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Road to Division:
Ethnic Favouritism in the Provision of Road Infrastructure in Ethiopia

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Abstract

Ethnic favouritism has long been considered by scholars as intrinsic in explaining sub-optimal economic growth in African countries. Our case study, Ethiopia, represents an unicum in the African political context, as ethnicity has been institutionalised as the key element of the post-authoritarian state order, yielding a system that has been labelled "ethnic federalism". This paper aims to analyse whether this particular institutional setting has proven to be a deterrent to logics of ethnic favouritism in the allocation of public goods. In order to do so, the study exploits a national scale road investment project spanning almost twenty years, the Ethiopian Road Sector Development Programme. We seek to assess whether the politically dominant ethnicity, Tigrays, have benefited disproportionately from the project with respect to other ethnically identified Ethiopian regions. By exploiting a novel dataset containing spatially explicit information on the location of new road constructions and road surface improvements, we leverage quasi-experimental econometric methods in order to identify a causal effect of coethnicity with the Tigray People's Liberation Front, the dominant component of the Ethiopian People's Revolutionary Democratic Front, in the reception of new road construction and road improvements. The main contribution of this paper resides in the quantification of the disproportional allocation of road investments. We find that ethnic Tigrays obtain on average 5-7% more roads with respect to other ethnic groups, once pre-treatment characteristics are balanced across treatment and control units. Moreover, the result is consistent when expressed in terms of road improvements, with road speed on Tigray territories increasing by an additional 10 km/h with respect to non-Tigray observations. These results may be considered as evidence of ethnically unbalanced economic growth inside the Ethiopian territory.

Keywords:
Infrastructure, Roads, Ethnic Favouritism, Ethiopia, GIS
JEL: H54, H77, J15, R42, O15

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1. Introduction

One of the *circumstances*[1] that has been considered an impediment to economic growth, especially in the African continent, is the instrumental use of ethnicity: in particular, ethnic favouritism. "*The phenomenon of ethnicity is being declared by many to be the cause of all the problems of Africa, especially those of violent conflicts*" (Abbink, 1997). The role of ethnicity and in particular ethnic tensions has always been a central theme in development economics, especially in explaining African backwardness (Herbst, 2000; Alesina *et al.*, 2003; Posner, 2005; Alesina and La Ferrara, 2005; Ahlerup and Isaksson, 2014; Alesina *et al.*, 2016). In their seminal work, Easterly and Levine (1997) show that the presence of high level of ethnic diversity in sub-Saharan Africa encourages the adoption of poor economic policies and the under-provision of key "growth-enhancing" public goods.[2] Ethnically polarized societies are more inclined to select sub-optimal economic policies, following logics like ethnic favouritism (De Luca *et al.*, 2018). Following LaPorta *et al.* (1999), Alesina *et al.* (2003), Burgess *et al.* (2015), and Walters *et al.* (2019), ethnic favouritism emerges in contexts with weak political institutions, where members of the same ethnicity (hereafter, coethnics) "*benefit from patronage and public policy decisions, and thus receive a disproportionate share of public resources, when members of their ethnic group control the government*" (Burgess *et al.*, 2015). Bates (1974), Mytelka (1977), and Posner (2005) show how people believe to be better off if coethnics hold the power, rather than if they do not. This expectation that political leaders will favour their ethnic kin has become a staple in the study of African countries' politics (Ejdemyr *et al.*, 2018). This is in line with what Posner (2005) reported in the case of Zambia, where the fact the president favours his ethnic groups is perceived as an "*axiom of politics*" to be confronted with.

The theoretical background of ethnic favouritism finds its origins in the literature on distributive politics in democracies, in particular how incumbents choose the allocation of public resources to "*ensure their political survival*" (Kasara, 2007). In particular, formal treatments of this issue have been proposed by Cox and McCubbins (1986), Lindbeck *et al.* (1987), and Dixit and Londregan (1996). These models of political competition may be contextualised in the African political landscape to describe the relations between the political leader and the various ethnic groups. Recent empirical studies have often exploited the change in the presidency of the country leader to measure the extent of ethnic favouritism, using the switch

[1] Following the concept of inequality of opportunity discussed by Roemer (1993) , Roemer (1998) and Roemer and Trannoy (2016), inequality between individuals may depend upon two sets of factors: *effort*, which is a broad formula to describe abilities, actions, and all the choices for which each individual should be considered responsible for; and *circumstances*, all the factors that are beyond the control of individuals and for which they can not be held responsible, such as gender, parental education, ethnicity. Paraphrasing this, inequality may be considered morally acceptable if the unequal distributions of outcomes between individuals depend on *effort*, while should be perceived as morally unacceptable if it totally depends on *circumstances*. What the authors stress is the importance of *equality of opportunity* to allow people to achieve their outcomes, such as income, wealth, and education.

[2] Indeed, they find in the greater ethnic fragmentation of the African continent the principal reason of the growth differential between the countries of Africa and East Asia.

as an exogenous treatment (Franck and Rainer, 2012; Burgess *et al.*, 2015; Kramon and Posner, 2016; Walters *et al.*, 2019; De Luca *et al.*, 2018; Hodler and Raschky, 2014). The literature regarding ethnic favouritism has become a prominent theme of political economy. Nevertheless, as highlighted by Kramon and Posner (2013), almost all these studies suffer from an excessive specificity. This means that even if some coethnic groups may have been favoured with respect to some outcomes, it could be equally true that they may have been disadvantaged with respect to others. Therefore, even if some of these studies may provide some interesting insights about the effects of ethnic favouritism regarding a *particular* policy, in a *particular* country, in a *particular* time, more general conclusions appear to be founded on shaky theoretical basis and lacking external validity.

Aware of the limitations and the difficulties arising from studying ethnic favouritism, or its declinations in terms of political favouritism, we intend to study this phenomenon in a particular context, such as the Ethiopian one, that has been defined by many as an *unicum* in the African panorama (Abbink, 2012). Indeed, Ethiopia in many ways represents a real "African political laboratory", where for the first time ethnicity has been "institutionalised" and where "ethnic identity is considered the normative identity" (Abbink, 1997). Using the words of Abbink (1995) "*one has to acknowledge that the Ethiopian experiment in devolution of central state power to regions and of 'ethnicisation' of national politics can be characterised as unique in Africa, and that it has its negative as well as its positive points*"[3]. Therefore, assessing whether the Ethiopian ethnic federalism may have represented a deterrent to logics of ethnic favouritism may endorse significant insights for the African' political and economic future.

In this paper, we propose an investigation of the role played by ethnic favouritism in the allocation of road investments under the Road Sector Development Programme (RSDP) in Ethiopia between 1998 to 2016. There is a growing body of literature which focuses on the study of transport investments – e.g. Redding (2020), Jedwab and Storeygard (2020), Akbulut-Yuksel *et al.* (2020), Alder (2015), and Faber (2014). This strand of literature is recent and challenging, since it is hard to take possession of detailed geo-localised datasets on infrastructure investments, especially in developing countries. However, transport facilities should be considered paramount determinants of development and understanding their design may allow to foster growth and regional development. Moreover, Sub-Saharan Africa is one of the least urbanised geographical areas in the world with a very poor transport network, even with respect to India and China (Jedwab and Storeygard, 2020). The lack of a capillary transport network entails substantial difficulties in the access to health and school services, but also important entrance barriers to the national and international markets. Besides, high transport costs may translate in ethnic segregation, contributing to high level of spatial inequality and poverty (Jedwab and Storeygard, 2020; Herbst, 2000).

[3] Differently for example from Rwanda and South Africa, which have given to ethnicity a measure of official recognition, "*in 1991 Ethiopia accommodated ethnicity as a formal political element in the new state order*" (Abbink, 2012)

Thus, the Ethiopian Road Sector Development Programme (RSDP) represents an ideal setting to study the phenomenon of ethnic favouritism. Indeed, in Ethiopia ethnic identity has been "*declared the ideological basis of political organization and administration*", after the writing of the new Federal Constitution of December 1994 (Abbink, 2006). Therefore this project represents a sound case study to analyse the potential consequences of ethnic favouritism and eventually, the ability of ethnic federalism to possibly mitigate its effects. Moreover, since roads represent the major mode for intra-national movement in Ethiopia, it is important to study their allocation, which may influence many others subsequent economic and social aspects. Besides, disentangling the relationship between politics of ethnicity and road construction may provide a unique opportunity to assess the performance of ethnic federalism and the developmental state[4].

In the academic literature on ethnic favouritism, the usual empirical strategy exploits the coethnicity with the president to assess the incurrence of an unfair allocation of economic resources towards coethnic communities or entire coethnic regions. Starting from this strategy, we have developed an alternative one that exploits the insights proposed by Beiser-McGrath *et al.* (2018) and the Spatially Interpolated Data on Ethnicity, (hereafter SIDE). Using EPR-core dataset Vogt *et al.* (2015), we are able to identify the component which truthfully holds the power, namely the Tigray party, among the multiple ethnically connotated parties comprised in the Ethiopian Federal State. The originality of this paper is rooted in the quasi-experimental methods employed in the analysis to discover whether the areas inhabited by Tigray have registered a disproportionate allocation of roads investments with respect to other Ethiopian areas, though similar in terms of economic potential, social characteristics and morphological features.

Identifying the causal effect of coethnicity in the allocation decisions regarding roads is challenging for several reasons. *In primis* because the choice of where to build an infrastructure is not exogenous, since the random assignment of route placements is implausible. Indeed, it is reasonable to assume that planners may have decided to allocate investments with specific goals (e.g. where high growth was expected or specifics peripheral counties on the way between targeted nodes). A further challenge is brought forward by the identification problem, which could be plagued on one hand by omitted variable bias (e.g. sudden population changes, or natural impediments which may be considered as unmeasured factors, which may influence the allocation decisions of road investments) and on the other hand by the limitations that we face with respect to data: indeed, ideally we would be able to compare a pre-programme

[4]There have been authors, such as Adugna (2019) who have tried to study whether some Ethiopian regions, characterised by a particular ethnic component have registered significant measurable material gains in respects to other parts of the country. In particular, Adugna (2019) has studied whether there has been a disproportionate resource allocation towards the Tigray region, between 2001-2017. The study analyses the phenomenon of ethnic favouritism using two different group of variables: the ownership of modern amenities, and the DHS' wealth index. The results show that the alleged misdirection of public goods to Tigray regions has constituted a significance loss for the country as whole, but seems unlikely to have benefitted the general population of Tigray. In conclusion, what appears is that even if politicians purported to help their region of birth, the general public in Tigray failed to see significant change in their economic standing.

road expansion observed during the hegemony of another Ethiopian ethnic group (namely, Amhara) with the expansion observed under the Tigray dominance. By relying on data from 1996-2016, our entire period of analysis coincides instead with the Tigray party as the major partner in the Ethiopian executive; the effect we find, i.e. disproportionate increases in road investment allocations towards the Tigray region, could be contaminated by disproportionate pre-programme economic conditions which would justify the observed disparities. However, this seems implausible since until the early 1990s the Tigrays had not yet achieved sufficient political influence to guarantee themselves favourable treatment. We believe that our strategy may contribute to give important insights to handle these issues.

Using as observational units grid cells of dimensions 11km x 11km, we employ a spatial propensity score matching and difference-in-differences design (hereafter, DID) to assess whether Tigray have been favoured in the allocation of road investments. This empirical approach allows us to understand whether, under the same economic, social and construction cost conditions, the cells dominated by Tigray still received more roads. Alternative approaches, together with different units of analysis are offered to strengthen the confidence in our methodology. We find evidence that cells dominated by a Tigray majority have obtained on average between 5%-7% more roads with respect to other comparable areas of the Ethiopian territory. Moreover, we show that they seem to have benefitted also in terms of road surface, with improvements of around 9-10 km/h with respect to other cells. We further show that our results remain consistent, positive and with the same level of significance across all specifications and by using different units of analysis. This gives us confidence on the detection of the presence of ethnic favouritism mechanisms in the allocation of road investments during the implementation of the RSDP. This methodology allows us to quantify the ethnic favouritism in road investments allocations in their geo-spatial distribution component, both in terms of road lengths and road improvements. Then, this paper should be regarded as one of the first attempts of quantification of asymmetries of public goods assignments due to mechanisms of ethnic favouritism, contributing to the literature on the political economy of development.

Drawing from some of the insights proposed by (De Luca *et al.*, 2018), we aim to emphasise that the disproportionate allocations of road investments towards the Tigray region should not be regarded necessarily as detrimental for the economic performance of Ethiopia as a whole. What we argue is that ethnic favouritism logics were present in the decisional process of the RSDP allocation. Being ethnic favouritism already detected in Ethiopia (e.g. Franck and Rainer (2012), Adugna (2019)), our study should be considered as a further confirmation of its presence, regarding the infrastructure investment aspects. In particular, the work of Mergo *et al.* (2019) should be identified as crucial support for our thesis. Indeed, the authors exploit the natural experiment of the institution of the ethno-linguistic federalism in 1991 to test their hypothesis of an uneven distribution of public goods in favour of the Tigray ethnic group. By using the Ethiopian censuses of 1994 and 2007, the Welfare Monitoring Surveys of 1995 and 2011, and a DID strategy, they show that in almost all cases, co-ethnicity with the federally-dominant ethnic group, Tigray, improves access to public goods (e.g. piped water, electricity, proximity to health institutions). Therefore, our thesis is that quantifying and analysing the presence of ethnic favouritism in the distribution of roads can be considered as a determining and triggering factor in a chain process from which all other considerations about the appropriation of further facilities, both in terms of public and private goods, necessarily derive. However, a final conclusion in terms of welfare implications for the whole of Ethiopia is left unexplained. Further research on the topic may provide important evidence on welfare and growth implications for the whole of Ethiopia. Even so, learning about ethnic favouritism and its presents is interesting per se, since it may provide lens to analyse the socio-economic aspects of a country, contextualizing it in his history and political determinants. This is particularly true for the Ethiopian case, in which the civil war started in 2020 in the Tigray province should not be disregarded, without considering the aftermath of a Tigray domination that was far from balanced and equitable (De Waal, 2020; Gedamu, 2020; Mergo *et al.*, 2019).

"*When the state builds asphalt roads, it makes good on promise of growth and development*" (Mains and Kinfu, 2016), being roads essential tools for promoting growth and achieving legitimacy in the eyes of voters. Indeed, when inspecting the positive effects of road investments on the beneficiary areas, one should take into account the potential for investment spillovers, such as the increase in the economic opportunities, the increase in the value of property located near the new built constructions, and finally the better access to markets, school and health facilities[5](Mains and Kinfu, 2016). Hence, the studying on the influence of mechanisms like ethnic favouritism should be considered paramount in their potential of influencing an efficient allocation of public goods investments, since this may undermine a balanced economic growth. Following the insights of Burgess *et al.* (2015), we believe that studying road programmes is extremely valuable to assess the presence of ethnic preferences, since "*roads investments is centrally allocated and a highly visible form of public investment and thus a prime area for political patronage. Road building thus represents an attractive setting in which to analyse the extent of ethnic favouritism*".

The paper is organised as follows: the following Section describes the Road Sector Development Programme (RSDP); Section 2 presents the data; Section 3 outlines the empirical approach, from which the presentation of the results follows in Sections 4 and 5; Section 6 provides a suite of robustness checks; Section 7 concludes. Additional information can be found in the Appendix.

[5]Another important aspect found in the literature is the reduction of the inhaled dust due to the investment in the better quality of road surface (Mains and Kinfu, 2016)

1.1. The Road Sector Development Programme (RSDP)

Starting from 1994, the government has been committed to a major national economic development plan, where "political considerations" should have been considered as "*secondary*" and where the "*legitimacy of the government would be sought in the economic growth achievements through infrastructures, road building, hydropower mega-projects, 'double-digit' GDP growth, foreign investments, etc.*" (Abbink, 2012; Mains and Kinfu, 2016). Then, the government's 2010 *Growth and Transformation Plan* should be considered as in line with this goal, "*stressing economic growth and not much less*". For this reason, international observers have denounced the leading role given to economic development at the expense of democracy and forms of representation, neglecting the increased "*ethnic awareness and tensions created by regionalisation policy and their potentially explosive consequences*" (International Crisis Group, 2009).

The RSDP, an investment plan implemented in Ethiopia between 1997 and 2016, hinges on this ambitious project of economic development [6]. The objective of improving the national road network has been considered as fundamental driver to fuel up the growth process. Indeed, road transport facilities are assumed to foster the accessibility of other crucial collateral services such as the provision of education and health services, trade, and private sector activities. Besides, the improvement of roads should be considered as a considerable stimulus "*in both the production and consumption decisions of every household in their day-to-day activities*"(Worku, 2011). To understand the relevance of this project, however, it is necessary to highlight the importance of the road network in Ethiopia, which is the dominant transport mode, accounting for approximately 95% of motorised inter-urban freight and passenger transport (Worku, 2011). Since the secession of Eritrea in 1993, Ethiopia has been a landlocked country, with almost no navigable rivers. In the absence of railway systems, most of Ethiopia's international trade has been made possible by the connection with the port of Djibouti and the international Kenya-Ethiopia highway. Then, road transport connections then play a crucial role in determining the Ethiopian economic performance. Indeed, as reported by Escribano *et al.* (2009), Ethiopian firms perceive poor infrastructures as one of the impediments to their development. This major-large scale project consists in the improvement of road conditions, rehabilitation of road surface, enhancement of road networks and road access to promote both agriculture and economic development [7].

This project has seen the involvement of many different donors, but the authorities in charge

[6] The RSDP can be divided in four pahses: i) RSDP 1 - from July 1997 to June 2002 (5years plan); ii) RSDP 2 - from July 2002 to June 2007 (5 years plan); iii) RSDP 3 - from July 2007 to June 2010 (3 years plan); RSDP 4 - from July 201o to June 2015 (5 years plan). A fifth phase which is not cover by tha availability of our data is between. 2015 to 2020

[7] Proposed by the single regional states, the Ethiopian Road Authority should officially use the following five criteria during the preliminary selection of road improvements sites: i) areas with economic development potential (20%); ii) areas with surplus food and cash crop production (20%); iii) link existing major roads (20%); iv) large and isolated population centres (30%); access to emerging regions (10%))(Shiferaw *et al.*, 2015).

of its implementation have been the Ethiopian Roads Authority (ERA) and the Regional Roads Authorities (RRAs).

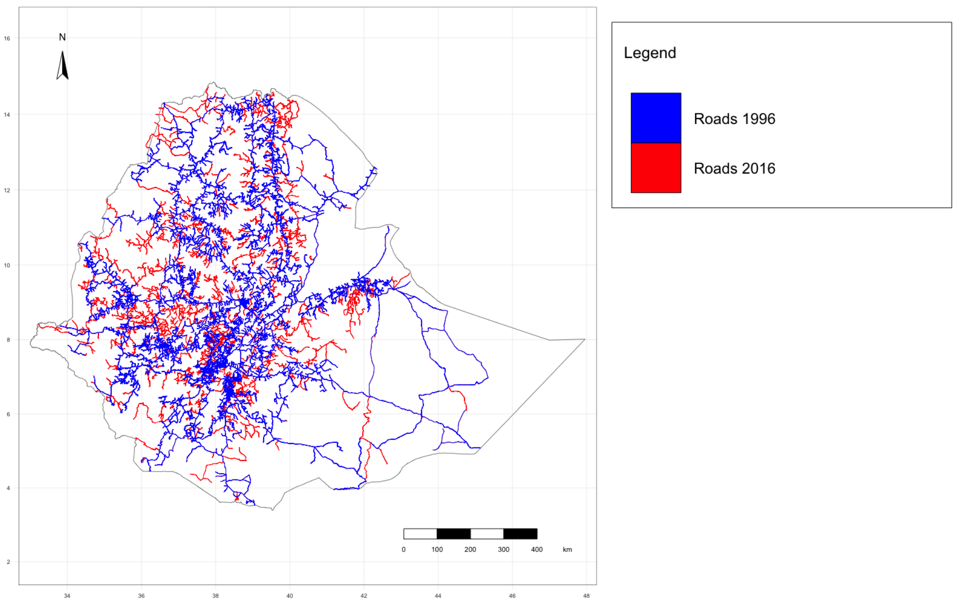

Figure 1: Author's elaboration: Road upgrades 1996-2016.

Formally, priority has been given to areas with high economic potential and surplus food production, although ERA accounts for population distribution, social and regional equity in economic development[8]. The planning department of ERA, relying on feasibility studies and additional information provided by regional states and government ministries, selects the projects and decides the proposed budget. The approved investments are then presented to the Prime Minister and all the other relevant ministries, in particular to the Ministry of Finance and Economic Development (MoFED) who has to approve the final budget allocation decision. The upgrading projects follow a similar decisional pattern, although the criteria are slightly different. However, it should be highlighted that "*in spite of formal policy and rhetoric, Ethiopia has only nominally devolved decision-making power to local levels*" (International Crisis Group, 2009). Indeed, all important decisions are taken by the centre and the EPRDF controls all the bureaucracy and all the public resources. The party "*extends from the federal to the regional, from the regional to the woreda, and from the woreda to the kebelle and sub-kebelle levels*"(International Crisis Group, 2009). This of course has fuelled the disparities in the provision of public resources and in the decisional process of the allocation of public goods. Furthermore, ethnic federalism has not been able to solve the "national ques-

[8] In particular, the investment decisions for the improvement in road surface observe the following guidelines: i) improvements should be concentrated towards roads with high traffic density (30%); towards roads with better network connectivity (20%); towards roads that are in poor conditions (20%); iv) towards roads that link import/export and regional integration corridors (20%); v) towards roads which connect investment routs (10%) (Shiferaw *et al.*, 2015).

tion". Indeed, the increased competition among ethnic groups for land, natural resources, as well as administrative boundaries and government budget has only tightened up the internal conflicts. The EPRDF has empowered and favoured only some groups, without providing counterbalance material assistance to the others.

Data reported by the ERA indicate that the road network expanded for an amount of around 28,682 km; a parallel improvement in terms of road surface "in good conditions" (22% to 57%) was observed between 1997-2011 for the whole Ethiopian territory (Shiferaw *et al.*, 2015)

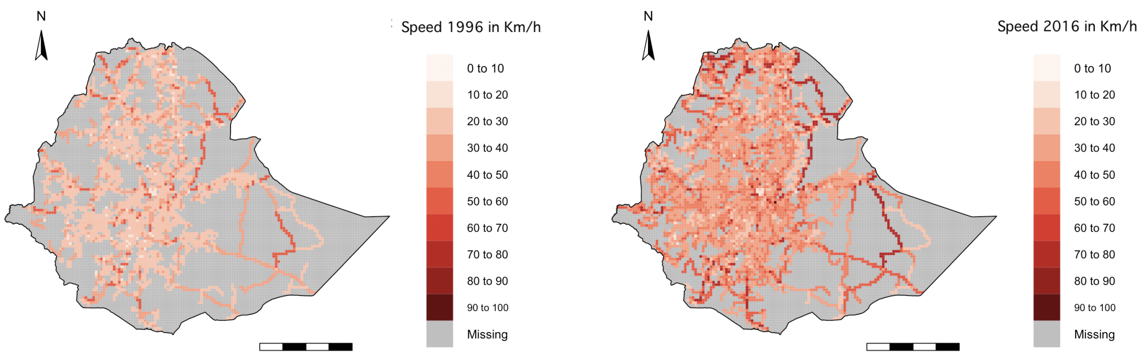

Figure 2: Author's elaboration: Upgrades in Road Quality 1996-2016, using speed as a proxy for road conditions.

The criteria that have been set are not sufficiently stringent to avoid potential mismanagement by the authority in charge of the allocation investment decisions. From a preliminary descriptive analysis, it appears that areas inhabited by at least 90%-50% of Tigrays have obtained between 8%-10% of the total RSDP investments, vis-à-vis a population covering approximately 6% of the total Ethiopian population. Although not a decisive proof of the presence of ethnic favouritism mechanism, this statistic may signal an imbalance in the provision of road investments. This potential imbalance is the motivation for our study, which aims to uncover whether the asymmetry arises when Tigray areas are made comparable with the rest of the Ethiopian territory [9]. Indeed, as reported by Shiferaw *et al.* (2015) "*it is not*

[9]These values have been obtained by calculating the total amount of roads obtained by the Tigray territories

clear how exactly economic potentials of different geographic locations are assessed or how regional inequality is evaluated". This lack of clarity may leave room for ethnic favouritism mechanisms, left untouched by these broad guidelines.

Several studies have analysed the impact of the RSDP on a variety of outcomes, both qualitative (e.g Emmenegger (2012)) and quantitative ones (e.g. Moneke (2019) and Gebresilasse (2018)). Most of these studies have exploited the variation generated by the increased in roads network and its subsequent reflection on the market access increment, to study their effects on agricultural and manufacturing productivity (Gebresilasse, 2018; Stifel *et al.*, 2016; Shiferaw *et al.*, 2015), on urban dynamics (Legovini *et al.*, 2020) and on multidimensional aspects as in Moneke (2019), who exploiting a spatial general equilibrium model, shows how "big push infrastructure investments" act as crucial propellent to growth and welfare in low income countries, allowing structural transformation processes. Other authors have studied the impact of the road infrastructure development with an historical approach (Bertazzini, 2018), examining the relationship between cheap transport networks and agglomeration dynamics of economic activity. However, none of these papers have addressed the question of the distribution of the roads themselves, which instead should be considered as paramount to understand potential development disparities and policy implications.

with at least 90%-50% of Tigrays' presence, over the total amount of roads build during the RSDP for all the Ethiopian territory.

2. Data Sources

2.1. Data on access to power and ethnic composition

One of the main novelties of this paper is the employment of the Ethnic Power Relations (EPR) Core Dataset (Vogt *et al.*, 2015), updated in 2019. This dataset reports "*all politically relevant ethnic groups and their access to power state in every country of the world from 1946 to 2017*". Moreover, this dataset contains each ethnic group's degree of representativeness within the government, including minority and majority stakes and their level of discrimination in the executive-level state power [10]. For the case of Ethiopia, it is reported whether each ethnic group should be considered: "*senior partner*" or "*junior partner*" of the government, "*depending on the group's absolute influence in the executive (i.e. irrespective of group size)*"[11],[12]. From 1992 to 2017, indeed, the Tigray ethnicity appears to be the "*senior partner*" of the executive: documenting the shift from the Amhara Derg dictatorship to the takeover of the ERDP, orchestrally exploited by the Tigray minority.

In the academic literature on ethnic favouritism, empirical analyses usually exploit the coethnicity with the president to assess whether there has been an unfair preferential treatment by the government towards coethnic individuals or coethnic regions (e.g Walters *et al.* (2019), De Luca *et al.* (2018), and Burgess *et al.* (2015)). In this paper, instead, we decide to follow the insights proposed by Beiser-McGrath *et al.* (2018), who exploit the EPR dataset to account for "*government élites, others than the president's group, which are also engaged in favouritism, showing how the coalition-based approach yields more precise measures of government co-ethnicity*" (Beiser-McGrath *et al.*, 2018). The empirical strategy adopted, then, instead of considering the coethnicity with the president's ethnic group, focuses on whether an ethnic group is labelled as "*senior partner*" of the government. This approach appears to be more appropriate for the Ethiopian case. Although executive power is formally held by a multi-ethnic party, the Ethiopian People Revolutionary Front (EPRDF), the government is controlled in practice by a minority group, the Tigray People's Liberation Front (TPLF) (for more details about the Ethiopian historical and political context see the Appendix). Coherently, out of all the ethnic groups belonging to the coalition, the EPR core labels only the

[10]The measure of power access has been built employing an ordinal scale which refers to how power is distributed among the various ethnic groups. In particular, Vogt *et al.* (2015) identify three broad categories: i) one ethnic group holds the power alone; ii) one ethnic group shares the power with other ethnic groups; iii) one ethnic group is completely excluded from the executive state power. Each of these three categories is then subdivided in other categories

[11]Moreover, the dataset also lists whether an ethnic group is reputed to be "*powerless*", "*discriminated*" or "*self-excluded*", where "*powerless*" means that the reference ethnic group is not represented in the executive, "*discriminated*" indicates that there is a deliberate intention to alienate it from public politics, and finally "*self-excluded*", which applies to those that "*exclude themselves from central state power, since they control a particular state, which they declared independent from the central government*", as for the case of Ethiopia, Eritreans (Vogt *et al.*, 2015)

[12]Inspecting this data, Ethiopian political history may be easily reconstructed. Indeed, until 1990 Amhara are classified as "*dominant*", a status which indicates that the *de facto* power of the executive is in their hands, although there is a symbolic representation of all the other ethnic groups in the government

Tigray ethnicity as "*senior partner*" [13].

To measure the proportion of population that is co-ethnic with the "*senior partner*" of the executive in a given year, we employ the Spatially Interpolated Data on Ethnicity, hereafter SIDE[14], developed by Müller-Crepon and Hunziker (2018) [15]. Linking the SIDE data with population data from SEDAC, (CIESIN - Columbia, 2018)[16] and EPR Core data, we are able to calculate the percentage of "*senior partner*" coethnics for each reference unit. The employment of this dataset enables us to have more accurate geo-coded information on ethnic settlement patterns with respect to more ordinary ethnic datasets; among them, the Geo-Referencing of Ethnic Groups (hereafter GREG) (Weidmann *et al.*, 2010)[17]; and the Geo-referencing Ethnic Power Relations (hereafter GeoEPR) (Wucherpfennig *et al.*, 2011), based on GREG [18].

[13]The hypothesis here is that irrespective of the ethnicity of the prime minister, what is fundamental to consider in the analysis of ethnic favouritism is party politics, which holds more weight than the potential political influence of a single individual. However, it is equally true that in most cases the ethnic group of the president is equivalent with the EPR-coding of "*senior partner*". This is confirmed in Ethiopia, where from 1995 to 2012 the ethnic Tigray Meles Zenawi has acted as the prime minister. Nevertheless, for the period of our analysis, 1994-2016, there has also been a shift in the ethnicity of the prime minister, with the election of Hailemariam Desalegn, of the Wolayta ethnic group - the second largest ethnic community in the Southern Nations, Nationalities, and People's Region (SNNPR)(International Crisis Group, 2012) - who held the power from 2012 to 2018. Our *a priori* hypothesis is that the shift in the ethnicity of the prime minister leaves the ethic favouritism mechanism untouched, with the Tigray favoured over all other ethnic groups. This seems realistic, since Hailemariam Desalegn is considered "*loyal and already part of the inner circle of the TPLF*", and the agreement within the TPLF to appoint "*a non-Tigrayan prime minister, has been motivated to give the appearance of a broad base, designed to placate potential critics, while the Tigrayan TPLF élite keep real power.*"(International Crisis Group, 2012)

[14](*Spatially Interpolated Data on Ethnicity - SIDE*)

[15]SIDE provides high resolution geo-referenced information on local ethnic demographies, for 47 low-and middle-income countries across the globe. It offers a raster dataset that encodes estimates of local ethnic composition at about 1km x 1km resolution. The main novelty of this dataset consists on the fact that its estimates have been obtained via spatial interpolation and machine learning methods, employing DHS survey locations on ethnic population shares. The granularity of the information obtained allows us to account for local variation in groups population shares, and "*the extent and nature of local ethnic diversity for arbitrary spatial units*" Müller-Crepon and Hunziker (2018)

[16]Using the procedure of proposed by Müller-Crepon and Hunziker (2018), `https://github.com/carl-mc/sidedata`, we aggregate Ethiopian population count of 2000 to the different spatial units. We use population count of 2000, as our second best choice, since the oldest DHS employed for the construction of SIDE dates back to 2000.

[17]This dataset is the digitalisation format of the *Soviet Atlas Narodov Mira*, which reports the time invariant information of the composition of about 928 ethnic groups all over the world, at the early 1960s

[18]Both GREG and GeoEPR provide polygon-based coding on ethnic settlement patterns; nevertheless, they are unable to identify local ethnic diversity. Indeed, their main shortcoming appears to be the fact that they are only adequate when ethnic groups are spatially segregated, and not in contexts in which countries are ethnically fragmented, such as Ethiopia. SIDE allows to pinpoint ethnic settlement data, which also report local ethnic mixing in a dynamic time span

2.2. Geo-spatial dataset

Investment decisions on road development networks strictly depend on the morphology of the territory. At each level of the analysis we proceed to aggregate geo-coded datasets and to create specific geo-morphological indices. In particular, we combine datasets on Ethiopian elevation and Ethiopian slope, consulting Ferranti (2017)[19], both of them at 3 arc-second resolution. Following the insights of Nunn and Puga (2007), we decide to construct a measure of terrain ruggedness, the terrain roughness index (hereafter, TRI). We derive detailed information about mean annual temperature and mean annual precipitation from Fick and Hijmans (2017)[20][21].

Then, we spatially aggregate socio-economic variables such as Night Lights (hereafter, NTLs), atmospheric particulate matter (hereafter, PM2.5), and population count, from SEDAC (abovementioned). In the academic literature NTLs are considered as a good proxy for economic activities, especially for Developing Countries (Henderson *et al.*, 2012; Elvidge *et al.*, 1997; Doll *et al.*, 2000; Gibson *et al.*, 2014). Following the burgeoning literature on the coupling between economic activity and emissions (e.g. Neumayer (2004)), we are confident that PM2.5 may contribute to give significant information about the concentration of business and human activity [22]. NTLs have been derived from NOAA (2013), while PM2.5 data from Donkelaar *et al.* (2016).[23] To have a more comprehensive economic framework, we decide to also aggregate Gross Cell Product (GCP), measured at 1 degree longitude and 1 degree latitude resolution, by *Global Gridded Geographically Based Economic Data (G-Econ), Version 4*.

2.3. Outcome Variables

The Ethiopian Roads Authority (ERA) and the Regional Roads Authorities (RRAS) provide geo-localised datasets reporting information about the road construction sites of the RSDP. The database consists of a time series of shapefiles of the Ethiopian road network programme for the period 1994 to 2016, and in particular it describes the incremental improvements in terms of the type of road surface[24] and road condition for each road segment of the dataset

[19] *World Pop: SRTM Slope*, *World Pop: SRTM Elevation*

[20] *WorldClim: Global Climate Data*

[21] These two indicators allow us to have a precise overview of the climatic characteristics of the Ethiopian territory, expecting to find less road investments in more arid and inhospitable areas (In the Appendix, Figures are provided to show the spatial variation of elevation, slope and terrain roughness index across the Ethiopian Territory)

[22] Indeed, PM2.5 are fine particles which come from different industrial and domestic sources. They may be produced by the pollution of motor vehicles, such as cars, trucks, buses and off-road vehicles, but more generally they involve all the activities that interest the burning of fuels, "*heating oil or coal and natural sources such as forest and grass fires*". Moreover, PM2.5 particles may also come from more common residential activities, such as cooking, burning candles or oil lamps, and by the use of fireplaces and fuel-burning space heaters (e.g., kerosene heaters), retrieved on `https://www.health.ny.gov/environmental/indoors/air/pmq_a.htm`

[23] Retrieved on *Atmospheric Composition Analysis Group*

[24] It provides information about four type of road surfaces: i) earth sirface; ii) minor gravel; ii) major gravel; asphalt. Moreover, the dataset categories those roads that are considered: i) not rehabilitated; ii) new; iii)

[25]. This exhaustive and detailed dataset represents a significant source of information, with respect to the usual limited availability of time series data on transport infrastructures in low-income developing countries [26]. Indeed, we are interested in inspecting not only whether ethnic favouritism has favoured the Tigray region and their coethnic community in terms of enhancement in road networks, but also whether it has incremented the investment in road quality with respect to other regions. Therefore, for each level of analysis we construct two main outcome variables.

- The first one is *Length*, which records the improvement in kilometres for each segment of roads added to the original road networks system of 1996.
- The second is *Quality*, that is linked to time needed to cross each road segment. We refer to the information related to the four types of road surfaces in the data[27]. The availability of data on the travel time needed to cross each segment of road allows us to check for improvements in road quality, using speed as a proxy. Thus, if there have been improvements in the road surface for each particular road segment, the travel time for the same stretch should be reduced, and *speed* should increase. This outcome variable has been constructed by combining the information related to the quality of the road surface and the average travel speed for each road segment, at each point time.[28] Differently from Burgess *et al.* (2015) then, we are able to investigate not only whether some areas have been privileged in terms of greater road infrastructures, but also whether those areas have benefitted from a disproportionate amelioration in terms of road quality.

$$Quality_j = \frac{1}{n}\sum_{i=1}^{N} Speed_i \tag{1}$$

where $i = 1, ..., N$ is a road segment located on grid cell j.

In this paper, we aggregate all the above-mentioned datasets a two different levels of analysis: i) our preferred specification, namely grid cells of dimensions 0.1 x 0.1 degrees grid squares (which corresponds approximately at 11 km x 11 km), as in (Jedwab and Storeygard, 2020)

rehabilitated.

[25]Following Fiorini *et al.* (2019), it appears evident how the programme had a positive impact in terms of the substantial improvement in road infrastructures, either in the enhancement of the road surface or in the capillarity of the road networks. Nevertheless, what we seek to test is whether these improvements have been concentrated in one region, rather than on an equal economic and geographical basis

[26]Indeed, for example Burgess *et al.* (2015) have been forced to digitalise 11 Michelin Maps to have a measure of road investment in Kenya, creating a district-map year panel dataset, by splicing the historical road maps with the 1963 district boundaries. Nevertheless, they were only able to catch the actual physical extent of paved roads. On the contrary, our dataset allows us to create two different outcome variables, which regard on one hand the increase in road connections, and on the other hand the improvements in road surface

[27]i) earth surface; ii) minor gravel; iii) major gravel; iv) asphalt.

[28]The average travel speed refers to the speed matrix proposed by ERA and reported in Table 2 in Fiorini *et al.* (2019)

(which match 9134 cells for the Ethiopian territory, $j = 1, ..., 9134$); ii) and a more canonical reference unit, districts, labelled "woreda" in the Ethiopian administrative system. This alternative reference unit is more in line with the research on the topic (e.g. Burgess *et al.* (2015)). Unfortunately, the woreda administrative units are not consistent during the period under examination, but suffer from a restructuring of the Ethiopian administrative system, with some districts being aggregated and some disappearing from the records. Therefore, to have a more accurate and stable unit of reference, we proceed in a meticulous procedure to employ in our analysis only woreda that remain stable through out the period of our analysis 1994-2016 [29]. Due to the dramatic reduction with respect to the original sample, we decide to use this unit of reference in the robustness analysis, in order to assess the general trends and direction of our results.

We argue that these two different reference units, on one hand grid cells and on the other hand districts, enable us to have a more comprehensive overview of the potential effects of ethnic favouritism in the Ethiopian context. Indeed, our analysis at the grid cell level allows us to conduct a more disaggregated study on the allocation of road investment programme, accounting for the geo-localised mixing ethnic presence in the Ethiopian territory [30]. Districts level analyses, instead, may reflect more canonical impacts of ethnic favouritism. In these specifications, districts are used as stable ethnic markers allowing us to precisely assign road investments to particular ethnic groups, testing whether districts which share the ethnicity of the coethnic leader group receive more road infrastructure.

Moreover, the employment of these two different units of analysis must be considered as an additional tool to investigate the reliability of the effect of this phenomenon in the allocation of these infrastructure investments. Indeed, by exploiting woreda units we are able to conduct a complementary specification, with robust economic and social variable, relying on the data retrieved by the 1994 Ethiopian Census (Central Statistics Agency (CSA), 1994). Besides, woreda analysis allows us to create an alternative outcome variable, capable of capturing the implicit benefits of increased public investment in infrastructure. Indeed, by exploiting the accuracy of the RSDP dataset, we construct a measure of market access. Following the definition of Harris (1954), market access is "*an abstract index of the intensity of possible contact with markets*".

[29] To isolate those stable woreda, we employ different datasources: in particular Census data from 1994, three different waves of National Labour Surveys, 1999, 2005 and 2013, and spatially connotated administrative units from GADM version 3.6. We use the district's IPUMS code as discriminant to assess which districts remain fixed (since the listed datasets are maintained by IPUMS International (Ruggles *et al.*, 2020), they contain a woreda-level identifier which we are able to match over time to assess which districts are consistently reported in Censuses and Labour Surveys. In this way we have reduced our sample from 690 woreda to 220

[30] Following the reasoning of Beiser-McGrath *et al.* (2018), this approach allows us to test whether areas where the majority of the population is co-ethnic with the national government receive non-excludable goods, which benefit all the citizen independently of their ethnicity, showing in this way how "*goods provision is less discriminatory in co-ethnic strongholds than in government minority regions. Thus, government co-ethnics benefit from favouritism everywhere whereas non-co-ethnics only benefit if they reside in their government's ethnic strongholds*"

In this paper we follow the insights of Donaldson and Hornbeck (2016), adapting the construction of their indicator using the structure proposed by Storeygard (2016). Our definition of market access is the same as the one of Fiorini *et al.* (2019):

$$MarketAccess_{b,y} = log(\sum_{a \neq b} Dist_{b,a,y}^{-1} * NTL_{a,1996}) \tag{2}$$

This indicator measures the minimum distance between between centroid[31] a of district a and centroid b of district b, given the road and speed present at year y; while NTL, night lights at 1996, have been used as proxy of the economic activity at the baseline period. The minimum distance in hours time have been calculated employing Dijkstra's algorithm, an algorithm derived from graph theory which calculates the shortest path between "nodes" in a network by taking into account the length of network segments and weighing it by each segment's travel time.[32].

We believe that this outcome variable may give us further insights on the implications of improvements of roads, especially regarding the positive spillovers generated by the reduction of the entry costs to the national market through the decrease of transport costs. Thus, by employing this alternative outcome variable we may be able to assess whether woreda whith a coethnic majority of Tigray have benefitted by these indirect positive implications derived by the allocations of road investments with respect to equivalent Ethiopian areas, giving some potential insights of the derived welfare implications.

[31] Defined as the geometric center of each Ethiopian district.

[32] For further details on the construction of this indicator see the specific section in the Appendix.

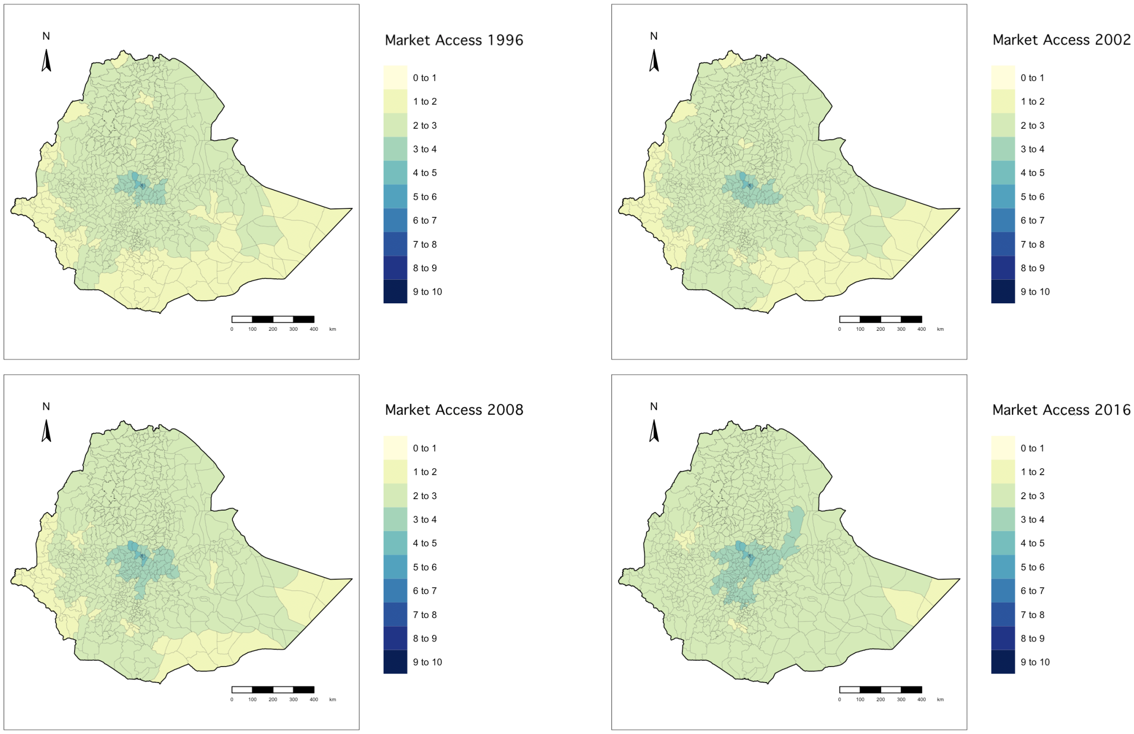

Figure 3: Spatial Representation of the Market Access for 1996, 2002, 2008 and 2016.

In the Appendix tables report summary statistics for the above-mentioned datasets.

3. Empirical Strategy

This study attempts to test whether road investments have been concentrated in the areas most densely inhabited by Tigrays, rather than on equitable economic and geographic bases. We provide one of the first analyses at a completely disaggregated level (independent of regional boundaries), exploiting 11Km x 11Km grid cells as observational units, as in Jedwab and Storeygard (2020), an econometric framework which stems from the economic geography literature.

In order to perform our analysis and consolidate the confidence in our results, we run multiple specifications and robustness checks. Across all specifications employed in this analysis, *treatment status* is defined as the interaction between Tigray coethnicity (a time-invariant characteristic in our dataset) and the period coinciding with the implementation of the RSDP (1998-2016). In different specifications of our regressions, $Treatment$ and $Control$ cohorts are subject to change in accordance with different levels of coethnicity that we take as the cut-off. The intuition here is assessing at which level of Tigray presence ethnic favouritism on roads construction becomes not negligible and significant. Thus, we exploit different levels of Tigray presence on the Ethiopian territory by using: (i) *Spatially Interpolated Data on Ethnicity - SIDE*, in particular thresholds of 90% and 50%, as in Burgess *et al.* (2015); (ii) Static information on ethnic composition of the Ethiopian population provided by GREG (Weidmann *et al.*, 2010) and Geo-EPR (Wucherpfennig *et al.*, 2011). We also exert a specification in which we use the geographic boundaries of the Tigray administrative region as the treatment cut-off. In particular, $Treatment_1$ corresponds to a Tigray ethnic presence higher than 90% for each cell; $Treatment_2$ corresponds to a presence higher than 50%; $Treatment_3$ includes all the cells which belong to the administrative areas of the Tigray Region; $Treatment_4$ and $Treatment_5$ refer to the static spatial definition of ethnic presence given by Geo-EPR and GREG, respectively.

Our preferred econometric approach is based on matching techniques combined with non-parametric difference-in-differences (PSM-DID) (Heckman *et al.*, 1997). This methodology allows us to match our observational units on the basis on socio-economic and geographic observable characteristics, enabling us to assess whether Tigray areas have received a disproportionate level of road investments, with respect to other non-coethnic zones. This methodology has found little application in the study of ethnic favouritism, mainly due to the lack of observational data and adequate experimental settings for its application. Thus, we believe that this paper may be considered as of one of the first attempts to exploit this statistical procedure to analyse the implications of ethnic favouritism. PSM-DID derives global treatment effects from the individual effects observed on pairwise matched cells. We also test the robustness of PSM-DID results via standard parametric methods, namely: (i) OLS ; (ii) OLS with propensity score reweighting; (iii) standard difference-in-differences; (iv) parametric difference-in-differences on the matched sample[33]. We follow up the analysis with a suite of

[33] We also follow the insights of Burgess *et al.* (2015) and we investigate the effects of the switch in coethnicity of the Prime Minister, Melese Zenawi (Tigray) in 2012, who has been succeeded by Hailemariam Desalegn

robustness checks, first employing woredas as the units of analysis, and subsequently running falsification tests to validate our results. Furthermore, in order to shield ourselves from potential criticism regarding the possibility that the results may be partly conditioned by the particular choice of the matched cells, throughout the analysis we show that both by changing the sample and by exploiting other methodologies (Regression Discontinuity Design - RDD), the results are consistent and in the same direction with PSM-DID (Olmos and Govindasamy, 2015).

The methodological challenge that we attempt to tackle is the identification of the causal effects of being in power while administering the RSDP, i.e. the interaction of Tigray coethnicity with the 1998-2016 period in which the programme has been rolled out.
Matching methods allow us to balance the key predictors of road allocation, thereby selecting grid cells which are "similar" across a range of covariates. In our disaggregated-scale setting, matched treated and untreated cells should have the same average propensity for being connected, except that those belonging to the treated group are characterised by a Tigray majority. If the treated cells are shown to obtain more roads, it is not implausible to attribute this outcome to their Tigray ethnic component, the only factor that makes them different from control cells.

The employment of various treatment cut-offs allows us to achieve sound and reliable results on the presence of ethnic favouritism, but is also an indirect mechanism of double-checking the consistency of the results, both in terms of different specifications and of different observational units[34].

Matching methods allow us to overcome issues related to observable factors, but in order to deal with the removal of selection bias due to unobservable characteristics, we rely on their combination with difference-in-differences estimation (Heckman *et al.*, 1997) [35]. The combination of PSM and DID allows us to simultaneously control unobserved time-varying heterogeneity and observable time-invariant characteristics that could influence the allocation of road investments (Khandker *et al.*, 2010). However, it is important to stress that DID requires data from the pre-intervention period to test whether treatment and control groups respect the assumption of parallel trends, meaning that the untreated units (non-coethnic) represent an appropriate counterfactual for the treated ones. Unfortunately, we only have one

(Wolayta). This approach allows us to test whether the place/ethnicity of birth of the Prime Minister plays a role in influencing the patterns of the road investment allocations. As expected there is not any significant difference in the ethnic favouritism mechanism, since Desalegn is considered a loyal member of the TPLF, indeed is election has been motivated by many as a way of limiting criticism over the excessive centralisation of power by the Tigray's party.

[34]To some extent, alternative treatment assignment combined with matching procedures allows us to shield ourselves from the critique of "excessive specificity" of Kramon and Posner (2013), by demonstrating that, *ceteris paribus*, there are no reasons besides coethnicity to favour some areas over others.

[35]Indeed, as reported by Heckman *et al.* (1997) this procedure is "*generally more effective than conventional matching methods in removing bias from our data, especially when such data is contaminated by temporally-invariant components of bias such as unobserved sites and questionnaire effects*"

data point before the implementation of the RSDP, namely 1996[36]. Visual inspection of pre-intervention trends, however, cannot rule out the validity of the parallel trends assumption, especially with respect to road quality. Moreover, it seems reasonable to think that before the birth of the Ethiopian federal state in 1994, the Tigray were not powerful enough to have sufficient economic means to create a pre-programme infrastructure gap between them and the other ethnic groups. At the beginning of 1991 the ethnicity of Tigray was still labelled as "discriminated" in the EPR Core dataset of Vogt *et al.* (2015). Nonetheless, we rely on the combination of PSM-DID in order to ensure that the parallel trends assumption is respected; we include all available lags of the outcome variable in the matching algorithm as a way to reduce the potential insurgence of bias due to instances of Ashenfelter's dip in the outcome variable (Chabé-Ferret, 2017)[37].

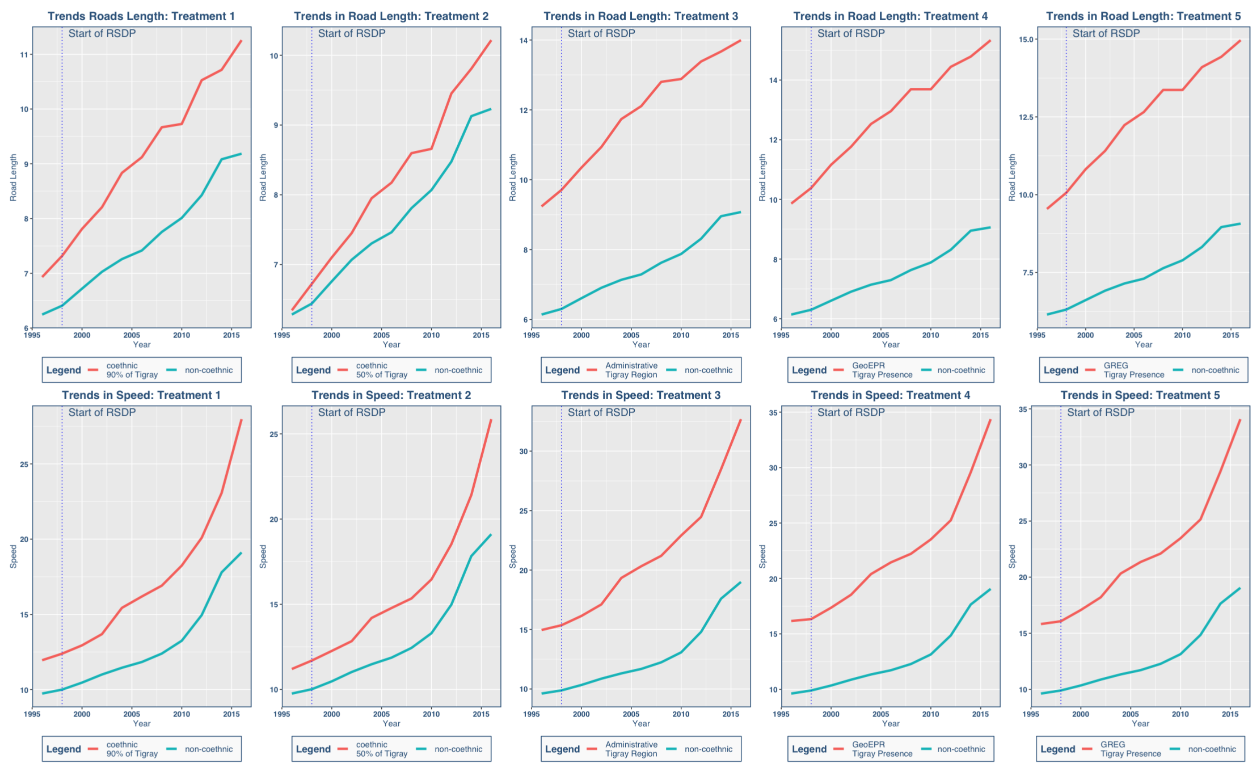

Figure 4: Trends for road length and road speed for each different treatment status definition at grid cells of dimension 0.1 arc-degrees

PSM is used at the baseline in order to match participant and control units, while the treatment impact of the Road Sector Development Program is calculated across matched

[36] A possible solution to this problem could be the digitalisation of the Michelin Maps, as in Burgess *et al.* (2015) and Moneke (2019).

[37] However, we argue that this issue is unlikely to happen in our setting, since treatment is not determined by voluntary adhesion but rather by coethnicity, a characteristic which is stable over time

treated and control cells, within the region of common support[38]. For the two time periods $t = \{1998, 2016\}$, for which we calculate the double difference, the PSM-DID estimator is defined as:

$$ATT_{PSM}^{DD} = \frac{1}{N_T}\left[\sum_{i \in T} Y_{i2016}^{T} - Y_{i1998}^{T} - \sum_{j \in C} \omega(i,j) Y_{j2016}^{C} - Y_{j1998}^{C}\right] \tag{3}$$

Where, T and C stand for treatment and control, respectively; ω is the vector of weights, derived by the PSM procedure; while i, j correspond to observational units in the treatment and control groups.

This estimator allows us to identify the DID Average Treatment Effect on the Treated (hereafter, ATT), given the assumption of time-invariant trends between treatment and control groups (Nguyen, 2012). The derived outcome is conditional on a set of covariates, X, that we consider to be key indicators on which performing the matching procedure to get matched treated and control units.

$$\begin{aligned} ATT_{PSM}^{DD} = E\left[Y_{2016T} \mid X, D=1\right] - E\left[Y_{1998T} \mid X, D=0\right] - \\ E\left[Y_{2016C} \mid X, D=1\right] - E\left[Y_{1998C} \mid X, D=0\right] \end{aligned} \tag{4}$$

We select covariates based on their potential to maximise attractiveness for road investments. Accordingly, the set of covariates employed in the analysis are the results of a balanced choice between those which take into account morphological considerations of the terrain (e.g. Slope, Elevation, TRI) and economic and social components (e.g. PM 2.5, Night Lights, GDP, population density). Indeed, morphological and environmental features, alongside economic and social characteristics, are the crucial factor in determining the implementation costs of the project (in the Appendix, balance tables and detailed explanation on the choices of the variables are provided).

[38]We are aware of the potential limitations of this approach. Indeed, macroeconomic changes during the period of our analysis may have impacted differently on our treatment control units. However, the employment of alternative definition of coethnicity allows us to assess the stability of our results and of our methodology.

4. Results

Table 1 presents the results for the PSM-DID for observational units of grid cell dimension 0.1 arc degrees. After matching on pre-treatment covariates and outcome lags, territories which share the same ethnicity with the Tigray government appear to have received a disproportionate amount of road investments. Moreover, the results appear to be consistent across all specifications and do not depend on the particular definition of coethicity. The differential public goods provision in terms of *RoadLength* ranges from 2.15 km to 3.746 km for grid cells of dimension 0.1 arc degrees. By using our preferred specifications, namely *treatment 1* and *treatment 2*, it appears that Tigray cells have obtained between 5% and 7% of additional road length improvements with respect to other territories, an increase which amounts for 23-27% of their total road surface in 2016.

The differences in terms of road quality improvements between Tigray and the rest of Ethiopia are in the same direction and with the same significance levels. Indeed, the mean speed on Tigray cells is 8.96 km/h to 11.84 km/h higher than on control cells. After the implementation of the RSDP, we calculate that the average benefit in terms of speed for each cell is around 10.08 km/h; it is thus evident how the extra road quality improvements achieved by Tigray territories are significant in magnitude and a reflection of ethnic favouritism mechanisms.

Treatment 1: Coethnicity 90%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.862***	0.4340	6.600	0.0000	527	471
Quality	9.877***	1.1040	8.944	0.0000	527	461
Treatment 2 : Coethnicity 50%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	3.093***	0.3640	8.499	0.0000	706	625
Quality	8.959***	0.9060	9.893	0.0000	706	614
Treatment 3: Tigray Administrative Region						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.149***	0.4580	4.687	0.000	423	288
Quality	11.87***	1.0780	11.016	0.0000	423	300
Treatment 4: Geo-EPR Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	3.746***	0.4850	7.723	0.000	359	259
Quality	10.644***	1.1320	9.399	0.0000	359	250
Treatment 5: GREG Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	3.328***	0.5330	6.242	0.000	362	275
Quality	10.805***	1.1640	9.280	0.0000	362	275

Notes: Abadie and Imbens (2006) standard errors.

Maximum caliper width: 0.01 standard deviations.

1-to-1 matching with replacement, keeping ties.

* $p < 0.01$, ** $p < 0.05$, *** $p < 0.01$.

Table 1: Results at grid cells dimension of 0.1 arc-degrees

In order to establish the stability and consistency of our results for our main specifications, we also consider regressions which employ a parametric structure. In particular, Tables 2 and 3 show the results for road length and quality improvements for both *treatment 1* and *treatment 2*. Column (1) reports the coefficient of the OLS regression, in which we test the simple correlation between being Tigray and the reception of road investments; Columns (2) and (3) report the estimates obtained by propensity score reweighting regressions (Busso *et al.*, 2014). These specifications allow us to test the consistency of the reweighting procedure, but also they control for potential simultaneity bias (or at least, check for observable heterogeneity over time between T and C), maintaining a similar approach to matching; Columns (4) and (5) show the results obtained through parametric DID regression and finally columns (6) and (7) report the results obtained by reducing the sample to matched cells only and then running parametric DID on the matched sample (Imbens, 2014).

Notably, the results arising from parametric specifications are smaller across all regressions with respect to the Heckman *et al.* (1997) non-parametric one-to-one matching algorithm. Nonetheless, almost every outcome[39] yields a positive and significant coefficient for the variable of interest. While the non-parametric procedure is preferred due to its ability to account for individual differences between pairwise matched cells, the parametric regressions still identify a positive and strongly significant impact of coethnicity in the reception of RSDP investments. The relative stability of the coefficients of interest across regressions enhances confidence on the presence of ethnic favouritism in Ethiopia.

[39]Except for PSW omitting controls in the case of road quality for treatment 1.

	Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	2.188***	0.686*	2.621***				
	(0.197)	(0.277)	(0.300)				
DID				1.017***	0.995***	1.892***	1.719***
				(0.232)	(0.230)	(0.306)	(0.307)
Constant	7.835***	7.841***	21.521***				
	(0.075)	(0.101)	(2.318)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	100,474	100,474	100,474	100,474	100,474	9,306	9,306

	Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	5.279***	-0.078	2.807***				
	(0.265)	(0.390)	(0.387)				
DID				2.619***	2.624***	3.959***	3.585***
				(0.494)	(0.487)	(0.636)	(0.613)
Constant	13.260***	13.474***	-0.424				
	(0.058)	(0.065)	(1.737)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	100,474	100,474	100,474	100,474	100,474	9,020	9,020

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table 2: Results of OLS, PSW, panel DID and matched DID, treatment 1.

	Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	1.079***	3.145***	4.693***				
	(0.167)	(0.319)	(0.247)				
DID				0.595**	0.598**	1.860***	1.758***
				(0.185)	(0.184)	(0.230)	(0.227)
Constant	7.877***	8.212***	38.024***				
	(0.0765)	(0.190)	(4.530)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	100,474	100,474	100,474	100,474	100,474	11,627	11,627

	Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	3.694***	3.71***	5.050***				
	(0.229)	(0.276)	(0.247)				
DID				1.774***	1.839***	3.282***	2.960***
				(0.393)	(0.387)	(0.521)	(0.508)
Constant	13.279***	13.816***	12.661***				
	(0.059)	(0.087)	(1.212)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	100,474	100,474	100,474	100,474	100,474	11,495	11,495

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table 3: Results of OLS, PSW, panel DID and matched DID, treatment 2.

5. Woreda-level Analysis

We then replicate our analysis on the incidence of ethnic favouritism on the allocation of the RSDP at the woreda (district) level. For this specification, we only focus on the normalised measurement of $Length/Km^2$ and $Length/Pixel^2$. Indeed, the "pure" measure of $RoadLength$ does not provide any reliable indication of the incidence of this phenomenon, since woredas are heterogeneous in size. All the results for SIDE 90% and 50% appear to be significant and consistent in terms of detecting ethnic favouritism mechanisms on the Ethiopian territory, thus confirming the general pattern that we have already shown at a more granular level. Indeed, it appears confirmed that there is a concentration of roads investments in districts with a Tigray majority. However, there are a few noteworthy caveats: (i) the set of woredas employed in the analysis is limited to those for which administrative boundaries were not altered during the period 1996-2016, thereby substantially reducing the available sample; (ii) for lack of cross-sectional variability we are unable to construct the $Quality$ outcome variable[40].

Notwithstanding the impossibility of analysing the impact of the RSDP on road quality at the woreda level, we test a specification which employs market access, as defined in Storeygard (2016), as the outcome variable. Effectively, this outcome combines improvements in road length and road quality, since the market access variable consists of the shortest paths between the centroids of each woreda, weighted by travel time and the economic mass of destination woredas (for details on the construction of market access variable see Appendix)[41]. The market access indicator is extremely important for our analysis since it allows us to verify whether the impact of road improvements has contributed to generate positive economic externalities and virtuous cycles. Indeed, market access is considered a fundamental determinant of attractiveness of economic activities, since better connectivity implies on one hand reductions in transport costs and entry barriers, and on the other hand improvements in terms of economies of scale and reception of collateral investments (Redding, 2020). Moreover, to some extent this outcome shields the analysis from the critiques of excessive specificity moved to ethnic favouritism studies by Kramon and Posner (2013).

The market access indicator should be regarded as a multidimensional indicator which condenses multiple information, in particular regarding increases in economic potential. The fact that woredas with a Tigray majority are characterised by a positive and significant value of the ATT in Table 4 highlights that these areas have benefitted from the RSDP over a range of determinants of economic development, thus attracting a larger potential for future growth. Even though the market access indicator in this context is just used as proxy of an increase

[40] While road quality proxied by road speed is a sensible approximation at the grid cell level, due to the comparable surface covered by each observation, this characteristic is not verified at the woreda level. We include the road length results in order to show the consistency of our estimates to different observational units, but we maintain that our preferred specifications is at the 0.1 degrees grid cell level.

[41] This procedure allows us to overcome the issues of the different size of the woredas, by collapsing the information to single points in the network (woreda centroids).

in connectivity and economic exchange, it provides us with some indications of the indirect repercussions generated in terms of welfare, once again reinforcing the idea of unbalanced growth in favour of a specific ethnic group.

	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
Treatment 1: Coethnicity 90%						
$Length/Km^2$	0.019*	0.0110	1.697	0.090	23	20
$Length/Pixel^2$	0.016*	0.0090	1.682	0.093	23	20
$MarketAccess$	0.075**	0.0290	2.620	0.009	23	20
Treatment 2: Coethnicity 50%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
$Length/Km^2$	0.018*	0.0090	1.886	0.059	27	24
$Length/Pixel^2$	0.015*	0.0080	1.857	0.063	27	24
$MarketAccess$	0.044*	0.0230	1.918	0.055	27	25

Notes: Abadie and Imbens (2006) standard errors.

Maximum caliper width: 0.25 standard deviations.

1-to-1 matching with replacement, keeping ties.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Results at woreda level

6. Robustness Checks and Falsification Tests

In the following sections we present alternative specifications to assess the robustness of our results. We conduct four different analysis: (i) we use a Regression Discontinuity Design (RDD) to assess the difference in terms of infrastructural investments is statistically significant once we cross the Tigray administrative border; (ii) we employ as observational units only cells that were "unconnected" in 1996. This strategy allows us to take into consideration only those cells which were considered "not a priority" in the decision making scale of the RSDP allocation investments. In this way, we are able to detect whether cells dominated by a Tigray majority are favoured over the others, *ceteris paribus*, even in the unlikely case in which the matching procedure described above fails to produce balanced cohorts; (iii) We conduct a specification in which we only focus on those cells which are characterised by the presence of at least 50% of ethnic Omoros, Amharas and Tigrays, enabling us to focus only on those ethnicities that the EPR-Core denominated as participants in the Ethiopian governing coalition. This framework provides interesting insights on the presence of ethnic favouritism at higher levels of the Ethiopian power hierarchy. Furthermore, this specification allows us to defend ourselves against possible criticisms of the PSM-DID of our main specification. Indeed, by restricting our sample only to the most influential ethnic groups we can show that the mechanism of ethnic facilitation in favour of Tigrays is prevalent even with respect to coalition partners and not a result of the matching algorithm presented in the previous section; (iv) finally, we perform a falsification test in which the treatment status is being coethic with the Amhara ethnic group, to assess the reliability of our results.

6.1. Regression Discontinuity Design at the Tigray Border

RDD gives us two possibilities: on one hand, assessing whether the ethnic favouritism mechanism is an already perceptible phenomenon at the administrative border, on the other hand, shielding ourselves from potential criticism regarding the choice of the sample selected by the matching algorithm. In fact, by selecting cells in close proximity to the Tigray border, RDD derives its treatment effect on cohorts which should be considered similar both in terms of their socio-economic outcomes and morphological characteristics by construction. Thus, any estimate discrepancy in terms of infrastructural investments should be reasonably attributed to the different ethnic component.

We employ a regression discontinuity design with a sharp cut-off at the Tigray administrative border, estimating in this way the Local Average Treatment Effect (LATE) in the proximity of its boundary (Gelman and Imbens, 2019; Lee and Lemieux, 2010). In particular, we estimate the following equation:

$$I_i = \alpha + \beta_1 Treatment3_i + \beta_2 X_i + f(Distance_i) + \epsilon_i \tag{5}$$

where I_i stands for infrastructural investments (length and speed) in grid cell i; $Treatment3_i$ is the binary indicator employed in the analysis to assess whether a cell i is inside the Tigray administrative areas or not; X_i is a vector of cross-sectional variables, namely slope, elevation, distances from water and a measure of accessibility, while

$$f(Distance_i) = Treat3_i * f_{Treat3}(Distance_i) + (1 - Treat3) f_{Non-Treat3}(Distance_i) \quad (6)$$

is a polynomial term which weights observational units with respect to their distance to the Tigray's border (i.e. weighing more cells closer to the frontier). We estimate a separate linear model on both sides of the Tigray's border cut-off (Gelman and Imbens, 2019), and estimate treatment effects through an OLS regressions with robust standard errors. Our preferred specifications are those obtained via separate polynomials and bandwidths of 55km and 110km.

Hereafter, we report the results of the RDD analysis along the Tigray border, including the treatment effects at the discontinuity each year between 1996 - 2016 for *length* (Figure 5) and for *Speed* (Figure 6).

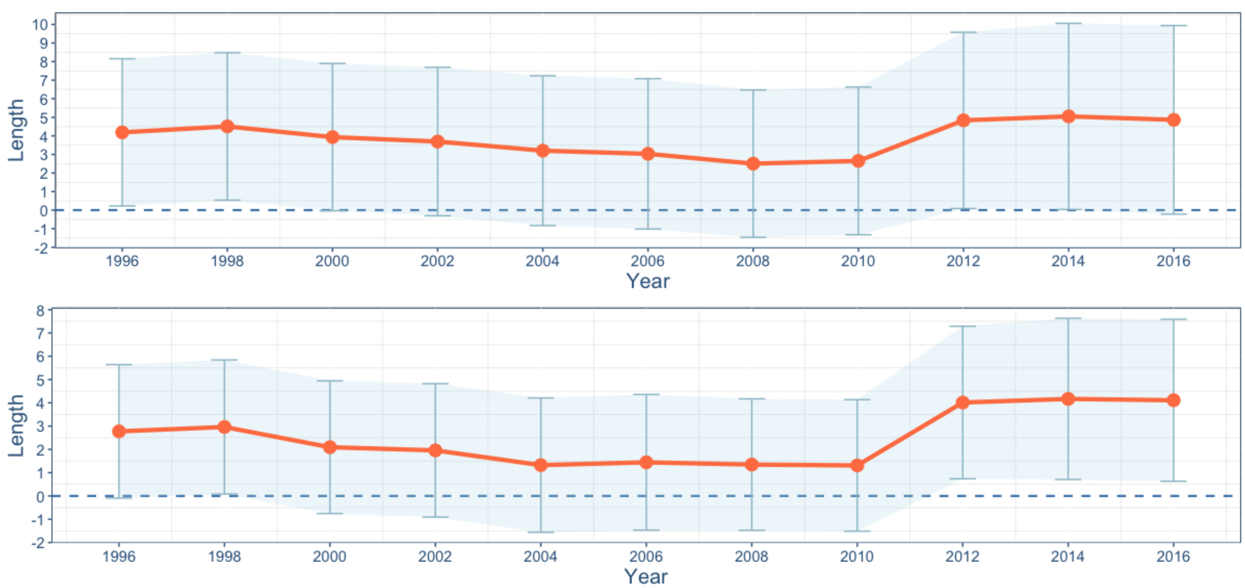

Figure 5: Regression discontinuity LATE with bandwidth 55 km from Tigray border on the top; regression discontinuity LATE with bandwidth 110 km from the border on the bottom. Outcome Length.

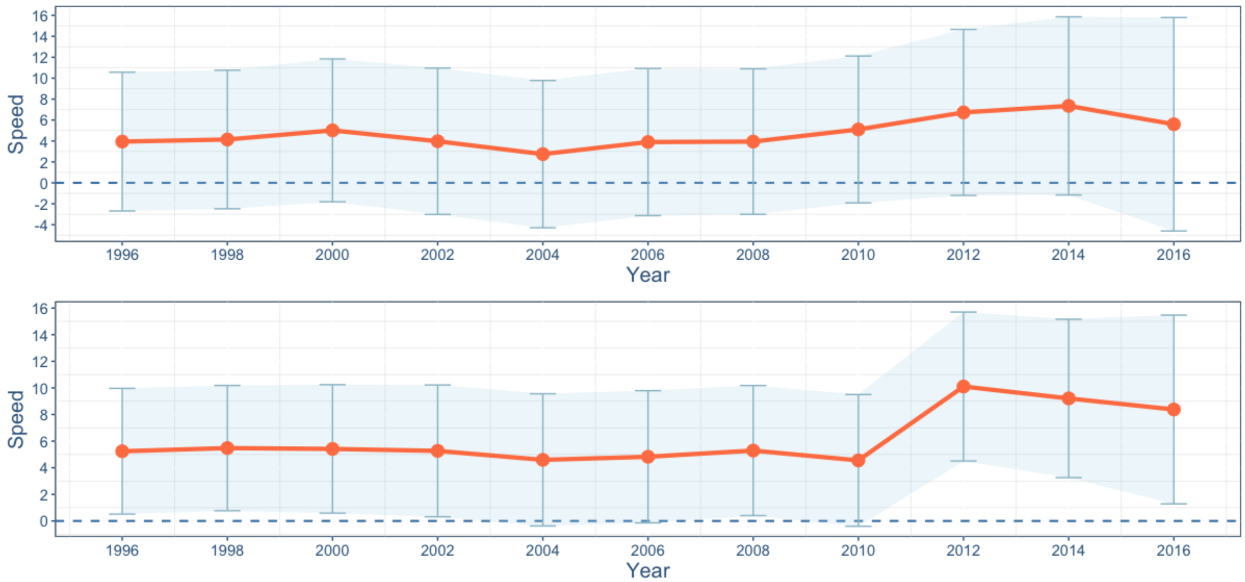

Figure 6: Regression discontinuity LATE with bandwidth 55 km from Tigray border on the top; regression discontinuity LATE with bandwidth 110 km from the border on the bottom. Outcome Speed.

By inspecting these graphs it is extremely interesting to notice that the point estimate of the Local Average Treatment Effect (LATE) is always positive at the $\alpha = 0.05$ significance level, implying then that in general, the territories within the Tigray administrative boundary are characterised from a disproportional infrastructure concentration (both in terms of the extent of road junctions and quality of the investments) with respect to the surrounding territories. Although these inequalities were already visible at the border at the beginning of 1996, it is clear that the RSDP has continued and exacerbated this inequality. Moreover, inspecting Figure 6, we can observe that the point estimate for the variable *Speed* at the end of the period 2016, seems to start reversing the previous trend, indeed the difference at the border appears to be not significant. This may be due to a perceptible improvement in the redistributive allocation of investments road quality in the areas neighbouring the Tigray region. However, looking closely at the graph below which shows the trend at the bandwidth of 110 km, it is evident how the inequality at the border only exacerbated as the border recedes. Following this reasoning, it seems plausible to assume that at the distance of 55km from the Tigray border the areas are still more densely populated by the Tigray ethnic component and this fact somehow still affects the distribution of investments, consistently as one moves away from the border, inequality increases (see next Figure 7).

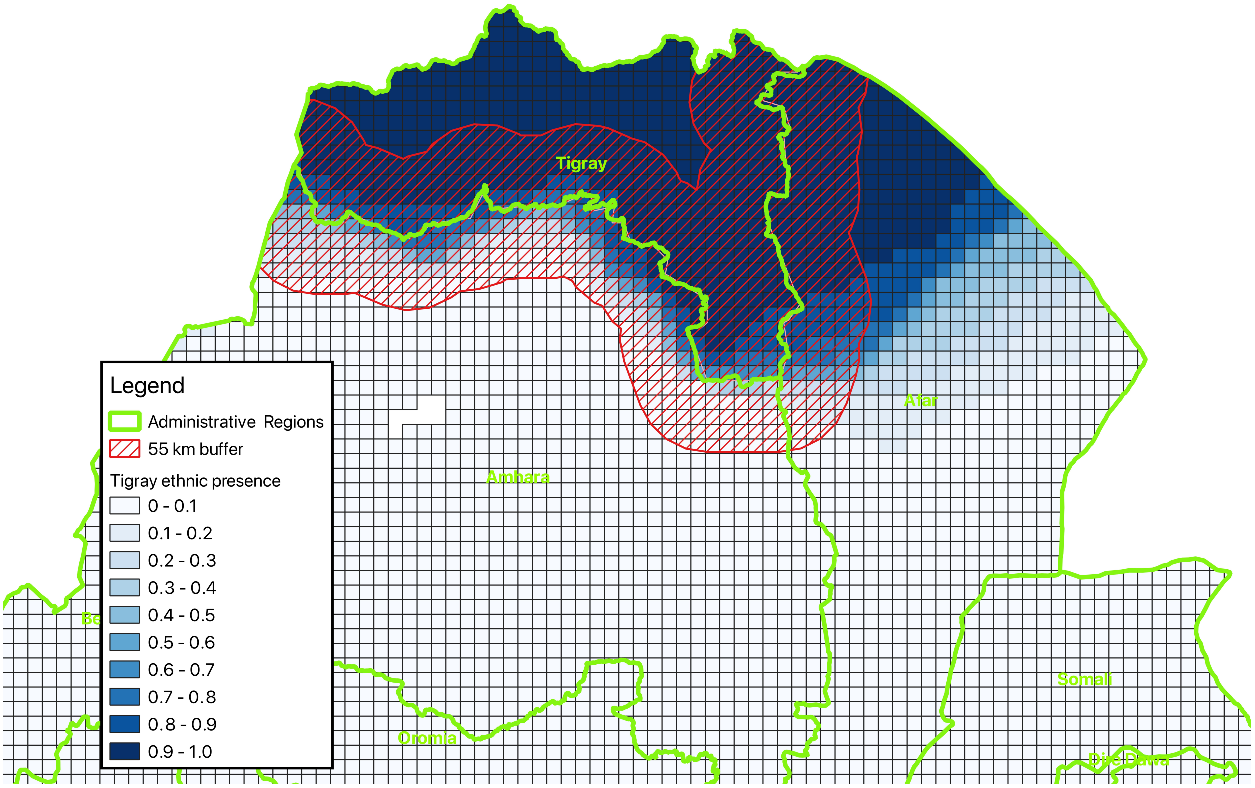

Figure 7: Graphical representation of the cells included with a bandwidth of 55 km from the Tigray Administrative Border.

In Figure 8-9 we report the post-treatment effects to have a visual idea of the jump observed at the Tigray administrative border in terms of concentration of road investments due to the RSDP.

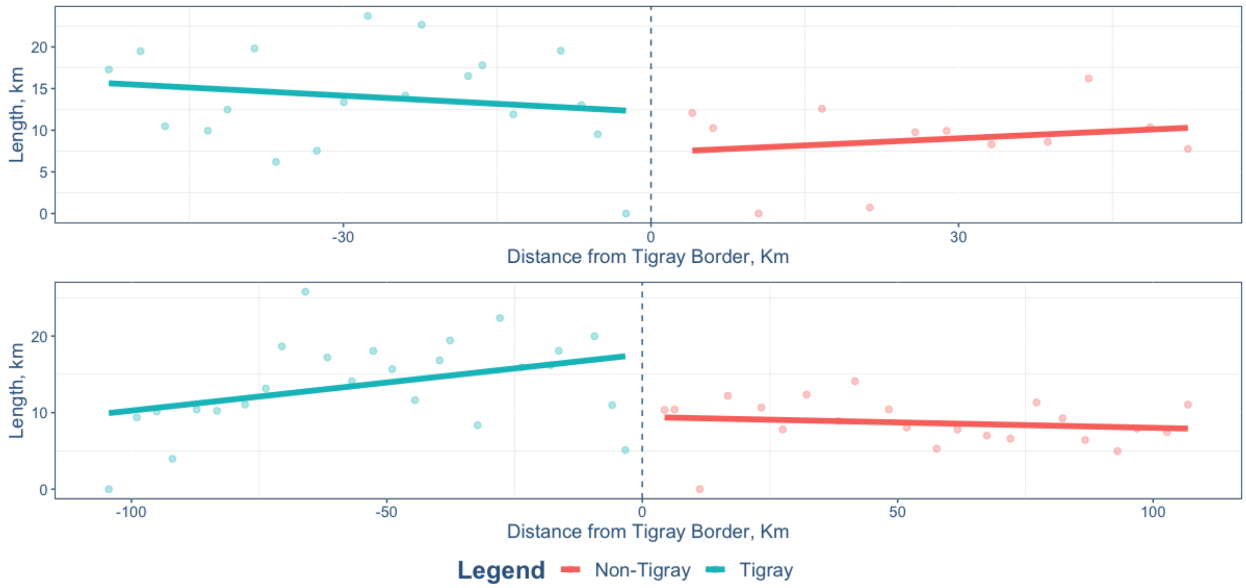

Figure 8: Regression discontinuity in the proximity of the Tigray border on the top (bandwidth 55 km); Regression discontinuity in the proximity of the Tigray border on the bottom (bandwidth 55 km). Outcome Length.

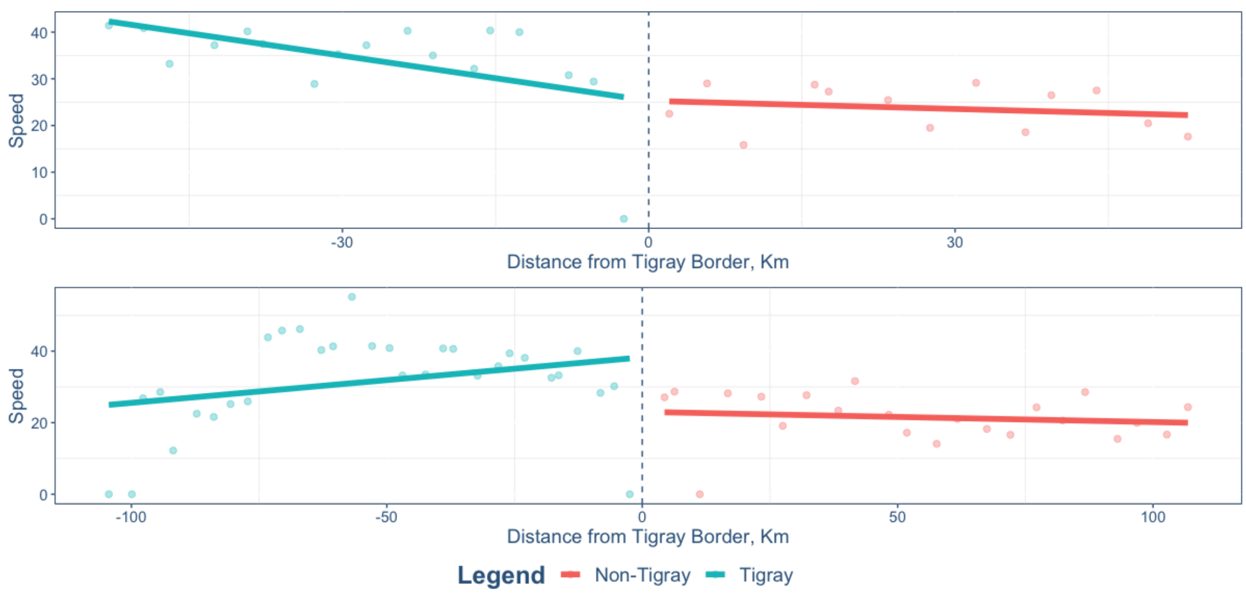

Figure 9: Regression discontinuity in the proximity of the Tigray border on the top (bandwidth 55 km); Regression discontinuity in the proximity of the Tigray border on the bottom (bandwidth 55 km). Outcome Speed.

6.2. Unconnected Grid Cells

We turn then our analysis on a sub-group of cells, unconnected to the road network in 1996 (see Figure 10). This alternative specification allows us to take into considerations mainly two factors: (i) by excluding grid cells which were already part of the road networks, we are able to isolate "greenfield investments" in road infrastructure; (ii) this procedure allows us to focus only on those cells that are not on the main road lines, meaning those cells that are in proximity of the main cities or road junctions. Therefore, this method enables us to assess whether the "non-strategic cells" that are populated by a Tigray majority have received more road infrastructure and quality road improvements, *ceteris paribus*, with respect to the other cells[42].

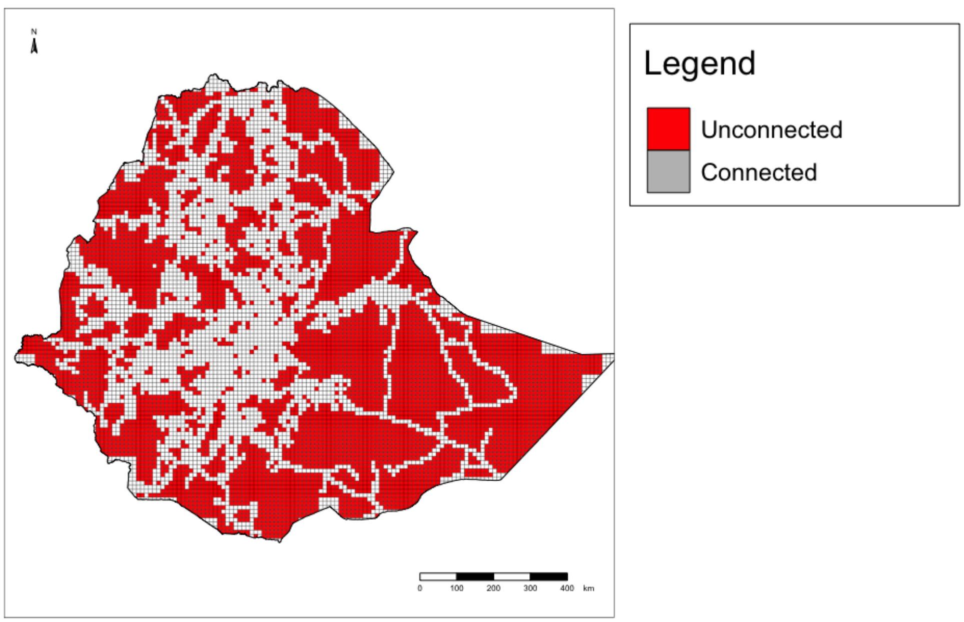

Figure 10: Unconnected cells at the baseline

All results appear to be positive and significant at the $\alpha = 0.01$ confidence level. Therefore, if our matching covariates properly reflect the propensity of a grid cell to receive road investments, then these analyses have shown how Tigray cells have been significantly favoured. Indeed, unconnected cells exhibit the same patterns of the main specification, with the same order of magnitude. The differential in road investments appears to be consistent across the specifications: for *RoadLength* it ranges from 3.66 km to 6.75 km. Results obtained for the *Quality* outcome variable confirm the general trend. Indeed, they range from a minimum of 13.11 km/h, in the specification in which we consider as treatment those cells with almost 50% of Tigray presence, to a maximum of 20.81 km/h, in the specification in which we use as

[42]Balance tables for unconnected grid cells of dimension 0.1 arc degrees are reported in the Appendix.

treatment the Tigray Administrative Region [43].

Treatment 1: Coethnicity 90%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	4.209***	0.6150	6.847	0.000	279	215
Quality	13.137***	1.6210	8.105	0.000	279	215
Treatment 2 : Coethnicity 50%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	3.662***	0.5300	6.911	0.000	401	302
Quality	13.116***	1.4120	9.289	0.000	401	302
Treatment 3: Tigray Administrative Region						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	6.753***	0.7650	8.826	0.000	177	86
Quality	20.819***	2.0080	10.368	0.000	177	86
Treatment 4: Geo-EPR Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	5.322***	1.0040	5.301	0.000	140	99
Quality	17.361***	2.2900	7.582	0.000	140	99
Treatment 5: GREG Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	5.22***	0.9140	5.710	0.000	143	102
Quality	18.817***	2.4870	7.565	0.000	143	102

Notes: Abadie and Imbens (2006) standard errors.

Maximum caliper width: 0.01 standard deviations.

1-to-1 matching with replacement, keeping ties.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Results for Unconnected cells of dimension 0.1 arc-degree

[43] We also assess the reliability of our results via parametric regressions, see Tables F.22 and F.23 in the Appendix.

6.3. Junior Partner of the Government

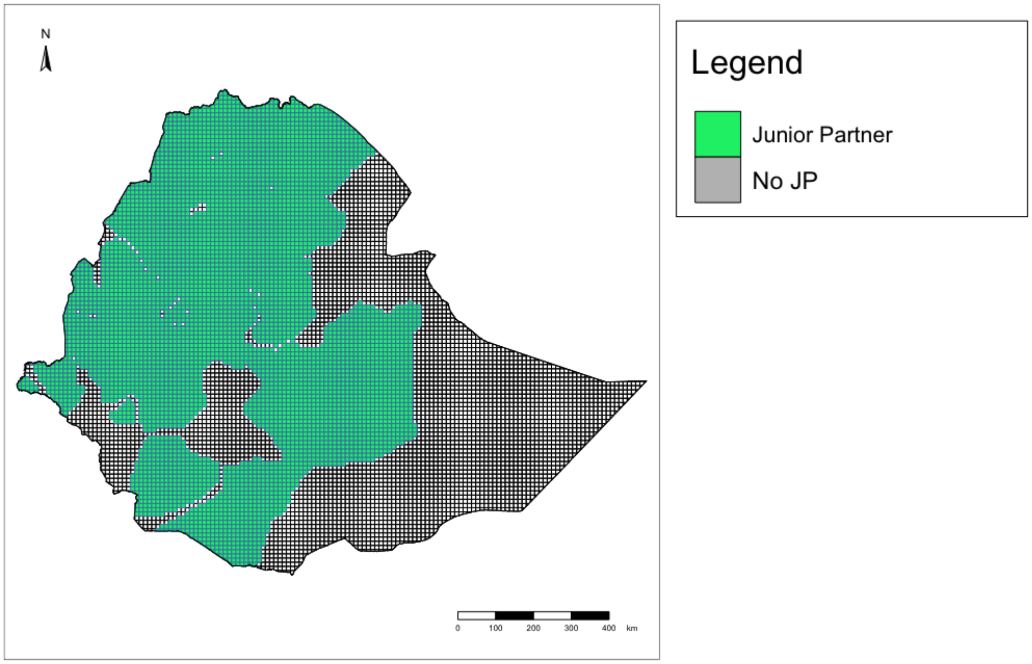

Figure 11: Geo spatial representation of the cells labelled Junior Partner of the Ethiopian government

In this specification, we reduce our sample to those cells which are characterised by as Tigray, Oromo or Amhara ethnic presence of at least 50%. This framework of analysis allows us to consider only those cells that are dominated by those ethnicities that the EPR-Core Dataset (Vogt *et al.*, 2015) classifies as *junior partners* of the coalition, meaning those ethnic groups which are not only represented in the Ethiopian government, but share some degree of political power. Indeed, all the other ethnic groups appear to be classified as *irrelevant* (e.g Harari), or *discriminated*, (e.g. Somali). From 1994, the year in which the TPLF took power, only the Oromo and the Amhara ethnic groups carried some "de facto" political representativeness.

Therefore, this specification permits to identify whether ethnic favouritism manifests itself also for this subsample and whether it does with the same degree of intensity.

The reported estimates share the same positive direction as all the other specifications. Indeed, inspecting the following Tables it appears evident how for our preferred specifications, namely SIDE at 90% and 50% of Tigray ethnic presence, the results are consistent and robust across alternative analyses. This is also confirmed by the *Quality* ATT, which ranges from 5.905 km/h to 11.60 km/h, at the $\alpha = 0.01$ level of significance[44].

However, some others considerations may be derived, from the junior partner specification.

[44] Balance tables for this exercise are again reported in the Appendix.

Indeed, what is interesting to notice is that the magnitude of ethnic favouritism seems to be less pronounced and scaled down for this sub-sample. Nevertheless, although less dramatic, this phenomenon is still present, especially for what concerns *Quality*, meaning the investment in terms of road surface improvements. What should be stressed is that even considering the particular framework of the analysis, ethnic favouritism is still registered, both in terms of length and in terms of *Quality*. This means that the Tigray minority was able to behave undisturbed in the decisional process of investment allocations, even "at the expense" of those ethnic groups that have a similar degree of political power. This result is even more impressive once we take into consideration the fact that Oromos and Amharas constitute the two largest ethnic groups in the Ethiopian territory, representing 34,4% and 27% of the population, compared to 6.1% for Tigrays.

Treatment 1: Coethnicity 90%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.959***	0.4900	6.043	0.0000	527	508
Quality	5.905***	1.0660	5.538	0.0000	527	447
Treatment 2 : Coethnicity 50%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.555***	0.4370	5.852	0.0000	706	653
Quality	8.52***	0.9820	8.671	0.0000	706	597
Treatment 3: Tigray Administrative Region						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.792***	0.5190	5.379	0.0000	423	338
Quality	9.548***	1.1810	8.084	0.0000	423	383
Treatment 4: Geo-EPR Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	2.806***	0.5320	5.274	0.0000	359	303
Quality	11.60***	1.2310	9.422	0.0000	359	278
Treatment 5: GREG Dataset						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	3.405***	0.5480	6.209	0.0000	362	312
Quality	8.763***	1.2910	6.787	0.0000	362	266

Notes: Abadie and Imbens (2006) standard errors.

Maximum caliper width: 0.01 standard deviations.

1-to-1 matching with replacement, keeping ties.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Results using as sample only JP of the government

6.4. Falsification Test: Amhara coethnicity

We perform an in-space falsification test, assigning the "*dominant*" status to the Amhara ethnicity and inspecting with this procedure whether the effects found in the previous section are an artefact of the underlying data distribution or credible causal effects. If the ATT found through these regressions was positive and significant, it would discredit the claims about the presence of an ethnic mechanism favouring Tigrays made in the previous section. On the contrary, negative or non-significant results from this exercise would reinforce the confidence we place on the aforementioned results. We test again two thresholds of Amhara ethnic presence, namely the preferred specification of SIDE 90% and 50%. The following Figures 12-13 show the geographical distribution of Amhara on the Ethiopian territory. Notably, a consistent portion of ethnic Amharas inhabit the central corridor connecting Addis Abeba to Northern Ethiopia, a part of the country in which pre-RSDP road density was generally higher and thus susceptible of both investments in connectivity and improvements in terms of quality. Nonetheless, as shown in Table 7, the ATT is negative for the 90% case and negative, but not statistically significant for the 50% case. Therefore, there is no evidence of ethnic favouritism towards the Amhara ethnicity, confirming our *a priori* expectations.

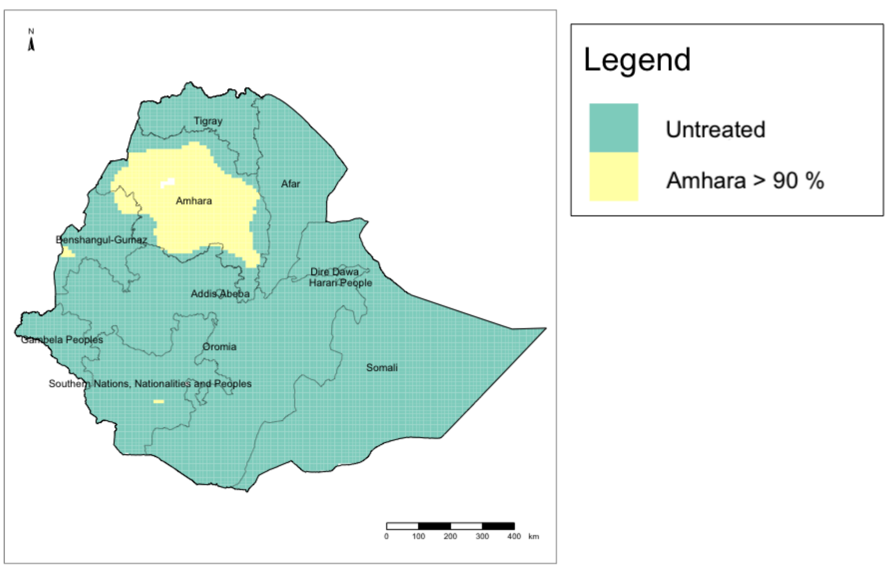

Figure 12: Geo spatial representation of the cells with Amhara presence $> 90\%$

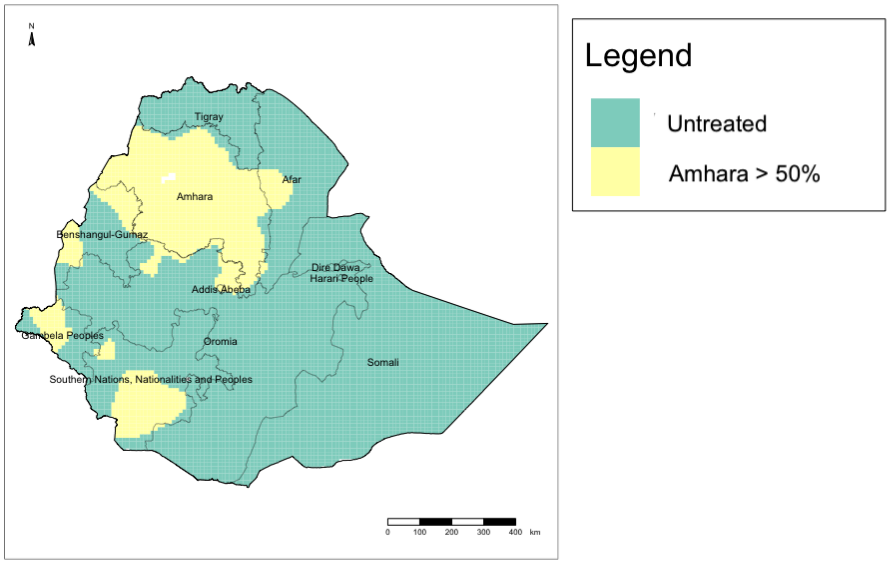

Figure 13: Geo spatial representation of the cells with Amhara presence > 50%

Falsification Test 1: Coethnicity 90%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	-1.134***	0.2090	-5.427	0.0000	907	267
Quality	-2.565***	0.3500	-7.336	0.0000	907	253
Falsification Test 2 : Coethnicity 50%						
	ATT	**AI SE**	**t-stat**	**pvalue**	**Treat**	**Matched**
RoadLength	-0.136	0.2080	-0.653	0.5140	1930	1129
Quality	0.686	0.3760	1.822	0.0690	1930	1129

Notes: Abadie and Imbens (2006) standard errors.

Maximum caliper width: 0.001 standard deviations.

1-to-1 matching with replacement, keeping ties.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Results using as treatment being coethnic with Amhara

7. Conclusion

In this paper we proposed an investigation of the role played by ethnic favouritism in the preferential allocation of road investment towards the Tigray ethnicity, during the 1998-2016 implementation of the RSDP in Ethiopia. This study compiles a unique dataset in which original, spatially and temporally explicit data on the RSDP are assembled together with spatial information on ethnicity, morphological and economic features. We present one of the first attempts to employ quasi-experimental methods to detect ethnic favouritism, performing an analysis which combines tools and observational units taken from economic geography literature.

In our paper, we argue that areas dominated by a Tigray majority have received a disproportionate level of road investments, around 5-7% higher than the rest of the country. The results are consistent across all our specifications and robust to the variation of grid cell dimension and observational units. Such stability gives us confidence about the robustness of our findings. What can be assessed by inspecting the results of the PSM-DID analysis is that for the road length outcome, the ATT at the threshold of 50% of Tigray presence is highest, settling at about 3km more road investment for each cell dominated by Tigray coethnics. The ATT for road quality, instead, is maximum at the 90% Tigray presence threshold, where speed is on average higher by almost 10 km/h. This is in line with our *a priori* expectations. Indeed, it is reasonable to expect that while new connections are necessary to link Tigray areas to the rest of Ethiopia (meaning that new investments in road length are necessary even in areas not overwhelmingly dominated by a Tigray majority, but nonetheless located close to the Tigrayan region), investments in road surface are more concentrated in the core of the Tigray region, namely those areas more densely populated by the Tigray. This is furthermore confirmed by the RDD LATE results, which show that near the Tigray administrative border we assist to a significant jump in terms of infrastructural investments, which becomes even more pronounced as more distant observational cells units are included in the analysis.

The main contribution of this paper is its attempt to quantify the unequal spatial distribution of road investments on the Ethiopian territory. Although we cannot empirically affirm the *exact* amount of extra kilometres and quality investments obtained by the Tigray areas, what we have shown is not only the presence of ethnic favouritism mechanisms, but also a range of possible estimates of this unequal distribution. Moreover, thanks to the employment of the market access as an additional outcome variable, we reconstruct the economic repercussions of this allocation, showing that woredas in the Tigrayan region have benefited significantly from extensive investments, enhancing their economic attractiveness. However, what is crucial to emphasise is that although this paper has focused on highlighting the unequal allocation of infrastructure investment to an ethnic minority, one must always keep in mind the role played by roads in a country's path towards economic development. "*Roads are the arteries through which the economy pulses. By linking producers to markets, workers to jobs, students to school, and the sick to hospitals, roads are vital to any development agenda. (...) The World Bank lends more for roads than for education, health, and social services combined*" (Berg *et al.*, 2015). This means that a disproportionate allocation of infrastructure investment to the Tigray has further implicit consequences that an indicator such as market access may only partly represent. In this regard we hope to develop further interesting research building on these insights.

We do not want go so far as to decline whether or not this has been to the detriment of the entire economy of the country. In fact, although this exploitation of resources in favour of the Tigray region has occurred, it is possible that the Ethiopian country as a whole may have benefited from it, in any case. We leave this question untouched for the moment as it may be an interesting avenue for extending this research. However, we believe that understanding ethnic favouritism mechanisms is important "per se", and it should be regarded as paramount in describing socio-economic dynamics and explaining ethnic tensions, as is unfortunately happening in Ethiopia. Therefore, we think that this paper may help to better decipher how these strategic investments with crucial long-term economic and social consequences are allocated, casting doubts about the ability of Ethiopian ethnic federalism to be a deterrent to ethnic favouritism logics and to be able to truly represent all ethnic groups and their potential for development and growth.

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Appendix A. Brief Historical Overview

From the end of Mengistu to the birth of the Federal Democratic Republic

From late 1989, the implosion of the communist-oriented regime of Mengistu Haile Mariam, "officially committed to Marxism-Leninism" (Ottaway, 1995), receives its decisive blow when years of mismanagement of public resources, high corruption, severe repression of opposition and failed economic policies, reached their peak. Moreover, "*the cutting of Derg's ideological and material support lines to the Soviet Union and other communist-bloc countries*" (Abbink, 1995) contributed to the precariousness of the regime. Nevertheless, Mengistu was officially overthrown by the combined efforts of a number of rebel groups, which pursued a warfare strategy to defeat the Derg dictatorship. The most significant ones were: the Tigray People's Liberation Front (TPLF), the Eritrean People's Liberation Front (EPLF) and on a lesser scale, the Oromo Liberation Front (OLF), which "*waged hit-and-run attacks in the east and south east and from across the Sudanese border*" (International Crisis Group, 2009). Between 1989 and 1990, the two principal rebel groups, TPLF and EPLF achieved important military gains that led to the flight of Meginstu to Zimbabwe on 21 May 1991 (International Crisis Group, 2009).

"*The victorious rebel forces reached Addis Ababa a week after*"(International Crisis Group, 2009), carrying with them different goals and motivations. In particular, the Eritrean People's Liberation Front (EPLF), the northern-most administrative region of Ethiopia, had always fought for his independence, since the regime of Haile Selassie. Therefore, the EPLF saw in this victory the achievement of a single goal: the long-awaited Eritrean independence, obtained after a referendum, on 25 May 1993 (Ottaway, 1995). From that moment the TPLF had the responsibility to govern Ethiopia (Ottaway, 1995). Preparing for the national leadership, the TPLF established the Ethiopian People's Revolutionary Democratic Front (EPRDF), a coalition of ethnic movements, which was instrumentally used as an umbrella against the suspicious that the Tigrean movement was trying to "*impose the rule of a minority on the entire country*" (Ottaway, 1995). The EPRDF includes: the Ethiopian People's Democratic Movement (EPDM), the Oromo People's Democratic Organisation (OPDO), the Southern Ethiopia Peoples Democratic Front (SEPDF), and of course the TPLF, which was undoubtedly the real director of this "new political creature". Birru (2018) reports how "*the power and all the go-ahead orders are in the hands of the Tigray People's Liberation Front. It is the TPLF that rules the country*". Indeed, even if nominally was the EPRDF that defeated the Mengistu's regime, "*in the eyes of most Ethiopians - an in actual fact - the EPRDF was simply an instrument of the TPLF*" (Ottaway, 1995; Cohen, 1995)[45]. After the "National

[45]In line with many other political organisations, the TPLF took its roots in Socialist-Marxist-Leninist oriented movements of the late 1960s and early 1970s, which reject political and economic liberalisation. Nevertheless, in 1991 "*the days of socialism were over*" (Ottaway, 1995). With the end of the Cold War and with the USSR's dissolution, the Tigrean political narrative had to change. To obtain recognition and assistance from the United States, the TPLF needs to change its political radical rhetoric, rooted in the communist ideology, to adopt "the language of democracy" (Ottaway, 1995). Nevertheless, it is important to point out that also the United States were concerned in engaging in diplomatic relations with the TPLF

Conference of Peace and Reconciliation", held in Addis Ababa in July 1991, the Transitional Government of Ethiopia (TGE), led by the EPRDF, was formed. The TGE was in charge to organise the "*new democratic order, including the prospects for elections, preparation of the constitution, press freedom and freedom of movement and association*"(Abbink, 1995).

Nevertheless, it was clear from the beginning that the Addis Ababa Conference was closely controlled by the TPLF, indeed, "*the so-called process of democratisation started in the absence of any real countervailing power to that of this dominant group*" (Ottaway, 1995). In 1991, Meles Zenawi was elected President, while on June 1992 the first multiparty regional and district elections took place. From the beginning, Meles Zenawi appeared just as an "*extension of the Tigray élite*", and all the other political parties were completed dominated by his figure (International Crisis Group, 2012). Indeed, "*it was clear from the beginning that the TPLF pushed for election just to formally legitimize the EPRDF*" (Cohen, 1995). As evidence of the imbalance of power, the results of the elections show that the EPRDF "*received 96.6% of the vote, and international observes qualified the election as sterile, surreal and wholly formalistic*" (International Crisis Group, 2009) [46]. However, the results were legally accepted, also by the international community, and from that moment it was "*delcared a triumph of democracy by the EPRDF*"(Ottaway, 1995). On June 1994, there were the elections for the constitutional assembly, while in 1995 the first federal and regional parliamentary ones. All of them were characterised by the lack of participation by the main opposition parties, and by a climate of repression and manipulation. International observes declared that the "*the elections were technically acceptable, but withheld judgment on their political significance*" (International Crisis Group, 2009). There was a constantly undisputed "*Tigrayanisation of the power structure*"(Abbink, 1995).

Nonetheless, in December 1994, a constitutional assembly ratified the new constitution, by which they establish an ethnic federal system, where they gave full recognition to ethnic autonomy, with a secession option (Birru, 2018).

(Vestal, 1996). As reported by Ottaway (1995), "*there were contacts between TPLF leader Meles Zenawi and the US government already in the late 1980s*". Indeed, different goals converged in the mutual support of TPLF and the United States. On one hand, the United States were interested in keeping the Horn of Africa as stable as possible, given the threats of islamic fundamentalism on the region and the necessity of replacing the role played by the USSR; one the other hand, the "*TPLF needed recognition and support in the difficult task of controlling a vast, multi-ethnic country, while representing an ethnic group of probably less than 10% of the population*"(Ottaway, 1995). Therefore, it is not surprising that the "National Conference of Peace and Reconciliation", organised at Addis Ababa in July 1991, by the EPRDF was encouraged by the United States (Birru, 2018). Almost all the ethno-political movements who had fought against the regime were welcome at the conference, with the only exception of the Ethiopian Peoples' Revolutionary Party (EPRP), "*a formerly popular leftist political and guerilla movement which had fought a tough battle with Mengistu's regime in the late 1970s, but which was also an old rival of the TPLF*" (Abbink, 1995). The conference led to the adoption of a national "Charter for the Transitional Period", which was a "transitional government set up" to face the institutional vacuum caused by the end of the dictatorship

[46] The subsequent federal elections of 2005 and the 2008 local ones, do not show any significant democratic development. The EPRDF did not accept opposition and "regarded the expression of differing views and interests as a form of betrayal"(International Crisis Group, 2009)

The Ethiopian Experimental Ethnic Federalism

"*The constitutional assembly ratified the new constitution, which was lauded for its commitment to federalism, liberal democracy and respect of political freedoms and human rights*" (International Crisis Group, 2009). From that moment, Ethiopia introduces the Ethnic Federalism, which operates on the basis of "ethno-national representation"(International Crisis Group, 2009). The Article 46.2 of the Constitution declares "*the states shall be delimited on the basis of settlement patterns, identity, languages and consent of the people concerned*", and Article 47.4 affirms that "*the member States of the Federal Democratic Republic of Ethiopia shall have equal powers and rights*".

The multicultural federation consists of 9 ethnic-based regional states: Tigray, Afar, Oromiya, Amhara, Somali, Benishangul-Gumuz, Southern Nations, Gambella and Harar. Addis Ababa and Dire Dawa, instead, have been legally considered federally administered city-states. From the beginning, the design of this ethnic federalism traces a clear asymmetry between "*the populous regional states like Oromiya and Amhara of the central highlands, and the sparsely populated, underdeveloped regional states like Gambella and Somali*" (International Crisis Group, 2009). Moreover, as reported by Ismagilova (2004) the criterion of the definition of the regional states was not clear. Indeed, although the logic of the division should be the ethno-linguistic principle, "*only few major ethnic groups were accorded the status of regional states, while a number of ethnic groups of a considerable numerical strength were denied this status*" (Ismagilova, 2004). A clear example of this abnormality is the case of the population of the Southern Nations', Nationalities' and Peoples' Regional State (SNNPRS), which consists of over 40 ethnic groups, each of them with a proper culture, political and economic view.[47]

It is not surprising that, as reported by Birru (2018), the perceptions around the Ethiopian Ethnic Federalism were various. There were those that saw in the ethnic federalism an "innovative choice", able to give new insights for thinking differently about the role played by ethnicity in the political African future (Chabal and Daloz, 2001). On the other side of the spectrum, there are those who saw in the prominent role assigned to ethnicity a serious danger for the coexistence of the country (Kidane, 1997; Vestal, 1996; Ottaway, 1995; Cohen, 1995; Abbink, 1995). Among those that strongly criticised the Ethiopian Ethnic Federalism, was Abbink (1997), who perceives how the discourse of ethnicity become increasingly strongly politicised, a reality that in Ethiopia never existed before. Indeed, "*the contemporary language of ethnicity is usually a political language in disguise*", which covers the real political power games (Abbink, 1997).

Others, such Habtu (2002), considered the "*Ethiopian federal system an unicum in its con-*

[47] A clear example is represented by Hawassa, the capital of the SNNPRS. The EPRDF's slogan pretended to exploit the image of the capital as the symbol of "Unity through diversity", but the residents often complained ethnic tensions. Indeed, the ethnically diverse urban population created many problems to the government, which sought to alleviate the tensions by making one ethnic group, Sidama, predominate on all the others. In other words, instead of eliminating ethnic tensions, the EPRDF strategy incremented the ethnic frictions, by discretionally favouring one ethnic group over all the other ethnic communities (Mains and Kinfu, 2016).

stitutional marrying of political pluralism and the right of secession. Nevertheless, there is a mismatch between the liberal-democratic political-pluralistic elements of the constitution and the political praxis of the dominant party". Indeed, although the "*Ethiopian constitutional shaping of ethnicity has been unprecedented and daring*", in practice, it has been used to "*consolidate the power of those who already held it*" (Abbink, 1997). One of the main problem retraced in the academic literature has been the fact that the draft of the constitution, although promoted as a democratic process, was dominated only by the will of the TPLF (Abbink, 1995). As denounced by Vestal (1996), by denying the political participation of the opposition groups in the constitutional process, the TPLF should be considered responsible for having missed a "*final opportunity to broaden, by peaceful means, the political base of governance*"[48].

In the academic literature, as reported by Aalen (2006), federal models based on ethnicity may be justified only when all the basic rights of citizens, who have different commitment to ethnicity, are safeguarded. Nevertheless, this is not the case of the Ethiopian Constitution. First of all, because there is not the complete recognition of all the ethnic groups present on the Ethiopian ground, but more importantly in the Constitution there is "*nothing like a super-national category and is therefore difficult to claim an all-Ethiopian or mixed ethnic identity*"(Aalen, 2006). Indeed, the interchangeability of the ethnic identity with nationality has become an extremely polarised argument and "*highly emotional issue in the minds of Ethiopians*" (Abbink, 1995).

The recognition of ethnicity as a pivotal in the Ethiopian Federalism, has been considered by many, the best means for the TPLF to retain a leading position in such a multiethnic state, where the Tigray people represents just a minority (Birru, 2018; Aalen, 2006; Young, 1998). This argument is in line, with the inclusion of the secession clause Art.39. Reading the constitution it is written that "*...every nation, nationality, and people in Ethiopia has an unconditional right to self-determination, including the right to secession*". The inclusion of this clause casts doubts on TPLF's real political interests. Indeed, as indicated by Birru (2018), Aalen (2006), Young (1998), and Ottaway (1995), this may be interpreted as the intentions

[48]Nevertheless, the two main objections to the Ethiopian Constitution of 1994 can be summarised in two main elements. The first of one regards the use of terminology and the second one regards the secession clause. Starting form the first concern, the discussion derived by the fact that "ethnicity and nationalities" are used as synonyms (Cohen, 1995). Art. 39.5 states that ethnicity can be defined as "*people having common culture reflecting considerable uniformity or similarity of custom language, belief in a common bond and identity, and a common consciousness the majority of whom live within a common territory*". Therefore, on the basis of this principle "*nations, nationalities and people of the country*" (Art. 8.1) should be considered as interchangeable terms. Undoubtedly, this definition is questionable, especially regarding the fact that many of these nations include various ethnic groups, with different cultures, languages and traditions, as for the case of the Southern Nation reported above. Moreover, as pointed out by Abbink (1997) this definition contains contradictory elements, that may be valid for some ethnic groups, but not for others, which may identify themselves on the basis of other principles, such as territorial, religious, traditional ones. Moreover, ethnicity is considered as an immutable concept, subjected to pre-defined characteristics and geographically concentrated. Of course, "*this is far from the reality in Ethiopian society, where marriages across ethnic lines are common and ethnic groups have intermingled, creating large ethnically mixed population.*" (Aalen, 2006)

of the TPLF "*to work for the disintegration of the country, while systematically building the 'Republic of Tigray', and preparing for the inevitable secession*"(Birru, 2018).

As reported by Birru (2018), "*if the EPRDF government is not in favour of the Tigrayan people, the TPLF will resort to the creation of an independent Tigray*". At the same time, the TPLF has skill-fully manipulated its political narrative and it has used its influence to take all the central leading managerial positions, creating a situation for which "*if Tigray secedes, it will leave Ethiopia in chaos*"(Birru, 2018). What appears clear is the fact that introduction of ethnic federalism has not be done for the sake of Ethiopia and Ethiopians, but for the interests in place of a minority group: the Tigray. (Birru, 2018; International Crisis Group, 2009; Aalen, 2006; Young, 1998; Ottaway, 1995)[49].

What is evident is that this federation is organised as if ethnic identity is the only real political identity that matters. Nevertheless, this has created the conditions for a precarious equilibrium, in which ethnic-regional inequality in the provision of education, infrastructures, development, but more importantly representation in the leading administrative positions have become increasingly intolerable (Abbink, 1997). Besides, ethnic federalism has generated a sort of disincentive to interregional movement, given by the fact that often "*all skilled and teaching jobs should be filled by locals, and not by 'immigrants'*"(Abbink, 1995). Therefore, surplus experts in one regions will be discouraged from relocating in another region where do they not "ethnically belong" (Abbink, 1995). This of course, creates structural inequalities and obstacles for natural economic growth. Ethiopia is "*no longer a unitary state, but a loose federation of ethnic-regions* "(Abbink, 1995)[50].

[49]Moreover, the same constitutional article, Art.39, leaves a glow of uncertainty. First of all, because it is not clear what does it mean by "*self-determination*", and then, it is not clear which are the sovereign units to which it refers. Indeed, this article applies to "*every nation, nationality, and people*" and not to the nine member states of the federation. This creates even more confusion, posing the basis for frictions in the interpretability of the rule.

[50]Moreover, "*in spite of formal policy and rhetoric, Ethiopia has only nominally devolved decision-making power to local levels*" (International Crisis Group, 2009). Indeed, all important decisions are taken by the centre and the EPRDF controls all the bureaucracy and all the public resources. The party "*extends from the federal to the regional, from the regional to the woreda, and from the woreda to the kebelle and sub-kebelle levels*"(International Crisis Group, 2009). This of course has fuelled the disparities in the provision of public resources and in the decisional process of the allocation of public goods. Furthermore, ethnic federalism has not been able to solve the "national question". Indeed, the increased competition among ethnic groups for land, natural resources, as well as administrative boundaries and government budget has only tightened up the internal conflicts. The EPRDF has empowered and favoured only some groups, without providing counterbalance material assistance to the others. As reported by Fessha (2019) what Ethiopia needs is a system that should be able to "*accomodate ethnic concerns while at the same time recognising the sense of communal bond that Ethiopians enjoy beyond their ethnic groups. What is needed is a model that takes ethnic concerns into account without making ethnic identity the only identity that matters.*"

Appendix B. Geo-Spatial Dataset: Visual Representation

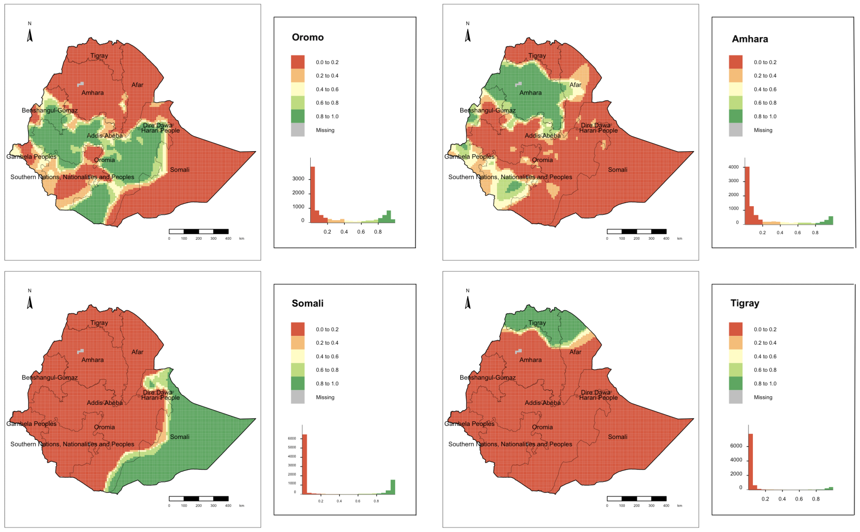

Figure B.14: Spatial Representation of the principal ethnic groups in Ethiopia

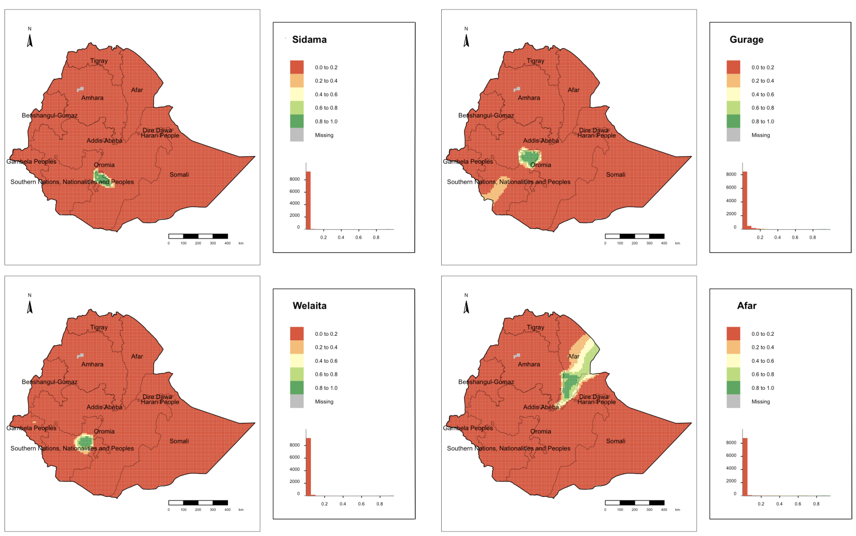

Figure B.15: Spatial Representation of the principal ethnic groups in Ethiopia

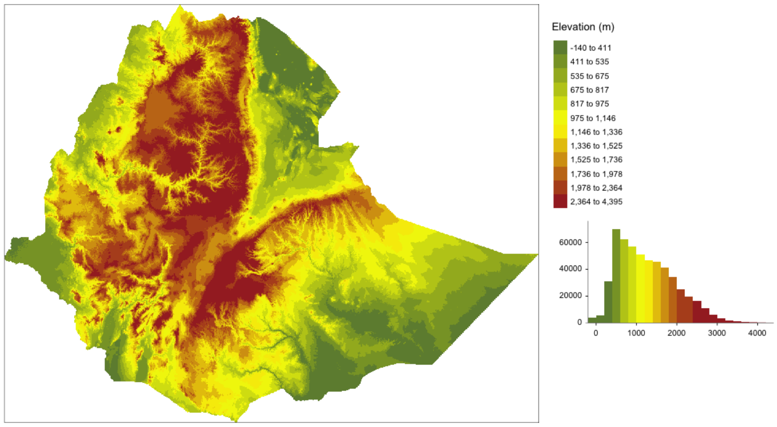

Figure B.16: Elevation in Ethiopia

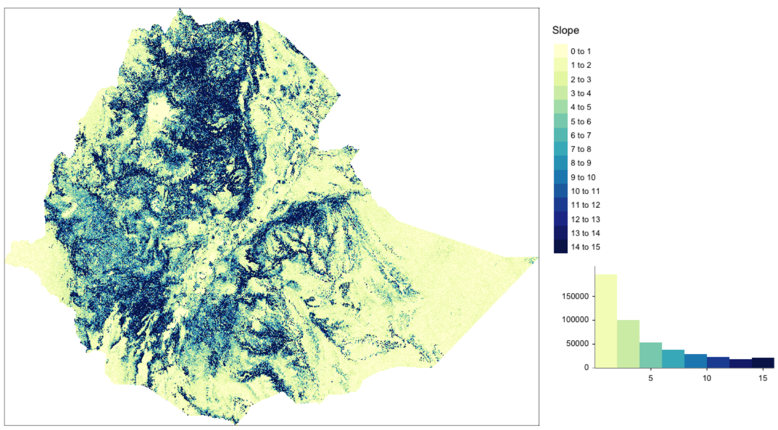

Figure B.17: Slope in Ethiopia

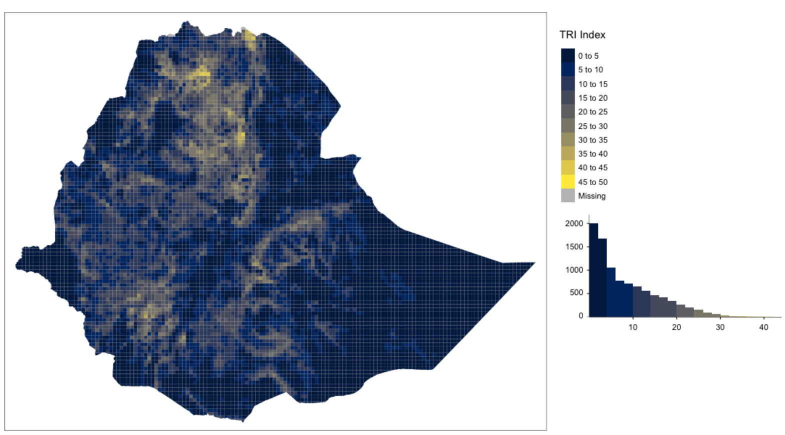

Figure B.18: TRI in Ethiopia

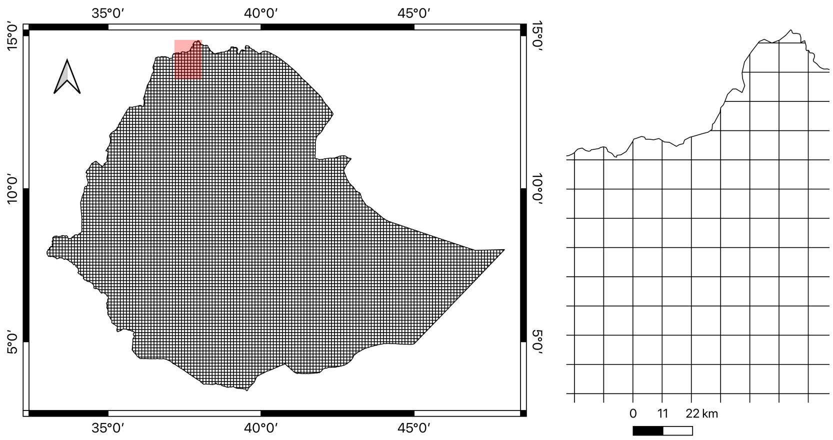

Figure B.19: Grid dimension of 0.1 arc-degrees

Figure B.20: Woreda which are stable under the period of our analysis.

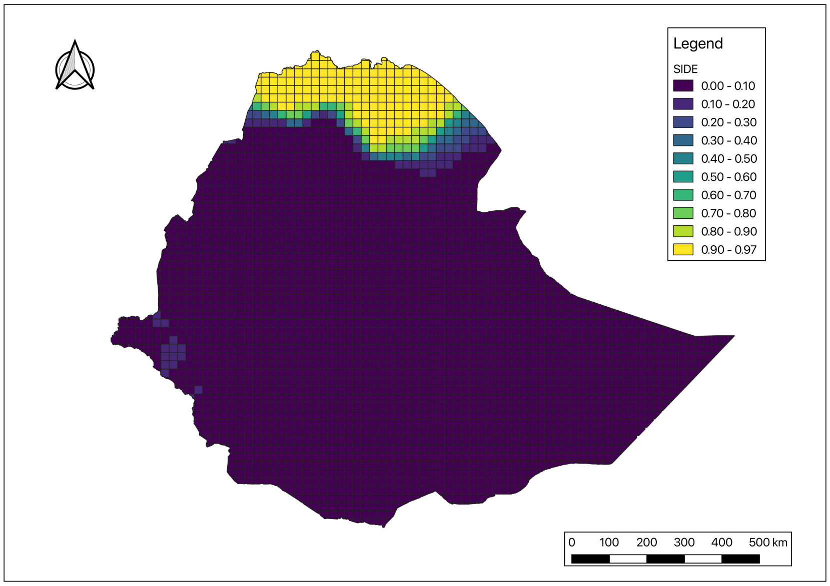

Figure B.21: SIDE geographical representation for grid cells of dimension 0.1 arc-degrees.

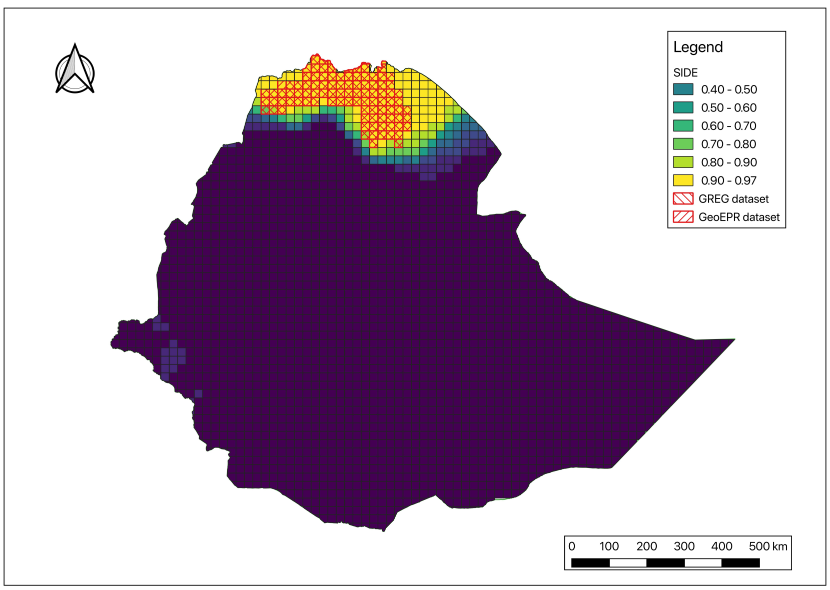

Figure B.22: GREG and Geo-EPR geographical representation for grid cells of dimension 0.1 arc-degrees.

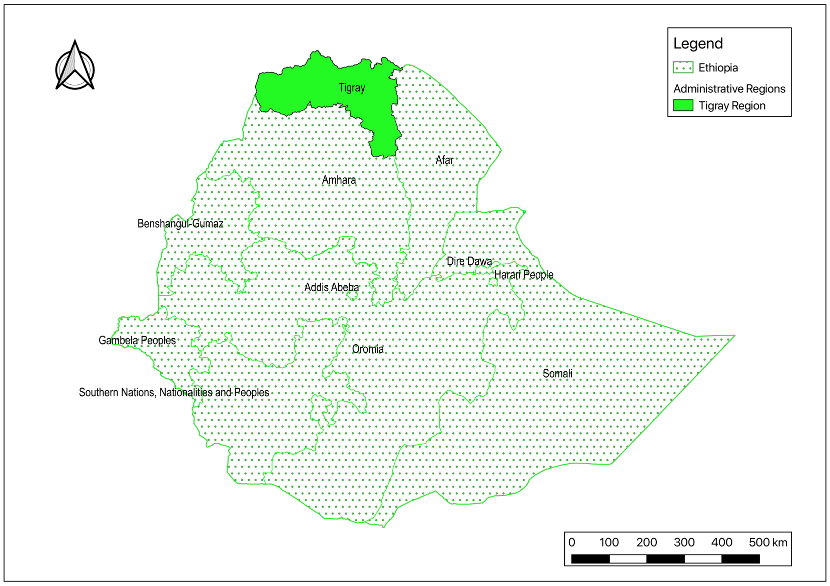

Figure B.23: Tigray Administrative Region.

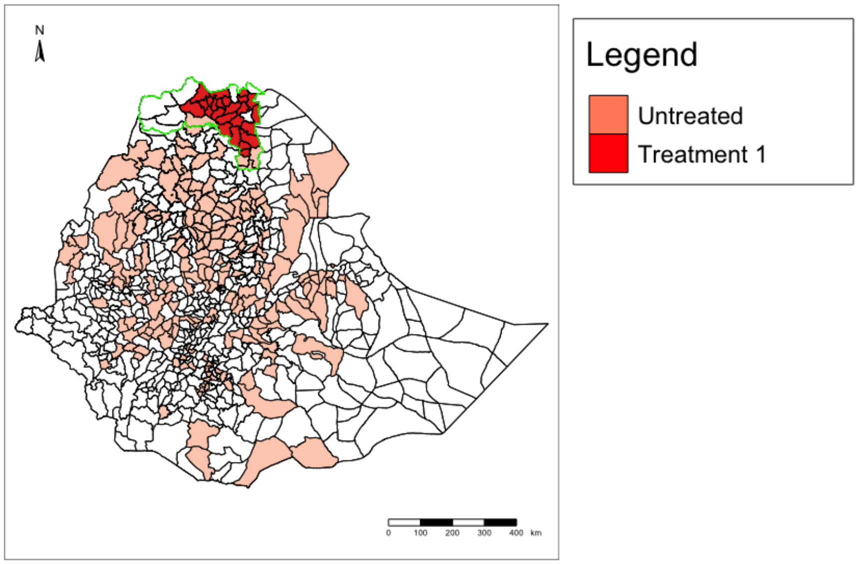

Figure B.24: Geospatial representation of woreda with coethnicity level > 90%

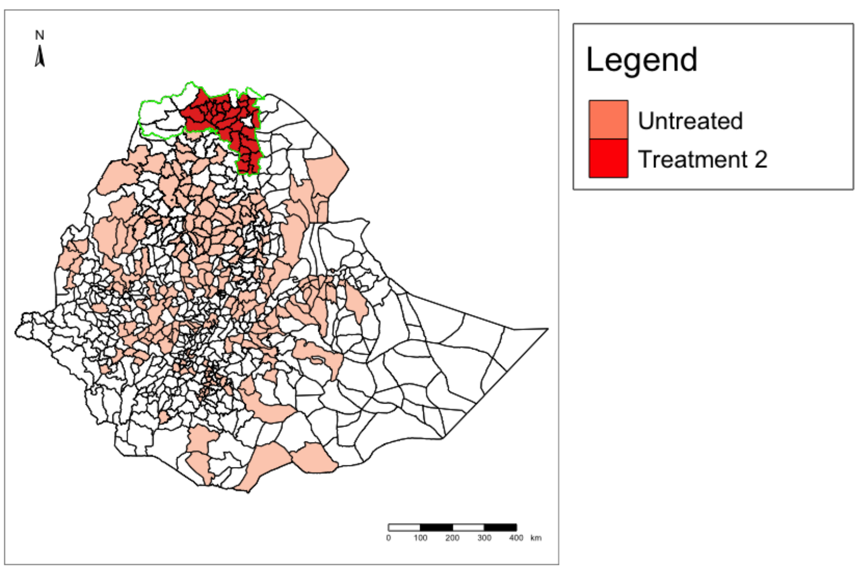

Figure B.25: Geospatial representation of woreda with coethnicity level > 50%

Appendix C. Summary Statistics: grid cell 0.1 arc-degrees

Summary Statistics for grid cells of dimension 0.1 arc-degrees					
Statistic	Mean	St. Dev.	Min	Max	N
Precipitation	67.201	37.230	9.742	161.027	9,134
Temperature	22.825	4.344	6.120	33.788	9,134
Precipitation $_{1996}$	71.573	43.010	9.240	182.993	9,134
Temperature $_{\text{Max } 1996}$	29.315	3.859	13.530	36.617	9,134
Temperature $_{\text{min } 1996}$	16.338	4.535	−0.374	26.198	9,134
Elevation	1,265.809	697.685	−120.424	4,078.611	9,134
Slope	6.000	5.191	0.004	28.136	9,134
TRI	8.704	7.371	0.007	42.808	9,134
Surface $_{\text{Km}^2}$	120.986	10.479	0.020	123.682	9,134
$Length/Km^2$ $_{1996}$	6.515	21.015	0	1,202	9,134
$Speed$ $_{1996}$	10.185	14.275	0	50	9,134
$Length/Km^2$ $_{1998}$	6.689	21.112	0	1,202	9,134
$Speed$ $_{1998}$	10.431	14.482	0	70	9,134
$Length/Km^2$ $_{2000}$	7.026	21.272	0	1,202	9,134
$Speed$ $_{2000}$	10.921	14.706	0	70	9,134
$Length/Km^2$ $_{2002}$	7.352	21.506	0	1,202	9,134
$Speed$ $_{2002}$	11.497	15.228	0	70	9,134
$Length/Km^2$ $_{2004}$	7.618	21.606	0	1,202	9,134
$Speed$ $_{2004}$	12.045	15.603	0	70	9,134
$Length/Km^2$ $_{2006}$	7.790	21.701	0	1,202	9,134
$Speed$ $_{2006}$	12.466	16.091	0	70	9,134
$Length/Km^2$ $_{2008}$	8.155	21.835	0	1,202	9,134
$Speed$ $_{2008}$	13.049	16.389	0	70	9,134
$Length/Km^2$ $_{2010}$	8.408	21.879	0	1,202	9,134
$Speed$ $_{2010}$	13.964	17.333	0	70	9,134
$Length/Km^2$ $_{2012}$	8.863	22.031	0	1,202	9,134
$Speed$ $_{2012}$	15.722	18.695	0	70	9,134
$Length/Km^2$ $_{2014}$	9.510	22.260	0	1,202	9,134
$Speed$ $_{2014}$	18.667	20.417	0	95	9,134
$Length/Km^2$ $_{2016}$	9.642	22.297	0	1,202	9,134
$Speed$ $_{2016}$	20.265	21.669	0	95	9,134
PM 2.5	18.036	6.001	7.419	31.133	9,134
CO_2 $_{2000}$	0.035	0.556	0	42	9,134
GDP (mln) $_{1995}$	280.860	235.60	6.7090	1886.126	9,133
Pop $_{1995}$	6,526.695	18,159.800	0.000	1,405,526.000	9,134
NTL $_{\text{mean } 1994}$	3.321	0.773	1.479	39.160	9,134
NTL $_{\text{mean } 1996}$	3.370	0.763	2.788	39.394	9,134

Table C.8: Summary Statistics for grid cells of dimension 0.1 arc-degrees

Appendix D. Summary Statistics: Woreda level

Summary Statistics at Woreda Level					
Statistic	Mean	St. Dev.	Min	Max	N
Precipitation	88.285	29.881	14.558	155.429	220
Temperature	19.364	3.213	12.938	29.302	220
Elevation	1,869.726	514.146	402.989	3,051.316	220
Slope	9.119	4.006	1.268	21.903	220
TRI	13.002	5.752	1.813	32.470	220
Surface $_{\mathrm{Km}^2}$	1,495.898	1,821.609	87.709	12,205.220	220
$Speed_{1996}$	21.329	8.480	0	50.000	220
$Length/Km^2{}_{1996}$	80.948	61.873	0	303.510	220
$Speed_{1998}$	21.789	8.374	0	50.000	220
$Length/Km^2{}_{1998}$	83.459	61.051	0	303.510	220
$Speed_{2000}$	22.642	7.454	0	50.000	220
$Length/Km^2{}_{2000}$	89.297	60.456	0	303.510	220
$Speed_{2002}$	22.857	7.651	0	50.000	220
$Length/Km^2{}_{2002}$	92.270	61.212	0	303.510	220
$Speed_{2004}$	23.595	7.453	0	48	220
$Length/Km^2{}_{2004}$	96.655	61.333	0	303.510	220
$Speed_{2006}$	24.140	7.962	0	53.333	220
$Length/Km^2{}_{2006}$	98.507	62.116	0	303.928	220
$Speed_{2008}$	24.860	7.275	0	53.333	220
$Length/Km^2{}_{2008}$	102.802	61.250	0	345.880	220
$Speed_{2010}$	25.987	7.062	0	57.500	220
$Length/Km^2{}_{2010}$	105.350	60.010	0	345.880	220
$Speed_{2012}$	27.808	6.666	0	55.833	220
$Length/Km^2{}_{2012}$	110.207	60.210	0	393.291	220
$Speed_{2014}$	32.152	7.298	0	57.083	220
$Length/Km^2{}_{2014}$	115.328	60.513	0	416.398	220
$Speed_{2016}$	34.731	7.123	0	57.083	220
$Length/Km^2{}_{2016}$	116.717	61.684	0	416.398	220
PM 2.5	19.870	4.616	8.105	29.461	220
GDP (ml)	450.67	246.935	64.646	1662.24	220
Pop $_{1995}$	108,467.800	56,125.430	13,577.280	348,471.300	220
NTL $_{\text{mean 1994}}$	3.304	0.373	2.881	5.136	220

Table D.9: Summary Statistics at Woreda Level

1994 Census Data at Woreda Level					
Statistic	Mean	St. Dev.	Min	Max	N
Sex	0.501	0.015	0.453	0.569	220
Age	21.725	1.460	18.576	26.296	220
Urban	0.098	0.132	0.000	1.000	220
Economic Active	0.506	0.079	0.320	0.654	220
Illiterate	0.695	0.082	0.271	0.849	220
Secondary	0.018	0.026	0.001	0.194	220
University	0.0002	0.001	0	0	220
Agriculture	0.461	0.105	0.003	0.649	220
Mining	0.0002	0.001	0.000	0.007	220
Industry	0.007	0.009	0.000	0.083	220
Service	0.028	0.027	0.002	0.197	220
Other Industry	0.503	0.084	0.347	0.736	220

Table D.10: Summary Statistics at Woreda Level

Market Access Indicator from 1996 to 2016					
Statistic	Mean	St. Dev.	Min	Max	N
Market Access_{1996}	2.411	0.384	1.348	4.575	220
Market Access_{1998}	2.408	0.386	1.354	4.574	220
Market Access_{2000}	2.414	0.385	1.344	4.575	220
Market Access_{2002}	2.434	0.389	1.352	4.576	220
Market Access_{2004}	2.463	0.398	1.387	4.581	220
Market Access_{2006}	2.528	0.401	1.395	4.588	220
Market Access_{2008}	2.543	0.425	1.212	4.627	220
Market Access_{2010}	2.588	0.414	1.228	4.631	220
Market Access_{2012}	2.626	0.396	1.235	4.633	220
Market Access_{2014}	2.655	0.384	1.268	4.634	220
Market Access_{2016}	2.719	0.368	1.279	4.639	220

Table D.11: Summary Statistics at Woreda Level

Appendix E. Balance Tables for the Main Specification

Balance Table at grid cell 0.1 arc-degrees

Hereafter, we show the set of covariates that we have selected as decisive to make observational units similar in terms of attractiveness for road investments and road quality improvements. The set of covariates on one hand have to take into account morphological characteristics of the terrain (e.g. Slope, Elevation, TRI) and on the other economic and social components (e.g. PM 2.5, Night Lights, GDP, population density). Indeed, morphological and environmental features represent crucial determinants for the construction of roads and fundamental drivers of the costs implementation of the projects. Equally, the economic and social characteristics are clearly fundamental elements in the allocation decision of resources. In fact, it is plausible to recognise that policymakers will try to improve the connection of major urban and economic centres with surrounding areas. Moreover, at the Woreda level analysis, we were also able to employ the information provided by the 1994 Census, giving us even more chances to make the units of observation similar on the socio-economic dimension[51].

Then, the choice of the variables to include in the matching algorithm should be considered as the result of the balance of two factors: on one hand, the theoretical motivations of their necessity (e.g. morphological features); on the other hand, the matching precision which is contingent on the trade-off between the inclusion of multiple covariates and predictors balance. Specifically, throughout the analysis we always prefer the specifications that allows us to obtain the best balance between treatment and control units, using the most parsimonious set of predictors (in order to avoid incurring in the curse of dimensionality).

Below we report the balance tables for grid cell dimension 0.1 arc-degrees for both the outcome variables: length and quality, proxied by speed[52]. For all the specifications the p-values of the matched means are greater than 0.1, which account for a significant balance across groups. We run all regressions and matching algorithms in `R`version 3.6, using the `Matching` package[53]. We employ 1-to-1 nearest neighbour matching with replacement, using calipers

[51] However, the selection of the covariates to be included in the matching algorithm encounters two main difficulties. The first one regards the fact that the selection of too many covariates may generate an increase in the overall variability of the sample under analysis; but at the same time the exclusion of "important" confounders might led to biased results. As reported by Caliendo and Kopeinig (2008) there are two school of thoughts: one, following Bryson *et al.* (2002), who state that is better to avoid the inclusion of extraneous variables to avoid the increase in their variance; and another, outlined e.g. Rubin and Thomas (1996) who instead argue "that a variable should only be excluded from analysis if there is consensus that the variable is either unrelated to the outcome or not a proper covariate". There is not an universal consensus on which is the best procedure, neither on how matching should be done or how to evaluate its performance (Sekhon, 2011), nevertheless the criteria that we follow is the one reported by Caliendo and Kopeinig (2008), meaning that the choice of the covariates should be based on both economic theory and empirical findings.

[52] Balance tables for all the other definition of treatment status, namely $Treatment3$, $Treatment4$ and $Treatment5$ are available on request. All the other specifications are consistent with these results and available on request

[53] In conjunction with the `MatchBalance`, which is a function that allows us to check whether the results of `Match` achieved balance on the set of chosen covariates between treated and control units

as a way of minimising the distance between treated and control observations' propensity scores(Olmos and Govindasamy, 2015).

An observation unit j with the propensity score P_j in the control sample I_0 is considered a match for the observation unit i with the propensity score P_i in the treatment group, if the absolute difference between them meets the following condition:

$$||P_i - P_J|| < \epsilon \tag{E.1}$$

Where, $P_{i,j}$ are the propensity scores for each treatment and control units, respectively and ϵ is the caliper. Rubin and Rosenbaum (1985) have suggested that $\epsilon < 0.25\sigma_p$, where σ_p stands for the estimated propensity scores of the sample under analysis[54]. These values provide the best baseline balancing between the explanatory variables. By default *Match* does 1-to-1 matching with replacements and it estimates the Average Treatment Effect on the Treated (hereafter, ATT). This means, that when one treated observation unit matches more than one control observation unit, the final matched dataset will contain the multiple matched control observations. Our estimation of the ATT appears not to be sensitive to caliper width, nor to the particular matching method employed in the analysis [55]

Balance Table for grid cells of dimension 0.1 arc-degrees, Treatment 1, 90% Tigray

	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.06	0.05	0.01	0.06	0.06	0.89
GDP (mln)	208.98	285.24	0.00	203.90	200.51	0.64
Pop_{1995}	7120.02	6490.37	0.09	7007.61	6832.52	0.88
NTL_{1994}	3.24	3.33	0.00	3.25	3.21	0.50
NTL_{1996}	3.28	3.38	0.00	3.29	3.22	0.33
PM 2.5	23.94	17.67	0.00	23.72	23.89	0.32
TRI	12.65	8.46	0.00	12.09	11.95	0.81
Slope	8.66	5.84	0.00	8.25	8.13	0.76
$\text{Precipitation}_{1996}$	47.98	73.02	0.00	47.79	46.99	0.60
Temp min_{1996}	17.45	16.27	0.00	17.57	17.51	0.85
Temp Max_{1996} 30.44	29.25	0.00	30.47	30.25	0.35	

Table E.12: Balance Table for cells of dimension 0.1 arc-degrees: outcome road length

[54] Throughout our analysis, we employ an ϵ of 0.01 and of ϵ of 0.05. Just for the Woreda level analysis, we employ a caliper of 0.25 to avoid an over reduction of the sample for the matching procedure.

[55] However, it should be remarked that there is not a better performing PSM estimator, but the choice of the matching algorithm strictly depends on the situation at hand (Caliendo and Kopeinig, 2008). In this particular case, we decide to opt for 1-to-1 matching with replacement, since our dataset has a considerable number of comparable untreated observational units, and replacement option allows us to gain more precision in our estimates.Following the insights of Sekhon (2011), the number of boostrap samples run is 1000.

Balance Table for grid cells of dimension 0.1 arc-degrees, Treatment 1, 90% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Speed_{1996}$	13.24	10.00	0.00	11.88	11.85	0.98
GDP (mln)	208.98	285.24	0.00	201.67	203.80	0.78
Pop_{1995}	7120.02	6490.37	0.09	6939.34	8474.52	0.62
NTL_{1994}	3.24	3.33	0.00	3.24	3.22	0.86
NTL_{1996}	3.28	3.38	0.00	3.28	3.34	0.47
PM 2.5	23.94	17.67	0.00	23.72	24.06	0.05
TRI	12.65	8.46	0.00	12.16	12.62	0.44
Slope	8.66	5.84	0.00	8.30	8.58	0.50
$Precipitation_{1996}$	47.98	73.02	0.00	47.78	48.72	0.51
Temp min_{1996}	17.45	16.27	0.00	17.62	17.52	0.75
Temp Max_{1996}	30.44	29.25	0.00	30.49	30.36	0.60

Table E.13: Balance Table for cells of dimension 0.1 arc-degrees: outcome quality of road (speed)

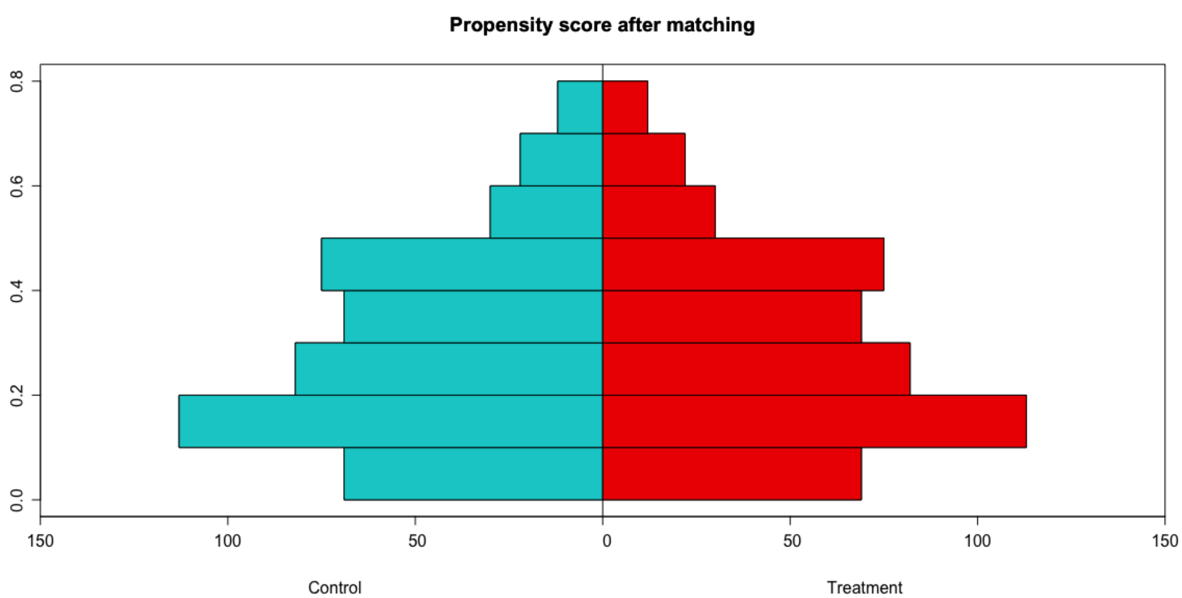

Figure E.26: Balance between treatment and control groups after the PSM. Treatment 1, outcome: length

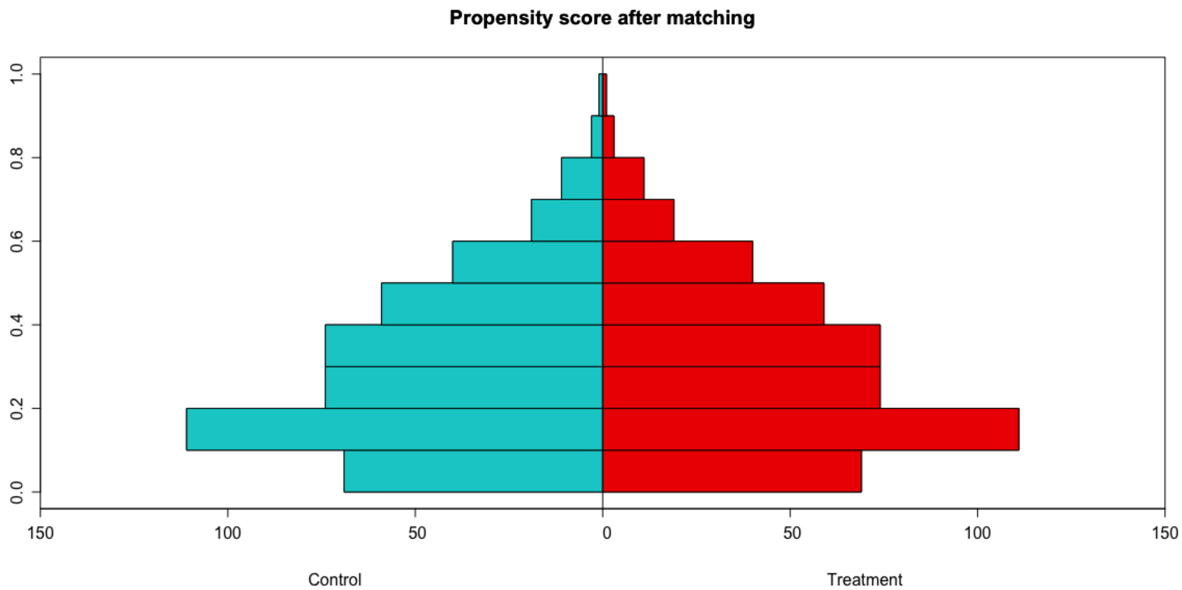

Figure E.27: Balance between treatment and control groups after the PSM. Treatment 1, outcome: quality

Balance Table for grid cells of dimension 0.1 arc-degrees, Treatment 2, 50% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.06	0.05	0.20	0.06	0.07	0.58
GDP (mln)	208.03	286.94	0.00	204.84	196.44	0.18
Pop_{1995}	6681.24	6513.75	0.60	6793.25	7451.69	0.65
NTL_{1994}	3.20	3.33	0.00	3.21	3.28	0.35
NTL_{1996}	3.27	3.38	0.00	3.27	3.32	0.54
PM 2.5	24.22	17.52	0.00	23.93	24.02	0.48
TRI	12.86	8.36	0.00	12.57	11.87	0.18
Slope	8.77	5.77	0.00	8.56	8.06	0.17
$\text{Precipitation}_{1996}$	48.39	73.52	0.00	48.49	46.44	0.12
Temp min_{1996}	17.84	16.21	0.00	17.79	17.93	0.63
Temp Max_{1996}	30.67	29.20	0.00	30.58	30.56	0.93

Table E.14: Balance Table for cells of dimension 0.1 arc-degrees: outcome road length

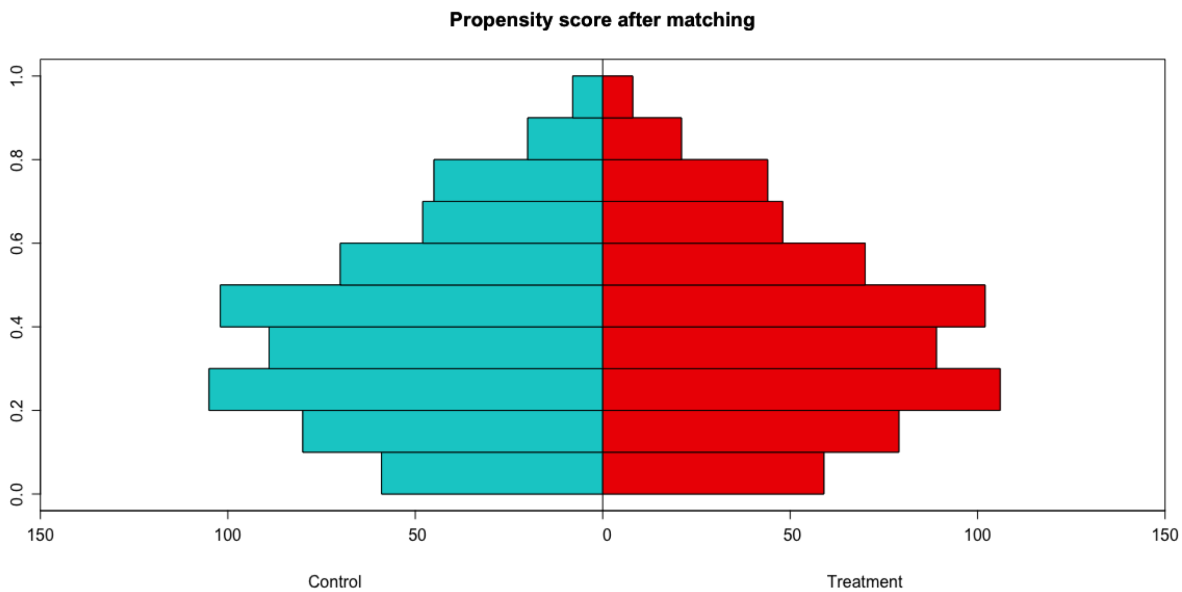

Figure E.28: Balance between treatment and control groups after the PSM. Treatment 2, outcome: length

Balance Table for grid cells of dimension 0.1 arc-degrees, Treatment 2, 50% Tigray

	Unmatched			Matched		
	T	C	p-value	T	C	p-value
Speed_{1996}	12.27	10.01	0.00	11.23	10.94	0.74
GDP (mln)	208.03	286.94	0.00	202.53	199.06	0.56
Pop_{1995}	6681.24	6513.75	0.60	6823.62	12447.20	0.16
NTL_{1994}	3.20	3.33	0.00	3.21	3.30	0.37
NTL_{1996}	3.27	3.38	0.00	3.27	3.35	0.45
PM 2.5	24.22	17.52	0.00	23.88	23.90	0.86
TRI	12.86	8.36	0.00	12.09	12.08	0.98
Slope	8.77	5.77	0.00	8.25	8.17	0.84
$\text{Precipitation}_{1996}$	48.39	73.52	0.00	47.96	47.84	0.93
Temp min_{1996}	17.84	16.21	0.00	17.92	17.76	0.61
Temp Max_{1996}	30.67	29.20	0.00	30.65	30.38	0.20

Table E.15: Balance Table for cells of dimension 0.1 arc-degrees: outcome quality of road (speed)

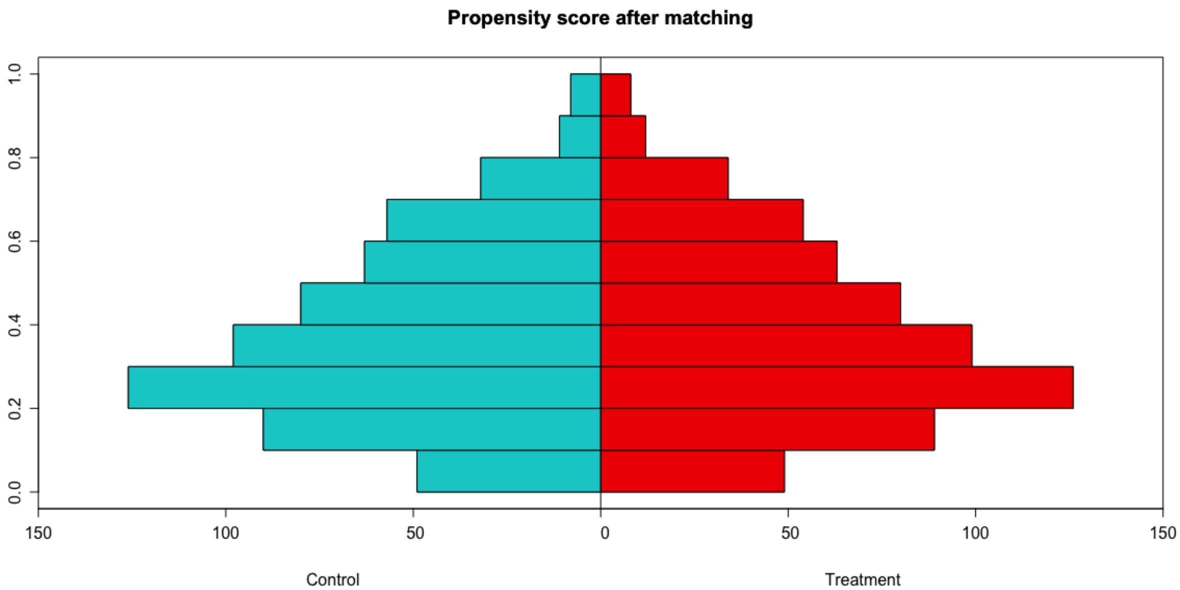

Figure E.29: Balance between treatment and control groups after the PSM. Treatment 1, outcome: quality

Balance Tables at Woreda Level

At the woreda level the balance tables for Treatment 1 and Treatment 2 coincide, meaning that the woreda selected by the propensity score matching are exactly the same.

Balance Table at Woreda Level for Treatment 1

	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.10	0.09	0.48	0.09	0.10	0.63
GDP (mln)	256.81	473.30	0.00	255.83	243.36	0.70
Industry	0.01	0.01	0.89	0.01	0.01	0.55
Agriculture	0.44	0.46	0.12	0.45	0.42	0.26
$\text{Other}_{\text{Industry}}$	0.53	0.50	0.03	0.52	0.54	0.26
Service	0.02	0.03	0.27	0.02	0.02	0.60
$\text{Economic}_{\text{Active}}$	0.48	0.51	0.03	0.49	0.47	0.26
Urban	0.11	0.10	0.43	0.10	0.11	0.81
NTL_{1994}	3.16	3.32	0.00	3.14	3.16	0.69
Slope	11.07	8.89	0.00	10.71	9.82	0.44
TRI	15.95	12.66	0.00	15.46	14.12	0.43

Table E.16: Balance Table at Woreda Level : outcome road length

Balance Table at Woreda Level for Treatment 2

	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.10	0.09	0.53	0.09	0.08	0.67
GDP (mln)	254.78	478.07	0.00	255.69	252.00	0.82
Industry	0.01	0.01	0.74	0.01	0.01	0.23
Agriculture	0.43	0.47	0.08	0.44	0.45	0.89
$\text{Other}_{\text{Industry}}$	0.53	0.50	0.02	0.52	0.52	0.99
Service	0.03	0.03	0.48	0.02	0.02	0.87
$\text{Economic}_{\text{Active}}$	0.48	0.51	0.03	0.49	0.48	0.87
Urban	0.12	0.10	0.26	0.11	0.10	0.85
NTL_{1994}	3.18	3.32	0.00	3.16	3.12	0.31
Slope	11.11	8.84	0.00	10.89	10.22	0.56
TRI	16.03	12.58	0.00	15.70	14.92	0.64

Table E.17: Balance Table at Woreda Level : outcome road length

Balance Table at Woreda Level for Treatment 1						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.10	0.09	0.48	0.09	0.11	0.17
GDP (mln)	256.81	473.30	0.00	258.20	269.49	0.31
area	1123.15	1539.42	0.02	1172.89	844.08	0.04
Industry	0.01	0.01	0.89	0.01	0.00	0.15
Agriculture	0.44	0.46	0.12	0.45	0.46	0.62
$\text{Other}_{\text{Industry}}$	0.53	0.50	0.03	0.52	0.52	0.85
Service	0.02	0.03	0.27	0.02	0.02	0.49
$\text{Economic}_{\text{Active}}$	0.48	0.51	0.03	0.49	0.49	0.82
Urban	0.11	0.10	0.43	0.10	0.08	0.52
NTL_{1994}	3.16	3.32	0.00	3.14	3.13	0.69
Slope	11.07	8.89	0.00	10.80	10.33	0.60
TRI	15.95	12.66	0.00	15.55	14.66	0.46

Table E.18: Balance Table at Woreda Level : outcome market access

Balance Table at Woreda Level for Treatment 2						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.10	0.09	0.53	0.10	0.11	0.41
GDP (mln)	254.78	478.07	0.00	257.88	279.93	0.24
area	1192.61	1538.33	0.05	1219.66	1058.71	0.56
Industry	0.01	0.01	0.74	0.01	0.00	0.06
Agriculture	0.43	0.47	0.08	0.44	0.47	0.17
$\text{Other}_{\text{Industry}}$	0.53	0.50	0.02	0.53	0.51	0.35
Service	0.03	0.03	0.48	0.02	0.02	0.05
$\text{Economic}_{\text{Active}}$	0.48	0.51	0.03	0.49	0.50	0.47
Urban	0.12	0.10	0.26	0.11	0.06	0.02
NTL_{1994}	3.18	3.32	0.00	3.17	3.19	0.72
Slope	11.11	8.84	0.00	10.86	12.82	0.09
TRI	16.03	12.58	0.00	15.65	18.52	0.09

Table E.19: Balance Table at Woreda Level : outcome market access

Appendix F. Unconnected Cells

Balance Tables for Unconnected Cells

Balance Table for Unconnected cells, Treatment 1, 90% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
GDP (mln)	182.74	216.87	0.00	181.80	181.04	0.93
Pop $_{1995}$	4613.00	3225.67	0.00	4462.42	4534.83	0.88
NTL $_{1994}$	3.30	3.33	0.61	3.27	3.30	0.68
NTL $_{1996}$	3.38	3.37	0.88	3.32	3.34	0.84
PM 2.5	24.87	17.16	0.00	24.53	24.60	0.76
TRI	12.65	7.70	0.00	11.59	11.71	0.90
Slope	8.57	5.27	0.00	7.82	7.93	0.87
Precipitation $_{1996}$	44.63	61.72	0.00	44.23	45.04	0.72
Temp min $_{1996}$	19.44	17.75	0.00	19.39	19.15	0.60
Temp Max $_{1996}$	31.72	30.40	0.00	31.62	31.31	0.34

Table F.20: Balance Table for Unconnected cells: outcome quality of road (speed)

Balance Table for Unconnected cells, Treatment 2, 50% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
GDP (mln)	187.82	217.27	0.00	181.74	194.00	0.13
Pop $_{1995}$	4673.90	3189.49	0.00	4607.13	4761.74	0.68
NTL $_{1994}$	3.23	3.33	0.00	3.20	3.17	0.48
NTL $_{1996}$	3.33	3.38	0.13	3.30	3.27	0.54
PM 2.5	25.04	16.97	0.00	24.63	24.54	0.57
TRI	12.79	7.58	0.00	11.99	12.61	0.42
Slope	8.63	5.19	0.00	8.09	8.53	0.40
Precipitation $_{1996}$	44.36	62.13	0.00	45.10	45.96	0.66
Temp min $_{1996}$	19.60	17.70	0.00	19.47	19.09	0.28
Temp Max $_{1996}$	31.76	30.37	0.00	31.64	31.47	0.46

Table F.21: Balance Table for Unconnected cells: outcome quality of road (speed)

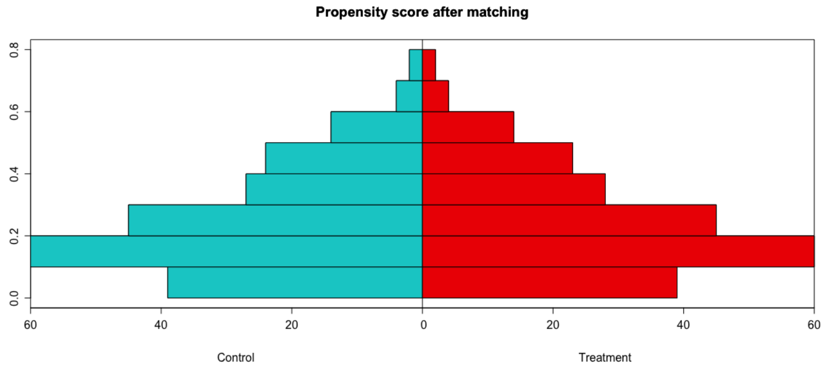

Figure F.30: Balance between treatment and control groups after the PSM. Treatment 1, outcome: road length and quality.

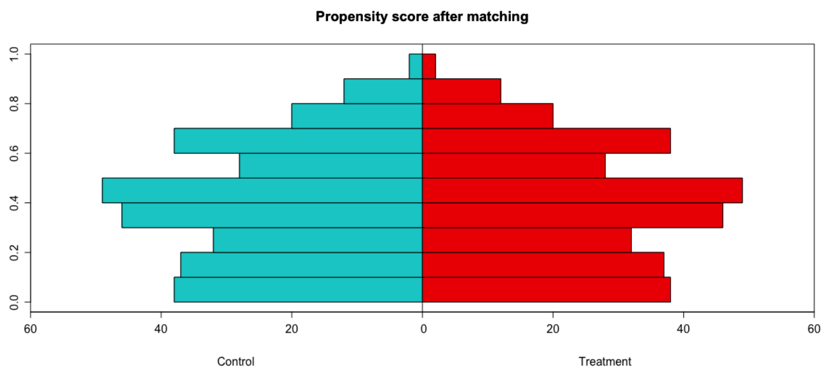

Figure F.31: Balance between treatment and control groups after the PSM. Treatment 2, outcome: road length and quality.

Results for Unconnected Cells

	Unconnected - Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	1.131***	3.770***	3.533***				
	(0.120)	(0.502)	(0.419)				
DID				1.352***	1.319***	2.384***	2.181***
				(0.335)	(0.332)	(0.436)	(0.425)
Constant	1.190***	1.154***	9.769***				
	(0.020)	(0.020)	(1.070)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	63,294	63,294	63,294	63,294	63,294	4,455	4,455
	Unconnected - Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	4.184***	6.080***	6.289***				
	(0.325)	(0.576)	(0.514)				
DID				5.157***	5.107***	6.839***	6.111***
				(0.898)	(0.881)	(1.088)	(1.035)
Constant	3.091***	3.013***	2.096***				
	(0.000)	(0.044)	(1.843)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	63,294	63,294	63,294	63,294	63,294	4,455	4,455

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table F.22: Results of OLS, PSW, panel DID and matched DID, treatment 1 (unconnected cells)

	Unconnected - Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	0.741***	5.070***	4.044***				
	(0.092)	(0.642)	(0.460)				
DID				0.795**	0.802**	1.713***	1.592***
				(0.250)	(0.247)	(0.389)	(0.388)
Constant	1.193***	1.128***	13.18***				
	(0.021)	(0.020)	(1.560)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	63,294	63,294	63,294	63,294	63,294	5,731	5,731

	Unconnected - Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	2.846***	7.038***	6.353***				
	(0.247)	(0.649)	(0.508)				
DID				3.355***	3.410**	5.40***	5.01***
				(0.672)	(0.660)	(0.998)	(0.976)
Constant	3.10***	2.95***	6.83***				
	(0.044)	(0.043)	(1.798)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	63,294	63,294	63,294	63,294	63,294	5,731	5,731

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table F.23: Results of OLS, PSW, panel DID and matched DID, treatment 2 (unconnected cells)

Appendix G. Junior Partner of the Government

Balance Tables for JP

Balance Table for JP, Treatment 1, 90% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.06	0.07	0.47	0.06	0.09	0.49
GDP (mln)	208.98	365.44	0.00	207.18	206.84	0.94
Pop_{1995}	7120.02	8541.53	0.00	7066.41	7101.63	0.99
NTL_{1994}	3.24	3.39	0.00	3.24	3.36	0.30
NTL_{1996}	3.28	3.51	0.00	3.29	3.39	0.32
PM 2.5	23.94	19.44	0.00	23.94	16.87	0.00
TRI	12.65	11.15	0.00	12.38	11.92	0.39
Slope	8.66	7.78	0.00	8.47	8.16	0.39
$\text{Precipitation}_{1996}$	47.98	93.63	0.00	47.96	46.69	0.16
Temp min_{1996}	17.45	14.20	0.00	17.50	17.41	0.71
Temp Max_{1996}	30.44	27.64	0.00	30.47	30.28	0.33

Table G.24: Balance Table for cells labelled JP: outcome road length

Balance Table for JP, Treatment 1, 90% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
Speed_{1996}	13.24	12.30	0.18	14.10	12.84	0.24
GDP (mln)	208.98	365.44	0.00	221.05	214.75	0.13
Pop_{1995}	7120.02	8541.53	0.00	7652.91	6916.76	0.14
NTL_{1994}	3.24	3.39	0.00	3.25	3.27	0.68
NTL_{1996}	3.28	3.51	0.00	3.30	3.36	0.15
PM 2.5	23.94	19.44	0.00	23.71	23.87	0.45
TRI	12.65	11.15	0.00	12.79	12.37	0.50
Slope	8.66	7.78	0.00	8.78	8.45	0.44
$\text{Precipitation}_{1996}$	47.98	93.63	0.00	48.76	73.66	0.00
Temp min_{1996}	17.45	14.20	0.00	16.91	16.67	0.45
Temp Max_{1996}	30.44	27.64	0.00	30.12	29.82	0.23

Table G.25: Balance Table for cells labelled JP: outcome quality of road (speed)

Balance Table for JP, Treatment 2, 50% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.06	0.07	0.02	0.06	0.06	0.91
GDP (mln)	208.03	371.60	0.00	207.20	201.64	0.25
Pop_{1995}	6681.24	8662.79	0.00	6793.89	6283.86	0.83
NTL_{1994}	3.20	3.40	0.00	3.21	3.24	0.72
NTL_{1996}	3.27	3.52	0.00	3.28	3.26	0.73
PM 2.5	24.22	19.23	0.00	24.13	15.27	0.00
TRI	12.86	11.06	0.00	12.65	12.18	0.37
Slope	8.77	7.73	0.00	8.62	8.32	0.39
$\text{Precipitation}_{1996}$	48.39	95.32	0.00	48.86	47.84	0.23
Temp min_{1996}	17.84	14.02	0.00	17.73	17.42	0.14
Temp Max_{1996}	30.67	27.50	0.00	30.61	30.39	0.19

Table G.26: Balance Table for cells labelled JP: outcome road length

Balance Table for JP, Treatment 2, 50% Tigray						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
Speed_{1996}	12.27	12.41	0.83	12.28	11.86	0.65
GDP (mln)	208.03	371.60	0.00	210.30	202.95	0.12
Pop_{1995}	6681.24	8662.79	0.00	6973.71	10186.15	0.43
NTL_{1994}	3.20	3.40	0.00	3.22	3.32	0.34
NTL_{1996}	3.27	3.52	0.00	3.28	3.36	0.48
PM 2.5	24.22	19.23	0.00	24.05	15.43	0.00
TRI	12.86	11.06	0.00	12.36	12.17	0.70
Slope	8.77	7.73	0.00	8.45	8.34	0.75
$\text{Precipitation}_{1996}$	48.39	95.32	0.00	49.73	49.10	0.46
Temp min_{1996}	17.84	14.02	0.00	17.42	17.49	0.74
Temp Max_{1996}	30.67	27.50	0.00	30.46	30.35	0.52

Table G.27: Balance Table for cells labelled JP: outcome road quality (speed)

Results for JP

	JP Specification - Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	-0.217	0.219	5.01***				
	(0.219)	(0.343)	(0.256)				
DID				0.431·	0.435·	2.122***	1.979***
				(0.238)	(0.237)	(0.272)	(0.271)
Constant	10.24***	10.19***	40.09***				
	(0.123)	(0.267)	(5.566)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	58,949	58,949	58,949	58,949	58,949	9,152	9,152
	JP Specification - Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 1	1.786***	0.865·	3.881***				
	(0.270)	(0.448)	(0.403)				
DID				1.207*	1.1907*	1.885**	1.829**
				(0.502)	(0.498)	(0.662)	(0.643)
Constant	16.75***	17.01***	31.85***				
	(0.077)	(0.096)	(2.563)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	58,949	58,949	58,949	58,949	58,949	8,602	8,602

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table G.28: Results of OLS, PSW, panel DID and matched DID, treatment 1 JP

	JP Specification - Dependent variable: ***Road Length***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	-1.453***	2.517***	6.434***				
	(0.196)	(0.372)	(0.315)				
DID				-0.023	-0.007	1.640***	1.508***
				(0.194)	(0.192)	(0.246)	(0.245)
Constant	10.41***	10.134***	36.155***				
	(0.127)	(0.248)	(4.545)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	58,949	58,949	58,949	58,949	58,949	11,154	11,154

	JP Specification - Dependent variable: ***Road Quality***						
	OLS	*PSW*		*panel DID*		*matched DID*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment 2	0.052	2.211***	3.173***				
	(0.235)	(0.303)	(0.345)				
DID				0.296	0.305	2.97***	2.860***
				(0.403)	(0.400)	(0.570)	(0.567)
Constant	16.92***	17.313***	8.725***				
	(0.078)	(0.111)	(1.769)				
Controls	No	No	Yes	No	Yes	No	Yes
Year FE	-	-	-	Yes	Yes	Yes	Yes
Entity FE	-	-	-	Yes	Yes	Yes	Yes
Observations	58,949	58,949	58,949	58,949	58,949	10,472	10,472

Note: Clustered standard errors (White, 1980) at regional level in parentheses .
Controls: rainfall, min temperature, max temperature.

*p<0.1; **p<0.05; ***p<0.01

Table G.29: Results of OLS, PSW, panel DID and matched DID, treatment 2 JP

Appendix H. Falsification Tests

Balance Tables for Falsification Test

Balance Table for Falsification 1, 90% Amhara						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.08	0.05	0.00	0.09	0.08	0.40
GDP (mln)	399.03	273.42	0.00	413.45	437.95	0.18
Pop_{1995}	12909.95	5742.40	0.00	12184.54	11500.74	0.56
NTL_{1994}	3.21	3.34	0.00	3.32	3.33	0.77
NTL_{1996}	3.44	3.37	0.02	3.48	3.56	0.22
TRI	15.62	7.48	0.00	12.29	12.94	0.31
Slope	10.89	5.15	0.00	8.63	8.95	0.46
$\text{Precipitation}_{1996}$	98.80	70.47	0.00	100.70	100.15	0.83
Temp min_{1996}	11.78	16.75	0.00	12.75	13.13	0.22
Temp Max_{1996}	26.66	29.51	0.00	27.01	27.34	0.29

Table H.30: Balance Table for cells of dimension 0.1 arc-degrees: outcome road length

Balance Table for Falsification 1, 90% Amhara						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
Speed_{1996}	15.57	9.34	0.00	16.11	14.05	0.10
GDP (mln)	399.03	273.42	0.00	406.54	432.59	0.15
Pop_{1995}	12909.95	5742.40	0.00	12056.70	11079.56	0.39
NTL_{1994}	3.21	3.34	0.00	3.33	3.27	0.25
NTL_{1996}	3.44	3.37	0.02	3.50	3.43	0.28
TRI	15.62	7.48	0.00	11.95	12.11	0.80
Slope	10.89	5.15	0.00	8.38	8.38	0.99
$\text{Precipitation}_{1996}$	98.80	70.47	0.00	100.19	99.47	0.78
Temp min_{1996}	11.78	16.75	0.00	13.00	13.21	0.48
Temp Max_{1996}	26.66	29.51	0.00	27.19	27.40	0.49

Table H.31: Balance Table for cells of dimension 0.1 arc-degrees: outcome quality (speed)

Balance Table for Falsification 2, 50% Amhara						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Length/Km^2{}_{1996}$	0.08	0.04	0.00	0.07	0.07	0.19
GDP (mln)	376.63	260.29	0.00	377.99	385.96	0.37
Pop_{1995}	10611.33	5296.71	0.00	8424.32	8600.24	0.68
NTL_{1994}	3.46	3.29	0.00	3.48	3.39	0.00
NTL_{1996}	3.59	3.32	0.00	3.53	3.48	0.05
TRI	12.75	7.05	0.00	9.38	9.77	0.14
Slope	8.85	4.85	0.00	6.52	6.82	0.11
$Precipitation_{1996}$	96.81	66.60	0.00	97.44	91.65	0.00
Temp min_{1996}	13.84	16.92	0.00	14.92	14.97	0.70
Temp Max_{1996}	27.90	29.59	0.00	28.34	28.39	0.73

Table H.32: Balance Table for cells of dimension 0.1 arc-degrees: outcome road length

Balance Table for Falsification 2, 50% Amhara						
	Unmatched			Matched		
	T	C	p-value	T	C	p-value
$Speed_{1996}$	14.04	8.81	0.00	13.11	13.29	0.77
GDP (mln)	376.63	260.29	0.00	376.85	395.88	0.04
Pop_{1995}	10611.33	5296.71	0.00	8496.95	8458.34	0.93
NTL_{1994}	3.46	3.29	0.00	3.46	3.39	0.02
NTL_{1996}	3.59	3.32	0.00	3.54	3.50	0.14
TRI	12.75	7.05	0.00	9.50	9.66	0.56
Slope	8.85	4.85	0.00	6.60	6.76	0.40
$Precipitation_{1996}$	96.81	66.60	0.00	97.60	93.04	0.00
Temp min_{1996}	13.84	16.92	0.00	14.89	15.00	0.48
Temp Max_{1996}	27.90	29.59	0.00	28.33	28.43	0.49

Table H.33: Balance Table for cells of dimension 0.1 arc-degrees: outcome quality (speed)

Appendix I. Market Access Construction

In order to construct the market access indicator, the first passage is to construct the bilateral distances between all woreda centroids. Here, we report the preliminary steps to construct the market access indicator, using as an illustrative example the road network at the baseline 1996 (all the passages were repeated for each year up to 2016).

All code is written and run in R, version 3.6.1. In order to perform network analysis, we need to work with a road network that has a clean topology. We use the *v.clean* tool from the GRASS GIS software, which provides automated functionalities for this task. In practice, cleaning the topology means breaking lines at their intersection and breaking lines that form collapsed loops. This allows to remove duplicate geometry features, small angles and dangles and getting a new spatial object that R can easily process. The *v.clean* toolset is able to break lines at each road intersection, in a way to ensure that the subsequent routing algorithm can actually turn right or left at an intersection. We cleaned the topology without compromising the geometry of the road sector itself (Figure I.32 shows the internal roads of Addis Abeba).

Figure I.32: Addis Abeba focus

It is likely that some segments of the road network do not intersect other street segments, or are simply not connected at all. However, in order to construct the shortest bilateral distances between centroids using the *Dijkstra algorithm*, we need to focus only on connected street segments. In Figure I.33, the coloured lines are the features that appear not to be connected to the whole road network. These segments are dropped by the original network, since they are considered as *disconnected islands.*

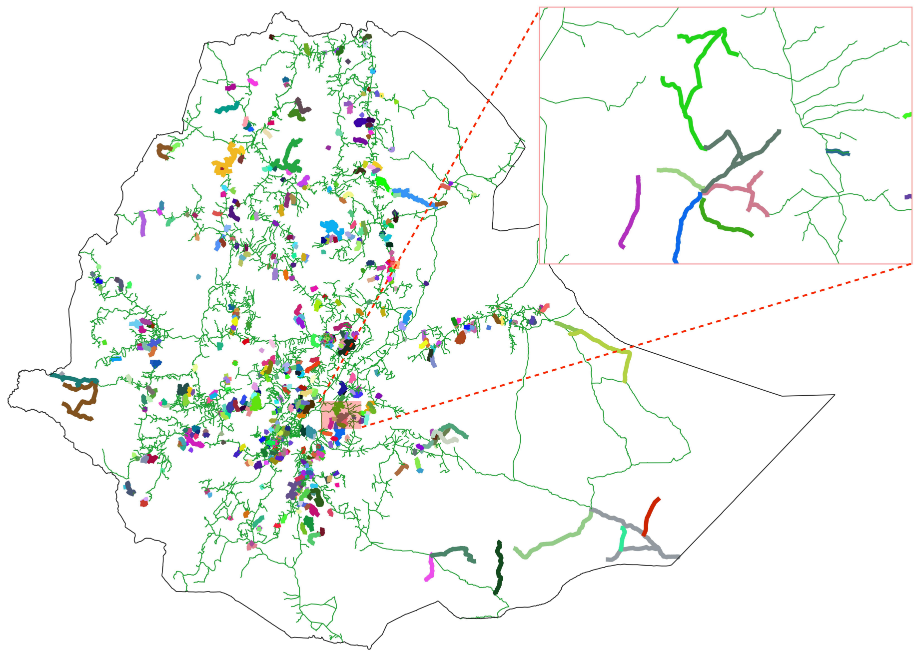

Figure I.33: Geo spatial representation of Disconnected Islands

Then, the roads network "cleaned" will be only a selected version of the road network of 1996 (see Figure I.34).

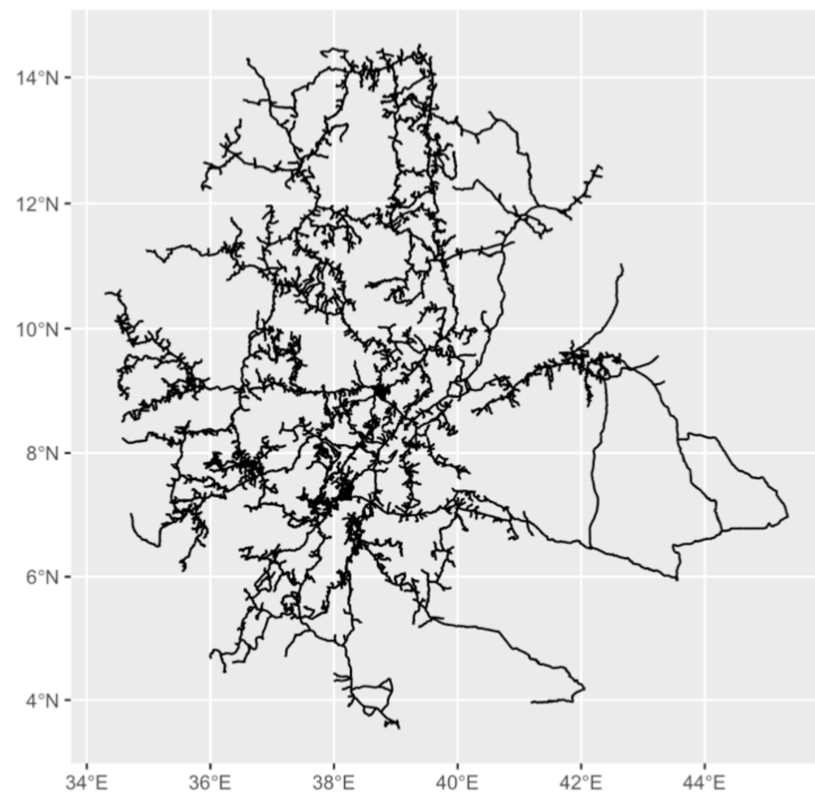

Figure I.34: Geo spatial representation of clean roads in 1996

The second passage is to get a unique ID for each edge and node in the network. The edges of the road network are simply the linestrings in the data, while the nodes represent the points (i.e. intersections, origins and destinations). Each of them must get a unique index, which can later be related to their start and end node. Then, we need to create nodes at the start and end point of each edge. Then, we combine the node indices with the edges. This is possible since we have given each start and endpoints a unique node ID. For each road segment, we then are able to specify its origin and destination node, allowing us to integrate the nodes and edges in to an *igraph* network structure. The visualisation of all this passages is represented in Figure I.35:

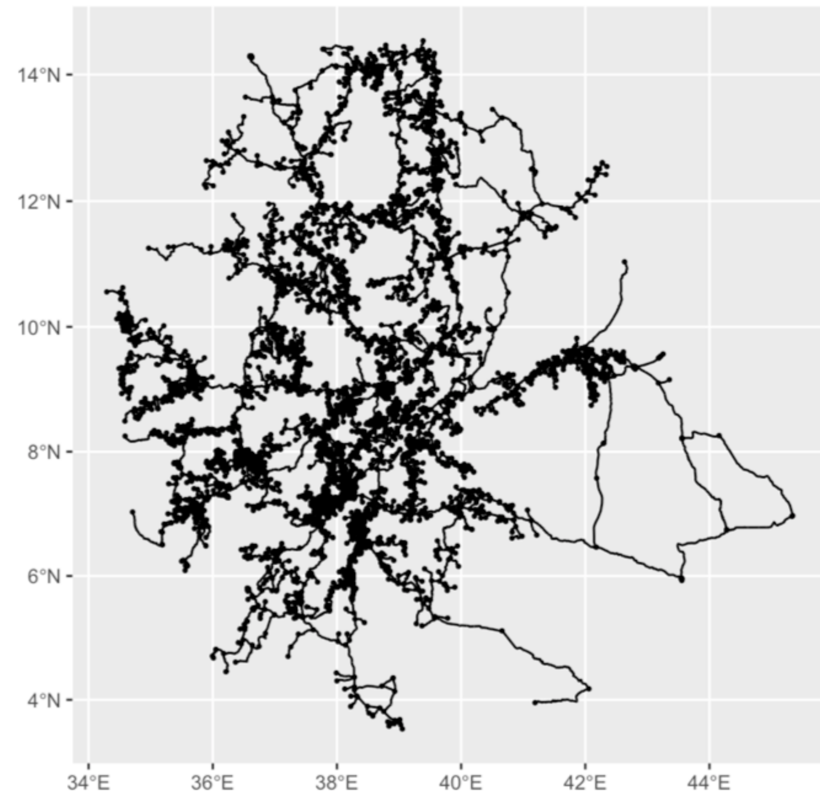

Figure I.35: Graph of roads in 1996

A further check is to inspect centrality measures, to assess whether the nodes that are considered important may be coherent with the Ethiopian road network. Thus, we construct the simplest of those measures, that is called betweenness centrality, which is the number of shortest paths that pass through a node. We calculate this measures both for nodes and edges, using traveltime as weight. Clearly, as it can be seen from Figure I.36, the more the colour tends to yellow the more the node is considered important. Addis Abeba, being the capital, appears to be the most important central knot. This reassures us about the validity of our procedure.

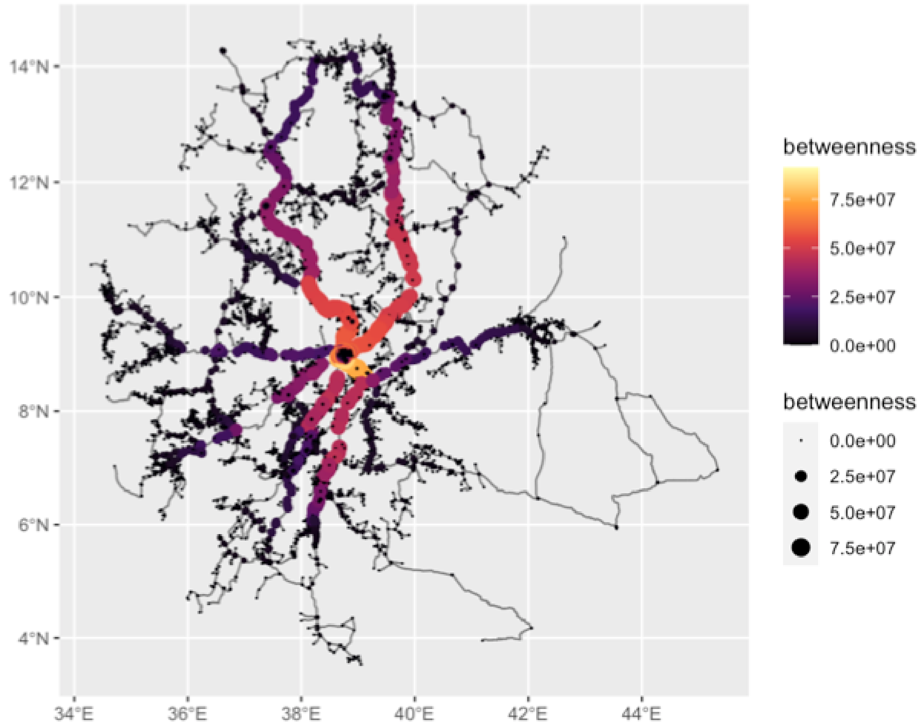

Figure I.36: Centrality measures in 1996

The last step is to calculate the shortest paths between centroids, minimizing travel time. We exploit the function *distances*, which returns a numeric matrix, containing the distances of the shortest path between every possible combination of nodes, by choosing the Dijkstra algorithm to calculate the shortest path. After having created the bilateral distances matrix for each year, we get to the last stage of this process: the creation of the proper market access following the definition of Storeygard (2016), employing night lights intensity at 1996 as indicator of economic activity at the baseline.