a. Share of properties by size and average property size density per period of settlement, Constantine in 1904/05 and 1913/14; 1b. Average property size and year of creation of a settlement center]



Note: *Settlement year* (*Creation*) is the average year of creation of settlement center in a municipality. Settler density is the number of European settlers per hectare in logarithms. The *Average size per property* is a weighted average of the size of properties in all groups. The lines *04fit* and *13fit* are the trend lines corresponding to the years 1904/05 and 1913/14. Source: SA (1904/05, 1913/14), Busson (1898), and ANOM-iREL.

This paper will argue that Algeria's constraints to agricultural improvement (or innovation) ``crowded out'' small rural settlers and forced the colonial administration to allow a higher presence of large properties that were devoted to cash crop production. Although the relative factor prices can often be regarded in literature as major forces that ``induced innovations'' during key-events in history - such as the British Industrial Revolution and the agricultural mechanization in the United States[7]- this paper demonstrates that they are not enough to explain agricultural improvement in colonial Algeria. To do this, it takes advantage of annual agricultural statistics reported by the French administration at the municipal level in Constantine at the beginning of the 1900s to identify the factors that permitted the adoption of new agricultural techniques.

This study illustrates how a rural economy can change during the years of settlement. As Frankema et al. (2014) explain, numerous studies on the effects of colonialism in the long term tend to neglect changes within the process of settlement itself, yet settlement must not be regarded as an ``event […] at a given point in time," rather it must be studied as a process that experienced significant changes throughout the colonial years. In addition, extensive research on economic development builds on Acemoglu, Johnson, and Robinson's (2001, p. 1369) argument that ``Europeans adopted very different colonization policies in different colonies, with very different associated institutions" to explain long-term economic growth and income distribution.[8] However, only a few scholars have taken into account that Europeans adopted different colonial land appropriation and redistribution policies within a colony itself, depending on the region being

[7] See Allen (2011) and Hayami and Ruttan (1971)

[8] For instance, ``settler economies" (e.g., Kenya, South Africa, and Zimbabwe), which were characterized by intensive European settlement and major land transfers from indigenous populations to settlers, relate to higher land inequality and lower potential for growth, as opposed to ``peasant export" economies (i.e., Ghana and Uganda), where smallholders were able to participate in exports (Bowden et al. 2008; Haas, 2017).

occupied and the timing of settlement. The data available for Constantine provides an opportunity to control for the timing of settlement and analyze differences in land market institutions and relative factors of production.

Furthermore, much of the literature tends to consider Africa as a whole, excluding relevant inter-country heterogeneities that should be included in the assessment of the impact of colonization on economic growth and development.[9] In general, French Algeria is regarded as a settler economy that should be included into a ``somewhat different type of settler colonialism that emerged in Africa over the 19th Century and early 20th Centuries," characterized by having a settler population smaller in size to the indigenous one and a *métropole* endowed with a significant economic, political, and often military power, that maintained the colony's dependence on it.[10] In comparative studies, scholars usually position Algeria together with Southern Rhodesia, Kenya, and South Africa due to the relative share of land owned by settlers, the dependence of settlers on the availability of indigenous labor, and the role of the state representing settlers and determining access to land and labor.[11] However, Algeria stands out from the rest because it was ``geographically, politically and economically" nearest to the ``mother country'[12] and, in contrast to other settler economies, it was considered as an integral part of France, and thus enjoyed a preferential trade policy that guaranteed a market demand that fully absorbed its agricultural exports. Finally, the land appropriation process was mostly undertaken after conquest, entailing a complex procedure where native traditional land norms and titles were intertwined with innovative French administrative measures.[13] Hence, studying this particular case of a settler economy can provide new insights regarding the effects of colonialism on agrarian structures, contributing to the settler-economy literature, and Gareth Austin's ``de-compression of history."[14]

The structure of this paper is as follows. The first two sections overview the international context and Algeria's specific agricultural constraints, and the third section focuses on the institutional restrictions to agriculture (i.e., land market regulations and access to agrarian credit). Following this, it expands upon Hayami and Ruttan’s (1971) induced innovation hypothesis to assess technical change, highlighting the role of land, labor, and capital as key constraints on agricultural production. In line with Olmstead and Rhode (1993), it includes the timing of settlement into the analysis to provide a more complete framework. The final section expands the analysis and builds upon secondary literature to improve the empirical model and discern the main forces related to agricultural change.

I

The international prices and the colonial tariff regime assumed a vital role and influenced settlers' production choices during the colonial years. They help explain the colonial market shift towards wine and cereal production and the boost in exports after the 1870s. The opening of new frontiers and their impact on international wheat prices at the turn of the twentieth century forced many

[9] Bertocchi, and Canova (2002). Authors such as Elkins and Pedersen (2005), Lützelschwab (2013), Mosley (1983) and Huillery, E. (2014) have improved accuracy by limiting comparison to the North African region or to similar settler colonies.
[10] Lloyd and Metzer (2013; p. 2)
[11] Lloyd and Metzer (2013), Lützelschwab (2013), Osterhammel & Frisch (1997).
[12] Good (1976; p. 598).
[13] Lützelschwab (2013)
[14] Austin (2008)

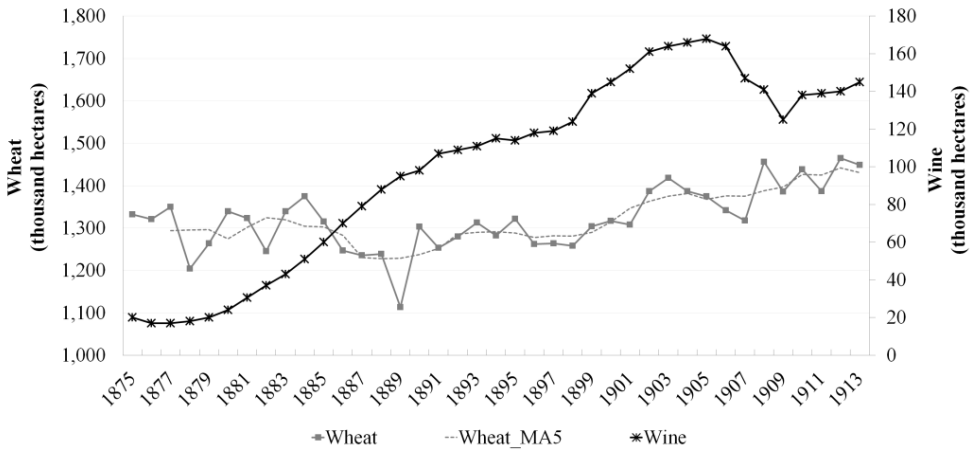
agricultural economies to specialize into higher value crops. In the case of Algeria, it pushed settlers to diverge into viticulture or to adopt relatively modern techniques to increase - or maintain - cereal yields. In addition, the French shift towards protectionism in the 1890s, together with the colonial assimilation regime, secured a reciprocal commercial relation between both countries and guaranteed an ``absolute freedom of duties," simplified formalities, and allowed Algerian producers to benefit from higher prices. Overall, around 80 percent of Algeria's trade was free of duties and the French market was sufficient to absorb Algeria's main agricultural products.[15]

The market integration set by the colonial trade policy linked agricultural production to cereal and wine prices in France. While international grain prices dropped in the second half of the 1870s, wine became lucrative as a result of the *phylloxera* vineyard aphid in Europe that devastated wine production in France.[16] In addition, Algerian wine was particularly strategic as its high alcohol content combined optimally with the weakened French wine that resulted from the use of hybrids.[17] However, production in Algeria's warm climate required advanced technology to complete the fermentation process and it became possible after the mid-1850s because of Pasteur's scientific innovations (i.e., known as ``cold fermentation") which, together with trade regulations, allowed wine to represent ``half of the Algerian exports and almost one third of [its] GDP" and helped Algeria becoming the first exporter to France."[18] By the 1880s, the area devoted to viticulture had grown significantly whereas the one dedicated to cereal, which was pushed South into less fertile regions, remained stagnant until 1900 (see Figure 2). Nevertheless, the situation reversed at the turn of the century. In the 1880s wine became less profitable as production recovered in France, while cereal began to be competitive thanks to French protectionism and new agricultural techniques that allowed cultivation in arid regions. This reversal is visible in the following quote in 1886 by the British Consul-General Playfair reporting that ``the hopes of the colony are now centred in vines […]'' as opposed to that of the British Vice-Consul Scratchley for the year 1900 stating that ``the question of how to get rid of wines is becoming serious in Algeria.''[19]

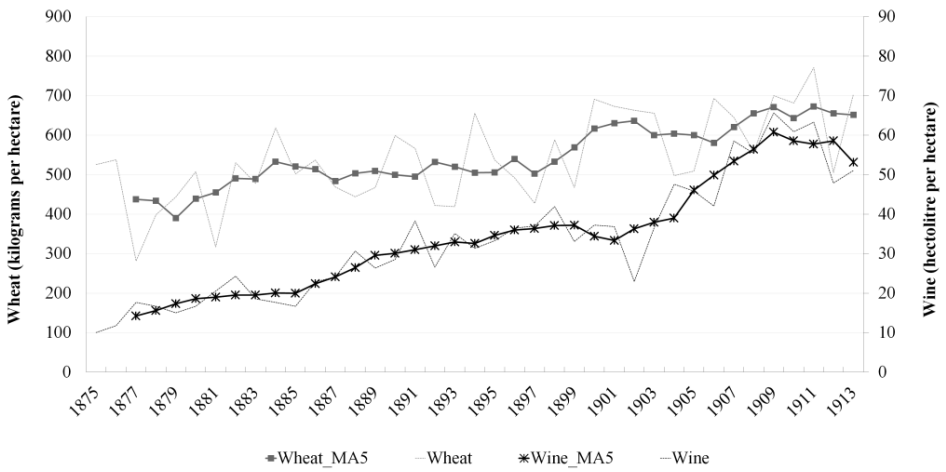
In fact, as a result of the new farming techniques, cereal yields per hectare experienced a significant increase particularly in the 1900s (Figure 3). Overall, based on Amin's (1966) estimates, between 1850 and 1910 the net annual cereal production growth rate was of 1.7 percent, while wine production experienced an annual 3 percent growth rate from the 1880s until 1910. During this period, both products ranked as the most important exports of Algeria in terms of their value within French statistical yearbooks. The export data obtained from these yearbooks and the output estimates reported in Mitchell (1994) suggest that the exported share of the total wine production passed from 40 percent in 1887, to 80 percent in 1899, and 70 percent in 1909, while the share of the cereal exports over the total production ranged between 10 to 15 percent. The years between 1900 and the First World War experienced the highest wheat production averages and, by 1913, settlers accounted for 45 percent of the total soft wheat produced in Algeria, 30 percent of the hard wheat, and 17 percent of barley.

[15] Girault (1916, p. 262).
[16] Isnard (1975) states: ``It is not exaggerated to say that Algeria was saved, in that occasion, by an insect."
[17] Pinilla & Ayuda (2002)
[18] Meloni & Swinnen (2014, p. 10)
[19] No. 2710 Annual Series. Diplomatic and Consular Reports. France. Report of 1900 on the trade of Algeria. Reference to previous report, Annual Series No. 2472. p. 31.

[Figure 2: Cultivated area of wine and wheat in hectares, French Algeria 1875-1913]



[Figure 3: Wheat and wine production per hectare, French Algeria 1875-1913]

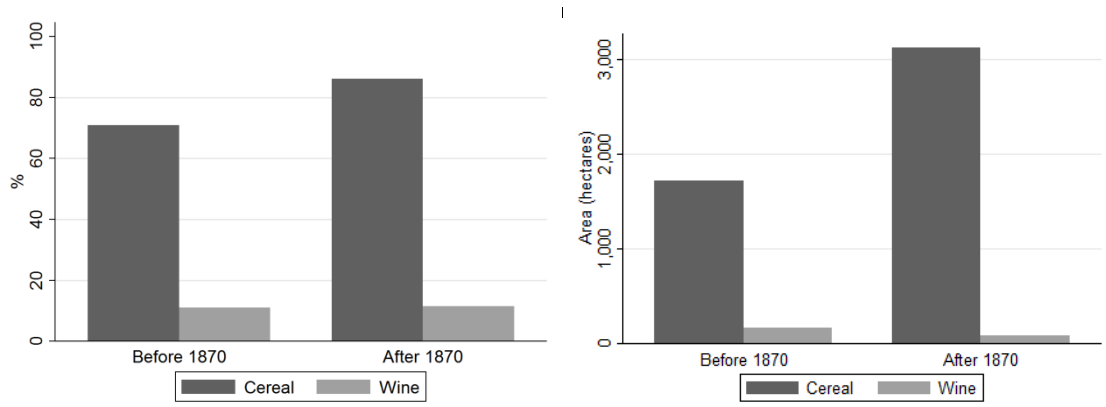


Notes to Figure 2 and 3: The series *Wheat_MA*5 displays the 5-year moving average of the *Wheat* series. The figures refer to the cultivated area during the crop year ending the year indicated. The value for 1881 was interpolated for both production and area cultivated. Source: ASF, 1930.

In addition, cereal facilitated colonial expansion. [20] Thanks to the newly introduced agricultural methods at the beginning of the 1900s, the French administration was able to provide previously uncultivated arid lands to settlers in the High Plains. The cultivated area expanded to the surroundings of Constantine, Batna, Guelma, Sétif, Mostaganem, Sidi-bel-Abbès, Miliana, and Orléansville, and, in all of Algeria, it was augmented by 170 thousand hectares between 1905 and 1915.[21] In Constantine, European wheat cultivation expanded from 160 thousand hectares in 1898/1902 to 209 thousand in 1906/1910. At a regional level, Figure 4a and 4b indicate that the share of wheat over the total cultivated area in Constantine was greater in the regions settled after the 1870s whereas viticulture represented a small portion of the cultivated area.

[20] See Lützelschwab (2006) for details on cultivation
[21] Mollard (1950)

[Figure 4a and 4b: 4a. Share and extension of the wheat-cultivated area and viticulture by year of creation of settlement centers, Constantine in 1904/5 and 1913/14; 4b. Area cultivated in hectares]



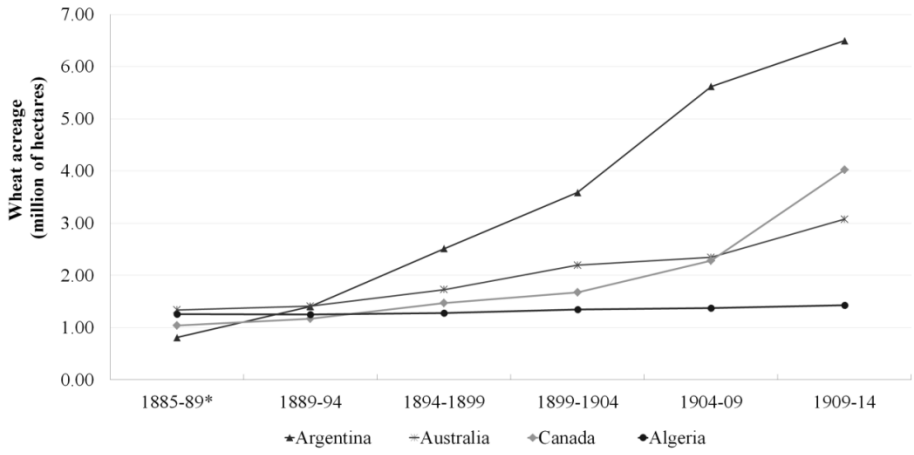
Note: Figure (a) is the average share of the area cultivated of wheat or wine over the total area cultivated in the municipality. Figure (b) displays the average total cultivated area in hectares of wheat and wine per municipality. *Source*: SA (1904/05, 1913/14), Busson (1898), ANOM-iREL. See Appendix for more detail on sources.

II

The relative factor endowments (i.e., land, labor, and capital) and selected crop are found to shape agrarian societies as they help determine the corresponding forms of farming. For instance, as explained by Offer (1991; p. 87), in the New World, grain suppliers farmers had ``sufficient land, draft animals and machinery, cheap credit, literacy, enterprise, education and scientific support'' and were characterized by a new social form endowed with cheap and available land, self-exploitation family units, low production costs, and small-scale economies, where the lack of power and no laborer-manager-landowner division led to more equal agrarian societies. Nevertheless, French Algeria was very different to the land-abundant New World. According to Malenbaum's (1954) estimates, in the mid-1880s the colony was positioned in terms of total wheat-devoted acreage extension above Argentina, Canada, and Rumania, and just behind Australia. However, as shown in Figure 5, in contrast to the rest, Algeria's acreage virtually stagnated throughout the period, with only a slight increase of 13.5 percent. In addition, according to the figures reported in Acemoglu et al. (2002) for the 1500s, the Algerian population density was almost 9 times that of Canada, nearly 64 times that of Argentina, and more than 200 times that of Australia.[22] Hence, although these aggregated figures must be regarded with caution, they suggest that, in contrast to the New World countries, cultivable land was scarce and already by the 1870s the frontier expansion had been nearly exhausted.

[Figure 5: Total wheat acreage, 1885-1914 (5-year moving average) from Malenbaum (1954)]

[22] Acemoglu et al. (2002) divide the population estimates for 1500 (obtained from McEvedy et al. (1978) by the estimated land area in 1995 (from the World Bank) adjusted for arable land area.



Note: * Is a 4-year moving average. *Source:* Malenbaum (1954).

However, the portion of land cultivated by settlers was comparatively high. Table 1 displays various indicators for Constantine relating land and rural population at a district level and according to the average year of settlement (before or after the 1870s). With respect to the settler population, if we divide the settler cultivated area by the number of European owners (in column IV) and compare the values to those reported in Simpson (1987) for 1880 and 1930,[23] it is clear that settler ownership in Constantine was high and in line with Great Britain (14.7 and 17 respectively) and the United States (25.4 and 40.5). In addition, given that settlers heavily relied on indigenous labor, if we take into account in the denominator the amount of indigenous workers (i.e., laborers and sharecroppers) in column V, the results suggest that at the beginning of the 1900s settler farming in Constantine was comparatively labor abundant relative to land.

The shortage of arable land was caused by its high aridity levels. Algeria's climate was similar to that of Spain which, as Simpson (1996) and Santiago Caballero (2013) explain, was very different from Atlantic Europe: its climatic conditions levels did not allow engaging in the agricultural revolution where new crops and pastures permitted higher husbandry densities. Thus, the later settled areas, which were particularly arid, heavily relied on new agricultural techniques that permitted increasing yields and developing at the extensive margin beyond the more fertile regions.[24] These techniques allowed for the succession of crops in the same plot (whereas previously a part was left fallow) thanks to the combination of superficial (10 to 15 cm) and deeper plowing (from 20 to even 40 cm) that preserved the moisture, avoided excessive soil erosion, and increased wheat yields.[25] Nevertheless, they required more intense labor, modern European plows, and stronger draft animals (see Figure 5a and 5b).[26] Therefore, the major technological advancement was the gradual adoption of modern plows. In fact, the type of plow introduced varied according to the regional geographical characteristics but none of them were significantly labor-saving. For instance, Chevalier (1924) describes that the mountainous regions required modern but very simple plows, made of wood and iron that could easily be transported, substituted, and fixed with local tools, without having to go to distant urban centers. In contrast,

[23] Based on Binswanger et al. (1978) and Simpson's (1987) calculations for Spain.
[24] See a similar case in Libecap & Hansen (2002) where settlers, in order to adopt dry-farming techniques in the American Great Plains, necessitated extensive plots and more intense land use methods to compete in the global market.
[25] For detail on the methods used in French Algeria see Trabut & Marès (1906) and Mollard (1950). Lützelschwab (2006) explains that in a three-year rotation system, which was the one used at the beginning of the 1880s by the *Compagnie Genevoise des Colonies Suisses*, land was cultivated with winter cereal in the same plot during two successive years and left to lay fallow during the third year.
[26] Lützelschwab (2006)

more advanced double-*Brabant* plows, which required only one worker instead of two, were made entirely of iron and resulted too heavy for the local labor and draft animals in the hinterland regions.

[Table 1: Total rural population densities per district, Constantine in 1904/05 and 1913/14]

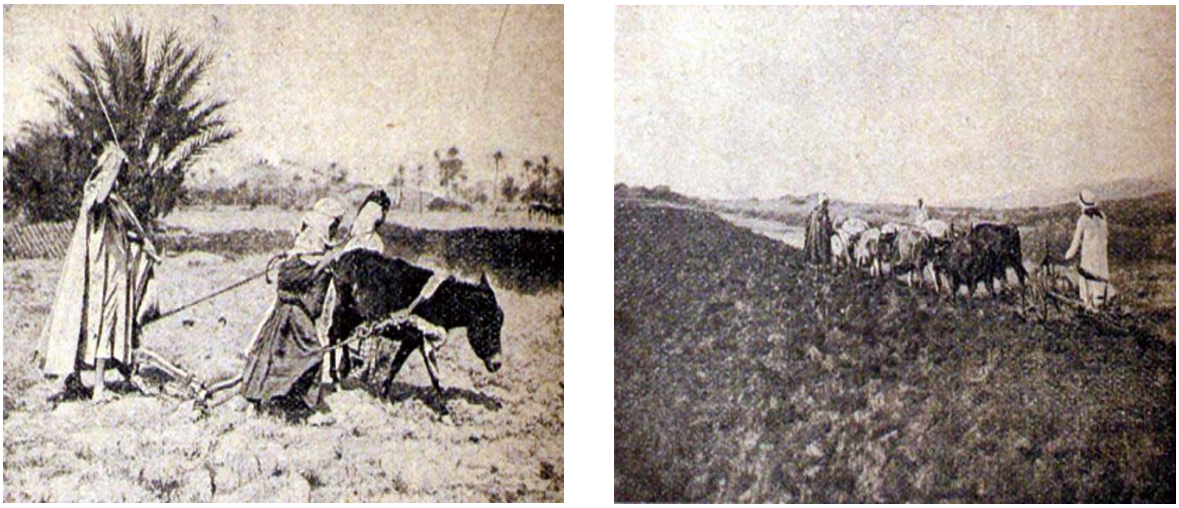
	Share cultivated area	Share owned area	Total cultivated area per capita (European and Indigenous)	European cultivated area divided by:	
				European owners	European and Indigenous laborers and sharecroppers
	(I)	(II)	(III)	(IV)	(V)
Old (pre-1870)	0.36	0.74	1.78	25.99	0.82
Frontier (post-1870)	0.35	0.90	1.71	24.25	0.80
1904					
Batna	0.20	0.39	2.39	13.84	0.93
Bone	0.21	0.64	0.95	13.90	0.57
Bougie	0.35	0.68	1.90	20.75	1.07
Constantine	0.43	1.04	1.84	38.10	0.81
Guelma	0.29	0.71	1.33	14.09	0.51
Philippeville	0.26	0.71	2.06	18.14	0.77
Setif	0.47	0.79	2.11	29.50	0.85
1913					
Batna	0.29	0.44	5.26	21.98	1.70
Bone	0.27	0.65	1.40	13.66	0.52
Bougie	0.28	0.67	1.96	17.06	0.98
Constantine	0.50	1.14	1.69	41.55	0.88
Guelma	0.26	0.62	0.98	15.57	0.67
Philippeville	0.29	0.77	1.79	21.46	0.75
Setif	0.49	0.87	1.65	23.09	0.82

Note: Column (I) is the ratio between the European and Indigenous cultivated hectares over the municipality's total area reported in 1902; Column (II) is the ratio between the European and Indigenous owned hectares over the municipality's total area reported in 1902; Column (III) is the European and Indigenous cultivated hectares divided by the European and Indigenous rural population; Column (IV) is the European cultivated area in hectares divided by the number of European owners; Column (V) is the number of European-owned hectares divided by the total European rural population and the number of laborers and sharecroppers. All wage laborers were employed by Europeans but, with respect to sharecroppers, it is assumed that only a 20 percent of the sharecroppers were employed by Europeans.

These techniques were more expensive as they required stronger draft animals (as shown in Figure 6) and removed the fallow fields used for animal feeding. As an illustration, with regard to cereal cultivation, the overall costs are visible in a detailed explanation by Trabut and Marès (1906) listing extensive costs (fixed, annual, and per hectare) required to establish a 200 hectare farm in the High Plains. To cultivate 100 hectares, as a fixed cost, the settler would have to buy land (40,000 francs),[27] 12 horses or mules (3,600 francs), 4 big modern plows for deep plowing (800 francs), around 7 small plows for the superficial work (600 francs), and approximately two reapers (6,000 francs). Farming also required the construction of a stable and a house at a cost of 6,000 francs. In addition, the corresponding annual costs to sow 100 hectares would require animal feeding (4,380 francs), labor (2,500 francs), reparations and machinery depreciation (1,500 francs), seeds (2,000 francs), and capital interests (4,133 francs), as well as other general costs (1,500 francs). Finally, the cost for all the agricultural labor tasks per hectare, such as plowing, sowing, and *planchage*,[28] harvesting, etc., would equal to approximately 160 francs per hectare.

[27] Assuming the price of the hectare is 200 fr.
[28] *Planchage* was the use of a three-meter board to avoid water evaporation.

[Figure 6: Indigenous plow (left) and modern plow (right) in French Algeria]



Notes: The photo on the left shows a traditional indigenous plow used for superficial land scratching, while the European modern plow shown in the picture on the right allowed a deeper plowing. Source: Clerc, Pascal (2008). *Les formes de la domination: paysages ruraux de l'Afrique du Nord colonisée*, Mappemonde, number 91 (3-2008). Retrieved from http://mappemonde-archive.mgm.fr/num19/articles/art08302.html. Original Source of photo: Gallouéec, L. and Maurette, F. (1922). Géographie de la France et de ses colonies. Classe de Troisième. Paris: Hachette, p. 286.

In addition, engaging in viticulture and owning a vineyard also required a significant amount of capital. According to Philippar (1903; p.126), ``vineyards demanded large investments, and costs of production per hectare were twice those of wheat, but net income was more than 6 times higher than from wheat […]." Algerian viticulture was characterized by capital-intensive wineries that specialized in cheap table wines, and relied on modern machinery and intensive labor.[29] When French wine production recovered and prices dropped in the 1880s, Algerian producers were forced to decrease production costs by means of hiring cheap indigenous labor.[30] As an example, based on Philippar (1903), the creation of one-hectare of vines (within a 25-hectare vineyard) required deeper plowing with modern plows (50 fr),[31] the first three-year cultivation costs (900 fr), the purchase of plants (50 fr), the cellar construction (500 fr), and the wine material (1000 fr). The yearly cultivation costs (not including manure) totaled up to 360 francs per hectare as a result of maintenance and the depreciation of live and dead livestock (60 fr), pruning and disbudding (30 fr), plowing and hoeing (80 fr), sulfuring (25 fr), treatment of the flea beetle (25 fr), sulfating against anthracnose and mildew (30 fr), sale costs (50 fr), and more general costs (60 fr).[32] In addition, the exploitation interests and the amortization of the start-up capital added up to approximately 600 francs per hectare. Finally, the author estimates that it would take about 10 years to reimburse the capital disbursed to create a vineyard and, if the climate conditions were good and exploitation costs added up to approximately 600 francs per hectare, the winegrower

[29] As Simspon (2011; p. 10) explains, ``by 1900, the new wine-making techniques included refrigerators, continuous presses, aero-crushing turbines, sterilizers, and pasteurizers, and these helped create economies of scale […]."

[30] Ageron (1991), Isnard (1949, 1959), Belkacemi (1984). Indigenous labor substituted the relatively more expensive settler daily laborers. It is found that viticulture laid the origins of wage labor in Algeria. For detail on viticulture in Algeria and its trade with France, see Meloni and Swinnen (2014) and Pinilla & Ayuda (2002). Regarding the effects of viticulture within the Algerian society see Isnard (1975).

[31] As an illustration, Simpson (2011; p. 10-11) explains, based on Augé-Laribé (1907; p. 143-137), that the vineyards in the Midi that usually required plows and hired labor were those above 25 hectares (smaller ones relied on hand hoes).

[32] The *phylloxera* plague raised costs as it required replanting disease-resistant vines and more delicate vines with a shorter life-span.

would need to produce at least 50 hectares of wine and sell them at 12 francs to cover all the expenses.

III

Certainly the international forces and the tariff policy influenced settlers' production choices and help explain the colonial market's shift towards wine and cereal production. An increasing lack of arable land and a growing need of agricultural advancement marked the beginning of an organizational structure that laid the groundwork for an agrarian economy very different to what was initially expected and incompatible with the small, rural peasant economy. Yet, accounting for technical improvement in agriculture is not straightforward and research has struggled to find a model that accurately explains it. In particular, the historical analysis of agricultural innovation must take into account not only the economic incentives generated by the relative quantities and prices of factor inputs, but it should also include the institutional capabilities that allow adapting to changes.[33] Thus, this section presents the institutional constraints regarding access to land and agrarian credit.

Access to land was strictly controlled by the colonial administration. The arrival of the French shaped the Algerian land market and settlement was officially organized and managed by the colonial administration. Thus, to become the rightful owner of a plot of land, a settler had to apply through the colonial administration. This brings us to an explanation that is key-relevant to understand rural settlement in Algeria:

> Until 1871, the state, master of an ever-expanding public domain in rural properties, was the principal intermediary in transferring Algerian land to Europeans; from the 1870s onward, changes in land legislation facilitated direct acquisition from Algerians and made this as important vehicle as the domain transfer (Ruedy, 2005; p. 70)

The year 1870 therefore marks the shift in colonial land policy and can be used as a benchmark - separating the “older” from the “frontier” municipalities - as it experienced the transition from a military administration that strictly regulated settlement to a civil one that favored expansion. During the military administration territorial expansion was limited and ownership was restricted by the government's concessions of free, small-size plots of land.[34] In contrast, after the 1870s, the new civil administration ``realized that large tracts of land were necessary to cultivate the semi-arid areas"[35] and supplied a larger amount of land -but still under land-size regulations. At the turn of the century, it becomes harder to link official colonization to rural settlement due to the introduction of a land market,[36] growing land scarcity, and rising crop suitability towards large-scale production. Ultimately, in 1904 a decree was passed that facilitated the direct purchase of land without the control of the colonial administration by allowing open-land sales to the public. Thus, it is particularly after the 1900s that regulations on property size gradually disappeared, allowing a tendency towards a greater land concentration.

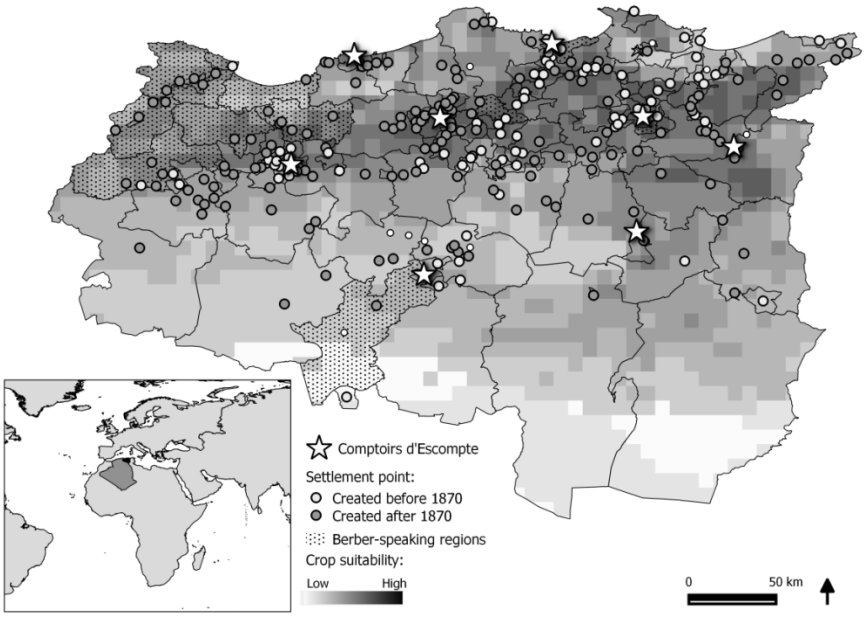
With respect to credit access, in his thesis on agrarian credit during the colonial years, Philippar (1903) explains that by the mid-1870s access to credit was limited and that there were only five

[33] See Pujol et al. (2001) and Rosenberg (1979, 1992)
[34] The military administration ``prized stability and clear channels of information-gathering, and the displacements provoked by settler colonialism were not germane to such goals" and its ``limited tolerance for the bourgeois ideals of private property and the free circulation of people and goods (…) complicated the picture" (Sivak, 2008; p. 97)
[35] Lützelschwab (2006, p. 7)
[36] In particular, the 1873 Warnier law began a free land market between indigenous and settler population, fragmented tribal land, boosted private land transactions, and expanded the French civil code.

villages with credit institutions and these were solely located in urban centers and orientated towards commercial activities. Credit did not adapt to Algeria's agrarian needs and bad harvests increased debts and had devastating effects on trades, banks, and farmers. By way of example, with regard to the *Banque de l'Algérie* (created in 1851) the author cites the following quote from a government official in 1876 (p. 80):[37]

> Credit! The word takes us back to a rather troubling situation; it highlights the very regrettable refusal of the Bank of Algeria to assure the funds required by the farmer for his work and the colonist's too often costly struggles. In the absence of regular and sure credit, the farmer's despair for cash attracts more and more attention. Finding a remedy becomes an absolute necessity.

[Figure 7: Regional distribution of the (*Comptoirs d'Escompte*) in 1899 and settlement centers at the beginning of the 1900s]



Notes: European settlements are classified as ``*Centres de colonisation*" and ``*Fermes, Hameaux*." The regions are dotted if agrarian statistics report a significant Kabylia or Berber-speaking population density. Crop suitability is an index for low input level rain-fed wheat from IIASA/FAO Global Agro-Ecological Zones. *Sources*: SA (1904/05), Busson (1898), and ANOM-iREL, and Philippar (1903).

As a response to the generalized discontent and to facilitate colonization, the *Banque de l'Algérie* changed orientation and experienced the renewal of the issuance privilege in 1880, increasing the number of operations and providing loans suitable to Algeria's agricultural conditions. For instance, it created small intermediary societies known as *comptoirs d'escompte*[38] (see Figure 7) that located in rural regions and were to provide loans to farmers in good terms. However, as explained by Philippar (1903), the discount rate set by these entities was relatively high and, even though their regional distribution responded to agricultural needs, they were criticized for various reasons. Namely, that most of the credits granted were secured with mortgages and were considered to have caused the vineyard boom by pushing settlers into long-term credits that prioritized large plantations over the annual agricultural campaigns. As an illustration, Philippar

[37] Author's own translation from: Guy, L., in *L'Algérie (Agriculture, commerce, industrie)*, Alger, 1876.
[38] This institution mostly received financial aid from the *Banque de l'Algérie*, but was also financed by other institutions such as the *Compagnie Algérienne* and *Crédit foncier et agricole.*

(1903; 131-132) cites a letter from a settler who had borrowed 30,000 francs from a *Comptoir d' Escompte*[39]

> my vines having reached the period of full yield, I had borrowed this sum to build my cellars and to obtain my useful equipment of exploitation I had borrowed it on the solicitations of the members of the said Comptoir who promised to renew my values to me until the income of my fifty years old vines allowed me to reimburse them.

Thus, the development of agrarian credit institutions was strongly tied to the vineyard expansion after the 1880s. Consequently, when *phylloxxera* spread to Algeria in the 1890s and French wine production recovered in the 1900s, the burden of the debt led to numerous expropriations.[40] Furthermore, these long-term loans immobilized circulation credit, were repeatedly assigned based on political considerations, the dividends were too high, and its board members were large borrowers who had frequently withdrawn cash over the counter and discriminated small settler farmers.[41] After 1892 the *Banque de l'Algérie*, after resolving all contentious claims and progressively liquidated the *Comptoirs d'Escompte*, it began expanding with other credit societies (such as the *Compagnie Algérienne* and the *Crédit Foncier et Agricole d'Algérie*) into hinterland regions.[42] Nevertheless, although credit institutions progressively increased their efforts to provide access to agrarian credit for small-scale settlers, they clearly helped lay the groundwork for the crowding-out of small-scale farmers.

IV

As a first step, this section applies the induced innovation model - firstly developed by Hicks (1932) and extended to agricultural economics by Hayami and Ruttan (1971) - to understand the regional differences in mechanization within wage-dependent estates. The basis of this dynamic model requires a comparative analysis of land, labor, and capital. However, in line with Olmstead and Rhode (1993; p. 111), the model should take into consideration whether the earlier settled regions were more ``constrained by past decisions about farm size and organization."[43] Thus, in order to account for institutional differences with regards to farm size, this part compares - based on the timing of settlement -the ``old" municipalities (that is, those created before the 1870s during the military administration) to the ``frontier" (those established after).

In fact, the agrarian statistics for the old and frontier municipalities in Constantine show significant differences with regards to ownership size. Figure 7 shows a positive relation between the presence of large ownership and the average year of settlement, as well as a boom in the number of settlements created immediately after the 1870s. The ownership share distribution (Figure 8a) was biased towards larger estates in the frontier areas and smaller in the older regions. Therefore, small ownership presence is clearly linked to firstly settled areas while larger estates located in areas settled during the civil administration and less affected by regulations on

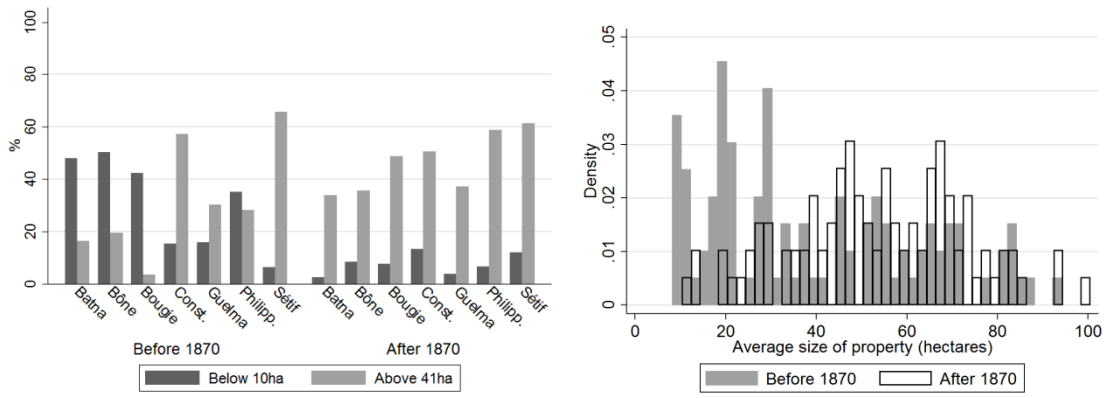
[39] Author's own translation from: M. Berbedette in *La verité sur la Banque de l'Algérie*.
[40] Issawi (2013; p. 126)
[41] Philippar (1903)
[42] The *Compagnie Algérienne* had been replaced in 1877 by the *Societé Générale Algérienne*.
[43] Olmstead & Rhode (1993) state that the model fails to fully account for agricultural development and innovation as it relies uniquely on factor prices and market signals. They argue that, at a regional level in the United States, the factor prices went in the opposite direction as the one predicted by the model, and only at an aggregate level for the whole country does the ratio of factors support Hayami and Ruttan's arguments. They find that the more settled areas had more stable land-to-labor ratios, while the frontier areas experienced rapid increases in land prices.

ownership size.[44] The histograms in Figure 8b show that the data approximate a bimodal distribution given that the density of the later settled municipalities ranges around a higher mean.

[Figure 7: Average property size and year of creation of settlement centers, Constantine in 1904/05 and 1913/14]

Note: The lines *04fit* and *13fit* are the trend lines for the years 1904/05 and 1913/14. The *Average size per property* is the European average property size in hectares per municipality (the upper bound limit is set to 100). *Settlement year* (or *Creation*) is the average year of creation of a settlement center per municipality. *Source*: SA (1904/05, 1913/14), Busson (1898), and ANOM-iREL.

[Figure 8a and Figure 8b: Share of properties by size and average property size density per period of settlement, Constantine in 1904/05 and 1913/14]



Note: Small landholdings are those below 10 hectares and large landholdings are those above 41 hectares. *Source*: SA (1904/05, 1913/14), Busson (1898), and ANOM-iREL.

Thus, based on this categorization, a first glance at the data from the agricultural statistics shows that the daily indigenous labor force employed during the agricultural seasons was relatively smaller and more expensive in the older areas (Table 2).[45] These results suggesting a higher

[44] Small properties include those below 10 hectares and large properties are those above 41 hectares. The municipalities settled the years prior to the 1870s show on average a significantly higher share of small properties (30 percent versus 10 percent) and a lower share of large properties (35 percent versus 50 percent). A t-test on the mean difference is significant at a 1 percent confidence level (under equal and unequal variance assumption) for both sizes categories.

[45] In addition, the correlation between the year of settlement and indigenous wages per day is negative and significant. However, the data reported in Table 2 must be regarded with caution as it only covers waged labor and it is available

supply of indigenous labor in the frontier are consistent with Algeria's colonial history. The supply was prompted after the 1870s as a result of colonial land policies, steady population growth, and the failed Kabylia rebellion in 1871, forcing the impoverished local populations to search for additional sources of income.[46] As an illustration, Ruedy (2005; p.98) describes that ``in the last years of the Second Empire, settlers had been surprised, for the first time, to see large numbers of natives searching for work in the colonization centers," and Belkacemi (1984; p. 245) stated that ``repressive military, fiscal and land policies resulted in the post 1871 period, in the disintegration of traditional peasant structures and the availability of a large supply of manpower." The frontier regions were particularly affected as colonial land policies pushed indigenous populations from the fertile coastal regions into the inland semi-arid areas.[47] In addition, the outcome of the 1871 rebellion in favor of the French resulted in severe sanctions -money contributions and land sequestrations - that increased the indigenous labor supply in the hinterland Kabylia regions, the plains of Sétif, and the Eastern areas in the proximities of Aïn Beïda, and Batna.[48] With respect to the land market, Table 2 demonstrates that land prices (average land value of one hectare of non-cleared land) were relatively cheaper in the frontier; despite numerous missing observations, a t-test on the mean differences shows that these were significantly lower.[49] This is logical given that the frontier had a lower settler occupation per colonized hectare (see Table 2) and an average lower land quality that is also reflected in significantly inferior annual cereal yields.[50] Indeed, with regard to cereal cultivation, the evidence shows that the cultivated area per property was higher in the regions settled later in time, suggesting that the latter increased yields at an extensive margin.[51]

The relative differences in quantities and prices of land and labor indicate that cereal farming in the frontier relied on more extensive cultivation and cheaper indigenous labor. However, in order to understand what drove settler modes of production in wage dependent estates, it is necessary to analyze the land-to-labor ratio. Column *Land to Labor* in Table 2 displays the number of properties that *most likely* relied on waged labor divided by the number of indigenous laborers.[52]

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at an aggregated annual basis, and thus it is not possible to account for seasonality which would allow a deeper understanding of changes in land use. Indeed, as Sumpsi (1978) explains, the transition from a three-field rotation system into a two-field intensive one (with no plot left fallow) increases seasonality as it requires a higher number of workers because of the more intensive preparatory plowing techniques at certain times of the year.

[46] The laws passed in 1873 and 1887 facilitated the fragmentation of indigenous lands that clashed with the indigenous population growth, thus decreasing the per capita size of property.

[47] Griffin (1976; p. 16).

[48] A dummy variable for these regions (equal to 1 if Kabylia, equal to 0 if others) is positively and significantly correlated to the municipalities with higher quantities of annual labor employed during the agricultural seasons.

[49] Values are consistent for cleared and non-cleared hectares, and annual tenancy rates (*fermage*).

[50] The pair-wise correlation between the crop suitability index and land prices is negative and significant at a 1 percent confidence level. The winter cereal yield is 9.5 grains (quintals) per cultivated hectare in the older municipalities and 8.1 in the frontier.

[51] The ratio between the European wheat cultivated area and the number of properties (or settler owners) is positive and significant at a 1 percent confidence level.

[52] The agricultural data used from the *Statistique Agricole* for 1904/05 and 1913/14 gives information on the total number of laborers, days worked, and wages, but it does not provide data on the corresponding area cultivated by such laborers. Thus, using the total number of European cultivated hectares as the numerator is inaccurate as it includes all types of properties, both small and large. These two farming units cannot be aggregated as they will respond differently to a given set of factors; for instance, small family farms are less affected by wages as they do not employ waged labor. Thus, based on Sumpsi (1978), wage-dependent farms are proxied by those above 40 hectares. The reasoning is as follows. A 40 hectare property would seem to require a total of around 326 daily laborers for annual sowing, which equals to 11 laborers working every day during a 30 day month (assuming sowing is done in October). The harvest for the same cultivated area in the month of June demanded approximately 7.4 daily laborers during 30 days. In addition, the timing of harvesting was particularly critical and the demand for seasonal labor was high and included also women, children, and industrial workers (Simpson, 1987). Thus, assuming a five-unit family farm with all five members working, a plot of 40 hectares would need more than one family working every day throughout the month for both

The results show that the *Land to Labor* is higher for the older municipalities, but it is not significantly different, allowing one to conclude that the number of estates relying on daily labor during the high seasonal peaks did not differ significantly between both areas -which is likely justified by seasonal labor force mobility.[53]

Table 2: Factor prices and quantities, Constantine 1904/5 and 1913/14

Region	Mean Prices		Quantity			Land	"Innovation" density		
	Land (fr/ha)	Labor (fr/day)	Share cereal	Settler density	Lab. per day	to Labor	Steam tractor	Mech. reaper	Modern plow
Older	218.47	1.83	0.70	0.06	0.03	21.56	0.004	0.005	0.105
Frontier	135.87	1.64	0.83	0.04	0.06	17.16	0.001	0.002	0.168
P-value	0.042**	0.004***	0.006***	0.005***	0.033**	0.224	0.024**	0.000***	0.196

* p<0.1; ** p<0.05; ***p<0.01. The values are shown for unequal variances although significance level is the same under the equal variance assumption. *Land* is the average value of one non-cleared, European-owned hectare; *Labor* refers to daily indigenous labor; *Share Cereal* is the European share of wheat cultivated hectares over the total European number of cultivated hectares; *Settler density* is the rural settler population over the number of hectares of the settlement centers in the municipality (estimated with the 1902 CCO map and GIS software); *Lab. per day* is the daily indigenous labor; *Land to Labor* is the ratio between the number of the European cultivated area in large landholdings over the number of indigenous laborers; *Steam Tractor, Mechanical Reaper,* and *Modern Plow* are per cultivated hectares. Source: SA (1904/05, 1913/14), Busson (1898), ANOM-iREL.

Once we have an approximate idea of the relative prices and quantities of land and labor, it becomes possible to finally test the induced innovation model. This model allows examining how wage-dependent estates responded to the relative factors of production. The key point is that technological change allows the substitution of the relatively scarce input for the abundant one in a given economy; i.e., if labor is scarce relative to land, then the innovation is labor-saving and will entail mechanization to increase the marginal product of land (for instance, as in the case of the United States and the mechanical reaper in the nineteenth century). Based on the period of settlement, the model allows assessing the dynamic process of regional adaptation to more advanced agricultural techniques (i.e., mechanization or land use methods) among the large, wage-dependent properties. Hence, if the cultivable land-to-labor ratio is higher in the older regions, and labor and land are more expensive, then it is to be expected that mechanization (and land-saving techniques) is also higher.[54] This is because technological advances are brought in to overcome factor scarcities. For example, in Algeria, the harvest of a 30 to 40 hectare lot using ten harvesters lasted a month, whereas two to three days were sufficient when employing a modern six draft-animal harvester with only two laborers.[55]

sowing and harvesting. These estimates are based on Sumpsi's (1978) case study of a 1,800 hectare wheat exploitation based on a two-field intensive rotation system with no fallow, animal traction, and seasonal labor.

[53] The land-to-labor ratio must also be regarded with caution, not only because Sumpsi's values are estimates and correspond to different regions that probably differ in the timing of tillage and harvesting, but also because the estimates are limited to cereal cultivation and thus a 40 size benchmark can differ from that of viticulture which was more dependent upon seasonal wage labor. For example, as Simpson (2011) argues, in the Midi, economies of scale appeared in viticulture beyond 30 hectares.

[54] Despite lack of data, Mollard (1959) argues that fertilizers were limited to advanced cultivated areas.

[55] Lützelschwab (2006)

The data confirm the prediction: the density of labor-saving agricultural instruments per hectare such as the steam tractor and the mechanical reaper was higher in the older municipalities.[56] Nevertheless, it is important to keep in mind that mechanization was particularly low in Algeria and that meaningful changes in agricultural techniques were reflected in the adoption of modern French plows that permitted deeper plowing.[57] Yet, Table 2 shows that the difference in the adoption of modern plows is insignificant and even higher in the frontier, suggesting that regional disparities in the production inputs are not enough to explain the adoption of more intensive preparatory plowing techniques that allowed cash-crop production.

Table 3: Descriptive statistics

Category	Variable	Mean	SD	Min.	Max.	N	Description
Innovation	Modern plow	0.055	0.055	0	0.343	194	Number of modern plows per European cultivated hectares for each municipality.
	Modernization	0.039	0.099	-0.856	0.343	195	The difference between modern and indigenous plows owned by Europeans per hectare
Labor	Wage	1.771	0.406	0.155	3	179	Indigenous wages per day
	Indig. density	1.851	2.114	0	14.74	196	Number of indigenous owners, laborers, sharecroppers, and tenants per hectare
Land	Land price	181.98	315.837	3	2500	149	Price of uncleared land per hectare.
	Crop suitability	6.116	1.47	0	8	198	Crop suitability index (class) for low input level rain-fed wheat (that is, under subsistence production)
Capital	Oxen density	0.092	0.122	0	0.758	197	Number of oxen per hectare
	Mules density	0.065	0.066	0.003	0.485	197	Number of mules per hectare.
Specialization	Share wine	0.094	0.14	0	0.69	197	Share of land devoted to viticulture relative to the total cultivated area
Institutions	D Credit	0.071	0.257	0	1	198	Dummy variable equal to 1 if there was an agrarian credit institution (proxied by Comptoirs d'Escompte in 1899).
	D Settl. year	0.495	0.501	0	1	198	Average year of creation of settlement center. It proxies for institutional property land size restrictions.

This seems reasonable as, in contrast to the mechanical reaper, the French plow was not a labor-saving technology (see Figure 6a and 6b).[58] Thus, to account for the adoption of modern plows, it is necessary to identify a more complete framework that includes additional institutional variables and is not limited to wage-dependent farms. The following equation specifies the ``innovation" - that is, the use of modern plows - as a function of a number of variables capturing prices and quantities of labor, land, and capital, the degree of wine specialization, the land policy restrictions, and credit institutions.

$$Innovation_{i,t} = f(Labor_{i,t}, Land_{i,t}, Capital_{i,t}, Specialization_{i,t}, Institutions_{i,t}, \mu_{i,t})$$

There are N sets of observations of municipalities *i* in two time periods (where t=0 is for 1904/05 and t=1 for 1913/14). The dependent variable can take the value of: i. the density of modern plows

[56] The density was also significantly higher for the harvester and the thresher.
[57] As explained by Olmstead and Rhode (2001), in the beginning of the 1900s tractors were still too big and unsuitable (defined as ``giant steam plows"), particularly for small properties, and its expansion was limited.
[58] Indeed, the mechanical reaper accounts for the most expensive fixed cost (together with the land purchase) and can be substituted by labor force. A deeper plowing, on the other hand, necessarily requires modern plows.

(Column I in Table *5*), ii. the density of modern plows owned by Europeans (column II); and, iii. a modernization proxy reflecting the use of modern plows relative to that of traditional plows (column III). The regressors in vector $Labor_{i,t}$ include the indigenous daily wages (*Wages per* $day_{i,t}$) and the total number of indigenous workers – that is, owners, sharecroppers, tenants, and laborers- per hectare (*Indigenous density* $_{i,t}$). The vector $Land_{i,t}$ includes the price of land (*Land* $price_{i,t}$) and its quality - i.e. average suitability of a municipality to wheat cultivation (*Crop* $suitability_i$) - that is assumed not to be affected by time change. The variables included in $Capital_{i,t}$ are the density of oxen and mules. $Specialization_{i,t}$ contains the share of land devoted to viticulture over the total cultivated area. The vector $Institutions_{i,t}$ comprises a dummy variable ($D\_Creation_{i,}$) equal to 1 if the average year of creation of a settlement center was after 1870 and 0 otherwise, and a dummy ($D\_Credit_{i,}$) that is equal to 1 if there was a *Comptoir d'Escompte* in the municipality. Ultimately, the model controls for a time dummy (D_Year_t) equal to 0 if 1904/05 and 1 if 1913/14. The equation allows for the constant term and μ_{it} is the time-varying error. The Hausman test shows that the unobserved fixed effects do not bias the results and the standard errors have been corrected for clustering on the district level.

Table 4: Mechanization in Constantine in 1904/5 and 1913/14

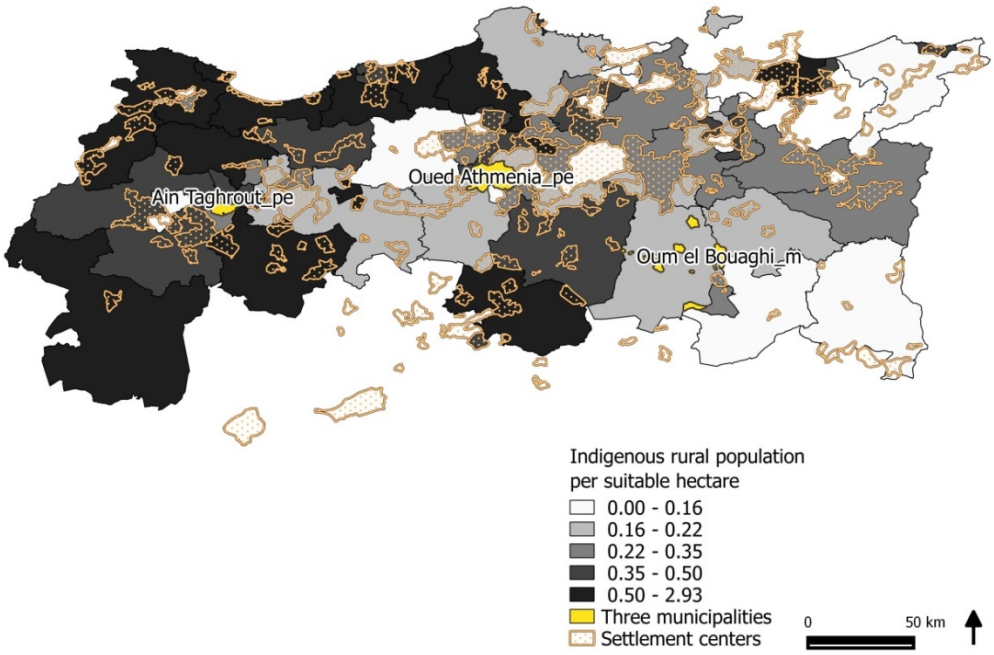
Dependent:	(1) Modern plow density All	(2) Modern plow density European	(3) Modernization ratio European
Wages per day	0.60**	0.64*	0.04
	(0.28)	(0.33)	(0.03)
Indigenous density	0.26***	0.34***	0.01***
	(0.10)	(0.08)	(0.00)
Land price	-0.03	-0.09	0.00
	(0.10)	(0.09)	(0.01)
Share wine	0.10*	0.15**	0.01**
	(0.05)	(0.06)	(0.00)
Crop Suitability	-0.14*	-0.16*	-0.01
	(0.07)	(0.08)	(0.01)
D Credit	-0.03	-0.04	0.01
	(0.11)	(0.13)	(0.01)
Share Large	0.06	-0.07	-0.01
	(0.26)	(0.29)	(0.02)
D Creation	0.31*	0.01	-0.01
	(0.18)	(0.19)	(0.02)
Oxen density	0.23***	0.20***	0.01**
	(0.06)	(0.06)	(0.00)
Mules density	0.19**	0.11	0.00
	(0.08)	(0.09)	(0.01)
D Year	0.18**	0.12	0.01
	(0.07)	(0.08)	(0.01)
Constant	-0.71	-0.72	0.09
	(0.94)	(0.98)	(0.06)
N	97	97	98
R^2 Within	0.50	0.47	0.27
R^2 Between	0.42	0.44	0.31
R^2 Overall	0.45	0.45	0.32

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Cluster-robust standard errors. *Land price*, *Share wine*, *Indigenous density*, *Wage per day*, *Oxen density*, and *Mules density* are in logarithms. Source: SA (1904/05, 1913/14), Busson (1898), ANOM-iREL.

The results in Table 4 show that the use of more intensive agrarian techniques per hectare relates most significantly (and with the expected signs) to the availability of indigenous labor. Most importantly, the variable *Indigenous density* is not limited to wage labor and includes also

sharecroppers. Indeed, the agrarian statistics for 1904/05 and 1913/14 show that the share of sharecroppers (among the indigenous population) was high and averaged approximately 30 percent, while that of settlers was on average less than 5 percent. In line with this, according to Lützelschwab (2006), the adoption of modern agricultural techniques among indigenous sharecroppers in a settler farming estate (the *Compagnie Genevoise des Colonies Suisses*) was possible due to the surplus of indigenous labor. The author argues that in the 1890s the colonial land measures to foment land markets changed the ratio between land and labor, leading to an excess supply of local labor which ultimately increased the landowners' bargaining power. This ultimately allowed agricultural innovation by increasing the working time and intensity without having to modify explicit clauses in the sharecropping contracts. In fact, a variable reflecting the share of land cultivated in the ``European style" (*à la mode Européenne*) by the indigenous population is positively and significantly correlated to the regions affected by the Kabylia rebellion and, on average, the frontier regions displayed significantly higher shares (40 versus 20 percent). [59]

Figure 9: Indigenous rural population per suitable hectare, Constantine in 1904/05



The indigenous rural population per suitable hectare data is classified according to quantiles (equal count). Suitable hectare refers to the number of hectares with a crop suitability for low input level rain-fed wheat above the medium level (that is, equal to 4). *Source*: SA (1904, 1913), IIASA/FAO Global Agro-Ecological Zones Database, Busson (1898), and ANOM-iREL.

Furthermore, the comparison of three municipalities endowed (almost entirely) with large properties (more than 41 hectares) and settled at different moments in time suggests that labor availability did make a difference in terms of adopting new agricultural techniques. Oum el Bouaghi (column III in Table 5) was settled after the 1890s while Aïn Taghrout (column II) was

[59] Constantine's data provides unusual information on the distribution of the cultivated area according to the cultivation method: *à la mode Européenne* (European modes of cultivation) and *à la mode indigène* (indigenous modes of cultivation). They are both available only for 1904. Despite no clarification as to what the characteristics of each method are, based on the literature on French Algeria, which continuously mentions the indigenous traditional means of cultivation as that relying on long fallow and the indigenous plow, it is reasonable to assume that *à la mode Européenne* refers to the modern agricultural practices introduced in the 1900s.

settled earlier in the 1870s (shortly after the civil administration had been established). If we compare the two of them, one can see that, given a similar crop suitability level, the later-settled municipality - with lower yields per hectare, a far lower share of land cultivated *à la mode Européenne*, an almost null mechanization level, no wage labor, and a considerably higher density of indigenous sharecropping - did not introduce modern agricultural techniques. Oued Athmenia (column I), on the other hand, was settled earlier in the late 1860s and had the best land quality for wheat cultivation; yet, as Table 5 reports, it displays lower yields and a lower share of land cultivated *à la mode Européenne* in comparison to Aïn Taghrout. Thus, what makes Aïn Taghrout different? Despite its lower land quality, it reports the highest density of indigenous rural population and wage labor, and, as shown in Figure 9, it is geographically surrounded by the most indigenous-populated areas as it was the nearest to the Kabylia region (the mountainous regions most intensively affected by land expropriations after the 1870s). Therefore, in line with the argument presented by Lützelschwab (2006), this region displayed the highest indigenous labor supply that probably eased the adoption of advanced techniques.

Table 5: Comparative analysis: Oued Athmenia, Aïn Taghrout, and Oum El Bouaghi in 1904/05

	Oued Athmenia	Aïn Taghrout	Oum El Bouaghi
Average year of settlement	1868	1873.5	1897
Average size of large property	426	380	142
Crop suitability	7.38	5.76	5.27
Share cultivated *À la Mode Europeenne*	0.60	0.82	0.05
Settlers			
Wheat cultivated area per settler	14.62	36.58	15.26
Wheat cultivated area per property	159	114	49
Wheat production per cultivated hectares	5.13	5.83	3.31
Share of wine (%)	4	0	3
Share of cereal (%)	64	58	81
Oxen per hectare	0.12	0.00	0.00
French plow per hectare	0.01	0.02	0.02
Mechanical reaper per hectare	0.00	0.01	0.00
Machine per hectare (Tractor)	0.00	0.00	0.00
Rural population per hectare	0.02	0.04	0.06
Rural population per suitable hectare	0.11	0.22	0.16
Indigenous			
Oxen per owned hectares	0.08	0.00	0.00
Sharecropper per cultivated hectares	0.06	0.11	0.23
Laborer per cultivated hectare	0.10	0.20	0.00

Source: SA (1904/05), IIASA/FAO Global Agro-Ecological Zones Database, Busson (1898), ANOM-iREL.

Table 4 also demonstrates that adopting new techniques went hand-in-hand with the use of draft animals (see variable of *Oxen density*). In fact, changes in tillage operations across farming systems are related to the quantities and prices of animals. In Algeria, the climate and soil required European animal-traction plows for a deeper preparatory plowing and a higher cultivation frequency. Therefore, it required draft animals and implied less land for livestock-feeding. Yet, in contrast to labor availability, draft animals in Algeria were scarce: the oxen and mule density levels reported in the agrarian statistics for Constantine were extremely low. For instance, if we compare the values reported by Simpson (1987) for different regions in Spain at the end of the nineteenth century, one can see that the lowest reported value in 1891 in Spain (for Cáceres) was 1.5 times larger than the highest one found in the department of Constantine, and 20 times larger than its overall mean.[60] These low values are explained by the lack of association between

[60] The author calculates that in 1891 the ratio between the number of mules over oxen and cows is 34.7 in Sevilla and Córdoba, 27.7 for Cáceres, and 96.7 for Castellón, Tarragona, and Valencia. In Constantine, the highest value for the

husbandry and agriculture within the settler sector and the more intensive rural methods that shortened the fallow period, decreased the amount of land available for pasture, and eroded the soil.[61] Thus, adopting animal-traction plows was relatively expensive.

In addition, consistent with Isnard (1975), the predominance of large wine properties (reflected in the variable *Share wine* in Table 4) provides a powerful explanation of the high degree of technical improvement. Yet, as explained in Section III, engaging in viticulture was expensive and agrarian credit institutions pushed settlers into long-term credits that prioritized large plantations over the annual agricultural campaigns. Thus, when *phylloxxera* spread to Algeria in the 1890s and French wine production recovered in the 1900s, the unpaid debts led to numerous expropriations that help explain the crowding out of small-scale farmers.[62] As Issawi (2013, p. 126) explains:

> […] in the process the number of European growers fell from 17,000 in the 1890s to 11,000 in 1914, and the average size of their farms went up from 2.5 hectares in 1879 to 14,2 in 1914. By then vineyards represented over 40 percent of the capital of Europeans in Algerian agriculture, a figure larger than that for cereal.

In conclusion, the main variables that relate most significantly (and with the expected signs) to agricultural innovation – i.e., the presence of viticulture and dependence upon the availability of labor and capital – help explain Algeria's tendency towards a higher presence of land concentration. The new agricultural requirements to participate in cash crop production (i.e., purchase of land, buying and feeding draft animals, agricultural instruments, seasonal labor, capital interests, reparations and machinery depreciation, wine cellars, planting disease-resistant vines, refrigerators, etc.) restricted access to small-scale rural settlers and ultimately prevailed over the institutional efforts to create a small-farm settler economy.

IV

Because ``the great grain or vinegrowing properties absorbed [the small settler's] concessions and spat out the people," Charles-Robert Ageron argued that French Algeria lost its ``colonial justification" (Ageron, 1991; p. 61-62). What shaped, then, these properties?

This paper disentangles the constraints to agricultural improvement that help explain the tendency towards large estates at the outset of the 1900s. It argues that Algeria's relative factor endowments – i.e., the ratio cultivable land-to-labor - prevailed over the institutional efforts undertaken to create a small-scale settler economy. After French occupation, it soon became evident in the 1870s that the amount of arable land required to expand and consolidate settlement was limited, particularly in the later settled regions. Thus, technical improvement that allowed overcoming agricultural constraints became key-relevant to participate in cash crop production and expand rural settlement. This study identifies the main determinants that explain the adoption of these modern agricultural techniques.

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ratio between the mules and oxen (not including bulls, oxen for manure, cows, and calfs) is 18.6 in 1904 for Aïn Abessa, the rest of the values are below 10, and the overall mean is 1.4. The density of mules per cultivated hectare has a maximum of 0.5 but the mean is 0.06, and that of oxen has a maximum of 0.6 and a mean of 0.09.

[61] Bennoune (2002), Lützelschwab (2006)

[62] In addition, although in the 1880s most winegrowers (around 77 percent) were still small owners, they only possessed 14 percent of the total vineyard plantations, while the owners of properties above 50 hectares (which were only 6 percent of all the winegrowers) accounted for more than half of all Algerian vineyards and harvests (Isnard, 1975). In 1863 the average property devoted to viticulture was around 1.2 hectares (Yacono, 1993), while in 1959 the average surface of a vineyard was of 26.7 hectares in Constantine (AAEEAA, 1990).

To do this, it takes advantage of annual agricultural statistics reported by the French administration at the municipal level in Constantine in 1904/05 and 1913/14. Based on the timing of settlement, it expands upon Hayami and Ruttan's (1971) induced innovation given that, as clarified by the authors, the model is an approximation to the dynamics of the mechanization diffusion that are not as clear-cut as expected. For example, mechanization might also be brought in by land-saving incentives: in Japan the horse plow was introduced to improve cultivating techniques so as to increase the yield per hectare, not to save labor. This also seems to be the case for Constantine. Algeria's major technical improvement at the beginning of the 1900s went hand-in hand with the use of modern plows, which were introduced to offset the worse land quality and improve yields but were not driven by labor-saving incentives. Thus, this paper argues that in the later settled regions - where the climate and soil did not favor cultivation, where irrigation and fertilizers were absent, and where land for pasture was too low to allow for mixed-husbandry - settler farmers were able to adopt more intensive techniques by hiring relatively cheap.

The final question is, then, whether these findings are consistent with the "crowding out" of small rural settlers and tendency towards a higher presence of large properties. On the one hand, the results show that technical improvement was highly related to viticulture which, together with credit institutions, pushed settlers into long-term credits that prioritized large plantations. When *phylloxxera* spread to Algeria in the 1890s and French wine production recovered in the 1900s, the unpaid debts led to numerous expropriations and a higher concentration of land in fewer hands. On the other hand, cash crop production required a significant amount of capital investment and more extensive cultivated plots to overcome rural constraints. The institutional land-market regulations ultimately adapted and flexibilized regulations on ownership size after the 1870s, hence biasing ownership to colons with sufficient resources to face the new cultivation requirements in the relatively less-cultivable regions. Thus, in other words, technical improvement of Algerian agriculture in the 1900s was constrained by a number of factors that help clarify why institutions failed to create a ``peasant's paradise […] with small farms and cosy villages" (Roberts, 1963; p. 215).

References

Table A1: Wheat acreage (in hectares) and total production (in quintals) from Malenbaum (1954), grain exporting countries 1885-1914

Countries	Wheat Area (5-year averages, million of hectares)						Wheat Production (millions of quintals)					
	1885-89*	89-94	94-99	1899-04	04-09	09-14	1885-89*	89-94	94-99	99-04	04-09	09-14
Argentina	0.81	1.40	2.51	3.59	5.62	6.50	5.22	12.87	16.22	25.39	43.03	40.04
Australia	1.34	1.41	1.73	2.20	2.35	3.08	7.05	8.52	7.43	11.62	16.14	24.63
Canada	1.04	1.17	1.47	1.68	2.28	4.03	10.42	11.13	14.10	20.85	28.31	53.65
USA	19.65	21.31	22.45	23.88	20.81	21.82	140.34	171.01	186.85	194.28	182.85	189.00
Total	22.84	25.30	28.16	31.34	31.06	35.41	163.23	203.54	224.61	252.15	270.33	307.32
Bulgaria	0.78	0.79	0.82	0.82	0.97	1.08	7.49	9.85	8.76	8.44	9.58	11.49
Hungary	2.93	3.25	3.29	3.59	3.73	3.68	36.12	39.14	38.87	43.36	44.69	46.16
Rumania	1.18	1.44	1.48	1.59	1.85	1.85	12.49	14.97	15.13	16.82	20.20	23.90
Yugoslavia	0.22	0.28	0.29	0.34	0.37	0.38	1.52	2.40	2.61	2.75	3.05	3.35
Poland	0.40	0.50	0.52	0.52	0.50	0.51	3.38	4.33	5.06	5.17	5.55	6.34
USSR	17.67	18.73	19.99	23.69	26.98	31.07	97.31	98.09	123.08	148.37	168.84	215.49
Total:												
Incl. USSR	23.17	24.99	26.38	30.55	34.41	38.57	158.30	168.78	193.52	224.90	251.91	306.72
Excl. USSR	5.50	6.26	6.39	6.86	7.42	7.50	61.00	70.69	70.44	76.54	83.07	91.24
Algeria	1.26	1.25	1.28	1.35	1.38	1.43	6.15	6.21	6.91	8.49	7.97	9.55
Morocco	0.42	0.44	0.46	0.48	0.52	0.56	2.86	2.97	3.10	3.24	3.48	3.76
Tunis	0.40	0.40	0.40	0.42	0.43	0.53	1.36	1.55	1.93	1.44	1.52	1.69
Chile	0.40	0.40	0.40	0.35	0.44	0.42	3.89	4.79	3.51	3.24	4.16	5.47
Uruguay	0.17	0.17	0.25	0.28	0.29	0.31	1.22	1.36	1.69	1.66	1.91	1.85
Indian Penin.	11.02	10.69	10.23	9.29	10.95	11.83	72.35	67.28	65.49	67.77	82.12	95.75
Total	13.68	13.36	13.03	12.17	14.01	15.08	87.83	84.16	82.63	85.85	101.17	118.07

In contrast to the original source, I changed acres to hectares (1 acre = 0.405 hectares) and wheat bushels to quintals (1 quintal = 3.675 wheat bushels); Morocco refers to French Morocco; * 4-year average. Source: Malenbaum (1954, p. 236-239).

Table A2. Correlation matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1)	AverPropSize	1.00																					
(2)	Creation	-0.12	1.00																				
(3)	ShareProp<10ha_E	0.15	-0.47	1.00																			
(4)	ShareProp>41ha_E	-0.22	0.32	-0.57	1.00																		
(5)	Crop suitability	-0.26	-0.15	-0.15	0.08	1.00																	
(6)	ShareCerealArea_E	-0.12	0.16	-0.22	0.21	0.16	1.00																
(7)	ShareWineArea E	0.21	0.01	0.25	-0.17	-0.35	-0.68	1.00															
(8)	Area Cer(ha) E	0.12	0.38	-0.16	0.26	-0.06	0.44	-0.32	1.00														
(9)	Area Wine(ha) E	0.28	-0.05	0.31	-0.17	-0.41	-0.55	0.79	-0.08	1.00													
(10)	LandPrice E	0.11	-0.21	0.39	-0.18	-0.36	-0.09	0.15	-0.01	0.23	1.00												
(11)	Wage/day I	0.05	-0.17	0.23	-0.12	-0.15	0.07	-0.02	0.00	0.03	0.15	1.00											
(12)	Mach/ha E	-0.06	0.10	-0.25	0.19	-0.10	0.25	-0.18	0.42	-0.14	-0.04	0.06	1.00										
(13)	L/day I	-0.04	0.16	-0.09	0.06	0.04	0.11	-0.13	0.06	-0.12	0.03	-0.04	0.17	1.00									
(14)	Land/Labour	0.02	-0.19	-0.02	-0.09	-0.05	0.03	-0.06	0.00	0.04	-0.01	0.02	0.15	-0.04	1.00								
(15)	LabScarc I	0.01	-0.16	0.07	-0.12	-0.17	-0.29	0.25	-0.12	0.36	0.05	0.11	0.12	0.03	0.33	1.00							
(16)	DYear	-0.05	-0.02	-0.05	0.05	-0.01	0.06	-0.06	0.07	-0.03	0.04	0.20	0.05	-0.15	0.13	0.07	1.00						
(17)	Mac/ha E	0.01	-0.24	0.51	-0.29	-0.39	-0.20	0.20	-0.17	0.18	0.88	0.13	-0.22	-0.11	-0.07	-0.03	0.05	1.00					
(18)	Tresh/ha E	-0.09	-0.15	0.28	-0.12	-0.21	-0.33	0.17	-0.14	0.05	0.17	-0.01	-0.08	-0.07	-0.08	0.06	0.02	0.40	1.00				
(19)	Reaper/ha_E	0.05	-0.37	0.30	-0.19	-0.11	-0.20	0.19	-0.08	0.33	0.26	0.02	0.02	-0.19	0.08	0.25	0.12	0.24	0.11	1.00			
(20)	FrPlow/ha E	0.02	-0.26	0.47	-0.30	-0.27	-0.39	0.57	-0.33	0.46	0.49	0.17	-0.19	-0.20	-0.14	0.07	0.02	0.57	0.24	0.36	1.00		
(21)	Instr/ha E	-0.03	-0.24	0.48	-0.29	-0.30	-0.32	0.45	-0.33	0.37	0.62	0.13	-0.21	-0.18	-0.13	0.07	-0.02	0.71	0.37	0.43	0.89	1.00	
(22)	Moderniz E	0.01	-0.26	0.48	-0.32	-0.27	-0.40	0.55	-0.31	0.46	0.45	0.17	-0.16	-0.20	-0.12	0.08	0.03	0.53	0.23	0.37	0.98	0.84	1.00

Main Sources

The sources for the historic maps mostly cited in the text are:

– CEPC (1876): *Carte des Étapes de la province de Constantine* (1876), scale 1/400,000. It is available online in the digital library Gallica from the *Bibliothèque nationale de France*, retrieved from http://catalogue.bnf.fr/ark:/12148/cb40683086f.

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– ASF (several years): The Annuaire Statistique de la France from the *Ministère de l'agriculture et du commerce, Service de la statistique générale de France, Direction de la statistique générale*. This source is available online in the Gallica digital library from the *Bibliothèque nationale de France*, retrieved from http://catalogue.bnf.fr/ark:/12148/cb343503965. After the 1900s the volume is called *Annuaire Statistique from the Ministère du commerce, de l'industrie, des postes et télégraphes, Office du travail, Statistique générale de la France* and it is also available online in Gallica digital library from the *Bibliothèque nationale de France*, retrieved from http://catalogue.bnf.fr/ark:/12148/cb34350395t.

– ANOM and ANOM-iREL: ANOM are the *Archives Nationales d'Outre-Mer* and ANOM-iREL are the *Archives Nationales d'Outre-Mer-Instruments de Recherche en Ligne*. The colonial archives are located in Aix-en-Provence and the online information is retrieved from http://anom.archivesnationales.culture.gouv.fr/geo.php?ir=

– TGdC (1884, 1892, 1897, 1902): *Tableau Général ... des communes de plein exercice, mixtes et indigènes des trois provinces (territoire civil et territoire militaire): avec indication du chiffre de la population et de la superficie. Gouvernement Général de l'Algérie, Direction Générale des affaires civiles et financières*. This source is available online in the Gallica digital library from the Bibliothèque nationale de France, retrieved from http://gallica.bnf.fr/ark: /12148/cb39214483r/date&rk=42918;4. There are four years

available: 1884, 1892, 1897, and 1902. It provides information on the municipal population density and area covered based on the nationality and type of settlement (i.e., settlement centers, portions of land, douars, and tribal areas).

Variable description

- *EurAgricPop/ha* is the rural settler population per hectare. It is the total number of European laborers, sharecroppers, tenants, and owners divided by the total number of cultivated and non-cultivated European-owned hectares. The population data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913-1914) in the folder on *La population agricole par catégories et par nationalités résidant dans la commune* from the ANOM in Aix-en-Provence.
- *Creation (or average year of settlement)* is the average year of creation of the settlement centers in a municipality. The information was collected from different sources. The webpage ANOM-iREL allows searching for historic settlements based on their colonial administrative name. The ANOM-iREL search engine shows the current geographic location of settlement points and, occasionally, it also provides information on administrative changes regarding names, territorial boundaries, year of establishment, type of municipality (*commune de plein exercice, commune mixte*, and *commune indigène*), etc. This information has been complemented with Busson (1898), the available TGdC (for instance, the latter provides the dates of the territorial enlargements), and the *Atlas Administratif de l'Algérie* 1830-1960. Ocasionally it was necessary to make a judgment call: for instance, the settlement center Randon was created/established in 1868 but populated in 1874, thus I kept the latter as it reflects more accurately the moment of settlement and land concessions
- *AverPropSize* (also called *Average property size*) is the European average property size in hectares per municipality. The mean value of hectares for each group category was multiplied by its weight over the total number of properties. The mean value assigned for each category was the following: 5 to properties below 10 hectares, 15 for the properties between 11 and 20 hectares, 25 to the ones between 21 and 30, 35 to 31-40, to 41-100 and 100 to the number of properties above 100 hectares. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Le nombre des propriétés agricoles particuliéres - Leur repartition d'aprés leur étendue et la nationalité des propriétaires* in ANOM in Aix-en-Provence. The data for the latter was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des propriétaires* from the ANOM in Aix-en-Provence.
- *ShareProp>41ha (or share of large properties)* is the share of European properties above 41 hectares over the total number of properties per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Nombre des propriétés agricoles particuliéres - Répartition d'après leur étendue et la nationalité des propriétaires* from the ANOM in Aix-en-Provence.
- *ShareProp<10ha_E* is the share of European properties below 10 hectares per municipality. It is the number of European properties below 10 hectares over the total number of European-owned properties. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder on *Nombre des propriétés agricoles particuliéres - Répartition d'après leur étendue et la nationalité des propriétaires* from the ANOM in Aix-en-Provence
- *CropSuit* (or *Crop Suitability*) is the crop suitability index (class) for low input level rain-fed wheat from IIASA/FAO Global Agro-Ecological Zones. The highest value is 9 while the lowest suitability value is 1. The model used to build this index considers the average climate for the period 1961 and 1990 and, as IIASA/FAO explains, it accounts for wheat cultivation under subsistence production without necessarily being oriented towards markets, labor intensive techniques, and no nutrients, chemicals or disease control, and minimum conservation measures. GIS software was used to measure the crop suitability within the settlement centers. I first calculated the area (in hectares) using the Africa Albers Equal Area Conic projection (ESRI: 102022) for the settlement centers and then calculated the average suitability within each settlement center. The source is IIASA/FAO, 2010. Global Agro-Ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.
- *ShareWine_E* (or *Share Wine*) is the number of European-owned cultivated hectares devoted to viticulture over the total cultivated area by Europeans per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence.

- *ShareCereal_E* (or *Share Cereal*) is the number of European-owned cereal-cultivated hectares over the total area cultivated by Europeans per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées* entre les differentes catégories des proprietéires from the ANOM in Aix-en-Provence.
- *AreaCereal_E* is the total European-owned cereal-cultivated area in hectares per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence
- *AreaWine_E* is the total number of European-owned hectares devoted to viticulture per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence.
- *LandPrice_E* is the average land value of one hectare of non-cleared land owned by Europeans per municipality. The data is also available for cleared land and tenancy rates. It was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence.
- *W/day_I* accounts for agricultural wages paid in francs to the indigenous population divided by the corresponding total amount of days worked per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder on *Ouvriers - Journées Agricoles - Salaires from the ANOM* in Aix-en-Provence
- *Lab/day_I* is the number of agricultural indigenous laborers divided by the corresponding total amount of days worked per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Ouvriers - Journées Agricoles -Salaire*s from the ANOM in Aix-en-Provence.
- The variables used to measure the mechanization density per European-owned cultivated hectares for each municipality are: (i) number of tractors (*Mach/ha_E*), (ii) number of threshers (*Tresh/ha_E*), (iii) number of mechanical reaper or harvester (*Harv/ha_E*), (iv) number of French plows (*FrPlow/ha_E*). In addition, I include a modernization indicator equal to the difference between French plows used by Europeans and indigenous plows used by Europeans divided by the total number of modern plows. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Matériel agricole* from the ANOM in Aix-en-Provence
- *YcerW/ha_E* (or *Wheat Production per Cultivated Hectares*) is the winter cereal (grain quintals) per European-owned cultivated hectares. Winter cereals include soft wheat, hard wheat, rye, barley, oats. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and 93/1H/61/1-9 (for the year 1913/14) in the folder *Céréales et les produits alimentaires autres que les céréales - Blé tendre, blé dur, seigle, orge, avoine, mais, bechna (sorgho), millet* from the ANOM in Aix-en-Provence.
- *ShareModeEurop_E* (or *Share Cultivated Á la Mode Européenne*) are the number of hectares cultivated *á la mode européenne* by both indigenous and Europeans (including Israelites) over the total number hectares cultivated (by Europeans and indigenous) per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence.
- *Wheat-cultivated area per settler* is the total European-owned cereal cultivated hectares divided by the total rural settler population per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires* from the ANOM in Aix-en-Provence.
- *Wheat-cultivated area per property* is the total European-owned cereal cultivated hectares divided by the total rural settler population per municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Superficie du territoire - Répartition des parties cultivées et non cultivées entre les differentes catégories des proprietáires*. I also calculated the variable *wheat cultivated area per property* that is equal to the total European-owned cereal cultivated hectares divided by the total number of properties per municipality. This data was obtained from the folder *Le nombre des propriétés agricoles particuliéres - Leur repartition d'aprés leur étendue et la nationalité des propriétaires* from the ANOM in Aix-en-Provence.

- *Oxen per hectare* is the total number of oxen divided by the owned hectares (cultivated and non-cultivated) respectively. I have calculated it for both the settler and the indigenous population. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and FR CAOM 93/1H61 (for the year 1913/14) in the folder *Animaux de ferme* from the ANOM in Aix-en-Provence.
- *Laborers/ha_I* (or *indigenous laborers per hectare*) is the number of indigenous rural laborers divided by the total number of European-owned cultivated hectares in a municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and 93/1H/61/1-9 (for the year 1913/14) in the folder *Population agricole par categories et par nationalités résidant dans la commune* from the ANOM in Aix-en-Provence.
- *Sharecropper/ha_I* (or indigenous sharecroppers per hectare) is the number of agricultural indigenous sharecroppers divided by the total European and indigenous-owned cultivated hectares in a municipality. The data was obtained from FR CAOM 93/1H60 (for the year 1904/05) and 93/1H/61/1-9 (for the year 1913/14) in the folder *Population agricole par categories et par nationalités résidant dans la commune* from the ANOM in Aix-en-Provence.

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