The long-term impact of Italian colonial roads in the Horn of Africa. 1935-2000.

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Abstract

Scholars disagree on the mechanisms through which colonialism has affected the African economies. The case study of Italian road construction, in Eritrea, Somalia and Ethiopia between 1935 and 1940, offers a unique opportunity to examine the interplay between colonial investments and post-colonial economic growth. First, by employing regression analysis on combined historical and present-day data, along with IV and placebo estimations, I show that Italian colonial roads have brought about higher contemporary levels of development within a 10 km radius. Second, by using the theoretical framework of the Krugman and Fujita model, I disentangle the direct from the indirect effect of Italian roads over time. I find that, in the late 1930s and in the 1950s, colonial infrastructure has fostered development directly, through a reduction in transportation costs. During this period, the effect was strengthened by the attraction that colonial roads exerted on other types of public investments. After 1960, historically better connected areas maintained their advantage only indirectly, through the initial increase in market potential. This paper sheds new light on the linkage between colonial investments and long-term inequality and deepens our understanding of the channels through which historical transportation infrastructure has shaped the post-colonial economic landscape of the African countries.

Contents

1 Introduction

Understanding the interplay between colonial legacy and post-WWII economic development of African countries is a fundamental step in the attempt to explain the economic history of the continent and to account for its unequal regional development. This paper aims to answer two main questions: *What sub-regional impact did colonial revolutions in transportation infrastructure have on long-term economic development?* and *What mechanisms explain this effect in historical perspective?*[1]

I focus on the natural experiment provided by the construction of Italian colonial roads in the Horn of Africa between 1935 and 1940. This neglected part of the African colonial history offers several advantages: firstly, these roads were built with a military and strategic purpose, in the context of the Italian-Ethiopian war of 1935-6 and during the occupation that followed. Their main objective was to connect major cities, that would have otherwise been isolated and exposed to attacks from the Ethiopian resistance. This helps in addressing endogeneity. Secondly, the Italian occupation lasted for just five years, which allows to isolate more effectively the role of infrastructure from other confounding factors that could be determined by a prolonged colonial occupation. Thirdly, the regional economy and the road network itself collapsed during WWII, which provides me with an useful discontinuity to test path-dependent mechanisms.

By exploiting this particular case study, this research unveils, on the one hand, the spatial relationship between exogenous construction of transportation infrastructure and long-term economic concentration. On the other, by disentangling the different forces that triggered a persistent path-dependent mechanism over time, my work sheds new light on how and why African economies adapted to colonial investments. Finally, with a more regional perspective, this paper deepens our knowledge of the economic history of the Horn of Africa.

To answer the described research questions, I carry out statistical analysis on two distinct datasets. Firstly, following a well-established methodology in the field (Jedwab and Moradi, 2015), I construct a gridded dataset made of 15,550 cells, each measuring roughly 11x11km and covering Eritrea, Ethiopia and Italian Somalia. For each cell, I measure distance from colonial roads and facilities (hospitals and schools), proxies for economic development (population density between 1920 and 2000 and night density at night in 2010), along with several pre-colonial and geographical control variables. Secondly, I build an individual dataset, composed by 13,528 men from the 650 villages of the Ethiopian Demographic and Health Survey (DHS) from 2011. I select individual variables that approximate income and living stan-

[1] I have started working on this topic during my MPhil at the University of Oxford. This paper is a substantially modified version of part of my master's dissertation (Bertazzini, 2015).

dards, such as profession, access to media and preferred method of payment. Each individual is also linked to a geo-coded village, which I employ to add colonial, pre-colonial and geographical variables to the dataset.

As a first step of my analysis, I regress proxies for contemporary economic development on distance from colonial paved roads. Since I am worried about endogeneity, after having added my full set of controls and fixed effects, I check the robustness of my estimates by instrumenting colonial roads for straight lines connecting major cities and by using planned roads, which were not built due to the outbreak of WWII, to implement a placebo treatment. All the different specifications demonstrate that colonial paved roads have fostered higher concentration of the economic activity within a radius of 10km.

As a second step, I study the channels of persistence. I find that the effect of colonial roads had emerged already by the end of the colonial period, in 1940, it reached its peak in 1960 and has declined in magnitude afterwards. Subsequently, I apply the concepts of the Krugman-Fujita model to disentangle the direct effect of roads, through lower transportation costs, from the indirect one, trough increased market potential and agglomeration. The results show that the direct effect of colonial roads mattered during the 1930s and the 1950s while, during the following period, the market potential of each cell completely captures the effect, therefore pointing at the predominant importance of agglomeration. Finally, I study whether an indirect "coordination" mechanism could explain part of the effect of colonial roads. I find that the effect exerted by roads through the attraction of other governmental investments, such as schools and hospitals, was relevant, but only between 1930 and 1960, in coincidence with the strongest direct effect of transportation infrastructure. After 1960, the effect of colonial roads only persisted through market potential. This result suggests that the economic landscape of the Horn of Africa had reached a stable equilibrium by this date; the major political changes that have occurred afterwards could not change economic regional distribution substantially.

By exploring the impact of colonial transportation in the Horn of Africa, this paper innovates the existing literature in several ways. Firstly, my analysis tackles the debate on the mechanisms that best explain the persistent impact of colonialism. In fact scholars disagree on whether institutions (Acemoglu, Johnson, and Robinson, 2001; Arbesu, 2011; Iyer, 2010), human capital formation (Glaeser et al., 2004; Huillery, 2009; Bolt and Bezemer, 2009) or infrastructural investments (Andrabi and Kuehlwein, 2010; Burgess and Donaldson, 2010; Jedwab and Moradi, 2015) played a major role. My analysis strongly supports the hypothesis that colonial transportation infrastructure had a much greater importance than other channels, especially when it comes to explaining contemporary living standards and post-colonial development. Secondly, this paper adds to the literature that has considered the long-term impact of colonial investments in transportation (Donaldson,

2010; Jedwab, Kerby, and Moradi, 2016; Andrabi and Kuehlwein, 2010) by, on the one hand, underscoring the importance of roads and, on the other, by providing a deeper analysis of the channels of persistence. Thirdly, this work addresses the debate on the relative importance of geography and pre-colonial factors (Nunn and Puga, 2012; Davis and Weinstein, 2002; Gennaioli and Rainer, 2007; Michalopoulos and Papaioannou, 2013) and that of economic activity and agglomeration (Bleakley and Lin, 2012; Jedwab and Moradi, 2015; Ploeckl, 2012). My contribution shows that, despite the indisputable historical importance of geographical factors in the economic development of the Horn of Africa and regardless of the extremely advanced institutional level of the Ethiopian empire, colonial investments in transportation have changed the regional distribution of the economic activity dramatically. Finally, this paper also adds to the specific historiography on the Horn of Africa, which has largely overlooked the importance of Italian colonialism in explaining the economic history of the region (Bekele, 1995; Podestà, 2004; Labanca, 2002).

This paper is structured in 8 additional sections. Section 2 presents a brief literature review, section 3 provides a detailed historical background. Sections 4 illustrates the empirical strategy and the conceptual framework, whereas section 5 describes the data and the employed sources. Empirical results, robustness checks and mechanisms are reported in section 6, 7 and 8, respectively. Section 9 concludes.

2 Literature Review

Scholars strongly disagree on how to explain contemporary inequality across countries and, more specifically, on the role played by colonialism. A first group of contributions has emphasised the resilience of geography and its importance in shaping long-term growth (Gallup, Sachs, and Mellinger, 1999; Diamond, 1999; Engerman and Sokoloff, 2002; Rappaport and Sachs, 2003; Nunn and Puga, 2012; Alsan, 2014; Fenske and Kala, 2015). By contrast, a second stream of the literature has underscored the role of pre-colonial institutions in explaining long-term development (Gennaioli and Rainer, 2007; Nunn, 2008; Nunn and Wantchekon, 2011; Frankema, 2010b; Davis and Weinstein, 2002). A third branch of the empirical research, instead, has highlighted the persistent impact of colonialism (Acemoglu, Johnson, and Robinson, 2001; Alesina, Easterly, and Matuszeski, 2011; Bruhn and Gallego, 2012; Dell, 2010). With respect to this broad debate, my contribution supports this third view and provides additional empirical evidence about how deeply colonialism has changed the pre-colonial African economic landscape. In doing so, I do not aim to assess the aggregated impact of Italian infrastructure or to make a case about counterfactual economic growth (Heldring and Robinson, 2012). Rather, I want to emphasize the causal

link between exogenous technological revolutions and persistent regional inequality.

Even among those academics who argue for a predominant effect of colonialism, there is large disagreement on the mechanisms through which colonial activities have shaped long-term growth. A first group of papers has revealed the long-lasting impact of colonial institutions (Acemoglu, Johnson, and Robinson, 2001; Bertocchi and Canova, 2002; Acemoglu, Johnson, and Robinson, 2002; Acemoglu and Johnson, 2005; Banerjee and Iyer, 2005; Iyer, 2010; Berger, 2009; Fors and Olsson, 2007; Fenske, 2011) and their effect through the implementation of diverse taxation regimes (Frankema, 2010a; Frankema, 2011; Gardner, 2012; Huillery, 2014). Conversely, a second stream of the research has pointed at the importance of human capital formation in explaining long-term economic performance (Glaeser et al., 2004; Huillery, 2009; Bolt and Bezemer, 2009; Arbesu, 2011; Cogneau and Moradi, 2014; Gallego and Woodberry, 2010; Gallego, 2010; Woodberry, 2012). A third group of contributions, instead, has focused on the effect that colonialism has had through altering agricultural modes of production (Mosley, 1983; Roberts, 1987; Larebo, 1994; Austin, 2005; Fenske, 2014; Bruhn and Gallego, 2012). Finally, a fourth cohort of scholars has emphasised the role of transportation infrastructure and the effect that this has exerted on long-term development, either through market integration (Burgess and Donaldson, 2010; Donaldson, 2010; Andrabi and Kuehlwein, 2010; Federico, 2007; Shiue and Keller, 2004), or by triggering increasing returns to scale and agglomeration (Jedwab and Moradi, 2015; Jedwab, Kerby, and Moradi, 2016; Banerjee, Duflo, and Qian, 2012; Bleakley and Lin, 2012; Berger and Enflo, 2015; Michaels, 2008). With regard to this more specific debate, my research contributes in two ways: on the one hand, this paper demonstrates the importance of roads among colonial investments which, in my opinion, has been largely underestimated. On the other hand, by exploring in depth the channels of persistence, this article provides a more dynamic and sophisticated explanation of the phenomenon, this way addressing the issue of the "compression of history" (Austin, 2008). By doing so, my work improves our understanding of the African economic history and, in particular, the interplay between colonial activities and post-colonial development.

Finally, both the historiography on the Italian colonialism and the post-colonial one, have largely overlooked the impact of Italian investments. This does not simply mean that there is a gap in the literature, but also that these contributions failed, mostly for political reasons, to highlight the persistent dependence between Italian colonialism and post-colonial regional development. The majority of the contributions furnishes an analytical narrative of the events (Rochat, 1973; Sbacchi, 1985; Del Boca, 1986; Labanca, 2002), others look at cultural legacy of the phenomenon (Triulzi et al., 2002; Andall and Duncan, 2005; Pes, 2012), whereas those contributions that analyse

different aspects of the economic history of the region completely underestimate the importance of Italian investments for the post-colonial economic development of Eritrea, Somalia and Ethiopia (Pankhurst, 1971; Larebo, 1994; Bekele, 1995; Podestà, 2004).

3 Historical framework. Italian colonialism and road construction in the Horn of Africa

3.1 A brief history of the Italian colonialism in the Horn of Africa

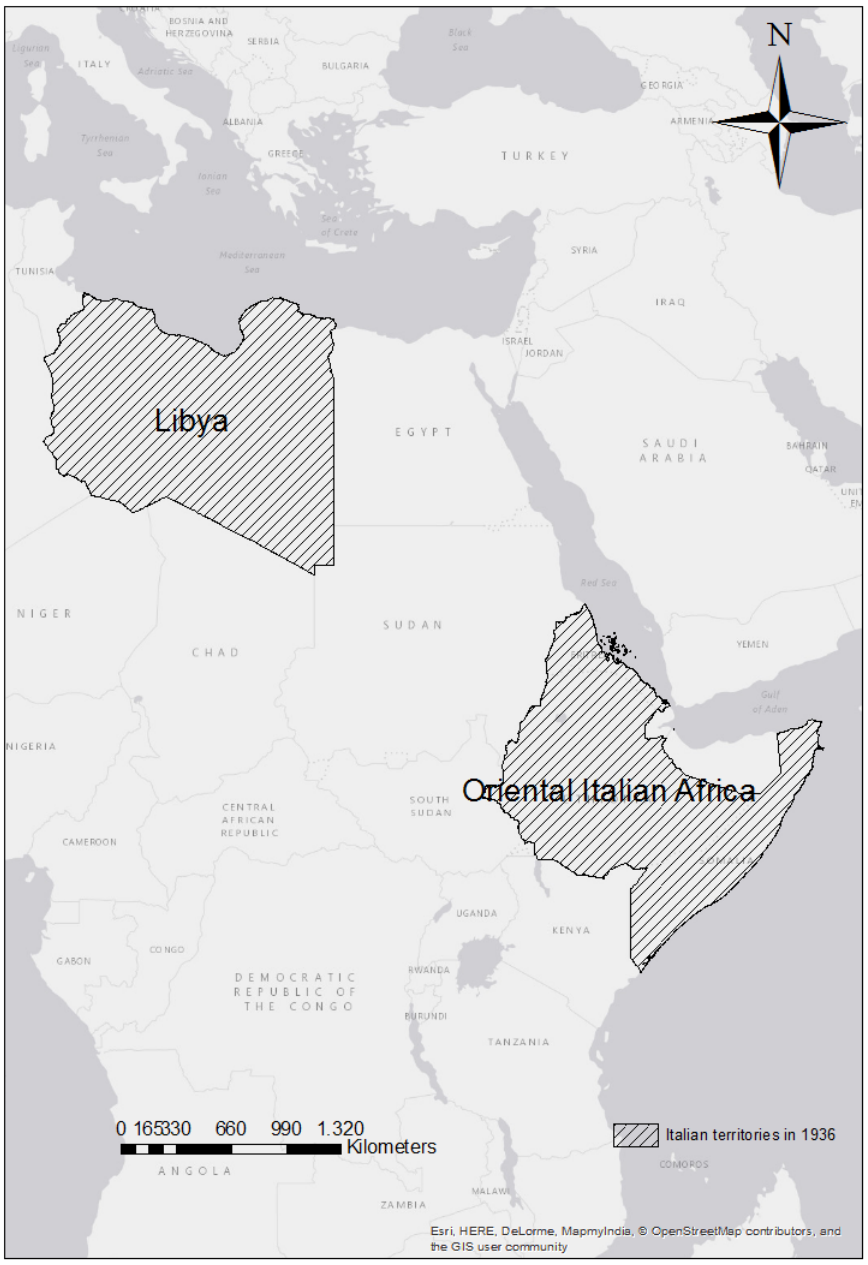
The Italian presence in the Horn of Africa began with the establishment of private commercial bases in Eritrea and Somalia. Initially, in fact, the Italian government was not willing to intervene directly and therefore only supported private enterprises' initiatives. Eritrea, where the first Italian settlement dates back to 1869, received the legal status of colony in 1882, whereas Somalia, where private capital penetration had begun in the early 1890s, became a colony in 1905. The intensity of the Italian colonial activity between 1880 and 1920 was low, due both to the limited resources that Eritrea and Somalia had to offer and the modest commitment of the liberal governments towards the development of these regions.

After Benito Mussolini seized power in 1922, the colonies received more attention and resources. The renovated emphasis that the dictator placed on colonial expansion was due, on the one hand, to the fact that the colonies could provide the regime with military successes and the mirage of unlimited land for the Italian people, both extremely important elements of the internal propaganda (Labanca, 2002, pp.237-53). On the other hand, especially after the autarchic shift of the early 1930s, Mussolini was convinced that a large colonial empire could furnish raw material for manufacturing and an export market for Italian goods (Dore, 2013, p.62). Consequently, the government implemented a more aggressive colonial policy, that ultimately culminated in the invasion of Ethiopia in 1936. This episode, which arguably has no precedent in colonial history both in terms of magnitude of the deployed army and violence against any form of organised resistance, allowed Mussolini to declare the foundation of the "empire" on the 9th of May 1936 (Del Boca, 1986, pp. 710-1).

The annexation of Ethiopia to Eritrea and Somalia substantially enlarged the Italian territories in the area, which were re-organised in the "Africa Orientale Italiana" (AOI).[2] The war and the subsequent large public expenditures, aimed to "develop" the Empire, constitute the historical framework for the intense road construction activity studied in this paper. The Italian occupation of the area ended in 1941, after one year and a half

[2]From now on AOI

Figure 1: The Italian African colonies in 1936



of harsh fighting against the combined forces of the Ethiopian patriots and the British troops.

3.2 A history of road contruction in the Horn of Africa

In this section, in order to help the interpretation of the empirical results and to support my econometric findings with qualitative evidence, I describe the main changes occurred to the road network in the Horn of Africa between the second half of the 19th and the end of the 20th century. Firstly, I outline the main intervention occurred in the area before 1935. Secondly, I study the infrastructural works carried out by the Italians between 1935 and 1940. Finally, I provide a brief description of the main infrastructural plans implemented by the different post-colonial Ethiopian governments. The narrative strongly supports the hypothesis of the exogenous placement of colonial roads and highlights a process of reconstruction of the colonial road network after independence.

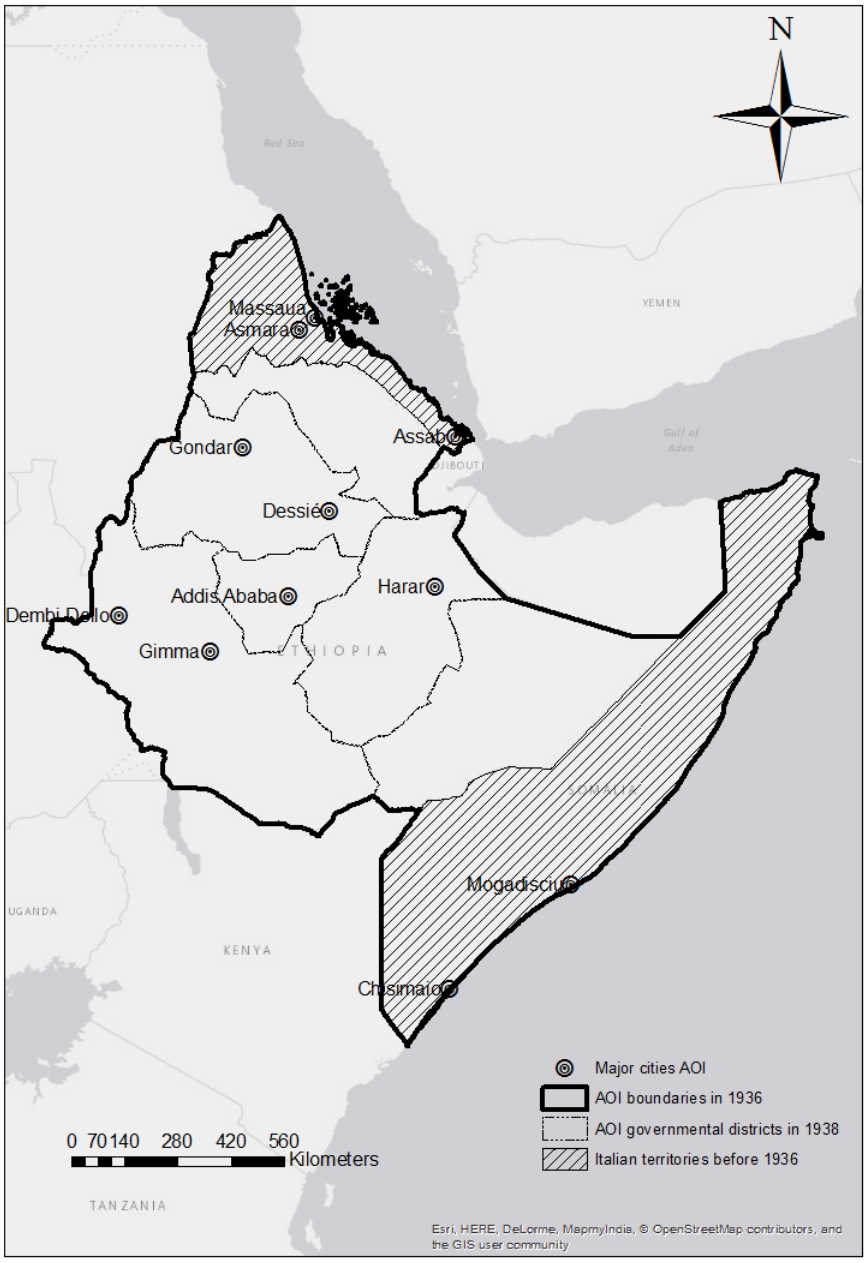
3.2.1 Road construction before 1936

The first organic intervention on the Ethiopian road network dates back to the second half of the nineteenth century and followed the formation and consolidation of the Amhara Empire. Emperor Tewodros (1855-68) was responsible for the creation of an embryonic centralised network which gravitated around the Amhara region in the northern part of the country. This network was comprised of simple paths, appropriate for the rapid deployment of infantry troops (Emmenegger, 2012, p.15). A net improvement, both in terms of quality and extension of the existing network, was achieved under the emperors Menelik II (1889-1913) and Hailé Selaissé (1920-1936), who better understood the importance of transportation infrastructure in achieving military and political control over the heterogeneous regions of the Ethiopian empire. The road network was then centred on Addis Ababa, elevated to the rank of capital of the empire by Menelik in 1889. Hailé Selaissé instituted the Ministry of Public Transport and promoted more structured road building plans, starting in the late 1920s. This project, which aimed to connect the major centers of the empire with Addis Ababa, was not completed due to the outbreak of war as well as the lack of financial resources, materials and know-how (Emmenegger, 2012, p.16). As a result, at the outset of the Italian-Ethiopian war, few roads were completed and none had modern asphalt surface. Only two major unpaved tracks for lorries existed in 1935, the Jimma-Addis Ababa and the Addis Ababa-Dessié.[3]

The situation in Eritrea and Somalia before 1935 did not greatly differ from the one described above: these colonies were neither particularly densely populated nor endowed with valuable natural resources that could justify significant investments in infrastructure. In Somalia, only 4 major lorry tracks existed in 1925, and none of them was paved: these connected

[3]Istituto Agricolo Coloniale (1946). *Main features of Italy's action in Ethiopia.* Istituto Agricolo Coloniale, plate 1

Figure 2: The Italian colonies of the Horn of Africa



Mogadisciu with Brava, Lugh Ferrandi, Oddur and Fer Fer.[4] In the same year in Eritrea, only the region of Asmara showed a more developed road network: paved roads with rudimentary asphalt surface connected Asmara with the port of Massawa and with the towns of Cheren, Adi Qualá and Adi Caieh.[5]

Between 1934 and 1935, several interventions were carried out in the two aforementioned colonies in order to provide logistic support during the Ethiopian military campaign. In Eritrea, the artery connecting Massawa to Asmara was re-paved and some parts of it were improved by making hairpin bends smoother and the carriageway larger. Moreover, the military engineers rapidly built the road Nefasit-Decameré *ex nihilo*, which aimed to direct the traffic coming from Massawa directly to Adigrat without passing through Asmara (Del Boca, 1979, p.297). After the occupation of Macallé, in 1935, the road Adigrat-Macallé was quickly built in order to support military penetration (Badoglio, 1937, pp.34-7). At the battle of the Ascianghi Lake (Mai Ceu, end of March 1936), the last part of the Ethiopian army was destroyed. General Badoglio, the Italian commander in chief, started planning the march towards Addis Ababa: all available men were employed to refurbish the track Macallé-Quoram-Dessié-Addis Ababa (Badoglio, 1937, pp.197-8).

Similarly, in Somalia, general Graziani employed remarkable means for the construction of strategic roads aimed to support the penetration of the Italian troops from the South. In 1935, the paved road Mogadisciu-Fer Fer-Mustahil was built; this satisfied the double need of connecting the outposts with the capital of the colony and of facilitating the march towards Harar and Dire Daua in the planned offensive of 1936. During the two main operations on the Southern front, the one leading to the occupation of Neghelli in January 1936 and the one aiming at the occupation of Gorrahei, Dagabur and Harar in the following April, Graziani ordered the construction of new tracks in these direction. Mogadisciu was therefore connected with Neghelli and Fer Fer with Harar (Graziani, 1938, pp.284-5).

3.2.2 The colonial road building activity between 1936 and 1941

After the conquest of Addis Ababa on the 5th of May 1936, the war was officially concluded. Mussolini immediately stated that the priority in the newly founded empire was to build an extensive highway network as quickly as possible. Several reasons motivated him: firstly, the peripheral regions such as those of Jimma and Gore were completely out of control, due to the impossibility of moving troops efficiently. Secondly, some of the major cities

[4]Istituto Agricolo Coloniale (1945). *Some data on Italian activity in the colonies.* Istituto Agricolo Coloniale, plate 69

[5]Istituto Agricolo Coloniale (1945). *Some data on Italian activity in the colonies.* Istituto Agricolo Coloniale, plate 66

of the empire, such as Gondar, Harar, Dire Daua and even Addis Ababa, were at risk of remaining isolated during the rainy season (between June and September). Thirdly, the army and the civilian personnel in the main centers needed a constant flow of supplies from the Italy. Finally, it was necessary to create a network through which the main cities of the AOI could be connected with each other and ultimately be integrated with the metropolitan market (Cobolli-Gigli, 1938, p.1480). Roads were cheaper to build than railroads, faster to realise and, moreover, it was clear that for at least the next 20 years the trade volumes would have not justified the construction of railroads (Marchitto, 1940, pp.78-81). Mussolini personally laid out a comprehensive infrastructural plan, that was officially communicated on the 19th of May 1936. Five main arteries had to be realised immediately. These were the Om Ager-Gondar-Debra Tabor-Dessié (650 km), the Debra Tabor-Debra Marcos-Addis Ababa (500 km), the Adigrat-Dessié-Addis Ababa (850 km), the Assab-Dessié (500 km) and the Addis Ababa-Jimma (350 km). The Addis Ababa-Allata-Neghelli-Dolo (1,100 km) had to be constructed in a second phase.[6] Some of these projects were started but not completed due to the outbreak of WWII.[7]

The simple list of the projected roads gives an idea of the magnitude of the investments undertaken. The vast majority of the works were managed the AASS (Azienda Autonoma Statale della Strada), a public company purposely created by the Minister of the public works (Sillani, 1937, p.242). The AASS obtained an incredibly large budget from Rome: not only did the six-year development plan destine more than 7.7bn Italian Lire (out of the total 12bn) for road construction (Sillani, 1937, p.233), but the AASS even received additional 3.1bn Lire, for the financial year 1936-7 (Sillani, 1937, p. 243).[8] In 1939, the newly built colonial transportation network totalled roughly 4,625 km paved roads and 4,877 km unpaved tracks.[9]

The construction of this vast road network did not prevent Italians from being expelled from the Horn of Africa in November 1941. During the military events of 1940-1, the Italian troops were progressively forced to abandon all the territories of the AOI. In order to slow down the British offensive, the army destroyed several bridges, tunnels and large parts of the asphalt surface. Some of the major threats to network's integrity were the disruption of Mussolini Bridge between Agordat and Cheren, of the ramp that gave access to Cheren from the North-West (Del Boca, 1986, p.411),

[6] Angelo Piccioli (Edited by) (1937–1943). *Gli Annali dell'Africa Italiana*, year 2, issue 4, pp. 321-2

[7] This original plan was marginally modified after the approval of the six-year plan on the 21st June 1937, but the fundamental arteries remained the same

[8] The plan, which was passed in 1936, was modified into a 12-year plan in 1937. Therefore, the total public capital invested in road construction amounted to roughly 7bn Italian Lire: 1bn for the 4 financial years 1936/7-1939/40, plus the 3bn allocated in 1936.

[9] Angelo Piccioli (Edited by) (1937–1943). *Gli Annali dell'Africa Italiana*, year 2, issue 4, p.365

the dismantlement of the surface of the Mogadisciu-Harar (Del Boca, 1986, p.451), of the Addis Ababa-Dessié (Del Boca, 1986, p.486) and of all the arteries that gave access to Gondar (Del Boca, 1986, p.507).

3.2.3 Road construction between 1941 and 2000

Emperor Hailé Selaissé regained control over Ethiopia and Eritrea by the end of 1941. The economic stagnation that hit the area in the 1940s along with the endemic lack of international capitals, prevented the independent imperial government from undertaking any comprehensive maintenance plan. This effect cumulated with the disruption caused by the war and yielded a substantial deterioration of the road network that shrank from about 6,000 km in 1940 to about 1,000 km in 1951 (Leul, Petros, and Kebede, 2008, p.9). Between 1951 and 1974, when the Communist coup led by Menghistu overthrew the imperial regime, four highway plans were implemented. The first one (1951-7) focused on reconstructing the Italian road network and restored about 4,200 km of paved roads, whereas the next three started building new trunks, often paving colonial and pre-colonial unpaved tracks. The paved road network was expanded from 6,400 km, in 1951, to 9,260 km, in 1974 (Emmenegger, 2012, p.17).

As opposed to the imperial government, that had given precedence to the creation of a large highway network, the Derg regime, that ruled Ethiopia and Eritrea between 1974 and 1991, placed more emphasis on the importance of rural local roads. These were consider fundamental to improve market accessibility for farmers and constituted a valuable propaganda tool in the countryside. Consequently, the Highway programs were progressively replaced by Sector Programmes (First Sector Programme 1977-1982), that extended the road network from 9,260 km to 19,020 km in 1991 (Emmenegger, 2012, p.17). During the 1990s, the last decade considered in this study, the liberal EPRDF government (Ethiopian People's Revolutionary Democratic Front) launched the First Road Sector Development Programme (1997-2007), which to some extend continued the investments in rural roads, recognising the absence of suitable transportation network in the countryside as a major limit to the Ethiopian development. The achievements of this last plan go beyond the period analysed in this paper.

From this succinct, though comprehensive, history of road construction in the Horn of Africa, it is possible to highlight some specific findings that constitute a fundamental background for the empirical analysis carried out in this study. Firstly, prior to the Italian occupation of Ethiopia, the existing road network was extremely underdeveloped. Secondly, the intense road building activity implemented by the Italians, between 1935 and 1940, was primarily aimed to achieving the military occupation of the region, which suggests an exogenous placement of the main arteries. Thirdly, an almost complete collapse of the colonial road network took place between 1940

and 1951. Finally, the majority of the infrastructural investments of the independent government were destined to the re-building of Italian roads during the 1950s, whereas new roads started being built only after 1960.

4 Conceptual framework and empirical strategy

4.1 Have colonial roads fostered development?

The first issue addressed by this paper is weather the grandiose colonial construction plans, have had a persistent impact on the economies of Eritrea, Somalia and Ethiopia. In order to answer this question, I employ econometric analysis. I create a spatially explicit gridded dataset, composed by a total of 15,550 cells (roughly 11x11km), that cover the territory of Eritrea, Italian Somalia and Ethiopia.[10] For each unit of observation, I calculate the average value of my dependent variables of interest and the Euclidean distance of each cell's centroid from colonial facilities and infrastructure. I also match each observation with pre-colonial, environmental and geographical controls.

As first step, I run regression analysis to check the effect that colonial roads had on economic development. I therefore estimate equation 1 through OLS:

$$\begin{aligned} y_{i,c} = \alpha + \beta_1 D10CPR_{i,c} + \beta_2 D20CPR_{i,c} \\ +\beta_3 D10CUR_{i,c} + x'_{i,c}\gamma + \delta_c + \epsilon_{i,c} \end{aligned} \tag{1}$$

$y_{i,c}$ represents my two dependent variables of interest, population density in 2000 and light density at night in 2010, in cell i and district c. These two variables are proxies for economic development largely employed in the literature (Michalopoulos and Papaioannou, 2013; Jedwab, Kerby, and Moradi, 2016). In order to make population density estimates comparable over time, I normalise it by standard deviations (*z-scores*). $D10CPR_{i,c}$ and $D20CPR_{i,c}$ are my main explanatory variables of interest, two dummy variables for a cell i in district c being within 10km from colonial paved roads and between 10 and 20km, respectively. $D10CUR_{i,c}$, instead, is a dummy for being less than 10km away from unpaved roads. If colonial infrastructure has changed the economic environment of the Horn of Africa, I expect colonial roads to have a positive and statistically significant effect on my proxies for economic development (β_1, β_2 and $\beta_3 > 0$). $x'_{i,c}$ is a vector representing the full set of controls. These can be divided into three groups, namely pre-colonial, colonial and geographical & environmental controls. δ_c is my standard set

[10] The employed gridded dataset is composed by a total of 15,550 cells measuring 0.1x0.1 decimal degrees, which equals 0.1x0.1 Km. If lakes are dropped (main specification) this gives me a total of 15,208 units of observation. I had to exclude 4 additional observations, due to errors in the reconstructed population density in 1940. This leaves me with 15,546 or 15,204 observations, depending on whether lakes are included or not.

of fixed effects, the 74 regional districts called "Commissariati", in which Oriental Italian Africa was divided. By introducing these fixed effects, I control for possible unobservable factors at a regional level. $\epsilon_{i,c}$ is the error term. In all the specifications, in order to make my estimates robust to spatial correlation, I cluster the standard errors by 202 colonial provinces, called "Residenze", which were the smallest administrative units in AOI.

More specifically, in order to control for possible confounding factors, I include the following variables: with regard to pre-colonial controls, I add proximity to pre-colonial main tracks (dummy <10km) and population density in both 1920 and 1930 (major population relocations occurred around 1930, due to Ethiopian reforms and in preparation for the 1935 war). This ensures that I am not capturing the persisting effect of pre-colonial infrastructure or the historical patterns of settlement. As a second step, I add several controls for other colonial investments, to make sure I am not measuring the effect of other facilities. I add dummy variables for being less than 10km away from colonial railroads, main hospitals, secondary hospitals, schools for Africans and colonial provincial capitals, along with a dummy for being in an area of mining interest during the colonial era. Thirdly, in order to make sure I am not capturing the effect of environmental factors, I control for latitude, longitude and altitude, for being within 10km from perennial rivers, within 30km from the coast, for annual rainfall average, malaria rate and FAO land suitability. I expect my estimates to be robust to these controls.

In order to rule out the omitted variable problem and to prove the causal relationship between colonial infrastructure and present-day development, I employ two main robustness checks. Firstly, I instrument colonial paved roads for straight lines connecting major cities, following a strategy largely employed in the field (Michaels, 2008; Jedwab and Moradi, 2015; Berger and Enflo, 2015). Secondly, I perform a placebo treatment, which exploits planned roads that had been projected by the Italians, but left unfinished due to the outbreak of WWII. Thirdly, I run additional robustness checks, such as the restriction of the sample to cells within 200 and 100km from colonial roads, the inclusion of various sets of fixed effects (ethnic boundaries, colonial provinces and colonial governments), the replication of the exercise with a dataset composed by bigger cells (30x30km) and the recalculation of the error term with the "Conley" estimator, robust to spatial dependence. I expect my results to be robust to these alternative specifications.

As a second step in my analysis, I want to ascertain that population density, the dependent variable I use in the majority of the estimations, is a good proxy for economic activity. In fact, despite this methodology is well established in the literature (Ciccone and Hall, 1996; Bleakley and Lin, 2012; Jedwab, Kerby, and Moradi, 2016), one might be worried that in the specific context of the Horn of Africa, a region plagued by civil wars and political instability throughout the post-colonial period, this was not the case and

that my estimates are capturing congestion effects, rather than higher living standards. A first robustness check in this sense is the estimation of equation 1, with luminosity as left-hand side variable, but this might still cast doubts about the reliability of the data.

In order to demonstrate that areas located next to colonial roads are not only more populous and luminous, but that also enjoy higher living standards, I use the men's individual data from the 2011 DHS survey for Ethiopia. I create a dataset composed by a total of 13,528 individuals, distributed across 650 villages. For each observation, I select three categorical variables that inform on type of employment, frequency in accessing newspapers, radio and television and preferred mode of payment. These measures are all very precise proxies for the level of development. In particular, type of job is an excellent proxy for income, as we know, from governmental statistics,[11] the average salary of the different sectors. Ethiopian wages are significantly higher for third sector employees and professionals. I also calculate the same explanatory and control variables employed in equation 1 (see above), at the village level. For each individual, I additionally select variables for age and ethnicity, in order to control for individual characteristics. I run Probit regression analysis in the form:

$$Y_{0,1,i,v} = \alpha + \beta_1 D10CPR_{i,v} + \beta_2 D10CUR_{i,v} + x'_{i,c}\gamma + \epsilon_{i,v} \qquad (2)$$

$Y_{0,1,i,v}$ is a binary variable for whether or not an individual i, living in village v, is performing a specific job (clergyman, agricultural workers, manager/professor/technician, salesman, low or high skilled labourer or whether is unemployed), has access to newspapers, television or radio with a certain frequency (not at all, less than once a week or at least once a week) and pays with a recurrent method (no transactions, cash only, cash and kind, kind only). $D10CPR_{i,v}$ and $D10CUR_{i,v}$ represent my main explanatory variables of interest and are two dummy variables equalling 1 if an individual i in village v lives within 10km from colonial paved or unpaved roads, respectively. $x'_{i,c}\gamma$ is my set of control, the same pre-colonial, colonial and geographical variables, along with a dummy for living less than 10km away from contemporary roads and individual controls. $\epsilon_{i,v}$ is the error term, which I cluster at a village level. In order to make the interpretation of the coefficients easier, I calculate the marginal effects in all the regressions. I expect my explanatory variables to predict an average increase in the likelihood of finding higher living standards in historically better connected areas. In other words, I expect to observe that people living next to primary and secondary colonial roads are more likely to be employed in the tertiary sector, to access media regularly and to pay in cash.

[11] http://www.wageindicator.org/main/salary/minimum-wage/ethiopia, lastly accessed on 21st of April 2016

4.2 How can we explain the long-term effect of colonial transportation infrastructure?

Once the causal link between the colonial technological revolution in transportation and contemporary higher levels of economic development has been demonstrated, I turn my attention to the mechanisms that explain the long-term impact of colonial roads. *What mechanisms explain the persistent effect of primary colonial roads over time? What are the channels through which colonial transportation infrastructure has triggered development?*

As a first step, to answer the outlined questions, I estimate equation 1 with population density between 1930 and 1990 as dependent variable. This will inform about when the effect of colonial roads has emerged and how it has changed over time.

Secondly, I test whether roads were affecting the economy mainly through a direct effect (attracting firms thanks to lower transportation costs) or indirectly, by fostering agglomeration and by increasing market potential. I am also interested in how the relative effect of these mechanisms has changed over time. In order to do so, I apply the concepts of the Krugman-Fujita "Economic Geography" model. The first channel that might explain the effect of roads over time is the direct attraction of economic activities that they exerted through comparative advantage in transportation, which might have been influential during both the colonial and post-colonial periods. Following this reasoning, more firms would have settled next to colonial roads, due to cheaper input goods and accessibility to larger markets for output ones (Krugman, 1991). But roads could have also attracted people indirectly, through an agglomeration effect. If roads determined a higher concentration of firms in better connected areas, this might have fostered additional development endogenously, by increasing the size of local market potential. In fact, this latter was not only determined by the size of the markets accessible through better transportation infrastructure, but it was also enlarged by the workers, employed by the firms themselves. These were likely to spend a fraction of their income on goods produced in the same region, progressively triggering an increasing returns to scale mechanism. In turn, this phenomenon, along with cheaper transportation costs, could reduce prices, indirectly increasing real wages which, in a virtuous circle, could attract additional people through an in-bound migratory phenomenon.

In order to test the relative importance of these different forces, I employ the conceptual framework of the Fujita & Krugman model, which defines economic concentration as a function of amenities and increasing returns to scale, formally $Ec = f(A + IR)$. In turn, increasing returns to scale can be defined as a function of transportation costs, internal and external market potentials: $IR = f(Tcost + InMP + ExMP)$. We can therefore define economic concentration as:

$$Ec = f(A + Tcost + InMP + ExMP)$$

The previous equation allows to disentangle the direct effect of colonial infrastructure from its indirect one: transportation costs represent the direct effect of colonial roads, whereas market potential constitutes the indirect (or endogenous) one. In order to estimate this model, I rely on OLS dynamic cross-sectional analysis. The lack of reliable data on GDP for the studied period forces me to employ population density data extensively. Firstly, as for the previous sections, average population density per cell is employed as a proxy for economic activity. Secondly, I use a dummy for the average altitude of a cell being between 1,500 and 2,500 meters above the see level to approximate amenities. The Ethiopian highlands are, in fact, the only pleasant location of the Horn of Africa in terms of temperature and humidity. Thirdly, I employ my two main explanatory variables (Two dummy variables for being within 10km and between 10 and 20km from colonial paved roads) as an approximation for lower transportation costs brought about by colonial investments. Finally, I reconstruct historical market potential for every cell. To accomplish this, I adapt the methodology employed by some related contributions on the determinants of industrial location (Crafts, 2005; Martinez-Galarraga, 2012) to the available data for my case study. I calculate internal market potential as the sum of the population density of a cell plus the average population density of those cells whose centroid lies within 20km from its center: $InMP_{i,t} = Popd_{i,t} + AvPopd_{i<20km,t}$. Conversely, I define the external market potential of each cell as the internal market potential of the closest colonial district capital (with whom the cell is most likely to trade) divided by their Euclidean distance: $ExMP_{i,t} = \frac{InMP_{closestDC,t}}{Dist_{i,closestDC}}$. The idea of this exercise is that taking the average population density of the surrounding area of a certain cell gives us a good approximation of the size of the accessible local market. The size of the market potential of the closest urban center, instead, approximates the demand through which large and close urban areas could support the agricultural and industrial production of each cell (Vandercasteelen et al., 2016).

Clearly, this strategy has some important shortcomings. Firstly, my estimations of market potential are endogenous to my dependent variable, but I partially address this issue by employing lagged market potential. Secondly, a few implicit assumptions need to be made. In order for population density to be a good approximation of market potential, we need to assume that the correlation between population concentration and higher GDP per capita, demonstrated for the early 2000s, holds backward in time. Moreover, as I am using colonial district capital to calculate the external market potential over time, I need to assume that the closest urban markets remain roughly the same for each cell after 1940, regardless of the important political and economic changes. In spite of these limitations, I am convinced that this identification strategy is solid enough for the purpose of this section.

In order to check the hypotheses outlined above, I estimate equation 3

through OLS:

$$Popd_{i,s,t} = \alpha + \beta_1 D10CPR_{i,s} + \beta_2 D20CPR_{i,s} + \beta_3 InMP_{i,s,t-1} + \beta_4 ExMP_{i,s,t-1} + \beta_5 Dhighlands_{i,s} + \delta_s + \epsilon_{i,s} \quad (3)$$

$Popd_{i,s,t}$ is population density in cell i, year t and region s. $D10CPR_{i,s}$ and $D20CPR_{i,s}$ are my dummy variables for being within 10km and between 10 and 20km from colonial paved roads, respectively. $InMP_{i,s,t-1}$ and $ExMP_{i,s,t-1}$ are internal and external market potentials for cell i in region s and year $t-1$, while $Dhighlands$ is my dummy for whether a location c in region s is comfortable for settlement. Finally, δ_s is my set of fixed effects, the 6 governments in which the region was divided during the colonial era.

The third and last step I take in order to account for the effect of colonial roads over time is the "coordination" mechanism. Arguably, the comparative advantage in transportation that colonial roads provided for a certain period of time to better connected regions, gave an incentive to both colonial and post-colonial governments to invest more in these areas, due to the lower costs they had to face. By "coordinating" the allocation of investments for different facilities, such as hospitals, schools and new roads, Italian transportation infrastructure might have caused the persistence of the comparative advantage for the treated regions, potentially until present. This, in turn, could have translated into a higher likelihood for firms to settle next to colonial roads and for people to migrate nearby to take advantage of these facilities. This indirect mechanism could have increased market potential further, endogenously fostering growth. Moreover, although the allocation of additional resources should have stopped after the transportation advantage was lost due to the construction of new arteries in the post-colonial period, colonial facilities might have acted as sunk investments, providing an additional incentive to the imperial Ethiopian government to keep investing in these areas. The presence of physical and human capital next to colonial roads, in fact, might have given an incentive to build new facilities in these regions even after the initial advantage in transportation was lost. In order to test the "coordination" hypothesis, I employ a two-steps strategy.

Firstly, I run Probit regression analysis in order to test: a) whether colonial roads attracted more hospitals and schools during the colonial period, b) whether colonial roads caused relocation of new roads in the post-independent period and c) how well the position of colonial schools and hospitals predicts the location of contemporary facilities. In order to do that, I estimate the following equation:

$$D10DifInv_{i,t} = \alpha + \beta_1 D10CPR_i + \beta_2 D20CPR_i + PopD_{i,t-1} + x_i'\gamma + \epsilon_i \quad (4)$$

Where $D10DifInv_{i,t}$ is a dummy for a cell i in year t being within 10km from either a colonial or post-colonial state asset. This can be either a hospital, a school or a post-colonial road. $D10CPR_i$ and $D20CPR_i$ are my dummy variables for being within 10km and between 10 and 20km from colonial paved roads, respectively. $PopD_{i,t-1}$ is standardized population density in year $t-1$ with respect to the decade when the new investments were made. Finally, $x_i'\gamma$ and ϵ_i represent a vector, containing my baseline controls, and the error term, respectively.

As a second step, I add distance from colonial schools and hospitals and distance from post-colonial all weathers roads to equation 3.

If a "coordination" mechanism is in place, I expect to observe, on the one hand, that colonial roads are good predictors for the location of other governmental facilities (equation 4) and, on the other, that the magnitude of the direct effect of colonial roads is further reduced, when controlling for distance from other investments (equation 3). Conversely, in case the placement of colonial schools and hospitals is purely driven by exogenous transportation infrastructure and not endogenously placed in already more developed areas, I expect the effect of market potential to be only marginally reduced when the additional controls are added to equation 3. The opposite applies in case policy makers were taking levels of development in year $t-1$ into consideration.

5 Data

The analysed data can be divided into three categories: dependent variables, explanatory historical variables and geographical & environmental controls.

5.1 Dependent variables

The main dependent variable employed is decennial population density between 1920 and 2000. For the years 1960, 1970, 1980, 1990 and 2000, the data come from the Unep/Grid Sioux Falls dataset[12]. This can be downloaded in spatially explicit raster format (pixels' size 0.04x0.04 decimal degrees) and are constructed by matching population density data at district level with population of villages and towns, accessibility to transportation facilities and waterways. For the years 1920, 1930, 1940 and 1950, instead, the data come from the History Database of Global Environment (HYDE)[13], which combines historical population density data, cropland and pasture statistics to reconstruct historical population density at a fine spatial level (0.08x0.08 decimal degrees) (Klein Goldewijk et al., 2011).

[12] Available at http://na.unep.net/siouxfalls/datasets/datalist.php, lastly accessed on 20th of April 2016

[13] Available at http://themasites.pbl.nl/tridion/en/themasites/hyde/download/index-2.html, lastly accessed on 20th of April 2016

The second dependent variable employed is light density at night in 2010. These data are downloaded from the National Geophysical Data Center (NOAA) also in raster format (0.008x0.008 decimal degrees)[14]. To include these variables in my gridded dataset, I convert pixels to points and, for each cell, I calculate the average value of the contained points.

The individual dataset has been downloaded from the USAID website[15] and was collected in the context of the Ethiopian "Demographic and Health Survey" from 2011. This provides me with individual categorical information about profession, frequency in accessing media (television, radio and newspapers) and preferred types of payment for a total of 13,528 adult Ethiopian males. Each individual is linked to one of the 650 geo-coded Ethiopian villages, that compose the survey.

These data, which are also used to construct market potential estimates in the mechanisms section, are generally of good quality. The main limitations concern the reconstructed data from the HYDE project, which largely relies on approximations to calculate population density. Unfortunately, information on historical population density at a suitable disaggregate level is not available. The second issue pertains the coverage of the DHS survey, which does not include Eritrea and Somalia. This means that the estimations that rely on this particular dataset cover just about 2/3 of the total analysed area.

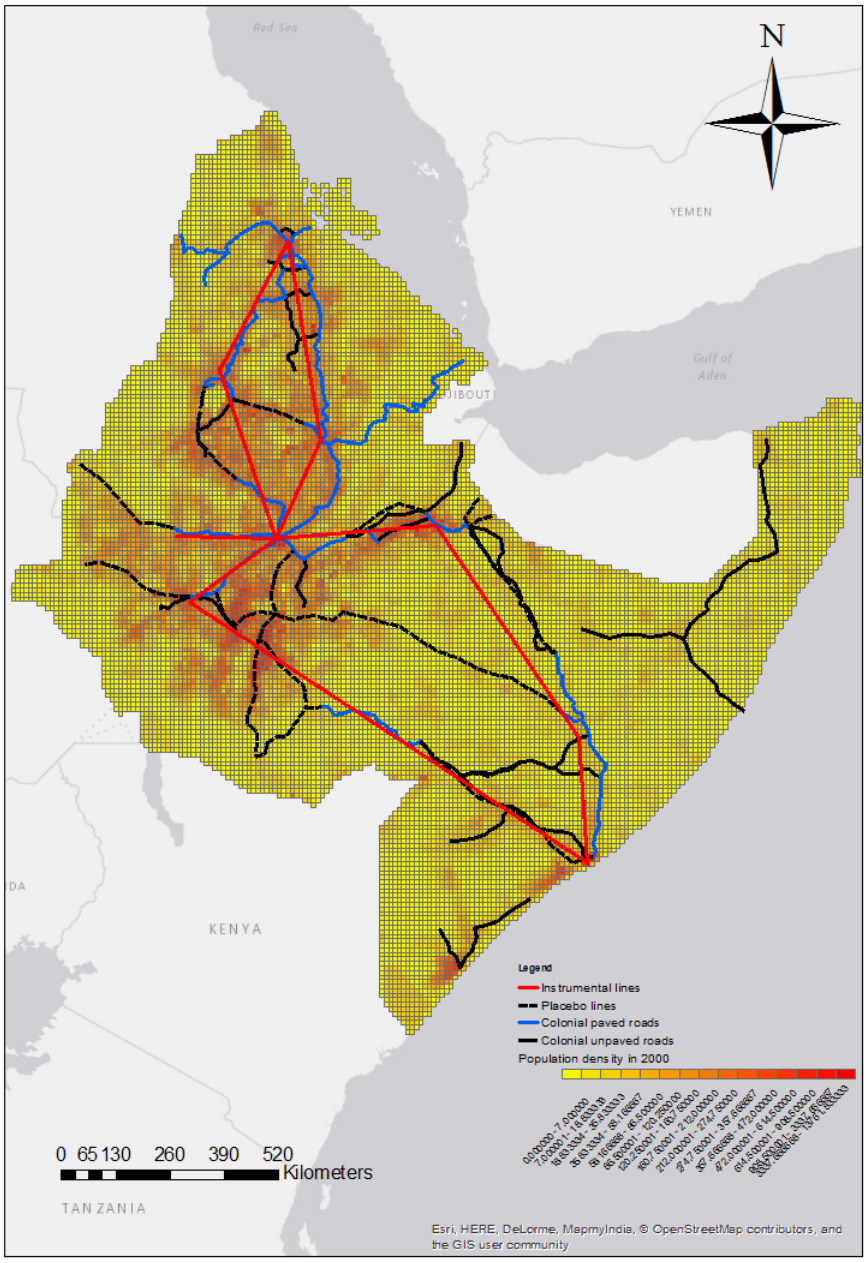
5.2 Historical explanatory variables

The vast majority of the historical data has been collected from primary printed sources. My main sources for colonial investments are the 3rd and 4th issues of 1939 and the 1st and 2nd of 1940 of "Gli Annali dell'Africa Italiana", a review edited by the Italian Ministry of the Colonies, which describes the public investments implemented by the Italian Government in Oriental Italian Africa . The location of colonial paved and unpaved roads in 1939 comes from a map contained in the 4th issue of 1939, which I have geo-referenced and digitised. Colonial district capitals, along with provincial (Residenze), regional (Commissariati) and governmental (Governi) boundaries, in which the AOI was divided in 1938, come from a map in the 3rd issue of 1939. These are employed as fixed effects and for clustering. From issue 1 of 1940, I have collected data on the location of colonial schools for locals, which have been manually geo-coded by attributing them to each town or village. The location of primary colonial hospitals and clinics has been obtained by geo-referencing a series of maps from the same volume. Information on whether a cell's centroid falls within a zone of mining inter-

[14] Available at http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html, lastly accessed on 20th April 2016

[15] Available at http://www.dhsprogram.com/Data/, lastly accessed on 20th of April 2016

Figure 3: Population density in 2000 and colonial roads



est at the colonial time is collected by geo-referencing a map from issue 2 of 1940.

With regard to the location of colonial railroads, for Eritrea and Ethiopia the data come from DIVA GIS[16] (the functioning railroads have not changed since 1941) whereas, for Somalia, where the colonial trunk was dismissed, I have geo-referenced a map from Corni's book (1937). Placebo lines are taken from Sillani's book (1937). Finally, pre-colonial tracks come from maps contained in "Some data on Italian activity in the colonies" and "Main features of Italy's action in Ethiopia", two apologetic publications of the Italian government dating 1945 and 1946, respectively. I calculate the Euclidean distance in kilometres of each cell's centroid from the closest historical infrastructure or facility.

Since the vast majority of the employed sources had either a propagandistic or an apologetic purpose, one might be worried about their reliability. Although these are official governmental publications in which the risk of significant bias for the mentioned investments seems small, I have double checked the data with alternative archival sources. I have cross-checked pre-colonial track locations with Dardano's map (1935), the roads projects and realisations with some reports from minister Cobolli-Gigli (Cobolli-Gigli, 1938) and balance sheets reporting road realisations in 1939. The data coincide with negligible variations. With regard to the instrumental variable, I employ straight lines connecting major cities of the AOI.[17]

Post-colonial data on the extension of the road network come from maps and atlases published by the Ethiopian government, which I have geo-coded and digitised. These only cover the territories of Ethiopia and Eritrea. The road network in 1955 has been reconstructed from a map produced by the Ethiopian Imperial Highway Authority.[18] I have employed the same procedure on maps from 1962[19] and 1973.[20] Finally, maps from the "National Atlas of Ethiopia" (1988)[21] were employed to reconstruct the transportation network in the 1980s.

Finally, data on the location of contemporary schools and hospitals, employed to explore the "coordination" mechanism in section 8.3, were taken from online sources: locations of contemporary hospitals in Ethiopia come from the map "Ethiopia health facilities", available online on the ARC GIS platform. For contemporary schools, instead, due to the unavailability of similar sources, I had to rely on a list of Ethiopian schools taken from an Ethiopian social network, used by former students to keep in contact after

[16] Available at http://www.diva-gis.org/, lastly accessed on 20thof April 2016

[17] See figure 3

[18] Imperial Highway Authority (1955). *Highway Map of Ethiopia (map)*

[19] Imperial Highway Authority (1962). *Highway Map of Ethiopia (map)*

[20] Imperial Highway Authority (1973). *Highway Map of Ethiopia (map)*

[21] Ethiopian Mapping Authority (1988). *National Atlas of Ethiopia.* Ethiopian Mapping Authority

graduation,[22] from which I created a spatially explicit dataset of contemporary schools.

5.3 Geographical and environmental controls

I have also employed data on the geographical and environmental characteristics of each cell to control for confounding factors and to proxy for amenities. I use longitude and latitude of each cell's centroid, along with the average elevation in meters. Altitude can be downloaded, in raster format (0.008x0.008 decimal degrees) and foreach country, from the website DIVA-GIS. From the same source, I have also downloaded the annual average rainfall in centimetres in raster format (0.04x0.04 decimal degrees), along with shapefiles reporting contemporary roads, perennial rivers and waterways.[23]

The malaria transmission index data are available, in raster format (0.5x0.5 decimal degrees), from Kiszewski's dataset (Kiszewski et al., 2004). This informs on the rapidity and likelihood of malaria transmission in each cell. Since in this case pixels are slightly larger than dataset's cells, the value of each pixel's centroid from the raster dataset has been attributed to each cell. Land propensity score for each cell was calculated from the GAEZ-FAO land fertility database.[24] This spatially explicit dataset, which can be downloaded in raster format (0.5x0.5 decimal degrees), reports the average fertility of each cell in a scale from 0 to 9 (0 highest, 9 lowest). The same procedure was applied to join all different raster datasets to my grid: rasters' cells were converted to points and the average value for each cell was taken. For the individual dataset, the pixel's value was attributed to the overlapping village.

Finally, with regard to the ethnic boundaries employed as fixed effects, I have used the Murdoch's Atlas map of African ethnic boundaries, digitized by Nunn (2008) and available online. Each centroid has been attributed to the overlapping ethnic group.

[22] Available on the website graduates.com, http://www.graduates.com/Schools/Ethiopia, lastly accessed on 21st of April 2016

[23] Available at http://www.diva-gis.org/, lastly accessed on 20th of April 2016

[24] Available at http://www.fao.org/nr/gaez/about-data-portal/en/, lastly accessed on 21st of April 2016

Table 1: Summary Statistics

VARIABLES	(1) mean	(2) sd	(3) min	(4) max	(5) N
Latitude	8.053	3.826	-0.367	16.67	15,546
Longitude	41.22	4.001	34.53	51.27	15,546
Elevation in meters	954.1	741.7	-119.5	4,140	15,546
Rain Avg	11.24	11.53	0	95.17	15,546
Mal Avg	6.503	5.046	0	31.17	15,546
FAO	6.155	1.932	0	9	15,546
popd_av60	15.20	37.41	0	2,554	15,546
popd_1920	9.613	24.31	0	2,794	15,546
popd_1930	10.49	28.48	0	3,313	15,546
popd_1940	10.73	11.06	0	95	15,546
popd_1950	11.60	12.10	0	154	15,546
popd_1970	19.23	47.45	0	3,158	15,546
popd_1980	24.81	73.78	0	6,490	15,546
popd_1990	33.53	108.3	0	10,251	15,546
popd_2000	44.36	144.0	0	13,762	15,546
D<10km CSN	0.0117	0.108	0	1	15,546
D<10km CDC	0.0318	0.176	0	1	15,546
D<10km PCH	0.00264	0.0513	0	1	15,546
D<10km SCH	0.0342	0.182	0	1	15,546
D<10km CPR	0.0522	0.223	0	1	15,546
D>10km and <20km CPR	0.0493	0.217	0	1	15,546
D<10km CUR	0.0567	0.231	0	1	15,546
D<10km CRail	0.0113	0.106	0	1	15,546
D<10km PCT	0.147	0.354	0	1	15,546
D<10km Rivers	0.320	0.466	0	1	15,546
D Mining	0.143	0.350	0	1	15,546
D<30km coast	0.133	0.340	0	1	15,546
Loglight10av	-4.500	0.765	-4.605	4.103	15,546

6 Results

The first research question that this paper aims to answer is whether those areas, that were better connected during the colonial period, are more developed today. I begin by estimating equation 1. Firstly, I employ population density in 2000 as dependent variable, which constitutes a good approximation for concentration of the economic activities and development (Ciccone and Hall, 1996). Secondly, I estimate the same equation by using the logarithm of light density at night in 2010 as left hand-side variable, a somehow more precise measure of economic activity (Michalopoulos and Papaioannou, 2013).

Table 2 reports the OLS estimates for population density in 2000. For all columns, standardized population density in 2000 is employed, regional colonial fixed effects are included and standard errors are clustered by 202 colonial provinces. The estimation in column 1 has no controls, in column 2, unpaved colonial roads are introduced, column 3 controls for pre-colonial factors, while columns 4 and 5 include colonial controls and geographical controls, respectively.

Column 5 shows that cells located within 10km from colonial paved roads are, on average, 0.18 standard deviations more densely populated, once the full set of controls has been included in the equation. The introduction

of controls such as pre-colonial population density and distance from pre-colonial tracks in column 3 does not significantly reduce the magnitude of the coefficient, partially tackling the endogeneity issue. By contrast, the introduction of colonial controls, in column 4, and of geographical controls, in column 5, reduce the coefficient by about 40% and 30% respectively, possibly pinpointing the importance of other colonial activities and environmental factors in explaining population distribution in 2000. Nonetheless, as opposed to colonial unpaved roads, the coefficient of my explanatory variable of interest remains positive, large and statistically significant at the 1% level.

Table 2: The long-term effect of colonial roads on population density

	(1)	(2)	(3)	(4)	(5)
	zPopD 2000	zPopD 2000	zPopD 2000	zPopD 2000	zPopD 2000
$D10CPR$	0.502***	0.492***	0.442***	0.251***	0.185***
	(0.121)	(0.121)	(0.117)	(0.056)	(0.051)
$D20CPR$	0.247***	0.242***	0.201***	0.128	0.075
	(0.060)	(0.059)	(0.056)	(0.082)	(0.079)
$D10CUR$		0.219***	0.197***	0.144**	0.112*
		(0.056)	(0.056)	(0.062)	(0.061)
D<10km PCT			0.129***	0.135***	0.108***
			(0.033)	(0.036)	(0.034)
zPopD 1920			0.129***	0.095**	0.091**
			(0.037)	(0.044)	(0.041)
zPopD 1930			-0.044	-0.046	-0.051
			(0.041)	(0.041)	(0.038)
D<10km CRail				0.520	0.529
				(0.456)	(0.459)
D<10km CDC				0.152***	0.117**
				(0.050)	(0.047)
D<10km SCH				0.198***	0.154***
				(0.065)	(0.058)
D<10km PCH				3.039	3.150
				(2.236)	(2.238)
D<10km CSN				0.424*	0.371*
				(0.220)	(0.220)
Observations	15,204	15,204	15,204	15,204	15,204
R-squared	0.22	0.22	0.24	0.28	0.29
Provincial FE	YES	YES	YES	YES	YES
Pre-colonial controls	NO	NO	YES	YES	YES
Colonial controls	NO	NO	NO	YES	YES
Geographical Controls	NO	NO	NO	NO	YES

Robust standard errors clustered by 202 provincial colonial districts in parentheses, *** p<0.01, ** p<0.05, * p<0.1

As underlined above, population density is a good approximation if one wants to estimate the concentration of the economic activity, but leaves room to uncertainty when it comes to disentangling this latter from actual living standards of the resident population. However, the replication of the previous exercise, with light density at night in 2010 as left-hand side variable, will allow me to make a stronger statement about the relationship between colonial infrastructure and contemporary levels of development.

Table 3 shows the results with light density as dependent variable. The natural logarithm of luminosity at night is used as dependent variable, while colonial regional fixed effects and clustered standard errors at a provincial level are reported in all columns. The different sets of controls are pro-

gressively introduced in columns 1 to 5, as for table 2. When no controls are added (column 1), cells located within 10km from major colonial roads are 53% more luminous and the coefficient is statistically significant at the 1% level. This coefficient drops by about 50% when colonial controls are introduced in column 4 while, as expected, it is not sensitive to geographical factors (Column 5). In column 6, population density in 2000 is added to the equation in order to disentangle its effect from the one of colonial transportation infrastructure. The coefficient of interest is robust to this additional control, showing that historically better connected cells are 26% more luminous today.

Table 3: The long term effect of colonial roads on light density

	(1) Loglight10av	(2) Loglight10av	(3) Loglight10av	(4) Loglight10av	(5) Loglight10av	(6) Loglight10av
$D10CPR$	0.521***	0.517***	0.499***	0.290***	0.277***	0.260***
	(0.097)	(0.097)	(0.096)	(0.072)	(0.071)	(0.072)
$D20CPR$	0.129***	0.127**	0.122**	0.042	0.032	0.025
	(0.050)	(0.049)	(0.049)	(0.037)	(0.038)	(0.038)
$D10CUR$		0.096**	0.090**	0.021	0.014	0.004
		(0.043)	(0.041)	(0.039)	(0.039)	(0.037)
zPopD 2000						0.094***
						(0.031)
D<10km PCT			0.067**	0.070**	0.067**	0.057*
			(0.032)	(0.032)	(0.032)	(0.031)
zPopD 1920			-0.011	-0.033***	-0.033***	-0.042***
			(0.011)	(0.012)	(0.012)	(0.009)
zPopD 1930			-0.008	-0.010	-0.011	-0.006
			(0.012)	(0.012)	(0.012)	(0.009)
D<10km CRail				0.363	0.373	0.323
				(0.302)	(0.301)	(0.279)
D<10km CDC				0.501***	0.500***	0.489***
				(0.116)	(0.117)	(0.115)
D<10km SCH				0.108	0.105	0.090
				(0.080)	(0.079)	(0.078)
D<10km PCH				0.622	0.639	0.342
				(0.405)	(0.408)	(0.416)
D<10km CSN				1.121***	1.115***	1.080***
				(0.216)	(0.216)	(0.213)
Observations	15,204	15,204	15,204	15,204	15,204	15,204
R-squared	0.12	0.12	0.12	0.19	0.19	0.20
Provincial FE	YES	YES	YES	YES	YES	YES
Pre-colonial controls	NO	NO	YES	YES	YES	YES
Colonial controls	NO	NO	NO	YES	YES	YES
Geographical Controls	NO	NO	NO	NO	YES	YES

Robust standard errors in parentheses clustered by 202 provincial colonial districts, *** p<0.01, ** p<0.05, * p<0.1

In order to further underscore the relationship between proximity to colonial transportation infrastructure and present-day development and to make sure that I am measuring higher living standards and not a mere concentration of people (which might be connected with congestion effects), I employ the Ethiopian DHS database from 2011. As explained above, for each individual I have selected a set of variables that inform about his profession, his access to media and his preferred methods of payment. If population and night density are good approximations of economic development, I expect those Ethiopians who live in proximity of colonial roads to be more likely to be employed in the tertiary sectors, to access newspapers, radio and televi-

sion more often and to pay in cash. All these indicators are excellent proxies for living standards. In particular, employment by sector allows inferences on income, since governmental statistics show that the average salary in the tertiary sector exceeds the ones in manufacturing and agriculture.

Table 4 includes 3 separate panels and reports the results from equation 2. Panel A looks at the effect of roads on employment by sector, panel B at media accessibility and, finally, panel C explores the relationship between proximity to colonial roads and forms of payment. The employed model is a Probit and marginal effects reported for every estimation. Similarly to tables 2 and 3, pre-colonial, colonial, geographical and environmental controls are included and the standard errors are clustered by colonial province. Consistently with my main hypothesis, the data clearly show that regions, historically endowed with modern transportation infrastructure, perform substantially better today. In fact, Ethiopian males, who live less than 10km away from primary colonial roads, are 4% more likely to be professors, technicians or managers, have about 5% more chances to be employed in sales or to be skilled manuals and 1.5% more likely to be employed in services. Most importantly, Ethiopians are about 34% less likely to be involved in agriculture if they live next to colonial paved roads. All the mentioned coefficients are also statistically significant at the 1% level.

Results from panels B and C are consistent with these estimates. People living in historically better connected areas are not only more likely to be employed in the tertiary sector, but are also 30% more likely to perform transactions in cash only and 17% less likely to use both cash and kind in the same transaction. Moreover, panel B informs about the higher accessibility to media enjoyed in the treated locations: people in these zones are 9%, 14% and 27% more likely to access newspapers, radio or television, respectively, and between 7 and 25% less likely not to access them at all. Once more, all the described coefficient are statistically significant with a 99% confidence interval. Very similar results apply to unpaved colonial roads, although the size of the coefficients is smaller.

Table 4: Colonial roads and present day development indicators. Probit estimations

Panel A: Profession									
	(1) not working	(2) prof/tech/man	(3) clerical	(4) sales	(5) agric-employee	(6) services	(7) skilled manual	(8) unskilled manual	(9)
$D10CPR$	0.0358***	**0.0434*** **	0.00975***	**0.0480*** **	**-0.341*** **	**0.0150*** **	**0.0559*** **	0.00939***	
	(0.00732)	(0.00889)	(0.00279)	(0.0134)	(0.0527)	(0.00360)	(0.0128)	(0.00332)	
$D10CUR$	0.00484	0.0129	-0.000115	**0.0313** **	**-0.180*** **	-0.00427	**0.0395*** **	0.00591*	
	0.00856	0.00905	0.00304	0.0147	0.0571	0.00359	0.0124	0.00325	
Panel B: Access to Media									
	Newspapers not at all	Newspapers $<$ 1 a week	Newspapers $>$ 1 a week	Radio not at all	Radio $<$ 1 a week	Radio $>$ 1 a week	Television not at all	Television $<$ 1 a week	Television $>$ 1 a week
$D10CPR$	**-0.209*** **	0.0747***	**0.0942*** **	**-0.0787*** **	-0.0773***	**0.139*** **	**-0.249*** **	-0.0931***	**0.274*** **
	(0.0333)	(0.0209)	(0.0176)	(0.0225)	(0.0255)	(0.0307)	(0.0393)	(0.0287)	(0.0402)
$D10CUR$	**-0.0655** *	-0.0119	**0.0590*** **	0.0238	-0.0636***	0.0396	-0.0530	-0.0911***	**0.116*** **
	(0.0337)	(0.0198)	(0.0181)	(0.0207)	(0.0246)	(0.0280)	(0.0413)	(0.0328)	(0.0401)
Panel C:Method of payment									
	Not paid	Cash only	Cash and in-kind	In-kind only					
$D10CPR$	-0.120***	**0.303*** **	**-0.179*** **	-0.00726					
	(0.0239)	(0.0444)	(0.0415)	(0.00792)					
$D10CUR$	-0.0143	**0.173*** **	**-0.168*** **	-0.00118					
	(0.0243)	(0.0477)	(0.0498)	(0.00719)					
Individual Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Baseline Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	13,528	13,528	13,528	13,528	13,528	13,528	13,528	13,528	13,528

Robust standard errors clustered by clusters of DHS survey in parentheses. Columns 1 to 9 individual controls: age and ethnicity. Columns 1 to 9 baseline controls: latitude, longitude, elevation of the cluster, distance of the cluster from a colonial school for natives, distance of the cluster from a colonial district capital, distance from the coast, distance from a colonial railroad, distance from a perennial river, distance from pre-colonial tracks, distance from mineral area, rainfall annual average, FAO land propensity index, population density in 1920, population density in 2000, distance from contemporary road. *** p<0.01, ** p<0.05, * p<0.1

To summarize the results from tables 2, 3 and 4, it is possible to see how different indicators give consistent estimates on the higher levels of development experienced today, by historically better connected areas. Despite the limited extension of the colonial road network, the destruction occurred during WWII and the poor maintenance between 1941 and 1950, colonial roads had a persistent effect on the economies of the Horn of Africa. Historically better connected areas are not only more populous, but also more luminous at night and have an economy more oriented towards the tertiary sector, that most likely employs cash in transactions. The resident population is, on average, wealthier and has better access to media. All together these results tell us that in contemporary Ethiopia, Eritrea and Somalia areas that lie next to paved Italian colonial paved roads have more intense economic activity, are inhabited by people with higher income and are, on average, more developed.

7 Robustness checks

The consistency of the results across the different estimations of section 5, the introduction of fixed effects, the numerous controls included, along with the historical qualitative evidence provided, already reassure about the possibility that the measured relationship is spurious. Nevertheless, my previous calculations do not completely eliminate the risk that colonial roads were placed endogenously. In order to address this issue, I focus on population density in 2000, which I consider my main dependent variable. In order to make sure that the relationship between historical investments and present-day development is of causal type, I employ two main strategies. Firstly, following a well established methodology in the related literature (Michaels, 2008), I instrument distance from colonial roads with distance from straight lines connecting major cities. This strategy is based upon the reasonable assumption that artificially drawn straight lines are a good proxy for roads and, at the same time, are unlikely to be correlated with anything in the error term I am not controlling for. Secondly, I employ roads projected by the Italian government, that were not completed due to the outbreak of WWII, as placebo test. As opposed to other similar exercises performed in related papers (Jedwab and Moradi, 2015; Berger and Enflo, 2015), the Italian case study offers a much higher level of randomness with respect to the reasons why some roads were projected but not completed: WWII is certainly exogenous to the road construction process in the Horn of Africa.

Table 5 reports my main robustness checks for the effect of colonial roads on population distribution in 2000. Column 1 is the baseline from table 2, column 2 and 3 show the first and second stage of my IV estimation, respectively. Column 4 shows the placebo estimates while, in column 5, I add contemporary roads as additional control and, in column 6, I replicate

the analysis employing bigger cells (30x30km) in order to address possible spatial correlation. All the different strategies support the hypothesis that road construction in the 1930s has causally determined higher levels of economic activity and development today. As it is visible in column 2, distance from straight lines is a good instrument, this being positively, strongly and significantly correlated with distance from colonial paved roads. Once the endogenous component of my explanatory variable of interest is eliminated in the second stage regression (column 3) the coefficient is still positive and statistically significant at the 1% level. The larger (compared to the baseline) size of the coefficient is not worrisome, since it is likely to be correcting for measurement error of distance from colonial roads. As expected, placebo lines have no effect on present day population density: the coefficient of the dummy variable for being within 10km from a placebo line is about 60% smaller than the baseline's coefficient and statistically insignificant. Finally, adding contemporary roads, in column 5, and using larger cells as units of observation, in column 6, does not eliminate the effect.

Table 5: Robustness check for the effect of colonial roads on population density in 2000

	(1) Baseline	(2) IV First Stage PAV	(3) IV	(4) PLACEBO	(5) Cont. Roads	(6) 30km Grid
$D10CPR$	0.185***		2.203***		0.166***	0.489**
	(0.051)		(0.764)		(0.049)	(0.221)
$D20CPR$	0.075	-0.238***	0.528***	0.033	0.067	0.388***
	(0.079)	(0.022)	(0.183)	(0.077)	(0.079)	(0.097)
$D10CUR$	0.112*	-0.012	0.118*	0.095	0.096	0.244**
	(0.061)	(0.012)	(0.064)	(0.060)	(0.059)	(0.103)
D<10km IV lines		0.102***				
		(0.028)				
D<10km Proj.CR				0.085		
				(0.054)		
Observations	15,204	15,204	15,204	15,204	15,204	1,713
R-squared	0.29	0.28	0.15	0.29	0.30	0.54
F	n	66.20	n	n	n	n
Geographical Controls	YES	YES	YES	YES	YES	YES
Provincial FE	YES	YES	YES	YES	YES	YES
Precolonial Controls	YES	YES	YES	YES	YES	YES
Colonial Controls	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses clustered by 202 provincial colonial districts, *** p<0.01, ** p<0.05, * p<0.1

Tables 10 and 11, in the appendix, report additional robustness checks for the effect of roads on population density in 2000 and light density at night in 2010, respectively. In table 10, I apply the same robustness checks to light density at night. The results are very similar to the ones I obtain for population density in 2000.[25] In table 11, I firstly restrict the sample to locations within 200km from colonial paved roads (column 2) and 100km (column 3); despite the substantial drop of the number of observations the

[25]The only noticeable exception is the second stage of the IV estimation, which has the expected sign, but no statistical significance

effect of paved colonial roads remains positive and statistically significant. Secondly, I replicate the estimation with different sets of fixed effects, in order to make sure I am not capturing the effect of unobservable factors at either a different colonial administrative or an ethnic level. Provincial administrative boundaries (Residenze), and governments (Governi), along with ethnic boundaries from Murdock are included in columns 4, 5 and 6, respectively. Finally, in column 7, I estimate the baseline equation with Conley standard errors robust to spatial correlation. My results do not significantly change for any of the proposed alternative estimations, which eventually demonstrate the causal impact that Italian colonial roads had on the economies of Eritrea, Somalia and Ethiopia.

8 Mechanisms

The analysis performed in the previous sections successfully underscored the relevance of looking at the colonial past of the Horn of Africa's countries if one wants to explain the contemporary economic landscape of this region. But this raises even more questions: how could the effect of roads persist for so long after their construction? What are the mechanisms that made historically better connected locations more developed today? In other words, why are these areas richer? Understanding the dynamics triggered by transportation infrastructure, will not only make the recent economic history of the Horn of Africa more comprehensible, by linking the colonial heritage to today's situation. This exercise will also deepen our knowledge of the determinants of subregional development for all countries that have experienced a technological revolution in transportation, similarly to former Italian colonies.

I exploit the dynamic component of my main dependent variable, population density. This allows me to track the varying impact of colonial roads over time and to disentangle their direct effect from the indirect one. The underling assumption of this section is that, consistently with the results for the early 2000s, population density is also a good proxy for economic development throughout the period between 1920 and 2000. As explained in section 4, I will consider three main mechanisms through which colonial roads might have affected the economies of Eritrea, Ethiopia and Somalia. Firstly, colonial roads could have fostered economic concentration directly, due to the comparative advantage they provided in terms of transportation costs. Secondly, colonial roads could have also triggered growth indirectly, thanks to an agglomeration mechanism and to increasing returns to scale (Krugman, 1991). Thirdly, colonial roads could have sustained higher levels of economic activity through the "coordination" mechanism (Jedwab, Kerby, and Moradi, 2016), in other words, by creating an incentive for the government to invest more in better connected locations.

8.1 The effect of colonial roads in historical perspective

With this general framework in mind, I start to explore the channels of persistence by studying the transformation of the effect of colonial roads over time. At which point in time has the effect roads emerged? How has this changed over time?

In table 6, I estimate equation 1 employing normalised population density between 1930 and 2000 as dependent variable. As expected, colonial roads built between 1936 and 1940 have no effect on population density in 1930. By contrast, the results show that the effect of colonial infrastructure emerges already by the end of the Italian occupation, in 1940, witnessing an extremely rapid adaptation of the local economy to colonial investments in transportation. The effect is identical in 1950, after a decade of financial hardship for the independent Ethiopian government, that was not able to implement any relevant infrastructural program. The road network did not expand further during this period and the economy generally stagnated (Bekele, 1995, p. 9), which potentially justifies the constant effect that colonial roads exerted during the period. For both 1930 and 1940, cells located next to colonial roads are 0.13 standard deviations more densely populated, with coefficients statistically significant at the 1% level.

The coefficient of interest increases by about 60% between 1950 and 1960, meaning that proximity to paved roads translated into a 0.3 standard deviations increase in population density in 1960. This reveals that the effect exerted by colonial infrastructures on the location of the economic activity reached its peak between 1950 and 1960, in coincidence with the first period of moderate growth (average of 3% per annum) for the regional economy (Bekele, 1995, p. 16) and, more interestingly, with the "First Highway Plan", launched by the Imperial Ethiopian government between 1951 and 1957. This plan was mainly aimed at reconstructing the existing Italian roads, which could partially explain their increased effect in 1960 (Emmenegger, 2012, p. 17).

After 1960 the effect of colonial paved roads remained stable, with the coefficients moderately decreasing in size throughout the 1960s and 1970s. During these two decades, Eritrea and Ethiopia witnessed a steady growth of the aggregate output (Bekele, 1995) and per capita income,[26] whereas regional inequality kept increasing especially after the outbreak of the Eritrean independence war in 1961 (Zewde, 2001, p. 219). During this period major construction works of both main and rural roads were undertaken, in the context of the 2nd to 5th "Highway Plans" implemented by the Imperial government and the 6th one (Emmenegger, 2012, p.17), which was developed after the communist revolution of 1974 (Henze, 2000, pp. 282-7).

The progressive moderate decline of the effect of colonial roads continues in the 1980s and 1990s, during a period of major political changes and

[26] See picture 3, appendix

economic setback (Henze, 2000, pp. 308-34). The effect of colonial paved roads drops by about 12% between 1980 and 2000. During these decades, that witnessed the violent civil war between the supporters of the Communist government (Derg) and the more liberal EPRDF, which seized power in 1991, and a terrible economic crisis during the 1980s,[27] the strongest infrastructural improvements were achieved in rural roads construction, that became a priority for both governments (Emmenegger, 2012, pp. 17-9).

Table 6: The effect of colonial roads over time (1930-2000)

	(1) zPopD 1930	(2) zPopD 1940	(3) zPopD 1950	(4) zPopD 1960	(5) zPopD 1970	(6) zPopD 1980	(7) zPopD 1990	(8) zPopD 2000
D <10km CPR	0.034	0.134***	0.134***	0.301***	0.292***	0.210***	0.187***	0.185***
	(0.073)	(0.048)	(0.048)	(0.076)	(0.069)	(0.057)	(0.052)	(0.051)
D >10km and <20km CPR	0.030	0.096**	0.090***	0.174**	0.151**	0.082	0.075	0.075
	(0.029)	(0.037)	(0.034)	(0.073)	(0.065)	(0.074)	(0.079)	(0.079)
D <10km CUR	0.061	-0.014	0.006	0.167**	0.174**	0.140**	0.114*	0.112*
	(0.059)	(0.029)	(0.028)	(0.073)	(0.072)	(0.066)	(0.061)	(0.061)
<10km from PCT	0.002	0.014	0.013	0.107***	0.108***	0.102***	0.110***	0.108***
	(0.015)	(0.020)	(0.020)	(0.036)	(0.034)	(0.032)	(0.034)	(0.034)
zPopD 1920	-0.197*	0.083	0.072	0.110**	0.099*	0.126***	0.101**	0.091**
	(0.116)	(0.054)	(0.047)	(0.044)	(0.057)	(0.048)	(0.043)	(0.041)
zPopD 1930		0.067	0.060	-0.054	-0.068	-0.067	-0.057	-0.051
		(0.056)	(0.050)	(0.043)	(0.058)	(0.046)	(0.040)	(0.038)
D <10km from CR	0.535	0.168*	0.165	0.474	0.507	0.610	0.547	0.529
	(0.414)	(0.095)	(0.105)	(0.345)	(0.323)	(0.431)	(0.458)	(0.459)
D <10km from CDC	-0.019	0.091**	0.120***	0.063	0.143**	0.089*	0.112**	0.117**
	(0.027)	(0.039)	(0.042)	(0.075)	(0.062)	(0.052)	(0.047)	(0.047)
D <10km from SCH	0.044	0.099*	0.106**	0.270***	0.179**	0.191***	0.156***	0.154***
	(0.030)	(0.052)	(0.052)	(0.084)	(0.070)	(0.063)	(0.058)	(0.058)
D <10km from PCH	-0.253	0.037	-0.006	2.908*	2.500	3.042	3.116	3.150
	(0.156)	(0.182)	(0.207)	(1.680)	(1.581)	(2.065)	(2.217)	(2.238)
D <10km from CSFR	-0.039	-0.075	-0.005	0.449**	0.503**	0.383*	0.370*	0.371*
	(0.042)	(0.085)	(0.098)	(0.204)	(0.210)	(0.208)	(0.218)	(0.220)
Observations	15,204	15,204	15,204	15,204	15,204	15,204	15,204	15,204
R-squared	0.30	0.82	0.78	0.42	0.43	0.35	0.30	0.29
Provincial FE	YES	YES	YES	YES	YES	YES	YES	YES
Geographical Controls	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses clustered by 202 provincial colonial districts, *** p<0.01, ** p<0.05, * p<0.1

Interestingly, a positive and statistically significant effect of colonial unpaved roads and pre-colonial tracks emerges in 1960 and persists until 2000. Although, the employed data do not allow to explain this trend empirically, it is possible to put forward the hypothesis that, since the infrastructural development plans of the Imperial Ethiopian government had also paved parts of secondary colonial roads between 1950 and 1970, these cells also started offering a comparative advantage in transportation, which might have attracted more firms and, consequently, population in these locations. This would be reflected in the magnitude of both coefficients that reach their peak in 1970. After that date they lose part of their advantage, but none the less remain more developed compared to other regions.

To summarize the results from table 6 we can split our period of analysis into 4 parts, which witness different trends with respect to the effect of colonial primary roads on economic development. The first period, that

[27] See picture 3, appendix

goes from 1930 to 1940, sees a strong impact of colonial roads on the local economies with better connected cells becoming 0.13 standard deviations more developed by end of the colonial era from no effect in 1930. The second period, going from 1940 to 1950, experiences a stagnation of the impact of the colonial infrastructural revolution. Historically better connected location maintain their previous advantage, but do not attract additional economic activity. Thirdly, during the 1950s, in coincidence with the revival of the Ethiopian economy, the effect of roads almost triples, with historically better connected cells increasing the gap with the rest of the territory. By 1960, these zones were 0.3 standard deviations more developed compared to the rest of the studied region. Finally, the period going from 1960 to 2000 sees a moderate decline of the effect of colonial roads, which remains positive and significant, but goes back to the levels observed at end of the colonial era.

8.2 Direct vs indirect of effect of colonial infrastructure. Market potential, colonial roads and amenities.

Now that the trends of the effect of colonial roads have been studied from a historical perspective, I turn my attention to explaining the channels through which colonial investments in infrastructure have shaped the economic development of the Horn of Africa between 1930 and 2000. The analysis of the interplay between the different mechanisms will unveil the real determinants of the causal effect that Italian colonial roads had on East African development over time. The main task for this section is to disentangle the relative importance of the direct effect that colonial roads had on economic concentration through lower transportation costs, from the indirect one, given by agglomeration and increased market potential.

Table 7 reports the results from equation 3. The estimates show that the direct effect exerted by colonial infrastructure is in place only in two periods, namely during the 1930s and 1950s. As it is visible in column 1, the emergence of colonial roads' effect in 1940 (column 2, table 6) can be fully explained by the direct effect of colonial roads, which directly fostered economic growth within a 20km radius from them. As expected, market potential in 1930 does not have any significant effect on population density in 1940, whereas amenities play a role in shaping population distribution in this period, but do not kill the direct effect of roads. If one looks at column 2 instead, it is clear how, during the 1940s, a period of economic stagnation and lack of any significant investment in infrastructure, the situation was reversed: colonial roads do not have any significant direct effect on population density in 1950, while market potential fully captures the colonial infrastructure's effect, showed in column 3 of table 6. A unit increase in market potential in 1940 predicts a 0.04 standard deviations increase in population density in 1950, with the coefficient being statistically significant

at the 1% level. Conversely, external market potential has a negative and statistically significant impact of 0.03 standard deviations on my dependent variable, which possibly mirrors a phenomenon of urban migration from the countryside to nearby towns during the 1940s.

The decade between 1950 and 1960 was an era of major changes in the geographical distribution of the economic activity in the Horn of Africa. In this period, which saw the strongest effect of colonial roads on population density (table 6, column 4), the direct effect of colonial roads boomed, with historically better connected areas becoming 0.47 standard deviations more developed than the average. Direct and indirect market potentials in 1950 also played a role in shaping the distribution of the economic activity during this period: both have a positive and statistically significant impact on population density in 1960, but do not eliminate the effect directly exerted by Italian roads. In sum, the strong effect that colonial roads had on population density in 1960 is a combination of direct attraction due to comparative advantage in transportation costs and indirect, through increased market potential in 1950. As underscored in the previous section, the 1950s were a decade of both sustained growth for the economy and of reconstruction of the colonial road network, which would explain the importance of both direct and indirect effect of colonial roads.

A different mechanism appears to be in place during the 1960s: not only the positive direct effect of colonial roads vanishes, but it even becomes negative, possibly mirroring the loss of comparative advantage in transportation cost, due to the construction of new roads. The positive effect of colonial roads between 1960 and 1970, measured in column 5 of table 6, is therefore fully accounted for by internal market potential in 1960, which produces a 0.02 standard deviations increase in economic activity for every unit. By contrast, the effect of external market potential becomes negative again, although smaller in size compared to 1950; this probably points out the gravitational attraction that more important urban centers were exerting on the location of economic activities during the roaring growth of the 1960s.

After 1970 the situation becomes more stable. The economies of the Horn of Africa seem to have reached a strongly resilient productive equilibrium, despite the major political shifts described in section 7.1. Colonial roads do not exert any direct effect between 1970 and 2000, with the coefficients of this variable becoming negative and statistically significant for the 1980s and 1990s, mirroring a loss of comparative advantage in transportation, probably due to the extension of the road network. The direct effect of amenities also becomes negative, picturing an economic environment increasingly less dependent upon exogenous factors. The effect of external market potential evaporates as well, whereas the persistence of the effect of colonial infrastructure relies on internal market potential only. During the entire sub-period, a one unit increase in this latter keeps rising population

density by between 0.007 and 0.013 standard deviations.

Table 7: Colonial Roads, Market Potential and Amenities 1930-2000

VARIABLES	(1) zPopD 1940	(2) zPopD 1950	(3) zPopD 1960	(4) zPopD 1970	(5) zPopD 1980	(6) zPopD 1990	(7) zPopD 2000
$D10CPR$	0.354***	0.035	0.468***	-0.105*	-0.127	-0.113*	-0.100**
	(0.095)	(0.027)	(0.125)	(0.056)	(0.086)	(0.066)	(0.047)
$D20CPR$	0.246***	0.025	0.201**	-0.079**	-0.098	-0.065	-0.052*
	(0.075)	(0.023)	(0.080)	(0.035)	(0.069)	(0.045)	(0.032)
$Dhighlands$	0.391***	0.009	0.547***	-0.117*	-0.248	-0.202*	-0.168**
	(0.076)	(0.027)	(0.065)	(0.068)	(0.155)	(0.106)	(0.072)
InMP_1930	0.007						
	(0.006)						
ExMP_1930	-0.008						
	(0.008)						
InMP_1940		0.046***					
		(0.002)					
ExMP_1940		-0.030***					
		(0.002)					
InMP_1950			0.012***				
			(0.002)				
ExMP_1950			0.029***				
			(0.002)				
InMP_1960				0.017***			
				(0.001)			
ExMP_1960				-0.008**			
				(0.004)			
InMP_1970					0.013***		
					(0.003)		
ExMP_1970					-0.004		
					(0.005)		
InMP_1980						0.009***	
						(0.002)	
ExMP_1980						-0.007	
						(0.005)	
InMP_1990							0.007***
							(0.001)
ExMP_1990							-0.005*
							(0.003)
Observations	15,544	15,544	15,544	15,544	15,544	15,544	15,544
R-squared	0.67	0.93	0.31	0.90	0.80	0.88	0.93
Colonial State FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses clustered by 202 provincial colonial districts, *** p<0.01, ** p<0.05, * p<0.1

8.3 Colonial roads and the coordination mechanism

This section examines the second indirect mechanism through which colonial roads might have caused higher economic concentration over time, the "coordination" effect that colonial infrastructure exerted over the allocation of other types of governmental facilities and infrastructure. According to this hypothesis, the higher levels of development observed next to colonial roads between 1940 and 2000 (Table 6), would also be the outcome of a third mechanism, which consisted in the preference that the different governments gave to historically better connected areas when it came to choosing where to allocate new investments. As a first step, in order to check this hypothesis, I examine to what extent the location of colonial roads explains the placement of colonial hospitals and schools and post-colonial roads.

Table 2 reports the marginal effects of the probit estimation from equa-

tion 4. As it is visible in columns 1 to 3, colonial roads have a strong predictive power with respect to the placement of sanitary and scholastic facilities for the African population during the colonial period. Cells located next to paved roads were 3% more likely to be close to a primary colonial hospital, almost 9% more probably located next to secondary colonial hospital and 6% more likely to be next to a school for Africans. Similar results apply to cells located between 10 and 20km from paved roads. A problem of reverse causality is unlikely to arise, due to the qualitative evidence shows that the construction of the majority of the mentioned facilities during the colonial era only happened after the construction of roads.[28] Colonial roads also perform well in predicting network connectivity in the post colonial period. In fact, as columns 4 to 7 show, historically better connected cells are more likely to be located next to all weathers tracks between 1955 and 1988, with coefficients ranging from 20 to 44%. The effect is positive and significant despite the introduction of population density in $t-1$ as a control. This pinpoints how the new infrastructure was placed following a path-dependent mechanism, that did not necessarily take demographics into account.

Finally, columns 8 and 9 relate historical investments to contemporary location of welfare facilities. This exercise aims to understand whether colonial roads could affect economic development over time due to the continuous relocation of state facilities, such as hospitals and schools, in the same areas. In case this relationship holds for 2000 I would reasonably expect this effect to be similar or even stronger for the previous decades. The lack of additional data between 1950 and 2000 makes this last point weaker than the rest of the analysis, but the purpose is simply to suggest another channels through which sunk colonial capitals could affect East African development in the long-run.

Colonial roads have no direct effect on the location of contemporary hospitals and schools, but the indirect one through sanitary and scholastic colonial sunk investments is strong and significant, even when population density in 2000 is introduced as a control. Being next to a colonial secondary hospital increases the likelihood of living next to a contemporary one by 7%, while colonial schools increase the probability of living next to a contemporary school by more than 10%.

[28] See historical framework, section 2

Table 8: Coordination mechanism: how colonial roads attracted other investments.

	(1) D <10km PCH	(2) D <10km SCH	(3) D <10km CSN	(4) D10km AWR 1955	(5) D10km AWR 1962	(6) D10km AWR 1973	(7) D10km AWR 1988	(8) D10km ContHosp	(9) D10km ContScho
D <10km CPR	0.029***	0.088***	0.057***	0.442***	0.196***	0.299***	0.384***	0.011	0.008**
	(0.010)	(0.019)	(0.014)	(0.052)	(0.037)	(0.043)	(0.047)	(0.010)	(0.003)
D >10km and <20km CPR	0.010**	0.034***	0.021***	0.180***	0.061***	0.085***	0.116***	0.008	0.005*
	(0.005)	(0.011)	(0.006)	(0.028)	(0.019)	(0.019)	(0.026)	(0.008)	(0.002)
D<10km CUR	0.001	0.050***	0.010**	0.052**	0.007	0.073***	0.095**	0.003	0.003
	(0.001)	(0.012)	(0.004)	(0.025)	(0.006)	(0.023)	(0.038)	(0.005)	(0.003)
zPopD 1940				0.010***					
				(0.003)					
zPopD 1950					0.004***				
					(0.002)				
zPopD 1960						0.016**			
						(0.006)			
zPopD 1980							0.029*		
							(0.015)		
D <10km PCH								-0.009	
								(0.008)	
D <10km SCH								0.070*	
								(0.042)	
zPopD 2000								0.015	0.004***
								(0.012)	(0.001)
D <10km CSN									0.105***
									(0.034)
Observations	15,546	15,546	15,546	15,546	15,546	15,546	15,546	15,546	13,474
Precolonial Controls	YES	YES	YES	NO	NO	NO	NO	NO	NO
Colonial Controls	NO	NO	NO	YES	YES	YES	YES	NO	NO
Geographical Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses clustered by 202 provincial colonial districts, *** p<0.01, ** p<0.05, * p<0.1

Table 8 has proved that areas located next to colonial roads were also more likely to receive more governmental expenditures in infrastructural, schooling and healthcare facilities, during both the colonial and post-colonial periods. I now want to study whether this "coordination" phenomenon has played a role in assuring to historically better connected areas persistent higher levels of development over time. In order to answer this question, I re-estimate equation 3 through OLS, this time controlling for the dependent variables, employed of table 8. In other words, I add distance from colonial schools and hospitals and post-colonial roads as control variables to equation 3. The idea of this exercise is that if part of the effect of colonial roads can be explained by the attraction of other types of investments, the introduction of these in the estimation should reduce the other coefficients significantly.

Table 9 shows the results of this exercise. Column 1 provides evidence of the importance of the coordination mechanism in explaining the aggregate effect of colonial roads in the late 1930s: the coefficients of both secondary colonial hospitals and schools are positive and significant at the 1% level. Their combined action reduces the coefficient of colonial paved roads by about 15% compared to table 7 (see table 7, column 1), proving that only part of the effect of colonial infrastructure measured in table 7 was actually direct. As expected, facilities build at the end of the decade do not significantly change the incidence of market potential in 1930.

With regard to the effect of my explanatory variables on economy concentration in 1950, there are no major changes from column 2, table 7. Interestingly, secondary colonial hospitals continued to attract population during the 1940s with these areas being, on average, 0.18 standard deviations more populous than the rest of the region. The coefficient of paved roads becomes negative once the new controls are added. The indirect effect of roads through the coordination mechanism maintains its importance during the 1950s. As shown in column 3, in fact, the introduction of distance from colonial facilities and all weather roads into the equation significantly reduces both the direct effect of colonial paved roads and its indirect effect through external market potential. The coefficients of these two variables drop by about 54 and 20%, respectively. Again, 1960 marks a turning point, with the situation becoming more stable and with colonial sunk investments progressively losing importance and finally becoming negative.

In conclusion, the indirect effect of roads through "coordination" of other investments played an important role between 1930 and 1960, in coincidence with the strong direct effect of colonial infrastructure. After this date, the persistence of the effect depended only upon internal market potential, as already underscored by the results in table 7.

Table 9: Coordination mechanism. Colonial roads and the attraction of other investments

	(1) zPopD 1940	(2) zPopD 1950	(3) zPopD 1960	(4) zPopD 1970	(5) zPopD 1980	(6) zPopD 1990	(7) zPopD 2000
$D10CPR$	0.301***	-0.006	0.218**	-0.099**	-0.067	-0.074	-0.117**
	(0.095)	(0.019)	(0.095)	(0.050)	(0.052)	(0.049)	(0.053)
$D20CPR$	0.229***	0.012	0.111	-0.075**	-0.077	-0.048	-0.056*
	(0.076)	(0.020)	(0.075)	(0.031)	(0.056)	(0.037)	(0.032)
D <10km PCH	0.005	0.226	3.022*	0.606	1.537*	0.889*	0.853**
	(0.236)	(0.190)	(1.670)	(0.377)	(0.788)	(0.453)	(0.406)
D <10km SCH	0.233***	0.179***	0.219**	-0.012	0.019	0.055	0.042
	(0.062)	(0.029)	(0.091)	(0.038)	(0.066)	(0.048)	(0.054)
D <10km CSFN	0.258***	0.144	0.384*	0.234**	-0.014	0.024	-0.007
	(0.096)	(0.088)	(0.219)	(0.091)	(0.113)	(0.091)	(0.068)
d_highlands	0.373***	-0.002	0.534***	-0.110*	-0.221	-0.185*	-0.162**
	(0.075)	(0.025)	(0.062)	(0.062)	(0.136)	(0.094)	(0.069)
InMP_1930	0.007						
	(0.006)						
ExMP_1930	-0.010						
	(0.010)						
InMP_1940		0.046***					
		(0.002)					
ExMP_1940		-0.032***					
		(0.002)					
InMP_1950			0.012***				
			(0.002)				
ExMP_1950			0.023***				
			(0.003)				
D10_AWR_1955			0.208***				
			(0.078)				
InMP_1960				0.017***			
				(0.001)			
ExMP_1960				-0.010**			
				(0.004)			
D10_AWR_1962				-0.091			
				(0.081)			
InMP_1970					0.013***		
					(0.003)		
ExMP_1970					-0.006		
					(0.006)		
D10_AWR_1973					-0.218*		
					(0.126)		
InMP_1980						0.010***	
						(0.001)	
ExMP_1980						-0.008*	
						(0.005)	
D10_AWR_1988						-0.136*	
						(0.073)	
InMP_1990							0.007***
							(0.001)
ExMP_1990							-0.006*
							(0.003)
Observations	15,544	15,544	15,544	15,544	15,544	15,544	15,544
R-squared	0.67	0.93	0.35	0.90	0.80	0.88	0.93
Colonial State FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

9 Conclusion

In this paper, I have exploited the natural experiment, provided by Italian road construction in Eritrea, Somalia and Ethiopia between 1935 and 1940, to study the effect that colonial revolutions in transportation technology had on the economic landscape, along with the mechanism that explain this phenomenon.

Firstly, I have run regression analysis to check whether areas located next to colonial roads show significantly higher levels of development today. I have employed an IV strategy and a placebo treatment to make sure the measured relationship is not spurious. I found that cells and villages, located within a 10km radius from colonial paved roads, are significantly richer today. Secondly, I have studied the channels of persistence. The results show that the effect of colonial roads on economic activity (proxied by population density) emerged already by the end of the colonial period, in 1940, it stagnated during the 1940s, it reached its peak in 1960 and then declined smoothly between 1970 and 2000. The employment of the Krugman-Fujita economic geography model, in a dynamic cross-sectional regression framework, allowed me to disentangle the relative importance of the direct effect of roads through lower transportation costs and the indirect one, through increases in market potential. Lastly, I have measured the relative importance of the "coordination" mechanism.

In synthesis, my results pinpoint the following mechanism: by lowering transportation costs, colonial infrastructure attracted firms, workers and other public facilities during the colonial era. This direct effect persisted in the early post-colonial period, in particular, between 1950 and 1960; the "coordination" effect, that incentivised the independent government to rebuild colonial roads and to maintain schools and hospitals in the same locations, indirectly strengthened this effect. After 1960, however, historically better connected locations lost their comparative advantage in transportation, due to the implementation of new infrastructural plans. Nevertheless, the analysed areas maintained higher levels of development endogenously, due to initial increase in market potential. This indirect mechanism ultimately explains the persistent higher levels of development in historically better connected locations between 1960 and 2000. In other words, the economic landscape of the Horn of Africa was substantially modified by the direct effect of colonial investments between 1930 and 1960. At this point, the regional economy had reached a resilient spatial equilibrium that persisted until present.

The main limitations of my analysis originate from data availability and quality. On the one hand, I had to rely on proxies for present-day development, due the impossibility to find governmental income statistics at a sufficiently disaggregated level. On the other hand, I was forced to use population density as dependent variable for the vast majority of the estimations in the mechanism section and to calculate market potential as well. This did not allow me to distinguish between agglomeration and congestion, which might be worrisome, especially for periods of economic boom. Finally, DHS surveys are not available for Somalia and Eritrea, which makes my claims on these two countries weaker than for the rest of the Ethiopian territory. Despite it satisfactorily accounts for the mechanisms that explain the long-term impact of colonial transportation infrastructure, this paper does not

provide a clear explanation for the effect that roads construction had on the African economies during the colonial era. Further research in this direction would be extremely beneficial in order to understand the economic history of former Italian colonies and, more generally, the impact of European colonial activities. A work in this direction should focus on explaining the degree of market integration brought about by colonial institutions and activities and the nature of the agglomeration triggered by colonial roads, whether these were creating increasing returns to scale or congestion effects.

My results innovate the related literature in several ways. With respect to the existing research on the impact of colonial transportation infrastructure (Jedwab, Kerby, and Moradi, 2016), my analysis shows that the long-term effect of colonial roads on African countries is very similar to that of extensive railroad networks. Moreover, my study provides a much more sophisticated empirical explanation of the channels of persistence: thanks to my methodology, I was able to disentangle the relative importance of the diverse mechanisms through which colonial infrastructure has shaped the economic landscape of former colonies. More in general, with regard to the debate on the economic legacy of colonialism, my research strongly takes position in favour of the stream of the literature that looks at colonial investments to explain sub-regional inequality across the globe and proves that geography, colonial institutions and pre-colonial conditions do not matter, provided that the invested capitals are sufficient to provoke a large shock in the traditional pre-colonial economies. Finally, contrary to the predominant view in the literature on the economic history of the Horn of Africa, my work shows that not only the Italian colonial experience has had a significant effect on its former colonies, but also that this effect is still very strong today.

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10 List of Abbreviations

- ACS = “Archivio Centrale dello Stato” (Central State Archive)
- AOI = “Africa Orientale Italiana” (Oriental Italian Africa)
- ASAIC = “Archivio Storico dell’Agenzia Italiana per la Cooperazione e lo Sviluppo” (Archive of the former “Oversea Agricultural Development”)
- ASMAE = “Archivio Storico del Ministero degli Affari Esteri” (Historical Archive of the Ministry of Foreign Affairs)
- DHS = “Demographic and Health Survey”

- CDC = Colonial District Capital
- CPR = Colonial Paved Roads
- CSN = Colonial School for Natives
- CUR = Colonial Unpaved Roads
- ExMP = External Market Potential
- InMP = Internal Market Potential
- PCH = Primary Colonial Hospital
- PCT = Pre-Colonial Tracks
- Proj. CR = Projected Colonial Roads
- SCH = Secondary Colonial Hospital

11 Appendix

Table 10: Additonal robustness checks for table 3

	(1) Baseline	(2) < 200km	(3) <100km	(4) Province FE	(5) State FE	(6) Ethnic FE	(7) Conley SE
D <10km CPR	0.185***	0.166***	0.166***	0.238***	0.173***	0.185***	0.185***
	(0.051)	(0.050)	(0.051)	(0.055)	(0.062)	(0.056)	(0.036)
D >10km and <20km CPR	0.075	0.068	0.070	0.090	0.054	0.062	
	(0.079)	(0.080)	(0.081)	(0.075)	(0.076)	(0.063)	
D <10km CUP	0.112*	0.122	0.145	0.123*	0.148*	0.127	
	(0.061)	(0.089)	(0.113)	(0.065)	(0.082)	(0.077)	
D <10km PCT	0.108***	0.144***	0.134**	0.116***	0.159***	0.155***	
	(0.034)	(0.044)	(0.060)	(0.034)	(0.047)	(0.047)	
zPopD 1920	0.091**	0.087**	0.074*	0.118***	0.150***	0.144***	
	(0.041)	(0.042)	(0.040)	(0.023)	(0.026)	(0.024)	
zPopD 1930	-0.051	-0.053	-0.063*	-0.025***	0.005	-0.001	
	(0.038)	(0.037)	(0.032)	(0.009)	(0.017)	(0.011)	
D <10km Crail	0.529	0.489	0.501	0.559	0.839	0.819	
	(0.459)	(0.449)	(0.484)	(0.538)	(0.610)	(0.642)	
D <10km CDC	0.117**	0.155***	0.134*	0.132***	0.068	0.057	
	(0.048)	(0.056)	(0.068)	(0.050)	(0.062)	(0.060)	
D <10km SCH	0.154***	0.189***	0.121	0.095	0.179**	0.133**	
	(0.058)	(0.064)	(0.077)	(0.073)	(0.070)	(0.060)	
D <10km PCH	3.153	3.441	3.912	3.235	3.054	2.984	
	(2.240)	(2.445)	(2.711)	(2.280)	(2.139)	(2.136)	
D <10km CSN	0.371*	0.351	0.322	0.377*	0.375*	0.460**	
	(0.220)	(0.229)	(0.207)	(0.204)	(0.215)	(0.221)	
Observations	15,204	11,220	6,708	15,546	15,546	15,546	15,204
R-squared	0.29	0.29	0.28	0.31	0.22	0.27	0.00
Regional FE	YES	YES	YES	NO	NO	NO	YES
Ethnicity FE	NO	NO	NO	NO	NO	YES	NO
State FE	NO	NO	NO	NO	YES	NO	NO
Provincial FE	NO	NO	NO	YES	NO	NO	NO
Pre-colonial controls	YES	YES	YES	YES	YES	YES	YES
Colonial controls	YES	YES	YES	YES	YES	YES	YES
Geographical Controls	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 11: Robustness checks from table 3

	(1) Baseline	(2) IV First Stage PAV	(3) IV	(4) PLACEBO	(5) Cont. Roads
D<10km CPR	0.277***		0.553		0.270***
	(0.071)		(0.371)		(0.071)
D>10km and <20km CPR	0.032	-0.238***	0.094	-0.030	0.029
	(0.038)	(0.022)	(0.087)	(0.046)	(0.038)
D <10km CUR	0.014	-0.012	0.015	0.005	0.008
	(0.039)	(0.012)	(0.039)	(0.042)	(0.039)
D <10km IV lines		0.102***			
		(0.028)			
D <10km proj. CPR				0.045	
				(0.041)	
Observations	15,204	15,204	15,204	15,204	15,204
R-squared	0.19	0.28	0.19	0.19	0.19
Provincial FE	YES	YES	YES	YES	YES
Pre-colonial controls	YES	YES	YES	YES	YES
Colonial controls	YES	YES	YES	YES	YES
Geographical controls	YES	YES	YES	YES	YES
F	n	66.20	n	n	n

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure 4: Ethiopian GDP per capita over time