THREE ESSAYS IN DEVELOPMENT ECONOMICS

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Economics – Doctor of Philosophy

2024

ABSTRACT

This dissertation studies the effects of transportation access on outcomes ranging from national identity to maternal health and household income. The first chapter studies how the improvement of infrastructure affects national identity. The post-colonial era in Africa witnessed nation-building efforts aimed at establishing a national identity. Nation building is driven by the need for a united population to prevent conflicts and ensure long-term political stability. One key component of nation building is constructing a sense of belonging to one nation and having a strong sense of national identity. This paper explores the role infrastructure development plays in shaping ethnic and national identity. I use georeferenced data from five Afrobarometer waves, combined with a digitized panel dataset on road quality. As roads are not exogenously distributed and can be allocated based on the location of policymakers' ethnic homelands, I propose an instrumental variable strategy based on a least cost path network. I find that living near a paved road reduces national attachment and increases ethnic attachment. In terms of mechanisms, we find that road paving improves Information and Communications Technology (ICT), thus strengthening social networks created along ethnic lines. I also find an increase in the perception of corruption in governments—both national and local. Infrastructure projects can create opportunities for financial misappropriation, thus weakening respondents' trust in government and consequently weakening their attachment to the nation.

The second chapter studies the relationship between access to paved roads and maternal health. One important aspect of public health in developing countries is maternal and child health. As developing countries continue to invest in the improvement of maternal and child health, studies have found a list of obstacles to improving these two key aspects of public health. One of said obstacles is poor access to infrastructure to access health facilities. This project studies the effect of access to road infrastructure on maternal and child health in sub-Saharan Africa. This paper aims to answer the following question: How does the development of road infrastructure affect maternal and child health? The condition of a road is not static over time. Often, roads are upgraded from unpaved to paved. Using a difference in differences estimation method, I study the extent to which the improvement of a mother's nearest road increases the likelihood of access to good antenatal and delivery care. When studying the effects of road improvement on child health, the paper studies the extent to which the improvement of a child's nearest road improves child malnutrition outcomes such as stunting and wasting. I find that women who deliver after a road is

paved have more access to skilled midwives. Regarding child malnutrition, I find a reduction in the likelihood of being stunted or underweight, when the child is born after the road is paved.

The third chapter studies the introduction of the bus rapid transit in Cape Town and the effects on the residents' income. As cities grew, planners developed a number of transportation systems to cater to their residents, two of which are Mass Rapid Transit (MRT) and Light Rapid Transit (LRT). While the MRT is represented by the subway or metro system, the LRT can be likened to the tram or streetcars. A third one, emerging as early as the 1930s is the Bus Rapid Transit system. The BRT is a bus-based transportation system with better capacity and efficiency than standard bus systems. The BRT combines the efficiency of a metro system with the low cost and flexibility of a bus system. Starting in 2010, the city of Cape Town introduced MyCiti, a new Bus Rapid Transit system. It was progressively rolled out across the city. This paper studies the following question: what are the effects of BRT system constructions on income and employment in Cape Town? I use the South Africa National Household Travel Survey, to study employment and income metrics. I find that living near a bus rapid transit station is associated with an increase in personal and household income. When the effects are broken down by racial group, I find that coloured households saw large increases in personal and household income, while there was no change in the personal and household income of black and white residents.

This Dissertation is Dedicated to Yaye and Papa
Thank You

ACKNOWLEDGEMENTS

Alhamdulillah

I am starting by expressing my deepest gratitude to my advisor, Professor Christian Ahlin, who guided, advised, and supported my growth into the scholar I am today. His drive, motivation, and dedication to my dissertation and growth as a researcher were instrumental in the production of the present thesis. I extend my sincerest appreciation to my guidance committee members, Professors Enrique Seira, Leslie Papke, and Jeffrey Conroy-Krutz, who provided fantastic feedback and advice towards the completion of my project.

I am very grateful for the mentorship and guidance I received from many of my current and former professors, notably Professors Jessica Goldberg, Lisa Cook, Prabhat Barnwal, Leonidas Murembya, Ben Zou, and Todd Elder. My time in East Lansing was made enjoyable by my friends and colleagues at the university level. I am grateful to the Department of Economics, the African Studies Center, the College of Social Science, and the Graduate School for their financial support throughout the past years, allowing me to present my research at academic conferences.

I am grateful for the mentorship I received during my predoctoral journey from my former supervisors Dr. Amadou Sy, Dr. Kemal Dervis, Dr. Brahima Coulibaly, Dr. Eyerusalem Siba, and Dr. Nicolas Berman. Their mentorship and feedback gave me the confidence to apply, enroll, and graduate with a PhD in Economics. The knowledge and skills they taught me made my graduate school journey a smooth one.

I am grateful to my parents, whose work and sacrifices allowed me to complete my educational journey. I am grateful to my amazing support system, comprised of the most supportive people I could wish for: Mohamed, Baba, Hareesa, Diarra, Mwika, Pamela, Mukhtar, Khadija, Lena and the entire Traore family. Your encouragement, support, gifts, adventures, and good vibes got me through graduate school, and I am forever thankful. I am grateful to Yusuf Ibrahima and Fatou for bringing a lot of joy to the Sow family in the past 2 years.

I am extremely grateful to my friends turned mentors: Dr. Camila Alvayay, Dr. Dallal Dendjellal, Dr. Katie Bollman, Dr. Radhika Goyal, Dr Salim Nuhu, and Dr. Tao Wang. You paved the way and showed me the type of economist I want to become: a kind and caring one. You provided support, guidance, and fantastic advice throughout the past few years and I am thankful for you.

Finally, I am grateful to the producers and cast of Love Island for providing me with endless entertainment during my graduate school journey.

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CHAPTER 1.

THE ROAD TO NATION BUILDING: INFRASTRUCTURE DEVELOPMENT, POLITICAL PATRONAGE, AND ETHNIC IDENTIFICATION IN AFRICA

1. Introduction

The post-colonial era in Africa saw a wave of nation building initiatives aiming to construct a sense of national identity. The initiatives ranged from providing mass education to mandating military service (Kpessa, Béland and Lecours 2011; Enyekit, Ubulom and Onuekwa 2011). The rationale for nation building stems from the importance of having a united population for the sake of conflict prevention and long-term political stability. One key component of nation building is constructing a sense of belonging to one nation and having a strong sense of national identity. In African countries where ethnic identities remain salient, ethnic ties can be formed at the detriment of national identity. In contexts where ethnic identities are strong and present, individuals may feel closer to their ethnic group than to their nation, as a whole. Identity and its determinants have been thoroughly studied throughout the political science literature. The primordialism approach describes identity as static, while the instrumentalist theory defines identity as a malleable social construct, which changes due to a myriad of factors (Williams 2015). This paper builds upon the instrumentalist theory of identity to study how changes in physical infrastructure can affect ethnic or national identity.

This paper explores the role infrastructure development plays in shaping ethnic and national identity. I use georeferenced data from five Afrobarometer waves, collected across 16 African countries between 2005 and 2018. The 122,000 individuals in my sample were surveyed on questions of ethnic and national identity, access to public goods, and opinions on their respective governments. Using the geolocation of respondents, I combined the Afrobarometer dataset with a digitized panel dataset on road status—that is, if a georeferenced road is labeled as a paved, improved, or a dirt road. Over the past decades, African governments have invested in the creation and rehabilitation of road infrastructure. Beyond road creation, some roads have been transformed from dirt roads to paved or improved roads, as highlighted in the road dataset. Since 1910, Michelin, the tire company, has been recording and compiling the paving status of African roads to create maps of road quality across the continent (Jedwab and Storeygard 2021; Jedwab and Storeygard 2019). Combining Afrobarometer and Michelin Data enabled me to investigate how improved local road infrastructure impacts individuals' connection to the nation and their ethnic

group.

Roads are notably important in the African context where 90 percent of goods and services are transported through roads (The World Bank 2014). Still, roads are not exogenously distributed. Road construction can involve political patronage, when political leaders grant infrastructure projects to regions where members of their ethnic groups reside (Burgess, et al., 2015; Perra 2022). In doing so, political leaders are rewarded with votes in subsequent elections. To remedy the endogeneity concerns in road allocation in sub-Saharan Africa, I propose an instrumental variable strategy based on creating physical connections between the capital city and other node cities in the country. The first instrument is a least cost path network created using data on elevation to assess the least costly way to connect the capital city to the node cities given the variation in the cost of road paving attributed to slopes. This method is borrowed from the engineering literature, which assigns higher construction costs to areas with steeper slope gradients (Faber, 2014). The second instrument is a straight lines instrument where I create straight line connections between the capital city and the node cities. An individual's distance to the nearest straight line or least cost path is used to predict access to a paved road.

The relevance of the instruments holds if respondents who live closer to the least cost network or the straight-line network connecting key cities will be more likely to have access to a paved road than residents who live farther away from the drawn instruments. The rationale is that it is easier and more cost effective to upgrade road building from an existing network. The exogeneity assumption requires that distance to the least cost path network or the straight-line network only affects the outcome variables through the paved road network. I conduct a balance test showing that villages closer to the drawn networks and those farther away have similar characteristics before the road is paved.

The empirical strategy in the paper is closest to empirical work exploring the relationship between transport infrastructure and outcomes such as trade, using straight lines or least cost path connections. My empirical strategy is closely related to a 2014 paper, in which Benjamin Faber constructs a least cost spanning tree network and a Euclidean spanning tree network to instrument for proximity to China's National Trunk Highway System, akin to my least cost network and straight-line instruments. Another empirically related paper is one by Melanie Morten and Jaqueline Oliveira (2024). In order to study the effects of roads on trade and migration in Brazil, they draw straight lines between Brasilia and Brazil's 26 state capitals to instrument for the

country's road network.

I study the effect of road paving on three binary outcomes: national identity, ethnic identity, and equal attachment to the nation and the ethnic group. In this paper, I find that living near a paved road reduces national attachment and increases ethnic attachment. Moreover, I find that respondents tend to move to the center of the ethnic-national identity spectrum as a result of road paving, by identifying with both their nation and their ethnic group upon witnessing road paving. In terms of mechanisms, I find that road paving increases employment in agriculture, a traditionally ethnically homogeneous activity. The increased interactions with co-ethnics may increase one's sense of ethnic identity. I also find an increase in the perception of corruption in governments—both national and local. Infrastructure projects can create opportunities for financial misappropriation, thus weakening respondents' trust in government and consequently weakening their attachment to the nation. A third mechanism affecting the increase in ethnic identity is the improvements in information and communications technology (ICT), which accompanies road building. On one hand, improved access to information could heighten the perception of corruption. On the other hand, improved ICT leads to the strengthening of social networks along digital lines, thus bringing co-ethnics together in the digital world.

The paper makes several contributions, including to the nation building literature. Transport infrastructure can play a key role in nation building through a list of mechanisms. Roads and highways connect people and create interpersonal relationships through infrastructure. Roads can encourage nation building through the integration of populations who live in the peripheries. In direct ways, roads connect remote areas to more central areas thus contributing to nation building. In indirect ways, roads promote market access and enable remote inhabitants to improve their access to goods, services, jobs, and employment. Thus, by bringing development to certain areas, roads serve as a pathway to nation building (Rigg 2002; Puentes 2015). In reconstruction eras, road building can be equated with nation building. In 1941, Mexican president Manual Ávila Camacho stated that the sense of a nation cannot exist without a suitable road network. The post-war era saw an increase in the highway network by eighty percent (Bess 2014). This paper contributes to the literature on the determinants of nation building by studying how infrastructure development, through road improvements, affects national identification. I find some nuance to the concept that infrastructure is instrumental in building nations. While I find some signals of nation building, as seen in the finding that some respondents tend to identify with both the nation

and their ethnic group upon road paving, I find a reduction in identifying solely with the nation. The effects on nation building may be negated by the increased perception of corruption.

A second strand of literature to which the paper contributes studies the determinants of ethnic identification. The determinants of the decision surrounding which identity one is close to vary from the presence of natural resources (Berman, Couttenier and Girard 2023) to performance in sports competitions (Depetris-Chauvin et al 2020). The literature review highlights the role of public good provision on ethnic identification, and I contribute to the literature by specifically studying the effect of infrastructure development, through road paving, on identity shaping. Per the instrumentalist theory, identity is known to be malleable, it can be used to amass votes through political patronage. That is, politicians offer certain resources to members of their ethnic groups in order to secure their votes in upcoming elections. The resource explored through this paper is infrastructure projects. Specifically, does infrastructure development strengthen ethnic or national identity? One hypothesis is that upon witnessing infrastructure projects in their neighborhoods, respondents feel a stronger attachment to their ethnic groups. Being part of such groups, in the case where the respondent shares an ethnic group with the ruling party, may have made the region a priority for infrastructure investment. I find some evidence that infrastructure development does indeed strengthen ethnic attachment. Roads may have brought co-ethnics closer physically, by making transportation more accessible, or digitally, through the improving effect of roads on ICT infrastructure.

The rest of the paper is structured as follows. The conceptual framework provides information on the relationship between economic development and nation building, the state of patronage politics, and the determinants of ethnic identification. The data section will review the data sourced from Afrobarometer and Michelin. The paper then presents the identification strategy. The following sections present the results and their mechanisms. The paper concludes with a discussion on policies that can enhance the nation building properties of infrastructure.

2. Literature and Conceptual Framework

2.1. Nation building and national identification

2.1.1. Defining Nation building

Nation building is defined as the process of creating and maintaining a shared national identity. That is, in a population with different groups, they all share a sense of community and loyalty to their nation. Despite the existence of differences—stemming from a different historical

background, ethnic diversity, a colonial divide and conquer legacy, etc…— among groups, nation building strives to build collective capacity and create a shared vision of the future (Bourgon 2010). Nation-building has several goals, one of which is the subject of this present paper: building a strong national identity. It is defined as a sense of belonging to a country and identifying with a place, its patterns, and cultural heritage. Key elements of nation building include ancestral, political, and cultural dimensions (Zajda 2009). While this paper studies national identity and ethnic identity separately, some have found that national identity is influenced by ethnic identity. The two concepts are not distinct as many identify with both their nation and their ethnic group. The position of one's ethnic group, in society, can determine the level of national identity. Elliott Green (2020) argues that certain nations have "core" ethnic groups and when the core group is in power, members of the group tend to identify more with the nation.

2.1.2. Nation building and economic development

Nation building is important for long-term economic growth and macroeconomic stability, as it affects economic development through direct and indirect channels. Indirectly, nation building is necessary for a politically stable state. By definition, nation building constructs national identity with the aim of creating a more politically stable society. A large body of literature states that ethnic diversity can lead to internal conflicts and political instability. Ranis (2009) argues that ethnic diversity can lead to political instability as ethnically diverse societies are less likely to come to a consensus on how public goods should be distributed (Ranis 2009). Moreover, Esteban, Mayoral, and Ray (2012) find that the presence of public goods is a key driver of conflict when a society is ethnically polarized. In other words, when there are no coveted public goods, the effect of ethnic polarization on conflict is null. In addition, ethnically diverse societies can be associated with high prevalence of patronage goods, which is a challenge to political stability (Easterly and Levine 1997; Kimenyi 2006). As such, by containing ethnic diversity, nation building can promote political stability. Precisely, the literature states that ethnolinguistic fractionalization, alone, does not directly affect economic growth and only affects it through its negative effect on political stability (Karnane and Quinn 2019). There exists a positive relationship between political stability and economic growth. Using a sample of 98 countries in a period spanning from 1960-1985, Robert Barro (1991) finds that economic growth rates are positively related to measures of political stability. The author proxies for political stability through measures of coups, revolutions, and political assassinations. Notably, these measures negatively affect growth through the deteriorating

effects on property rights and private investment (Barro 1991). Similarly, Uddin, Ali, and Masih (2017) find that political instability is a deterrent to economic growth due to poor human capital accumulation and the absence of strong institutions. (Uddin, Ali and Masih 2017).

Ethnolinguistic fractionalization can hinder income, growth and economic policies. Easterly and Levine (1997) find that, in Africa, poor economic growth is associated with political instability. High ethnic fractionalization is associated with an increased likelihood of discrimination and violence against minorities. Countries with high ethnic factions are also more likely to experience insurgence under separatist movements (Easterly and Levine 1997). One of the mechanisms behind this result is high ethnic fractionalization. Therefore, a direct channel through which nation building affects economic development is through the policies put in place during the process of assuaging ethnic factions. In the post-independence era, certain countries used nation building as a tool for economic development. In order to create national unity, many countries implemented social programs, which led to long term social benefits. The next section provides examples of such programs. The use of social policy as a nation building tool significantly aided poverty reduction and improved access to education, health, and housing. The continent saw improvements in literacy rates, nutritional status, and life expectancy (African Union 2005). In addition to enhancing socio-economic development, the nation building policies reinforced social cohesion. These programs—as they brought residents together through school, health care, and labor markets—increased inter-ethnic interaction and heavily promoted the sense of a shared national identity (Paine 2015).

2.1.3. Nation building mechanisms

There exist many channels to nation building. One is through the promotion of social and economic development. The modernist view states that national identity is a product of modernity, through mechanisms related to industrialization and mass education (Storm 2018). As countries develop, residents start to trade in other forms of identity for a more solid national identity. Richer areas tend to identify more with the nation—over their ethnic group— due to a lower reliance on ethnic networks (Ahlerup, Baskaran and Bigsten 2017).

A second nation building mechanism is mass education, which has been used across several countries, from India to Kenya, to foster a sense of national identity. Through mass primary education, populations are homogenized and taught a common curriculum. Such processes can be seen occurring as far as the 19th century when Alexander III aimed to create a Russian identity in

a linguistically diverse population, through the imposition of Russian as the instruction language in schools across the Baltic province (Alesina, Giuliano and Reich 2019). Similar efforts have been seen in post-apartheid South Africa. In 2002, the South African government released a new Education manifesto to foster the creation of a "democratic, united, and non-racial society" (Waghid 2009 p400).

A third tool is through the provision of health and other public services. The post-independence era in sub-Saharan Africa saw the use of health and education as tools for nation building (Kpessa, Béland and Lecours 2011; Enyekit, Ubulom and Onuekwa 2011). The nationalist view of health provision framed its provision as a right of every citizen. Tanzania's nationalist government of Nyerere created a national policy framework based on social rights and provided free healthcare services in public institutions (Mchomvu, et al. 1998).

Finally, another nation building mechanism is through political and military means. To decrease the power of local leaders, some countries have adopted centralization policies that abolished federal systems built along ethnic lines. Specifically, centralized political systems encourage citizens to pool their demands into one that suits the wider group of citizens, and abandon demands rooted in provincial origins (Acemoglu, Robinson and Torvik 2020). Moreover, political scientists have long studied the effect of mandatory military enlistment on nation building. Some of the arguments in favor of promoting mandatory enlistment state that it promotes national unity and subdues differences born from ethnic or sub-national disparities (Kibreab 2009; Bandyopadhyaya and Green 2013).

2.1.4. Nation building and infrastructure.

The use of infrastructure to build nations falls under the realm of the spatial nature of nation-building. In Africa notably, geographic features have affected state-building (Herbst 2000). Countries use spatial tools to create or improve national identity. One example of using space to build identity is through the placement of strategic cities within the nation. Some leaders have shifted the location of their capital city in order to make governments more central and closer to their citizens. This was seen in Brazil, which moved the capital city from Rio de Janeiro to Brasilia in 1960. In 1976, Nigeria moved the capital from Lagos to Abuja. Another tool involving nation building through spatial channels is seen through infrastructure placement. For example, Spain has done so in its historically and culturally fragmented land through the construction of rail infrastructure (García-Mejuto 2022).

‘Infrastructure equity’ defines the extent to which public investment in infrastructure is allocated equitably. The lack of infrastructure equity can serve as a threat to nation building (Desalegn and Solomon 2021). In Ethiopia for instance, the political process involves patronage where state power comes with certain public expectation and the equitability of infrastructure may differ based on the ruling party. By contrast, Tanzania made the centralization of infrastructure a key feature of its policies. Completed public goods projects are unrelated to the ethnic make-up of a given district. For instance, the quality of road infrastructure is not found to be correlated with ethnic diversity. The equitable distribution of resources has been a key part of Tanzania’s successful nation-building process in the post-colonial era (Edward 2004). This paper extends on the literature on infrastructure equity by studying how road improvement affects national identification, in the presence of high ethnic diversity. Roads can serve as a tool to connect people to the capital or other gathering spaces, such as markets and schools, thus creating a physical connection to the nation and boosting national identity. Conversely, roads can also connect co-ethnics with each other, thus creating stronger ethnic identity.

2.2. The determinants of ethnic identification

2.2.1. The instrumentalist theory of Ethnic identification

An ethnic group is defined as a community or population sharing common cultural background or descent. Ethnic identification refers to " a person's use of racial, national or religious terms to identify himself, and thereby, to relate himself to others.” (Glaser 1958, P31). There exist two key theories on the construction of ethnic identity. First, primordialism states that ethnic identity is static. It is assigned at birth and is not malleable. Second, instrumentalism defines ethnicity as a tool used by individuals of the group to unify and mobilize each other in the aim to achieve a common goal. This theory allows for the dynamic nature of ethnic identification (Williams 2015). That is ethnic identities are not fixed; they are socially constructed and can be formed through different channels (Wimmer 2008), such as economic, political, security, and nation building. The determinants of the decision surrounding which identity one is close to vary from the presence of natural resources (Berman, Couttenier and Girard 2023) to performance in sports competitions (Depetris-Chauvin et al, 2020). For example, they found that when individuals were asked the question “Are you more strongly attached to your country or your ethnic group?” they were more likely to declare national attachment if they were surveyed in days following an important victory

by the country's national football[1] team. Sports is one unexpected determinant of identity. The arguments presented in this paper will follow the instrumentalist theory of ethnic identification. The rest of this section will highlight the literature on the construction of ethnic identities through economic and political channels.

Arguments affirming the presence of a relationship between economic gains and ethnic identification state that ethnic based access to certain economic resources such as employment, land, housing, or ability to start businesses can strengthen ethnic identification. For example, in the 1980s, Mauritius underwent an economic boom that improved access to manufacturing jobs across ethnic lines. Nevertheless, promotions within firms were still accessed through ethnic networks (Hempel 2009). Here, one could argue that the access of pecuniary resources through ethnic lines can create a stronger sense of ethnic connection. The presence of natural resources in the home of a given ethnic group and the perceived economic benefit from mining can affect ethnic identification. Berman, Couttenier, and Girard (2023) find that individuals are more likely to identify with their ethnic groups over their national country when mineral resource exploitation intensifies in their region. One potential mechanism through which this result can occur is through the increased economic benefit of belonging to a group with access to mineral wealth, as mines can bring about positive spillovers (Berman, Couttenier, and Girard 2023).

2.2.2. Political patronage and ethnic identification

Ethnic identity is also constructed and strengthened through political channels. Research papers using Afrobarometer surveys in Uganda (Green 2020) and Benin (Koter 2019) find that ethnic identification is affected by whether or not the president is part of a respondent's ethnic group. That is, if the president is part of a given ethnic group, members of that group are more likely to identify with the nation over their ethnic group. This result compliments the argument that perceived exclusion of an ethnic group from power strengthens ethnic identification. Politicians use building infrastructure and strengthening the provision of public goods as tools to attract voters from their ethnic groups. Politicians engage in ethnically targeted outreach, which can lead to stronger ethnic identification in both the in-groups who see their ethnic groups catered to and the out-group who can perceive a threat through the exclusion (Higashijima and Nakai 2015). The use of public goods to enact ethnic favoritism is widespread throughout places with high ethnic factions (Franck and Rainer 2012).

[1] Football refers to American soccer.

The instrumentalist theory of ethnic identity states that politicians rally ethnic identities in the pursuit of state resources. In other words, development projects are used to engage in patronage politics—that is a system where projects are allocated to places where residents share an ethnic group with the ruling local members (Chandra 2004). In a 2020 paper, Ann-Sofie Isaksonn finds that living near a Chinese development project fortifies ethnic identities. Using geocoded development project data and Afrobarometer survey responses, the author finds that residents with an ongoing development project are 3.2 percentage points more likely to identify with their ethnic groups than residents with future projects. Specifically, the paper finds that the president's co-ethnics often have more Chinese development projects in their vicinity (Isaksson 2020). Moser (2008) finds that certain public goods projects were allocated on the basis of patronage concerns, a winning strategy for the incumbents, who were rewarded with votes in their districts, which received projects before the election (Moser 2008). A 2015 paper finds that in Ghana, road conditions affected election results. That is the incumbent candidate was rewarded or penalized based on the road conditions surrounding elections (Harding 2015).

This paper contributes to the literature on ethnic identification by building on the idea that politicians and local leaders use ethnic identification to amass political power. This leads to stronger ethnic identification. One tool they use is the provision of public goods. We explore the extent to which public goods provision, through road renovations can lead to stronger ethnic identification.

3. Data

To assess the impact of infrastructure development on national and ethnic identification, we combine two key datasets. The first one is extracted from the Afrobarometer surveys, the second one is a dataset providing information on road paving across the years.

3.1. Afrobarometer Surveys

The survey data comes from Afrobarometer. The company is headquartered in Ghana and is funded by USAID, the Gates Foundation, and the Mastercard foundation, among other funders. Afrobarometer is a non-profit company, working with national data collecting partners to gather data on public attitudes. Since 1999, Afrobarometer has been collecting data on attitudes and opinions on a myriad of topics ranging from trust in institutions to ethnic identification. The surveys provide information on democracy, governance, the economy, and society. The surveys also provide information on the socio-demographic characteristics of the respondents. In addition,

in a more restricted dataset than the ones publicly available, Afrobarometer provides the geolocation of said respondents. To date, the organization has collected 8 rounds of surveys in more than 35 African countries. The data is a repeated cross-section. In this paper, I restrict the analysis to rounds 3 to 7, covering 122,000 respondents across 16 countries[2]. The data was collected between 2005 and 2018 (Afrobarometer Data 2018).

Using the surveys, I study one key group of outcome variables, surrounding ethnic and national identification. As seen in the literature review, many factors, ranging from political factors to the presence of natural resources affect the extent to which one identifies with their ethnic group over their countries. The question here will assess whether people are more likely to feel ethnic ties after witnessing infrastructure development at the local level. There are key outcome variables to study identity. The first one is whether the respondent answered "Never" to the question "How often is [Respondent's Ethnic Group] treated unfairly by the government?" That is, the binary variable, labeled *Ethnic group is being treated unfairly*, is equal to 1 if the respondent replied *'Sometimes, Often, or Always'* to the question above and 0 if they replied '*Never*'.

The second and third outcomes study the answer to the question: "Let us suppose that you had to choose between being a [Respondent's Nationality] or being a [Respondent's Ethnic Group]. Which of the following best expresses your feelings?" The respondents give one of the following five responses: I feel only (Respondent's ethnic group), I feel more (Respondent's ethnic group) than (Respondent's nationality), I feel equally (Respondent's nationality) and (Respondent's ethnic group), I feel more (Respondent's nationality) than (Respondent's ethnic group), and I feel only (Respondent's nationality). I create a binary variable which is equal to 1 if the respondent admits to solely identifying with their ethnic group or identifying more with their ethnic group than their nation, the first two categories. In the regression tables, this variable is labeled '*The respondent identifies only/more with the ethnic group'*. I repeat this process to study ties to the nation. That is, I create a binary variable that is equal to 1 if a respondent only identifies with their ethnic group or identifies more with their ethnic group than their nation. In the analysis, this variable is labeled '*The respondent identifies only/more with the nation'*. I also study whether one moves closer to the middle of the spectrum by identifying with both their country and their ethnic groups. This variable is labeled *'The respondent identifies equally with the nation and the ethnic*

[2] The study covers Benin, Botswana, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe.

group'. Table 1.1 provides the descriptive statistics on the sample. In the sample 43 percent of respondents state that they only identify with their nation or that they identify more with their nation than their ethnic group Conversely, 15 percent of respondents declare only identifying with their ethnic group or identifying more with their ethnic group than their country. Finally, 19 percent of respondents believe that their ethnic group is being treated unfairly. In terms of access to roads, 49 percent of respondents live near a paved road and 17 percent live near an improved road. In the sample, 17 percent of respondents are co-ethnics with the president, whereas 46 percent are ethnic minorities. The unemployment rate among surveyed respondents is relatively high and lies around 37 percent. The residence of sample respondents is relatively rural as only 38 percent of residents live in an urban area. The average nightlight index is of 16 digital number (DN) values, which is relatively low. For context, the average nightlight index in a capital city such as Harare is of 48 DN values.

Figure 1.1 shows the 13-year evolution in the share of respondents reporting strong ethnic or national identity, as well as respondents reporting the unfair treatment of their ethnic groups. There was a large increase in national identification between 2005 and 2011, where the share of individuals who identified with the nation peaked at 58 percent. By the end of the sample period, the share of individuals who identify with the nation was only 32 percent. Across the sample, we also see a small decline in the feeling of one's ethnic group being treated unfairly. The literature review highlighted a few drivers of these changes—better mining resources, nation building policies, etc. The rest of the analysis will study the potential role of infrastructure development on identity.

3.2. Road Data

Since independence, the paved road network has seen a significant expansion fueled by a large wave of public investment (Jedwab and Storeygard 2021). Figure 1.2 shows the aggregate length of paved and improved roads in the early 1960s, the start of the road reporting period, and the 2010s, its end. The figure reflects the large road investment efforts seen in recent years. For example, figure 1.2 displays a 126 percent increase in the number of kilometers of paved roads. The continent had and continues to have a large need for road investment. Today, the United Nation estimates a $100 billion gap in infrastructure financing needs (Ighobor 2022). Given the large growth and developmental needs, combined with the monopolistic nature of public service provision, the task of road building was left in the hands of central governments, aided by the

inflow of foreign aid. However, once the road is built, the management and rehabilitation tasks are delegated to local governments. Local governments have limited fundraising capabilities and in turn rely on the transfers from the central government to complete the road maintenance tasks (Gwilliam 2011).

The structure and implementation of road building and road management varies across countries and depends largely on the political structure of a given country. In centralized countries, road building is planned at the central government level. In federated countries however, the central government has full control over the national network, with the management of departmental networks being left to the local governments (Wasike 2001). Most countries in the sample fall under the former scheme. As such, countries form parastatal road building agencies, responsible for building, management, and rehabilitation. For example, in 1998, South Africa founded SANRAL, which has jurisdiction over 92 percent of the country's roads—the remaining 8 percent are toll roads built and managed by private companies. SANRAL is directly funded by tax revenue from the national government. Nigeria presents the alternative road management scheme. Like South Africa, they created a Federal Road Management Agency (FERMA) responsible for maintaining the national roads. Local road management is handled at the state level, through—often insufficient—fund transfers from the government (Mostafa 2018).

As such, road building and rehabilitation is primarily implemented by the central government and Afrobarometer respondents in the sample seem aware of the entity responsible for the road improvements—or lack thereof– in their respective areas. For example, in the 2014 publication of the survey, the maintenance of local roads was cited as one of the areas under which the central Ghanaian government performed poorly, as cited by 68% of respondents. It was only surpassed by the dissatisfaction over the provision of reliable electricity (Armah-Attoh 2015).

As road conditions are not static over time, tire company Michelin has recorded the status of roads across the African continent. They have been using that data to produce maps since 1910. The information displayed on the Michelin maps is a combination of previous Michelin maps, population censuses, information from Michelin tire stores across Africa, and supplemental information from road users and truck drivers, who are part of Michelin's consumer base. The dataset is longitudinal and the average gap between years for which road quality data is reported is of 2.5 years (Jedwab and Storeygard 2021).

Figure 1.2 shows the extensive number of roads for which road condition was collected. There are

4 categories of roads: paved, improved, unpaved, and highways. By merging the road dataset with the Afrobarometer data, we can assess the road conditions of the roads near the respondents and evaluate how the increased investment in roads can affect attitudes. In the road dataset, there exist instances where an improved road loses its 'improved' status and is downgraded to being labeled as an unpaved road. In future work, I can study how the deterioration of roads affects respondents' views of governments, access to services, and community engagement.

3.3. Additional Datasets

In the analysis, I use nightlight data to proxy for an area's overall wealth. Nightlight data measures light intensity—captured from outer space— of the earth during the night. It is used by many economists to measure economic activity in a given area. I use a dataset developed by Xuecao Li, Yuyu Zhou, Min Zhao, Xia Zhao, from the Department of Geological and Atmospheric Science at Iowa State University. The dataset provides panel data ranging from 1992 to 2018 (Li, et al. 2020). Sixty-three percent of the respondents in the sample live in rural areas (Table 1.1). As such, the mean nightlight index is 14.8. In general, the index ranges from 0 to 63, where a value of 0 refers to non-illuminated areas and a value of 63 refers to strongly lit areas (Figure 1.3).

Another variable I control for is that of co-ethnicity with the president. To do so I use the Brookings African Leadership Transitions Tracker, which has information on every political transition since independence and the start and end date of a political leader's term (Songwe 2021). I then use information on a given president's ethnicity to code whether or not a respondent surveyed at a given time shares an ethnicity with the head of state.

4. Methodology

4.1. Empirical Specification

To estimate the effect of infrastructure construction on ethnic identification and nation building we estimate the following equation:

$$Y_{itc} = \beta_0 + \beta_1 * Paved_{itc} + \boldsymbol{\delta} * X_{itc} + \boldsymbol{\theta} * Z_{itc} + \gamma_c + \lambda_t + \varepsilon_{itc}. \quad (1.1)$$

Where Y_{itc} is the outcome of individual *i,* in country *c,* surveyed at time *t.* Our coefficient of interest is β_1. The binary indicator $Paved_{itc}$ indicates whether individual *i*'s nearest road is paved. I have *country* fixed effects and survey *year* fixed effects. $Paved_{itc}$ is instrumented with the distance to straight lines or least cost path drawn between the capital and other key cities in the country. X_{itc} are individual level controls such as age, employment status, education level, gender, urban/rural residence, distance to the capital city, co-ethnicity with the president and whether the respondent

is an ethnic minority. Z_{itc} are local level controls such as nightlight data.

4.2. Endogeneity Issues and Validity of Instruments

As the paper studies the effect of road paving on ethnic identity, a potential endogeneity issue arises from the finding that road paving is affected by ethnic favoritism. Here, the variable 'Paved' is not exogenous given the presence of ethnic favoritism. That is, ethnic ties to heads of states can be the cause for road paving in the first place. Several papers in the literature have studied the effect of ethnic favoritism in public goods provision. Burgess, et al. (2015) study the effects of ethnic favoritism on road building in Kenya and find that districts that share the same ethnicity as the president received twice the amount of road expenditure than those that did not. The increased road investment resulted in having five times the length of roads built. A similar result was found in Ethiopia. In a 2022 working paper, Elena Perra, finds that the districts in which reside the dominant ethnicity, the Tigrays, received disproportionately more road investments than other ethnic districts where lived ethnic minorities. Not only did the Tigray district receive a higher share of roads, but they also saw faster road speeds (Perra 2022). In my setting, ethnic identity can affect road paving, hence the use of the instrument to mitigate the potential endogeneity issues.

The literature has used straight lines and planned roads to study the effect of infrastructure on a variety of outcome variables ranging from trade to labor markets. Oliveira and Morten (forthcoming) study the effect of infrastructure on labor and goods markets. The mechanism they study is the cost of travel between cities. To instrument for travel time, they use a predicted highway system as an instrument for actual road networks. Specifically, they draw straight lines between Brasilia and other major Brazilian cities. Here, the validity of the instrument lies in the fact that small cities between Brasilia and other large Brazilian cities get automatically connected to the highway network. Ghani, Goswami and Kerr (2016) study the impact of transport infrastructure on the efficiency of manufacturing activity in India. They also create straight line instrumental variables. Specifically, they instrument being 0-10 kilometers away from the Golden Quadrilateral highway network with being 0-10 kilometers away from straight lines between nodal cities on the network. Similarly, Faber (2014) studies the effect of infrastructure investment on industrial and economic activities in peripheral cities on China's National Trunk highway system. Here the instrument used is a hypothetical least cost spanning tree network that would minimize the cost of connecting two cities.

4.2.1. The Straight Line Instrument

In my specification, I use two instruments. First, I use straight lines drawn from the capital to other major cities in the country. As such, I use the World Cities Database to identify the important cities in each country. The dataset provides information on the population size of a given city as well as whether a city is the national or administrative capital. Using the information on population sizes and administrative status of a city, I identify a country's node cities and construct the instrument connecting the capital city and other important cities in the country. As South Africa has three capitals, I draw lines between Pretoria and other major cities in the country. Figure 1.4 presents the map of the lines drawn in each country.

4.2.2. The Least Cost Network Instrument

Second, I construct a least cost roads network using elevation data from the NASA Shuttle Radar Topography Mission (SRTM). The analysis publishes data on a near-global scale to generate a topographical dataset of planet Earth. The engineering literature states that steeper slopes incur higher construction costs (Faber, 2014). To construct the instrument, I import the elevation data into a GIS software. I then create a raster data set indicating the slope at each point. I then create a construction cost raster, which indicates the direction one should move in order to stay on the least costly road construction path given the origin capital city. Figures 1.5 and 1.6 use Zambia as an example of how the least cost instrument works. First, we see the elevation data where a darker color indicates a lower altitude (Figure 1.5). Second, each cell on the construction backlink raster, Figure 1.6, indicates the neighbor that is the next cell on the least accumulative cost path to the capital city. For example, a dark blue cell indicates that the civil engineer would continue the road construction to the left, in order to stay on the least costly path on the way to Lusaka, the Zambia capital. Figures 1.5 and 1.6 also show the Zambia paved roads network, alongside the two instruments I constructed. Visually, we see that the road network closely follows the instruments' geographical features.

The first stages are as follow:

$$Paved_{ict} = \pi_0 + \pi_1 * Straight\_Line_{ict} + \boldsymbol{\delta} * X_{ict} + \boldsymbol{\theta} * Z_{ict} + \gamma_c + \lambda_t + \rho_{ict} \quad (1.2)$$

$$Paved_{ict} = \pi_0 + \pi_1 * LeastCostPath_{ict} + \boldsymbol{\delta} * X_{ict} + \boldsymbol{\theta} * Z_{ict} + \gamma_c + \lambda_t + \rho_{ict} \quad (1.3)$$

In this specification, $Straight\_Line_{ict}$ is the distance, from the surveyed individual's geolocation to the nearest straight line connecting the country's capital to a node city. $LeastCostPath_{ict}$ is analogously defined in relation to the least cost network. Table 1.2 presents the results from the

first stage estimates.

presents estimates from the first stage of the two-stage least squares estimation method. The coefficient on *Straight Line* indicates that a respondent who is 100 kilometers closer to a straight line drawn in Figure 1.4 is 7 percentage points more likely to live near a paved road than a counterpart in a more remote location. Whereas one who is 100 kilometers closer to the least cost network is 4 percentage points more likely to live near a paved road.

4.2.3. Exogeneity of Instruments

The validity of the instruments hinges on the argument that the only reason we may have observed modern day differences in villages close to the straight lines and those further away, conditional on observables, is due to the road that has now been constructed. To test this hypothesis, I use nightlight data from 1992, at the 10 km × 10 km cell level, as a dependent variable. Nightlight data is used as a measure of economic prosperity. If we suspect that the places close to the straight line are not similar to those away from the straight line, then we would find a statistically significant coefficient on the distance to the straight-line variable prior to road paving, however we do not find such a relationship.

In an ideal setting, I would test the hypothesis that villages close to the drawn instruments are similar to those farther away, using data generated before any roads were put in place, as Faber (2014) does in a falsification test. However, given that we have 16 countries in the sample, and there is no clear initiative to build a road network at a given time, the "before" year becomes hard to identify. As such, I regress nightlight data on distance to the straight line and the least cost path before and after the road was paved (Table 1.3). That is, I first conduct the analysis using the entire sample, I then restrict the sample to observations located near a road paved after 1992. I control for distance to the capital and node cities, and whether the center of the cell is located in a capital or node city. I also include district fixed effects. The results are in Table 1.3. In the full sample analysis, we find a small negative relationship between nightlight data and distance to the straight-line network or the least cost path. However, since some of the roads have already been built by 1992, this difference in the nightlight index could be driven by improved access to road infrastructure. An alternative is to restrict the sample to places where the road has yet to be paved; this ensures that any observed differences are not due to the road having been paved. These restricted-sample results, in Column 2 and 4, show no effect of distance to the straight line on the nightlight index.

It is important to note the drawbacks to the present balance test and how it falls short of an ideal test where we use data generated before the existence of any road. The restricted sample balance test is not a perfect solution, however. An instrument is only necessary if there are unobservables that explain road paving as well as the outcome. Restricting the sample to areas where the road has yet to be paved likely yields an altered distribution of unobservables and hence outcomes. That said, there are cases in which the bias balances between paved and unpaved areas, especially if the timing of road paving is somewhat random. Ultimately, the evidence provided is inconclusive but certainly consistent with the exclusion restriction holding.

5. Results

5.1. Baseline Results

This section reports the baseline results across different specifications for my outcomes of interest. In this section, I will present the results from the analysis using the straight-line instrument, the least cost path instrument, and their combination. The first outcome of interest is the extent to which one identifies with the nation upon road paving. In the analysis, I create a binary variable which is equal to 1 if the respondent declares identifying more with the nation or only identifying with the nation and 0 otherwise. Table 1.4 shows the results across the different specifications. I include survey year and country fixed effects. Standard errors are clustered at the district level. I find that living near a paved road negatively affects national identification. Across specifications, the coefficient is negative and significant. The coefficients differ in magnitude; nevertheless, the direction remains identical. In the specification where both instruments are used, I find that living near a paved road decreases the probability that a surveyed respondents identifies with the nation by 25 percentage points, from a baseline mean of 43 percent. The results hold in the omission of controls.

When the controls are omitted, the magnitude of the coefficients are similar across specifications and we find that, on average, living near a paved road is associated with a 15-percentage points reduction in national identification (Table 1.5). We do not see a significant effect of the interaction term. As reported in the literature, people who share an ethnicity with the president are more likely to feel a stronger sense of national identity, as seen in the third row.

The second outcome of interest is the proximity to one's ethnic group upon road paving. Here the binary variable is equal to 1 if a respondent admits that they identify more with their ethnic group or that they only identify with their ethnic group. I find that with road paving, respondents are

more likely to identify with their ethnic group. The coefficients are significant and positive across specifications. We see differences in the magnitudes of the coefficient. In the specification using both instruments, we find that respondents near paved roads are 16 percentage points more likely to identify with their ethnic group, from a baseline mean of 15 percent, over the nation (Table 1.6). At first glance, the first and second result tables show a movement away from national identity toward ethnic identity. The result from the third outcome indicates that a paved road does not necessarily lead to the substitution of national identity for ethnic identity. These specifications study the existence of a movement toward the middle of the spectrum, that is, individuals are identifying with both their ethnic group and their nation upon road paving. I find significant and positive evidence for the movement to the center. Using the straight-line instrument, I find that the respondent is 10 percentage points more likely to equally identify with both the nation and the ethnic group, from a baseline mean of 42 percent (Table 1.7). These results are robust to the omission of controls, where across all three specifications, I find a 16 percentage points increase in the likelihood of identifying with both. The coefficients are significant (Table 1.8).

Finally, I study if living near a paved road leads to a reduction in the feeling that one's ethnic group is being treated unfairly and I find no significant evidence for such a claim (Table 1.9).

The baseline results tables show OLS estimates, which are starkly different from the 2SLS estimates. Using the results from ethnic identification as an example, this subsection highlights the potential mechanism behind a downward bias in OLS estimates. In the analysis, we find a positive relationship between road paving and ethnic identification, using 2SLS. However, the OLS estimated coefficient is negative. We know that there exists a preferential bias in allocating road projects. That is, when members of a given ethnic group are in power, they allocate infrastructure projects to the places where they reside. Following the Griliches (Griliches 1977) literature on ability bias, let's introduce a preferential bias *F*. The regression with the preferential bias is:

$$Y = \alpha + \beta P + \gamma F + u \tag{1.4}$$

Where Y measures ethnic identity and P is the paved road. However, F is not in the model. Therefore, OLS estimates the following model:

$$Y = \alpha + \beta P + u \tag{1.5}$$

$$\text{Now, plim}(\hat{\beta}_{OLS}) = \beta + \frac{\gamma Cov(P,F)}{Var(P)} = \beta + \gamma \partial_{FS} \tag{1.6}$$

Where ∂_{FS} OLS slope coefficient from a regression of F on P.

From the literature, we know that $\partial_{FS} > 0$. That is, there is a positive relationship between having

a preferential policymaker in power and having better road infrastructure (Burgess et al, 2015). The literature also states that $\gamma < 0$. That is preferential treatment of a given ethnic group stems from said ethnic group being in power and the literature has found that when one's ethnic group is in power, they tend to substitute ethnic identification in favor of national identification (Green, 2020). Therefore, $\gamma\partial_{FS} < 0$. OLS Estimates of road paving on ethnic identity are biased down.

Overall, we find that upon road paving, respondents move away from national identity toward ethnic identity or toward equally identifying with the nation and the ethnic group. The next section will explore the mechanisms behind some of the baseline results.

5.2. Mechanisms

This section highlights some of the mechanisms behind the baseline results. Using additional data from Afrobarometer, I study the state of economic conditions, the perception of corruption, and the changes in access to information, from the point of view of respondents. This section shows the results from the straight-line instruments, the results from the least cost path are similar.

5.2.1. Economic Conditions and Agricultural Employment

The Afrobarometer survey asks respondents about the state of the country's economic conditions as well as their respective conditions. I find that, with paving, a respondent is 10 percentage points more likely to believe that their economic conditions are better than that of others, from a baseline mean of 25 percent (Table 1.10).

Living near a paved road brings a perceived relative improvement in one's living condition, but not an absolute improvement. As seen in the second column, there is no significant evidence of respondents seeing their economic conditions as good, in absolute terms. One interesting finding, from column 2 is the positive and significant coefficient of the interaction term, where respondents who share an ethnicity with the president and live near a paved road believe that they have better living conditions. Overall, upon road paving, respondents are 31 percentage points more likely to believe that the country's economic conditions are worse. This result is in line with some papers from the road evaluation literature. Sam Asher and Paul Novosad (2020) study the effect of road improvements in India and find that local roads bring very modest benefits to residents. Even with road improvements, remote areas lack economic opportunities. As with the result in column 2, I also find a positive interaction term; respondents who live near a paved road and share an ethnicity with the president have a more favorable view of the country's economic conditions. The absence of perception of better economic conditions can be a key mechanism behind the decline in national

identification.

Another variable studied is that of employment in the agricultural sector. The political science literature states that agricultural employment is more ethnically homogenous than employment in other sectors; to the extent that certain crops are farmed by certain ethnic groups (Montalvo and Reynal-Querol 2021; Robinson 2016; Katungi, Machethe and Smale 2007). In other words, respondents who work in agriculture are more likely to interact with their co-ethnics, compared to those who work in other sectors such as manufacturing or industry. Agricultural workers are also more likely to trust their co-ethnics over their non-co-ethnics, than non-agricultural workers (Robinson, 2020). These claims help interpret the column 4 results. As we find an increase in ethnic identity, we also find a 20 percentage points increase in the likelihood of being employed in the agricultural sector upon road paving, from a baseline mean of 38 percent. Along similar lines, Berg et al (2018) find that, in sub-Saharan Africa, road construction led to agricultural intensification. Asher and Novosad (2020) find a 33 percent growth in agricultural retail in response to a new road, in India. The increase in agricultural employment upon road paving can lead to someone working with people who share an ethnic group with him, thus strengthening ethnic identity.

5.2.2. Infrastructure Development and Corruption

The baseline results show a decline in national identity upon road paving. That result can partly be explained by the lack of trust in the government and an increased perception of corruption after the road is paved. Afrobarometer asks respondents about their views on corruption in four different categories. I find that upon road paving, respondents are 20 percentage points more likely to see the local government as corrupt (Table 1.11).

They are 26 percentage points more likely to see the Members of Parliament (MOP) as corrupt. They are 23 percentage points more likely to see the president as corrupt and they are 27 percentage points to see the tax officials as corrupt. The consistent perception of corruption across several levels is consistent with the claims drawing a relationship between infrastructure investments and corruption. The access to infrastructure development financial funds can be a vessel for embezzlement at several levels of government.

In evaluating the relationship between infrastructure development and corruption, estimates find that about 5 to 20 percent of construction costs are lost to bribe payments (Kenny 2009). Bribes is one of many mechanisms through which infrastructure costs are inflated.

It is important to note that my estimates report perceptions of corruption and not actual instances of proven corruption, however, the two are strongly correlated. In a 2009 paper Benjamin Olken conducts an experiment in Indonesia, after a road paving project. He hires engineers to collect road samples. He then interviews villagers on wages they received from the road paving project, and he creates his own estimate of the road project's cost. To create a measure of corruption, he compares his calculated costs to the costs the village officials reported. He then asks the village residents about their perception of corruption in the road construction project. He finds that the villages' residents are able to detect corruption in the road project. Moreover, the residents can discern the corruption from the road construction to general levels of corruption in the village. However, even though the residents were able to detect corruption, which resulted from the construction project, the residents were not able to detect the full magnitude of corruption and missing funds (Olken 2009). In our sample, the respondents who have an increased perception of corruption may be capturing the factual corruption associated with infrastructure projects. The perception of corruption may be eroding trust in the government and weakening the respondent's sense of national identity.

5.2.3. Road Improvements, Access to Information, and Integration

As seen in the literature, infrastructure projects can create avenues for the misappropriation of public funds. As we suspect corruption to play a role in poor confidence in government and the subsequent decline in national identification, one additional question is one of awareness and integration into the country's news cycle. Specifically, if there is indeed an increase in corruption instances at several levels of governments upon road paving, what are the channels through which respondents are becoming more aware of said corruption? To answer the question, I study how access to news and media changes after road paving. Afrobarometer asks respondents the following question: how often do you get news from the following sources? The sources in question are radio, tv, newspaper, and internet. Upon road paving, there is a 24 percentage points increase in the likelihood of having weekly access to any of the four news sources.

The increase in access to news can partly be explained by the following findings. There is an increase in newspaper deliveries. I find a 15 percentage points increase in the likelihood of obtaining news through the newspaper. Road improvements also lead to improved cell phone service and internet access, as seen in the 32 percentage points increase in the likelihood of the survey area having cell service and the 8 percentage points increase in the likelihood of using the

internet weekly (Table 1.12).

The improvement in cell phone and internet access can also explain the increase in ethnic identification as it may have made communication between co-ethnic more frequent. Improved cell phone and internet access can strengthen ethnic-based social networks and improve communication linkages among co-ethnics. In a 2016 paper, Bacishoga et al, study the effect of mobile phones on the creation of social capital among refugees in South Africa, who came from countries such as Angola, Zimbabwe, and Bangladesh, among others. They find that mobile phones play an important role in creating communities and aiding integration into the community. However, these linkages tend to be created with nationals from their respective homelands instead of the local communities. Through the improvements in information and communication technologies, road improvements can improve access to news and strengthen social networks.

6. Discussion and Conclusion

Nation building is one key pillar of a country's political stability. A lack thereof can hinder long term economic development by preventing the influx of investment. One key element of nation building is creating a nation of people who feel strong ties to their country and identify with their nation to some extent. Africa is home to nearly 3000 ethnic groups. The salience of ethnic identities can take away from national identity and hinder long term nation building efforts. As the literature has studied various factors that can affect how one identifies in regard to their nation or their ethnic group, this paper presents a tool that policymakers have indirectly used for nation building and studies its effectiveness in the African context.

In looking at the effects of road improvements on national and ethnic identity, I use the detailed geolocation of 122,000 Afrobarometer respondents and assess their positions in regard to the paved roads in their respective vicinities. I find that upon witnessing road paving, there is an increase in the likelihood of respondents identifying with both their nation and their ethnic group, providing little evidence that road paving can positively affect nation building. However, this conclusion is limited as I find a reduction in national identity upon road paving. When studying mechanisms, we find that respondents also find the government to be more corrupt. As infrastructure projects can serve as an opportunity for the misappropriation of funds, they can lead to a decline in trust in the government and the respondent's subsequent detachment from the nation. I also find the increase in identifying with one's own ethnic group, a potential result of stronger ethnic connections, both in the physical and digital world. Road paving improves ICT and can bring about

integration into social networks, most of which are built alongside ethnic lines.

When allocating infrastructure projects, it is important for policymakers to create needs-based mechanisms where ethnic favoritism does not play a role in project allocation. In addition, it is also important to reduce the opportunities for corruption in infrastructure projects as they can increase grievances among local populations. They can do so by increasing transparency in the allocation and transparency of infrastructure procurement as well as creating key criteria of selection and project allocation (Pattanayak and Verdugo-Yepes 2020).

As this paper explores the effects of road paving on ethnic and national identity, it can be expanded by studying road use. One would say that the extent to which road paving affects ethnic or national identity will vary depending on the extent to which a given road is served by public transportation or the respondent's access to cars. Future work can be expanded to include the effects of access to cars and public transportation.

CHAPTER 2.

THE PATH TO IMPROVED HEALTH: INFRASTRUCTURE DEVELOPMENT AND ACCESS TO MATERNAL AND CHILD HEALTH IN SUB-SAHARAN AFRICA

1. Introduction

Sub-Saharan African is the region with the worst maternal and under-5 health outcomes. Under-5 malnutrition is a key public health issue in sub-Saharan Africa, where, in certain regions, 1 child out of 3 is stunted (Figure 2.1) and 60 percent of children are anemic (Semedo, et al. 2014). Poor child malnutrition should be addressed as it can lead to long term disparities. Children who suffer from malnutrition in their young age are then affected by cognitive issues impacting their ability to learn in school. They become more vulnerable to illnesses. The consequences of poor early childhood malnutrition can even affect their labor market outcomes when they reach adulthood (McGovern, et al. 2017).

Another key public health issue is that of maternal mortality. The continent has the highest rates of maternal mortality and under5-mortality. In 2017, two-thirds of maternal deaths worldwide occurred in sub-Saharan Africa (Rodriguez 2021). Some of these trends can be attributed to the poor access to delivery and antenatal care. As seen in Figure 2.2 and Figure 2.3 the continent has the lowest percentage of women who are seen by a skilled professional during pregnancy and the lowest share of women whose children's deliveries are attended by skilled health professionals. In Chad for instance, only 31 and 24 percent of women have access to adequate antenatal and delivery care, respectively.

One of the reasons behind poor health service utilization is poor access. While additional health facilities, particularly in underserved areas can help bridge this access gap, little is known about how non-direct approaches such as (arguably less costly) improvements in road conditions can help improve access. Over the years, African countries have invested in infrastructure development and notably in the development and expansion of roads. Roads are particularly important, notably in a rural context, as they improve the access to goods and services. They provide access to jobs, education, and healthcare. In Africa, 90 percent of people and goods are transported via roads (The World Bank 2014), hence the importance of having roads for adequate delivery of all services, including health services.

Many studies on the effects of roads focus on traffic related incidents but there is a gap in addressing the short and long-term health effects. Therefore, the main contribution of the paper is

its analysis of the quality of roads and its effects on maternal and child health. As many studies looking at the effect of the proximity to roads on health outcomes use road density as an explanatory variable without much disaggregation on the quality of said roads, our paper studies the effects of road paving and road improvements. One can expect that living near a dirt road will not have the same effect as living close to a paved road. This paper will thus look at the effect of road quality on maternal and child health. As countries invest in improving roads, i.e. transforming a road from being a dirt road to being paved, the nearby residents can see their access to health services improve. This project will look at two sets of outcome variables. The first set is access to maternal health and the utilization of ante and post-natal services as well as delivery care. Does road improvement increase the probability of having frequent prenatal care visits? Does it increase the probability of the baby being delivered by a professional? The second set of outcome variables study early child health through incidences of stunting and wasting, vaccination history, and behavioral metrics.

To answer the question, I apply a difference-in-differences estimation strategy to micro-level data from 25 sub-Saharan African countries to study the effects of road improvement on delivery and early child health outcomes, using birth cohort and household fixed effects. In our data, we construct a pseudo-panel where we have children born to the same mother, across different years. Using household fixed effects, we thus study how the improvement of the road affects the delivery outcomes of the two children. We find that children born after the road is paved are more likely to have been delivered at a hospital. They are also more likely to have their delivery performed by a doctor. We also find that children who are born after the road is paved or improved are less likely to be delivered at home or by a relative. In regard to child malnutrition, we see a reduction in the likelihood of being stunted, underweight, or anemic, when the child is born after the road is paved.

2. Literature Review

While some studies on the relationship between road infrastructure and health observe the incidence of road-traffic injuries and deaths (Ameratunga, Hijar and Norton 2006; Racioppi, et al. 2004), other papers in the literature have used road investment to assess long term health effects. For instance, using OECD countries, Cornell Professors Liza von Grafenstein and H. Oliver Gao study the effect of road infrastructure on public health outcomes and find that a 1 percent increase in infrastructure investment as a share of GDP is associated with 18 per 100,000 fewer deaths

related to chronic obstructive pulmonary diseases (Grafenstein and Gao 2021). Some studies have observed how access to roads can serve to mitigate adverse effects of conflicts on health in developing countries. Using a sample of 29 countries in sub-Saharan Africa, in a period spanning from 2000 to 2018 Shanna Kirschner and Amelia Finaret study the effect of conflict on health and evaluate the mitigating role of infrastructure. The findings state that areas with improved road infrastructure have a smaller disabling effect of conflict on health. This result is limited to zones with high intensity of conflict; children who live in areas with improved road density are less likely to suffer from poor health effects during conflict. Roads can provide protection against insurgents as they provide government forces access to their constituents (Kirschner and Finare 2021). Relatedly, another paper finds that access to paved roads made a region less prone to being a victim of drought-related conflicts. The authors argue that the mechanism may be topological as areas with rough terrain are more likely to experience guerilla welfare and less likely to have paved roads (Detges 2016).

In the case of epidemics, access to paved roads has mixed effects on the spread of illnesses. In the 1300s, the black death originated in Asia but found its way to Europe through the Silk Road System (Schmid, et al. 2015). Recently, studies have shown that proximity to roads was positively correlated with Coronavirus Disease 19 (Covid 19 henceforth) infections. For instance, using road infrastructure as an instrument for mobility, researchers found a negative effect of distance to urban centers on the number of Covid 19 infections (Krenz and Strulik 2021). In sub-Saharan Africa, papers have studied the impact of road infrastructure on the spread of HIV. Paved road access is correlated with an increased probability of HIV infection. In a 2005 paper, the authors argue that this is a net effect as access to roads may bring HIV-infected people to non-HIV infected people, however roads reduce risky behavior by increasing access to protection against HIV and access to HIV-AIDS awareness tools (Djemai 2018).

Certain papers on the effect of roads on health specifically look at the role of road-based transport and its effects on public health. In Taiwan, researchers have found a strong correlation between traffic related pollutants and a lifetime prevalence of asthma in children. Specifically, children living near roads are more likely to have respiratory issues than their remote counterparts (Yueliang Leon Guo, et al. 1999). Road-transport can exacerbate pollution-related illnesses. While in developed countries the development of public transport can lead to decentralization and pollution reduction (Borck 2019), this finding is not always found in developing countries.

In developing countries, the studies on the relationship between spatial infrastructure and health often make use of Demographic and Health Surveys, which provide a large array of data related to maternal and child health. They have been thoroughly used to assess spatial disparities in maternal and child health. For instance, using DHS Data, a USAID report finds that geospatial factors such as mean temperature, drought conditions and light intensity affect the variance of child mortality across African countries. For instance, droughts and irregular rainfall can affect agricultural productivity and affect the survival of children between ages 1 and 4. Topography, which affects the ability to construct roads, also affects early child health through the effects on access to markets, city centers, and health facilities. Specifically, the report states that there exists a relationship between elevation on one hand and stunting and wasting on the other.

There exist disparities in access to care during the delivery process. Poor access to care can result from a list of factors ranging from wealth to geographical location (urban or rural). Using DHS data, a study on Indonesia finds that women residing in urban areas are 5.45 times more likely to give birth in a hospital and 1.45 times more likely to give birth via caesarean section (c-section), a medical procedure, which requires experienced medical staff. Similar results have been found across developing countries, with one explanation being the fact that rural areas typically have limited health staff and poor infrastructure (Nababan, et al. 2018; Adhikari 2016; Yaya, et al. 2018). Similarly, found three key determinants of low prenatal care utilization in Nigeria. At the individual level, they found that higher education was associated with higher service utilization. Second, on par with the Indonesia case study, they found that urban residence was a strong predictor of prenatal care utilization and third, access to community media communication was also a good predictor of prenatal care utilization (Babalola and Fatusi 2009). In relation to geographical determinants, a study on Burkina Faso finds that increased distance to a health center reduces the likelihood of accessing prenatal care and the likelihood of the birth being attended by a skilled professional. Our paper builds on this intuitive result and expands the study to evaluate the role of access to paved roads. In other words, the research cited in this section has named obstacles to maternal and child health, which were mainly related to wealth, education, place of residence, and distance to health centers. This paper will expand on the literature by studying the specific role of infrastructural investment in roads.

3. Data

3.1. Demographic and Health Surveys

Funded by the United States Agency for International Development, the Demographic and Health Surveys (DHS) collect and distribute data on the health status of populations in developing countries. To date, the program has collected 300 surveys across 90 countries. DHS also provides geospatial data by cluster, defined as a group of 25-30 households. Our analysis will make use of the data collected across 25 African countries since 1986[3]. Table 2.1 displays the years during which DHS surveys were collected across each country. I only use countries for which GPS data was available, this led to the exclusion of South Africa from the analysis. Figure 2.4 and Table 2.1 show the extent of the coverage. DHS is a repeated cross sectional data set. I use it to construct a panel dataset, by utilizing the reports of each woman's birth history (Table 2.2).

For our analysis, I will use two sets of DHS datasets. The first one covers women aged 15-49. In this data set, each observation is a birth from one woman. Our sample counts nearly 700,000 women and more than 2.3 million births, bringing our average to about 3 kids per woman. When I run the regression, the sample size ranges from 200,000 to 600,000 births. This can be attributed to the missing data on certain variables. For instance, not every woman reports whether or not they delivered at the hospital. For each of the births, the data provides information on the utilization of antenatal care, the use of skilled professionals during the delivery, and the access to postnatal care around the time of birth. When merged with the road construction data, we have information on road access during pregnancy and delivery. The second group of datasets studies the children born from these women. In that data set, we can find information on stunting, wasting, and anemia. We can also find information on the child's vaccination history and behavioral metrics, e.g. the reading abilities of the child and the ability to follow directions. These metrics are recorded during survey collection, which is between 1 and 4 years since childbirth. This dataset has around 800,000 observations, where each observation is a child under 5—in the births data set, women record the birthing metrics for all their child, not solely the ones below age 5, hence the disparity in the number of observations in the children dataset and the one of the births dataset.

[3] The 25 countries in my sample are Angola, Burkina Faso, Benin, Burundi, Republic of the Congo, Côte d'Ivoire, Cameroon, Ghana, Guinea, Kenya, Liberia, Lesotho, Mali, Malawi, Mozambique, Nigeria, Niger, Namibia, Rwanda, Senegal, Chad, Tanzania, Uganda, Zambia, Zimbabwe.

3.2. Road Data

In a 2021 paper, Rémi Jedwab and Adam Storeygard evaluate the effect of market access on the size and development of cities in sub-Saharan Africa. To measure market access they use Michelin Maps, which provide information on the status of roads through sub-Saharan Africa (Jedwab and Storeygard 2021). The road data provides longitudinal information of road status over the years. Figure 2.5 shows the extensive number of roads for which data was collected. Specifically, there exists four types of roads, dirt (unpaved) roads, improved roads, paved roads, and highways. Over the years, governments and their partners have invested in improving the status of roads across the continent. For example, Figure 2.6 highlights a road whose status went from improved to paved in 2000. The figure also shows the DHS clusters closest to the newly paved road. We can thus evaluate the outcomes of the women's pregnancy before and after the road was improved. This paper will study the effect of the improvement of a household's closest road on child and maternal health.

4. Empirical Specification

4.1. Two-way fixed effects

In the absence of endogeneity, we would use the following equation to evaluate the effect of road access on maternal and child health:

$$Y_{ict} = \beta_0 + \beta_1 R_{ct} + \delta X_{ict} + e_{ict} \quad (2.1)$$

Here β_1 is our parameter of interest.

Y_{ict} are the health outcomes of mother or child *i* in cluster *c* at time *t*. R_{ct} is a binary variable indicating the status (paved or unpaved) of the road nearest to cluster c[4], X_{ict} are individual and household covariates. The endogeneity issue lies in the fact that households in close proximity to paved roads can be richer and have better access to health centers than their more remote counterparts. To solve this endogeneity issue, some have used topology to instrument for road construction, however as seen in the USAID report cited in the literature review, topology also directly affects maternal health.

To assess the effect of road construction on child health, we use a difference in differences estimation method, with two-way fixed effects to estimate the following equation:

[4] The treatment measure is binary. In this paper, I do not discuss results which take into account the distance to the mother's nearest road. The measure can introduce some variation in the treatment but does not yield significant results.

$$Y_{iht} = \beta_0 + \beta_1 * Paved_{ht} + \boldsymbol{\delta} * X_{iht} + \gamma_h + \lambda_t + \varepsilon_{iht}. \quad (2.2)$$

Where Y_{iht} is the health outcome of mother i, in household *h* for a child born in year *t.* Our coefficient of interest is β_1. $Paved_{ht}$ indicates whether household *h* was near a paved road at time *t*. I have household and birth year fixed effects γ_h *and* λ_t , respectively. X_{iht} is a vector of controls such as parents' ages at birth[5], parents education, and birth orders. In another specification, when studying the effects on mother's antenatal and delivery outcomes, we use the logged number of years since the road was paved or improved as our treatment variable[6]. Given that many mothers do not live near a paved road, the variable measuring the number of years paved will be equal to zero. As such we conduct the data transformation (1+YearsPaved) to estimate the following equation:

$$Y_{iht} = \beta_0 + \beta_1 * \ln(1 + YearsPaved)_{ht} + \boldsymbol{\delta} * X_{iht} + \gamma_h + \lambda_t + \varepsilon_{iht}. \quad (2.3)$$

When studying the effects on child outcomes, I add *fraction of life paved* as a treatment. That is, given a survey collection date, what is the fraction of a child's life during which the road was paved. This variable is close to binary as most children either have a paved road during all of their lives or none. As such, when studying children's outcomes, we estimate the following equations:

$$Y_{iht} = \beta_0 + \beta_1 * \text{fracpaved}_{ht} + \boldsymbol{\delta} * X_{iht} + \gamma_h + \lambda_t + \varepsilon_{iht}. \quad (2.4)$$

Where Y_{iht} is the health outcome of *child i* in household *h* for a child born in year *t.* I have household and birth year fixed effects γ_h *and* λ_t , respectively. X_{iht} is a vector of controls such as parents' ages at birth, mother's BMI, and birth orders.

4.2. Pre-trend Outcomes

In order to use a difference in differences estimation method, we need to test the extent to which the parallel trend assumption holds. In our design, where the treatment is staggered, we do so by standardizing the time from and to treatment to create variable j, which indicates the number of years to/from treatment, i.e. j=(10, … -2, -1, 0, 1, …,10).

To study the pre-treatment trends, we estimate the following regression:

[5] One may argue that variables such as parents' age and education, are absorbed through household fixed effects. However, households in our sample may not necessarily be formed of nuclear families and one household may be composed of children with different parents.

[6] While there is no difference in R-Squared when the number of years since paving is used over the logged variable, using a linear-log model can account for the fact that the impact of road paving on delivery outcomes diminishes as the number of years the road is paved increases. The literature on the effect of infrastructure states that infrastructure investment, notably on paved roads, are subject to diminishing marginal return (Canning and Bennathan 1999; Kodongo and Ojah 2016).

$$Y_{iht} = \beta_0 + \sum_{\substack{j=-10 \\ j\neq 0}}^{10} \partial_j * D_{ji} + \boldsymbol{\delta} * X_{iht} + \gamma_h + \lambda_t + \varepsilon_{iht}. \quad (2.5)$$

Where Y_{iht} is the health outcome of mother or child *i* in household *h* for a child born in year *t.* D_{jt} are pre and post treatment dummies, equal to 1 if there are j years between the treatment and the birth years and 0 otherwise. We use household and birth year fixed effects $\gamma_h \; and \; \lambda_t$, respectively. X_{iht} is a vector of controls.

Figure 2.7 and Figure 2.8 present the plots of estimates of the treatment on maternal outcomes and early childhood outcomes, respectively. We do not find any indication that the change in certain delivery outcomes pre-dated the road paving. This is most visible in the analysis of the variable measuring the probability of the doctor delivering the baby via a Cesarean Section.

It is important to note that, across most variables, the coefficients are noisy and subject to large confidence intervals. As such, one cannot confidently prove that the parallel trend assumptions hold in this analysis.

5. Descriptive Statistics

5.1. Demographics

We have a sample of about 700,000 women totaling about 2,300,000 births. Table 2.3 presents summary statistics on the mothers. We see that 70 percent of the women in the sample did not achieve a level of education beyond primary schooling. More than 50 percent of our sample is below age 35. On the wealth measures, the majority of our sample is in the third wealth asset[7]quintile or lower. Seventy-five percent of the women in the sample reside in rural areas. As stated above, the data on roads has four classifications: unpaved, paved, improved, and highway. The summary statistics show that 43 percent of the women in the sample live near a paved road, 19 percent live near an unpaved road, and 38 percent live near an improved road.

A means comparison of women who live near paved and improved roads compared to those who do not yield the following facts (Table 2.4). On average women who live near unpaved roads are slightly older than those who do not. The opposite holds true for their counterparts near good roads. Households near paved roads are richer, have more educated mothers and household heads, and a fewer number of children. They are also, on average, closer to hospitals and urban centers.

[7] The DHS' wealth index is a composite index measuring household wealth using assets such as television ownership. Other metrics include the types of water and sanitation facilities in use at the household.

5.2. Maternal Outcomes

The key maternal outcomes we study are delivery and postnatal care. Specifically, we study who delivered the baby and where the baby was delivered. Due to data limitations, we do not study variables related to postnatal care. Throughout the sample, access to prenatal and adequate delivery care is limited. Only 8 percent of prenatal care visits are administered by a doctor. This share is even lower when considering the share of women whose babies were delivered by a doctor, a figure standing around 5 percent. Only 20 percent of women in the sample reported delivering at a hospital. Other delivery places reported include private clinics and village health posts, among others.

As seen in Figure 2.9 about 12 percent of pregnancies where the mothers were near paved roads had prenatal visits attended by doctors against 8 percent for pregnant women near unpaved roads. Women near paved roads were on average more likely to have prenatal care at the hospital. On delivery care, we find that 12 percent of pregnant women near unpaved roads gave birth at public hospitals, against 21 percent of women living near unpaved roads. On average, women who live near unpaved roads were less likely to have births attended by doctors. Women living close to paved roads are twice more likely to give birth via cesarean section.

5.3. Early Childhood Outcomes

In our sample, 17 percent of children are severely stunted, whereas 3 percent are severely wasted. Stunting results from long periods of chronic malnutrition, whereas wasting results from short ones. In short, an important share of children in our sample suffers from chronic malnutrition. Anemia is another key health challenge faced by the children in our sample. Nearly sixty percent of the children in the sample are anemic.

On average, with the exception of metrics measuring overweight incidences, children who live near unpaved roads have worse health outcomes than those who live near paved roads. They are more likely to be stunted, wasted, underweight, and anemic (Figure 2.10). To measure vaccination, we create a composite index measuring whether the child has received vaccines for polio, diphtheria, pertussis, tetanus, measles, vitamin a, tuberculosis, and yellow fever.

6. Results

6.1. Maternal Outcomes

Table 2.5 showcases the results where I estimate the equations using a two-way fixed effects estimation method. The analysis controls for parents' ages and education levels. I also add birth

order dummies, as the literature argues that a child's order of birth can affect health outcomes (Brenøe and Molitor 2018; Behrman 1988). With the exception of the variable measuring the number of antenatal visits[8], the outcome variables are binary. For instance, the variable 'Doctor gave prenatal care' takes the value 1 if, when asked about a given birth, the mother reports that a professional doctor administered prenatal care. It takes the value 0 otherwise.

Across the analysis, we do not find any significant effect of the access to a paved road on delivery outcomes. We find positive, but insignificant effects of access to paved roads on the number of prenatal visits and access to doctors for delivery and prenatal care.

Our analysis also studies the utilization of other, non-hospital, delivery avenues. As seen in Table 2.6, we find that there is a statistically significant, 3 percentage point increase in the likelihood of a midwife or a nurse delivering the baby, from a baseline mean of 36 percent. Though insignificant, we find a reduction in the likelihood that a traditional birth attendant delivered the baby.

We also study the intensity of the treatment. To do so, we observe the effects of the length of the time since the road was paved. To control for outliers, we take the log of the "years paved". In this specification, we also failed to find a significant effect of paving on maternal outcomes (Table 2.7)

6.2. Child Outcomes

Similarly, we estimate the effect of road improvement on childhood outcomes. On child malnutrition metrics, the variables take the value 1 if the child is reportedly stunted, wasted, underweight, or anemic during survey collection and 0, otherwise. The vaccination index takes values between 0 and 9 and the behavioral index takes values between 0 and 10. The analysis controls for mother's age, education, and body mass index. I also control for the child's birth order. The analysis finds that road improvement decreases the probability of the child being stunted by 14 percentage points, from a baseline mean of 38 percent. I find that being born after road improvement reduces the likelihood of the child being underweight by 4 percentage points, from a baseline mean of 24 percent (Table 2.8).[9] We also find a statistically significant reduction in the

[8] Under this specification, I also used a poisson regression to estimate the count model and did not find a significant effect of road paving on the number of antenatal visits, the magnitudes of the non statistically significant estimates were the same.

[9] The size of the estimates are in line with other papers studying how certain interventions can affect child malnutrition. For example, in a 2020 paper von der Goltz el al find that access to better nutrition led to a reduction in the probability of being underweight by 2.3 percentage points, though insignificant (von der Goltz et al, 2020).

vaccination index, a composite index measuring whether the child has received vaccines for polio, diphtheria, pertussis, tetanus, measles, vitamin a, tuberculosis, and yellow fever.

7. Discussion and conclusion

Our analysis studies the importance of road paving for maternal and childhood outcomes. The presence of roads is important due to increased accessibility to goods and services, labor markets, education, and other important amenities of one's place of living. The effect of roads on health has mainly been studying the access to roads and the quantity of roads (measured in kilometers) in a given region or survey area. The innovation in our paper comes in studying the effect of the quality of roads on health outcomes. Road quality is not static. Roads can deteriorate and are sometimes improved through investments from local governments, private sector actors, and sometimes non-profit organizations. This paper studies the effects of road improvement on maternal and child health outcomes.

Our results suggest that improving roads does not lead to a systematic improvement in delivery outcomes for mothers. One exception is the increased access to a midwife. The road may have improved the mobility of midwives and increased the access to midwives at home. Using the DHS definitions, midwives and nurses are trained and licensed medical professionals. Improving roads ensures that a nurse or midwife has better access to the woman's house, to facilitate a home delivery.

We do not find increases in the likelihood of delivering at the hospital or health care centers. While some papers have cited poor access to transportation as a barrier to improved maternal health (Dahab and Sakellariou 2020; Atuoye, et al. 2015 Baayd, et al. 2021), increasing road investments, alone, has not led to the systematic increase or improvement of access to adequate maternal care. There can be additional barriers, some related to personal preference and culture and others related to access. In certain rural settings, due to cultural practices, women may prefer to deliver at home. A qualitative study on the birth attitudes of rural Laotian women cites reasons why rural women are reluctant to give birth at a hospital (Sychareun, et al. 2012), one of which is poor access to health facilities. Other reasons include the lack of privacy, male presence at the hospital and a woman's wish to be close to their family and notably their children. Another reason behind the hospital delivery reticence is the mother's wish to follow traditional birth practices (Titaley, et al. 2011).

The second potential reason being the failure to find significant delivery improvements after the road is paved can be related to access to health facilities and their quality. In his work, Jishnu Das finds that lack of adequate hospital equipment and poorly trained doctors are key barriers to access quality healthcare in developing countries. Moreover, he cites that there is no found relationship between the lack of medical equipment at care facilities and access to physical infrastructure. Indeed, he finds no evidence that the poor medical care pregnant and delivering mothers are receiving is tied to infrastructure. Instead, the literature on the topic finds that one key barrier to accessing quality medical care are poor medical training of doctors, poor or inaccurate diagnosis made by the medical staff and low competence of doctors (Das and Hammer 2014; Das, Hammer and Leonard, 2008)). In short, poor road infrastructure is cited as one of the barriers to access to adequate maternal care. However, in order for road improvements to lead to better delivery and antenatal care, such improvements must be accompanied with better doctor training, improved equipment, and more trust in the mothers' trust of the medical system.

On the topic of child malnutrition, the results show a reduction in the likelihood of a child being stunted or underweight if they are born after the road is built. Road improvements can increase the parent's access to health centers, where they can be given or prescribed iron supplements. Another potential mechanism explaining the reduction in anemia prevalence after road improvements is the potential improvement in nutrition. Road access may provide households with increased access to food markets. As such, not only can the access to markets improve, the quality of food they have access to, can also improve. This effect follows a result from Kuyu, Tola and Abdi (2019), which studied the effects of good road access on the produce quality found in markets. Poor road access led to a reduction in the weight, firmness, and Vitamin C content in potatoes.

Improved income can also serve as a mechanism for better child nutrition. Controlling for birth order will partially capture some of the variation brought about by higher income gained as parents age, however, there could still remain additional channels through which income affects child nutrition. In addition, the roads may have improved access to employment opportunities, which then led to an improvement in parent income. Even though I do not test the hypothesis that better roads led to better income and subsequently improved children nutrition, the income mechanism deserves further discussion in future research.

In addition, it is important to note that certain improvements might be happening simultaneously with road improvements. Such improvements can be related to additional infrastructure (water,

electricity, health centers). Some scholars have found that public goods distribution is subject to patronage politics, where one political leader will provide roads to members of their ethnic group in exchange for votes (Moser 2008). The presence of patronage could confound estimates and further extension of the paper can address this issue through the use of road-predicting instruments. Many papers in the literature have argued about the importance of having roads and their role in increasing access to goods, services, education, and health services. My paper contributes to the literature by disaggregating the roads using quality as a metric in order to measure the different ways in which road quality affects access to prenatal and delivery services as well as early child health metrics. This research project can be extended in several ways. One can look at the mechanisms through which better roads improve access and the interaction between road quality and public transportation. We can also study the interaction between weather and road quality. For instance, given varying road qualities, how does rainfall affect delivery outcomes, notably noting that during the rainy season those living near dirt roads will have worse access to health services. Overall, there exist many potential extensions to the research project and the procurement of supplemental infrastructure and health related metrics can expand our understanding of the relationship between infrastructure development and maternal health.

CHAPTER 3.

MOVING TOWARDS BETTER EARNINGS: THE EFFECTS OF BRT SYSTEMS ON EMPLOYMENT IN CAPE TOWN

1. Introduction and Background

In recent years, countries have explored options to improve transportation access for their residents. In recent years, the Bus Rapid Transit has grown as a transportation option. Given its ability to provide efficient transportation at a relatively low cost, Bus Rapid Transit systems have grown in usage across the world and can be found in more than 176 countries worldwide. In Africa, new BRT systems are being built in Dakar and Accra. Existing BRT systems are present in Lagos, Nigeria, Dar es Salaam, Tanzania, and across four cities in South Africa, one of which being Cape Town. Cape Town launched its Bus Rapid Transit in 2010 and has progressively opened new stations and installed new routes.

Using the heterogeneity in the station launch dates, I study the effect of having improved access to the Bus Rapid Transit on income and employment, using South Africa's National Household Travel Survey from 2003, 2013, and 2020. The sample is representative of the South African population and is reported at the provincial, municipal, and travel analysis zone (TAZ henceforth) level. The TAZ is a unit of geography used for transportation planning. I use a difference in differences empirical strategy where I include time and TAZ fixed effects. I find that access to BRT stations brought about increases in income, though the magnitude and the significance of results vary across race. Specifically, I find that living close to the Bus Rapid Transit System increases the household and personal income of coloured[10] residents, but I find no significant indication that BRT access changes the personal and household income of black or white residents. As BRT Systems continue to be proposed as a viable transportation option, one argument is that BRT systems are useful for the promotion of employment. As such, in using Cape Town as a case study I contribute to the literature on the effectiveness of bus-based transport in promoting employment and boosting income.

The rest of the paper is structured as follows. First, with a focus on Cape Town's MyCiti. I provide some description of Bus Rapid Transit systems and the particularities that make them an attractive

[10] In the South African Context, the term colored represents a specific ethnic group, which became designated as an official racial designation under apartheid. They are a multiracial ethnic group with ancestry from Africa, Europe and Asia.

transportation option across the world. Second, I cover the literature on the relationship between transportation and income. Third, I present the data used in this paper as well as the methodology used. Fourth I present the result from the analysis. I then conclude with a discussion.

2. Background and Literature Review

2.1. MyCiti, the bus rapid transit

As cities grew, planners have developed a number of transportation systems to transport their residents, two of which are Mass Rapid Transit (MRT) and Light Rapid Transit (LRT). While the MRT is represented by the subway or metro system, the LRT can be referred to as the tram or streetcars. A third one, emerging as early as the 1930s is the Bus Rapid Transit system (Deng and Nelson 2011). The BRT is a bus-based transportation system with better capacity and efficiency than standard bus systems. The BRT operates on the principle of exclusivity and/or protected right of ways. That is, the buses often use their own lanes and buses are given priority at intersections (Figure 3.1). In short, the BRT combines the efficiency of a metro system with the low cost and flexibility of a bus system (Wright and Fjellstrom 2003) Another attractive feature of the BRT is its low building cost when compared to rail transit, while yielding similar benefits in terms of transporting consumers in populated cities (Levinson, et al. 2002)

Cape Town is a city of 4.6 million habitants, the second largest city in South Africa. It is characterized by relatively high levels of economic and racial segregation. Cape Town's current transportation system is made up of the BRT, a commuter rail system, minibusses, and privately operated buses (Palacios and Rayle 2021). The city started considering the adoption of a BRT system as early as 2002, in order to supplement its limited rail network. Specifically, the Mayor introduced the idea of an "Integrated Rapid Transit" (IRT). Contrasting BRTs, the IRT's long term goal is to link the BRT and the rail system. Before BRT constructions, residents could rely on the minibus bus system for transport needs, how those lacked safety, and involved long travel times, issues the BRT introduction worked to assuage (Gauthier and Weinstock 2010). Cape Town's BRT system, MyCiti, began operation before the 2010 World Cup. The largest expansion occurred in 2013, where the system added new routes and stations (Figure 3.2) The paper explores the effects of this BRT access on the employment and income of residents. The key hypothesis states that improving BRT access will lead to higher employment rates and higher income. Early studies of the Cape Town BRT found that it was successful in reducing commuting times. Residents who

shifted from using transit buses and commuter trains to using the BRT system saw an 18 and 11 minutes reduction in transit times, respectively (Palacios and Rayle 2021).

2.2. The Bus Rapid Transit, Employment, and Income

Bus Rapid Transit systems are often built in cities with existing transportation systems. In early stages, such systems can contribute to congestion in the new city and negatively affect commuter flows (Gaduh, Gračner and Rothenberg 2021). Nevertheless, certain policy makers claim that BRT systems have welfare enhancing qualities. This paper is concerned with two features of well-being: employment and income.

Creating a Bus Rapid Transit can bring about jobs to a city. In the United States, a 2016 study by a University of Utah team reviews the impact of BRT systems using a sample of BRT infrastructure in Arizona, California, Nevada, New York, Ohio, Oregon, and Utah. They found that the creation of BRT stations influenced an increase in manufacturing jobs. While manufacturing is in decline in the US, the authors find that the presence of BRT in the buffer area—the spatial unit of analysis used in the paper— added a number of jobs surpassing the ones lost to the manufacturing decline (Ganning, et al. 2016). Similarly, a 2018 study by the Inter-American Development Bank studies the effect of BRT construction on employment outcomes in Lima, using a difference in differences method, where they account for district fixed effects. They define their treatment areas as zones located within 1.5 kilometers of BRT lines. Whereas the control areas are the ones located within 2 to 6 kilometers of BRT lines. Therefore, they study the effect of BRT introduction on labor market outcomes such as employment, weekly hours worked, monthly earning, formality of employment, and social security contribution, among others. They find that BRT reduced travel time for those commuting to work. In the post introduction period, the authors find that the employment rate increased by 3.9 percentage points, while work hours and monthly income increased by 19 and 32 percent, respectively (Scholl, et al. 2018). The improvements in employment outcomes as a result of BRT construction can be attributed to the reduction in travel times and its effects on employment (Johnson, Ercolani and Mackie 2017). As highlighted above, the Bus Rapid Transit system benefits from exclusive lanes, thus allowing for a faster commute and better access to employment. This paper expands on the literature by studying the existence of improvements in income and employment in Cape Town as a result of the BRT launch.

2.3. Heterogeneous effects of BRT on employment and Income

While certain scholars have found that the Bus Rapid Transit has the potential to improve welfare for residents, the question remains, do all residents benefit equally? Studying the welfare effects of the BRT in Dar Es Salaam, Tanzania, Balboni et al. (2020) concluded that the BRT was a 'pro-poor investment'. In other words, the city's low-income residents saw their welfare improve. Here, welfare effects are measured using living and working metrics, earnings, and housing expenditures. Bringing transport connectivity to relatively poorer residents brought about higher welfare gains that the ones received by richer ones. Specifically, in terms of welfare gains, the low-income residents near BRT stations saw a 3 percent gain in welfare, against a 2.5 percent gain in welfare, experienced by high income residents (Balboni, et al. 2020).

The welfare improving effects of Bogotá's BRT, the Transmilenio, were found in a 2019 study. Specifically, after aggregating for the construction costs of the BRT, Nick Tsivanidis finds that average welfare increased by 1.49%. Another interesting finding of the paper is that high-skilled workers benefited the most from the BRT construction, which is contrary to the findings from the paper researching the welfare effects of the BRT in Tanzania. In Bogotá overall employment is concentrated in one band of the city, along the west side of the city. However, high skilled labor is a bit more spread out across the city, indicating that high skilled workers would have a higher need to access good transportation (Tsivanidis 2019).

There can also be differences in effects along gender and racial lines. A study of the BRT in Lima finds a 10-percentage point increase in the probability of employment for women living near BRT stations. The BRT made it safer and faster for women to access labor markets (Martinez, et al. 2020). In Cape Town, the BRT launch led to a reduction in the gap in commute time between different socioeconomic groups (Palacios and Rayle 2021). For example, Black Cape Town residents who shifted to BRT saw a 7-minute reduction in commute time, whereas the authors found no evidence that White residents saw a reduction in commuting time upon shifting (Palacios and Rayle 2021). This paper expands on the literate by studying the extent to which there was a difference in the BRT effects on employment and income along racial lines.

3. Empirical Analysis

3.1. Data

To measure employment, we will use data from the South African National Household Travel Survey (NHTS). It is a repeated cross-sectional survey, conducted by the Statistics department of

the South African government. Collected in 2003, 2013, and 2020, the survey provides information on attitudes towards transportation usage. We have data on household earnings, education, and employment status. The sample counts 23,000 respondents. Figure 3.3 superposes the travel analysis zones and the BRT Stations. It indicates average household income at the TAZ level.

The city of Cape Town provides data on the spatial outline of MyCiti, its lines, and its stations One drawback from the study is that, while we have the information on the traffic analysis zone each respondent resides in, we do not have data on their exact geolocation. Therefore, the analysis does not take into account the heterogeneity of effects brought about by the different distances to BRT lines. Instead, our main comparison is achieved by comparing respondents who had access to the bus rapid transit, to those who do not.

The survey provides information on the following outcome variable that will be used in the study. The employment outcomes study whether the respondent has a job and their monthly salary.

Table 3.1 describes the sample's summary statistics. The sample counts 23000 respondents across the 3 survey years. In 2013, 2 percent of the sample had access to the bus rapid transit. In 2020, that figure more quintupled as 10 percent of the sample had access to the BRT system. The Cape Town sample is relatively older and more educated than the rest of South Africa. At first glance, we see that 75 percent of the sample completed secondary school or higher. Women make up a large share of the sample and nearly half of the sample is aged above 45. In the analysis of treated and non-treated—the treatment being whether the traffic analysis zone in which the respondent lives was served by BRT lines built in the inter-survey period—survey respondents, there are some stark differences between the two zones. We find that respondents in BRT-served zones had higher household and personal income.

3.2. Methodology

Urban planners use travel analysis zones to model travel demand and create a spatial representation of population attributes such as employment, salaries, travel times, among others. In our data, individuals are distributed among 23 TAZs. In the analysis, I study the effects at the individual level by looking at variables such as salary, employment status, and household earnings

Hypothesis: The construction of the BRT improved access to employment and increased salaries

To assess the impact of the BRT on employment, we use a difference-in-differences methodology to estimate the following model:

$$Y_{izt} = \beta_0 + \beta_1 * Stat_{zt} + \boldsymbol{\delta X_{it}} + \gamma_z + \lambda_t + \varepsilon_{izt} \quad (3.1)$$

Where Y_{izt} is the outcome variable (salary, employment status, household income) of individual *i, in TAZ z,* at time *t*. We include TAZ fixed effects, γ_z, and time fixed effects, λ_t. $Stat_{zt}$ indicates whether the individual lives near a BRT station. This metric is sourced from the question "How many minutes does it take to walk to the nearest BRT Station?" I then create a binary variable equal to zero when the answer is coded as 'no service' and 1 otherwise.

One empirical consideration would study how distance to the BRT affected outcomes. However, in 2020, the BRT only served 9 percent of households. A specification in which we only restrict the analysis to those within walking distance of the BRT would significantly reduce the sample size. As such a binary indicator is preferred.

In the analysis, I attempt an alternative specification for robustness. Some respondents declared living up to 60 minutes away from the nearest BRT station. In the main specification those respondents will be considered treated, though one may assume that when the walking distance is large, the respondent may seek other means of transportation. To take into account distance, without creating large sample restrictions, I use a 15-minute walking distance cutoff. Here, I create a binary indicator equal to 1 if the respondent lives within 15 minutes of a BRT station or 0 otherwise. Across the entire sample, 1.4 percent of respondents live within 15 minutes of a station. The model in that specification is as follows:

$$Y_{izt} = \beta_0 + \beta_1 * Stat15_{zt} + \boldsymbol{\delta X_{it}} + \gamma_z + \lambda_t + \varepsilon_{izt} \quad (3.2)$$

Where $Stat15_{zt}$ indicates whether the individual lives within 15 minutes of a BRT station.

4. Results

In this section, I present the results from the estimation. The analysis studies three key outcomes of interest. First, I study changes in the likelihood of the respondent being employed. The second and third outcomes of interest are personal and household income. In addition to salaries and wages, household income also includes income from remittances, social grants, farming, among other sources (National Household Travel Survey 2021). I also study the extent to which the composition of households varied in the period following BRT construction. In addition, I study whether there is heterogeneity in the results along racial lines. As such, here is a brief breakdown of ethnic groups in South Africa. South Africa is made up of 4 key ethnic groups. The largest ethnic group is composed of Black South Africans, who make up 81.4 percent. The second largest ethnic group are Coloured residents. In the South Africa context, the term 'coloured' has a different meaning and history from the one found in other parts of the world. In the United States for

example, the term was historically used to describe black populations. In South Africa however, the term colored represents a specific ethnic group. They are a multiracial ethnic group with ancestry from Africa, Europe and Asia. They became defined as an official racial designation under apartheid (Oxford University Press 2014). They make up 8.2 percent of the South African population. They largely reside in Cape Town, as is described below. The third largest ethnic group are comprised of White South Africans, who make up 7.3 percent of the population. The fourth largest ethnic group is Indian/Asian, with 2.7 percent of the population (Statistics South Africa 2024). It is important to note that the racial breakdown in my sample differs from that of South Africa. In my sample, 54 percent of respondents identify as coloured. Twenty-seven percent identify as Black/African and 18 percent of respondents are white. In short, Cape Town has a larger white and coloured population than the rest of South Africa.

4.1. Baseline Results

Table 3.2 presents the results from the analysis. In measuring employment, the dependent variable is equal to 1 if the respondent is employed and 0 otherwise. When measuring income, the household and personal income metrics were converted to 2013 Rand (9.6 United Dollars). The set of controls include race, gender, and age. I include TAZ and survey year fixed effects.

When studying the effect of having access to the bus rapid transit on employment, I do not find any evidence that living close to a bus rapid transit station improved the probability of being employed.

The analysis studies how having improved access to the BRT affected the household and personal income of residents. I find that having access to the BRT leads to a 2479 rand increase (275 USD) in household income. I then study the heterogeneous effect of BRT access, across racial groups, and find that the increase is largely driven by the increase in household income among coloured respondents, who saw their household income increase by 4457 rand (464 USD). There was no significant change in the income of white or black households (Table 3.3). A similar pattern is found in the analysis of personal income. I find that BRT access is associated with a 2269 rand (236 USD) increase in personal income. When the results are broken down by racial groups, I find no significant change in the personal income of black and white respondents (Table 3.4). While the two measures are similar, personal income is more likely to be affected by access to public transportation. Salary is the main component of salary, whereas household income includes

transfers such as government subsidies, pensions, grants, and remittances. These variables are, likely, not affected by access to transportation (National Household Travel Survey 2021).

There can be a few reasons why the personal income results do not mirror the results using household income as an outcome variable. For instance, the sample in the analysis using personal income is smaller than the one in the analysis using household income as an outcome. As stated above, household income also includes grants and remittances and is reported for every member of the household, including those who do not report a personal income. Children, grandparents, and other non-earning members of the household can fall under that category. The South-African census reports that nearly 58 percent of households are non-nuclear, with grandparents sometimes living with their children and grandchildren (Statistics South Africa 2022). Hence, the household income variable may be a more meaningful indicator, in the absence of personal income observations. In addition, the National Household Travel Survey summary document report figures, and trends for the household income variable, over the personal income variable (National Household Travel Survey, 2021)

In the specification comparing those that are less than 15 minutes away from a BRT station those who are not. I find that proximity to the BRT station leads to a statistically significant increase in personal income. Living less than 15 minutes away from a BRT station leads to a 2477 rand (258 USD) increase in personal income (Table 3.5).

4.2. Compositional Change of Households after BRT construction.

The sample uses a repeated cross-sectional dataset. In an ideal setting, I would have access to panel dataset, which would strengthen the argument that the changes were a direct result of the BRT creating improvements among the households, which have existed in the surveyed neighborhoods for several years, prior to BRT introduction. Given that I use a cross-sectional dataset instead of a panel dataset, I test the hypothesis that the composition of households used in the National Household Travel Surveys remained unchanged. In order to conduct the test, I regress age, household size, and education on access to BRT (Table 3.6). The equation of interest is:

$$Y_{izt} = \beta_0 + \beta_1 * Stat_{zt} + \gamma_z + \lambda_t + \varepsilon_{izt} \quad (3.3)$$

Where Y_{izt} is the age, household size, or educational level of respondent i. I include TAZ and survey year fixed effects. The results from the analysis are highlighted in Table 3.6. The test results do not prove that the composition of households remained the same after the introduction of the bus rapid transit. I find that respondents near the BRT stations are one year older than those who

do not have access to the BRT station. I also find that respondents who live near BRT stations have 0.3 fewer years of educational attainment.

As such, the results above should be studied carefully as they can result from compositional changes at the neighborhood level, as opposed to changes in the well-being, income, or access to labor brought about with the introduction of the bus rapid transit.

5. Discussion and Conclusion

In this paper, I study the relationship between access to improved transportation, employment, and income. I find that having increased access to the bus rapid transit did not improve the probability of being employed. However, it did increase household and personal income. When breaking it down and studying heterogeneous effects across race, I find that access to BRT led to an increase in the household income of Cape Town's coloured residents but did not change the household income of black and white households.

The paper suggests that the construction of the BRT system was most beneficial to coloured residents. In terms of annual earnings, on average white residents earned the highest wages, followed by coloured residents, which are in turn followed by black residents (Statistics South Africa 2020). This ranking suggests that the transportation efforts may not have targeted the poorest factions of the country's population. Instead, it may target residents who are above a certain threshold, allowing them to afford BRT fares, but remain below an income threshold that would prevent them from not using public transportation altogether and using their own individual cars. Second, during apartheid, racial groups were spatially segregated. Some of those population placements remain today. Figure 3.4 shows a side-by-side comparison of population maps during apartheid and the current BRT routes. We can infer that most neighborhoods serviced by the BRT housed white or coloured residents during apartheid.

The study faces a couple of challenges. First, it only has 3 periods, 1 pre-treatment and 2 post-treatment periods. As such the analysis does not provide an analysis of pre-trends, that is we cannot confidently state that the changes were not in place before the BRT launch, additional survey years can assuage this issue, as we would have a larger sample of TAZs in the 'not-yet' treated group. Another possible issue is that residents can change their behavior as they witness BRT lines being built. This would create a sorting issue as residents self-select into close BRT proximity. As the data is a repeated cross-sectional dataset, I cannot track migration and self-selection. Having access to a panel dataset can solve this problem as we could track within city migration. In an extension

of the study, I would investigate the mechanisms behind the results and the channels through which having better access to transportation affects income and employment.

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APPENDIX A. CHAPTER 1 FIGURES AND TABLES

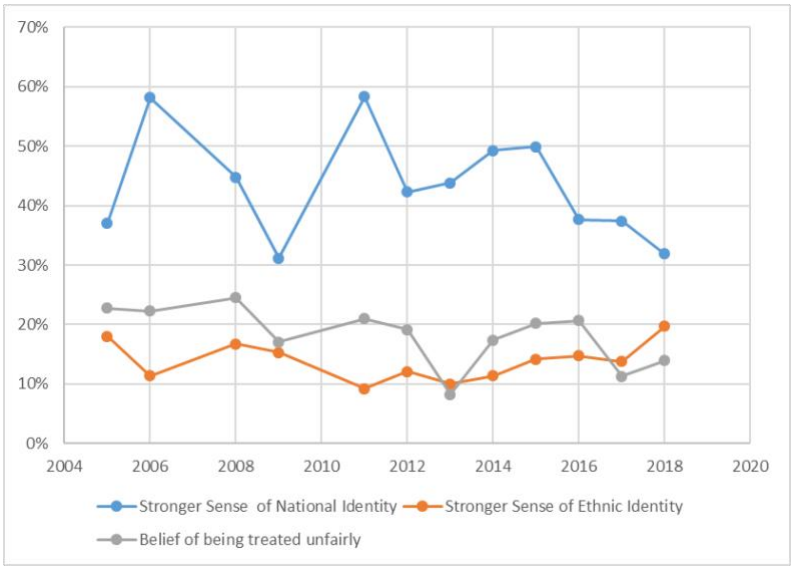

Figure 1.1 Trends in outcome variables

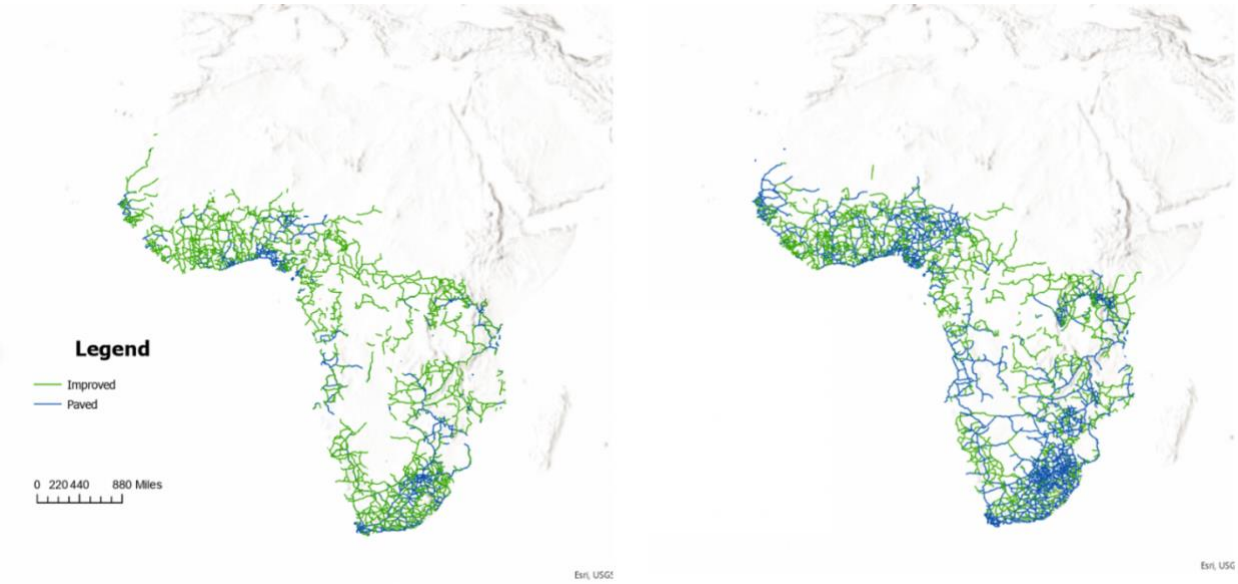

Figure 1.2a Paved and Improved Roads in the 1960s

Figure 1.2b Paved and Improved Roads in the 2000s

Figure 1.2 Roads in sub-Saharan Africa

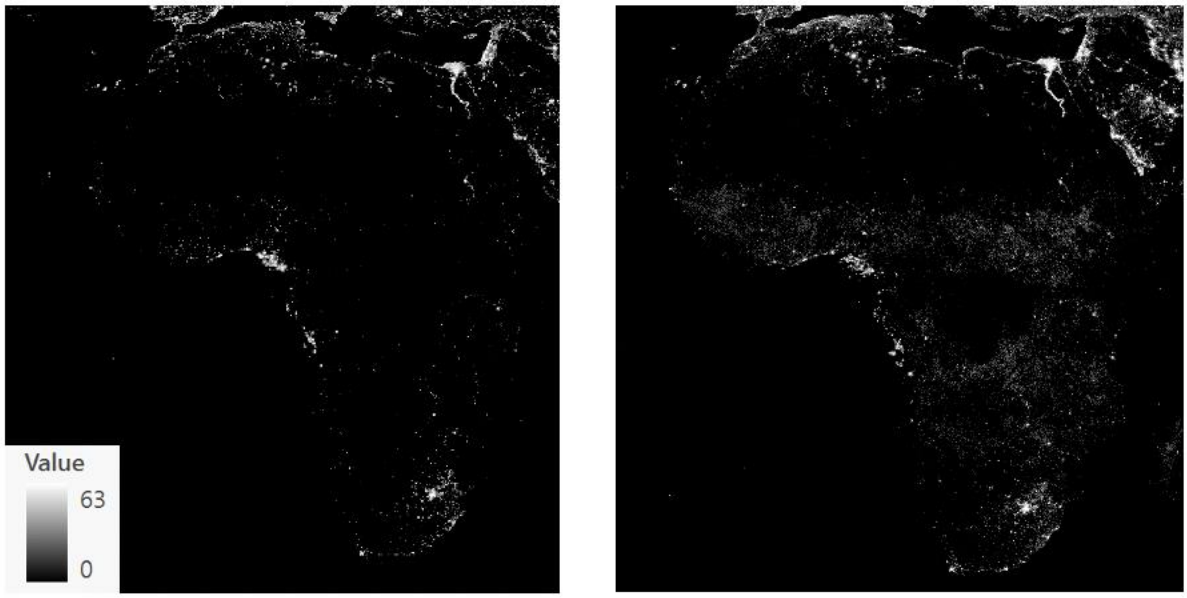

Figure 1.3 Spatial distribution of night-time light in Africa, 2005-2015

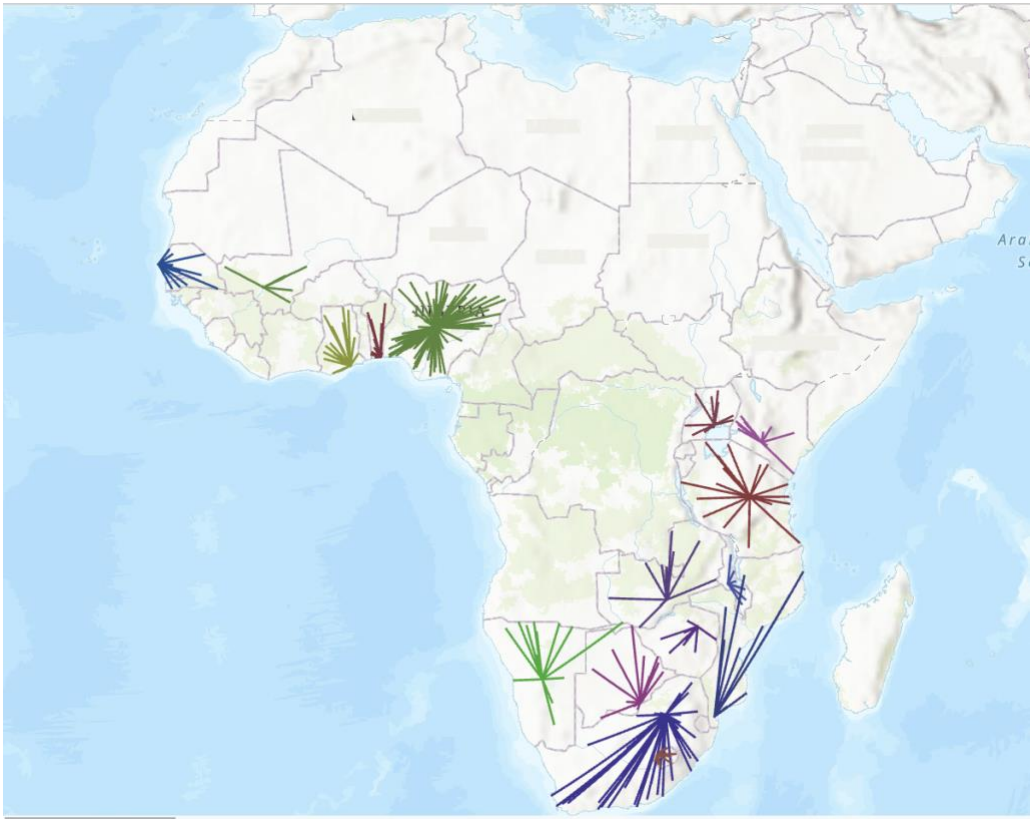

Figure 1.4 Straight lines as instruments

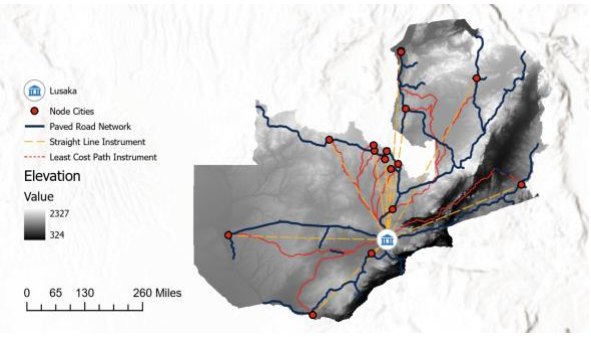

Figure 1.5 Elevation Data and Constructed Instruments in Zambia

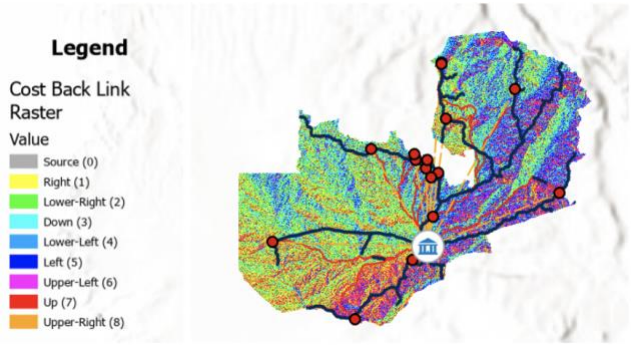

Figure 1.6 Cost Back Link Raster Dataset

Table 1.1 Descriptive Statistics

VARIABLES	Mean	Standard Deviation	Observations	Min	Max
Outcomes					
The respondent identifies only/more with the nation	44%	0.495834	124574	0	1
The respondent identifies only/more with the ethnic group	14%	0.347609	124574	0	1
Respondent identifies equally with the ethnic group and the country	42%	0.494166	124574	0	1
Respondent believes ethnic group is being treated unfairly	19%	0.39245	119593	0	1
Treatment					
Road is Paved	49%	0.49981	129432	0	1
Controls					
Respondent is Employed	38%	0.484343	129159	0	1
Male Dummy	50%	0.5	129693	0	1
Urban Dummy	38%	0.485452	129693	0	1
President and Respondents are co-ethnics	17%	0.379359	126388	0	1
Group is an Ethnic Minority	46%	0.498624	126388	0	1
Nightlight Data	16	21.664	129371	0	63
Age	37	14.7294	128598	18	130
Instruments					
Distance to Straight Line in 100 KM	0.317429	0.504391	129815	0	7.8955
Distance to Straight Least Cost Path in 100 KM	0.319297	0.488267	129815	0	7.8788

Table 1.2 First Stages Estimates

	Distance to Straight Line in 100 KM	Distance to Least Cost Path in 100 KM
Road is Paved	-0.069***	-0.045***
F-Stat	18.43	27.56
Prob>F	0.000	0.000
R-Squared	0.14	0.15
Observations	122,411	122,411

Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

Table 1.3 Testing for pre-treatment trends

	Entire Sample	Pre-Paving	Entire Sample	Pre-Paving
Variables	Nightlight Index in 1992			
Distance to Least Cost Path in KM	-0.00109***	-0.000308		
	(0.000350)	(0.000235)		
Distance to Straight Line in KM			-0.000753***	-0.000162
			(0.000239)	(0.000162)
Observations	10,246	7,749	10,246	7,749
R-squared	0.821	0.870	0.821	0.870

The table presents the results from a regression of the nightlight index, at the cell level, on the distance of the center of the cell to the straight line and the least cost path instrument. The pre-paving columns restrict the analysis to a sample of center points where the road has yet to be paved. I include district fixed effects.

Summary Statistics

Variables	Nightlight Index	Distance to Straight Line in KM	Distance to Least Cost Path in KM
Mean	0.3	120.4	122.8
Standard Deviation	2.8	189.5	186.5
Min	0	0	0
Max	63.0	1167.3	1164.0

Table 1.4 National Identification

	Straight Line IV	Least Cost Path IV	Both IVs	OLS
Dependent Variable	The respondent identifies only/more with the nation			
Road is Paved	-0.273***	-0.421***	-0.248***	0.00848
	(0.0922)	(0.138)	(0.0888)	(0.00607)
Road is Paved * Respondent and President are co-ethnics	-0.197	-0.249	-0.224	0.00763
	(0.152)	(0.198)	(0.154)	(0.0105)
President and Respondents are co-ethnics	0.140	0.170	0.155*	0.0247***
	(0.0860)	(0.111)	(0.0871)	(0.00841)
Baseline Mean	43%	43%	43%	43%
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	122,411	122,411	122,411	122,411

The variable 'The respondent identifies only/more with the nation ' is equal to 1 if a respondent declares being closer to their national identity and 0 otherwise. I include Country and Year fixed effects. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

Table 1.5 National Identification – Omitted Controls

	Straight Line IV	Least Cost Path IV	Both IVs
VARIABLES	The respondent identifies only/more with the nation	The respondent identifies only/more with the nation	The respondent identifies only/more with the nation
Road is Paved	-0.153***	-0.156***	-0.153***
	(0.0381)	(0.0407)	(0.0380)
Road is Paved * Respondent and President are co-ethnics	-0.210	-0.269	-0.225
	(0.191)	(0.227)	(0.198)
President and Respondents are co-ethnics	0.186*	0.220*	0.195*
	(0.112)	(0.132)	(0.116)
Constant	0.498***	0.500***	0.498***
	(0.0173)	(0.0184)	(0.0172)
Observations	124,086	124,086	124,086
R-squared			

The variable 'The respondent identifies only/more with the nation ' is equal to 1 if a respondent declares being closer to their national identity and 0 otherwise. Standard errors are clustered at the district level.
***1%, **5%, and *10% significance levels.

Table 1.6 Ethnic Identification

	Straight Line IV	Least Cost Path IV	Both IVs	OLS
Dependent Variable	The respondent identifies only/more with the ethnic group			
Road is Paved	0.169***	0.225***	0.160***	-0.00644*
	(0.0610)	(0.0859)	(0.0588)	(0.00346)
Road is Paved * Respondent and President are co-ethnics	0.0716	0.0955	0.0834	0.00133
	(0.0819)	(0.102)	(0.0833)	(0.00606)
President and Respondents are co-ethnics	-0.0832*	-0.0968*	-0.0897*	-0.0430***
	(0.0467)	(0.0578)	(0.0475)	(0.00510)
Baseline Mean	15%	15%	15%	15%
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	122,411	122,411	122,411	122,411

The variable 'The respondent identifies only/more with the ethnic group' is equal to 1 if a respondent declares being closer to their ethnic identity and 0 otherwise. I include Country and Year fixed effects. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

Table 1.7 Ethnic and National Identity

	Straight Line IV	Least Cost Path IV	Both IVs	OLS
Dependent Variable	The respondent identifies equally with the nation and the ethnic group			
Road is Paved	0.104*	0.196**	0.0888	-0.00204
	(0.0579)	(0.0820)	(0.0567)	(0.00548)
Road is Paved * Respondent and President are co-ethnics	0.125	0.154	0.141*	-0.00896
	(0.0855)	(0.108)	(0.0854)	(0.00963)
President and Respondents are co-ethnics	-0.0570	-0.0735	-0.0654	0.0183**
	(0.0476)	(0.0599)	(0.0475)	(0.00771)
Baseline Mean	42%	42%	42%	42%
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	122,411	122,411	122,411	122,411

The variable 'The respondent identifies equally with the nation and the ethnic group ' is equal to 1 if a respondent declares identifying with both the nation and the ethnic group and 0 otherwise. I Include Country and Year fixed effects. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

Table 1.8 Ethnic and National Identity – Omitted Controls

	Straight Line IV	Least Cost Path IV	Both IVs
VARIABLES	The respondent identifies equally with the nation and the ethnic group		
Road is Paved	0.165***	0.178***	0.168***
	-0.0333	-0.036	-0.0333
Road is Paved * Respondent and President are co-ethnics	0.196	0.232	0.206
	-0.172	-0.2	-0.177
President and Respondents are co-ethnics	-0.137	-0.159	-0.143
	-0.1	-0.116	-0.103
Observations	124086	124086	124086
R-squared			

The variable 'The respondent identifies equally with the nation and the ethnic group ' is equal to 1 if a respondent declares identifying with both the nation and the ethnic group and 0 otherwise.
Standard errors are clustered at the district level
***1%, **5%, and *10% significance levels.

Table 1.9 Feelings of being treated unfairly

	Straight Line IV	Least Cost Path IV	Both IVs
VARIABLES	Respondent believes ethnic group is being treated unfairly	Respondent believes ethnic group is being treated unfairly	Respondent believes ethnic group is being treated unfairly
Road is Paved	-0.0161	-0.00902	-0.0166
	(0.0616)	(0.0787)	(0.0601)
Road is Paved * Respondent and President are co-ethnics	0.103	0.141	0.117
	(0.0994)	(0.113)	(0.103)
President and Respondents are co-ethnics	-0.150**	-0.170**	-0.157***
	(0.0591)	(0.0666)	(0.0611)
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	117,601	117,601	117,601
R-squared	0.055	0.053	0.055

The variable 'Respondent believes ethnic group is being treated unfairly ' is equal to 1 if a respondent declares thinking their ethnic group is being treated unfairly and 0 otherwise. Standard errors are clustered at the district level.
***1%, **5%, and *10% significance levels

Table 1.10 Economic Conditions and Employment

VARIABLES	The respondent believes his/her living conditions are better than others	The respondent believes his/her living conditions are good	The respondent believes the country's economic conditions are good	Respondent Works in the Agricultural Sector
Road is Paved	0.0996**	-0.147**	-0.310***	0.199*
	(0.0495)	(0.0708)	(0.101)	(0.105)
Road is Paved * Respondent and President are co-ethnics	0.0157	0.121**	0.179***	-0.114
	(0.0636)	(0.0521)	(0.0655)	(0.0771)
President and Respondents are co-ethnics	0.0241	-0.0382	-0.0469	0.0452
	(0.0353)	(0.0288)	(0.0360)	(0.0437)
Baseline Mean	26%	29%	30%	38%
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	123,991	124,034	124,103	62,517

The variables are binary. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels

Table 1.11 Corruption Perceptions

VARIABLES	The respondent thinks most or all local government officials are corrupt	The respondent thinks most, or all MOPs are corrupt	The respondent thinks the president is corrupt	The respondent thinks most, or all of the tax officials are corrupt
Road is Paved	0.203***	0.264***	0.233***	0.273**
	(0.0736)	(0.0837)	(0.0824)	(0.110)
Road is Paved * Respondent and President are co-ethnics	-0.132*	-0.0953	-0.0818	0.0372
	(0.0730)	(0.0636)	(0.0646)	(0.115)
President and Respondents are co-ethnics	0.0662	0.0278	-0.0109	-0.0361
	(0.0415)	(0.0357)	(0.0365)	(0.0630)
Baseline Mean	31%	30%	26%	37%
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	121,820	124,107	124,122	100,629

The variables are binary. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

Table 1.12 Integration and News Consumption

Dependent Variables	The respondent consumes weekly news	The respondent consumes weekly newspaper news	The respondent consumes weekly Internet news	Cell Service in EA	Frequent Internet Use
Road is Paved	0.239***	0.154***	0.00244	0.328***	0.0862**
	(0.0632)	(0.0424)	(0.0404)	(0.107)	(0.0379)
Road is Paved * Respondent and President are co-ethnics	0.0608	-0.0404	0.0672	-0.142	0.0804
	(0.0794)	(0.0463)	(0.0558)	(0.0905)	(0.0805)
President and Respondents are co-ethnics	-0.0103	0.0288	-0.0408	0.0764	-0.0449
	(0.0445)	(0.0259)	(0.0319)	(0.0515)	(0.0465)
Observations	124,138	124,138	81,633	103,266	80,174

The variables are binary. I control for employment status, educational levels, age and its square, gender, urban residence, distance to the capital, nightlight, co-ethnicity with the president (interacted with the treatment) and whether the respondent is part of an ethnic minority. Standard errors are clustered at the district level. ***1%, **5%, and *10% significance levels.

APPENDIX B. CHAPTER 2 FIGURES AND TABLES

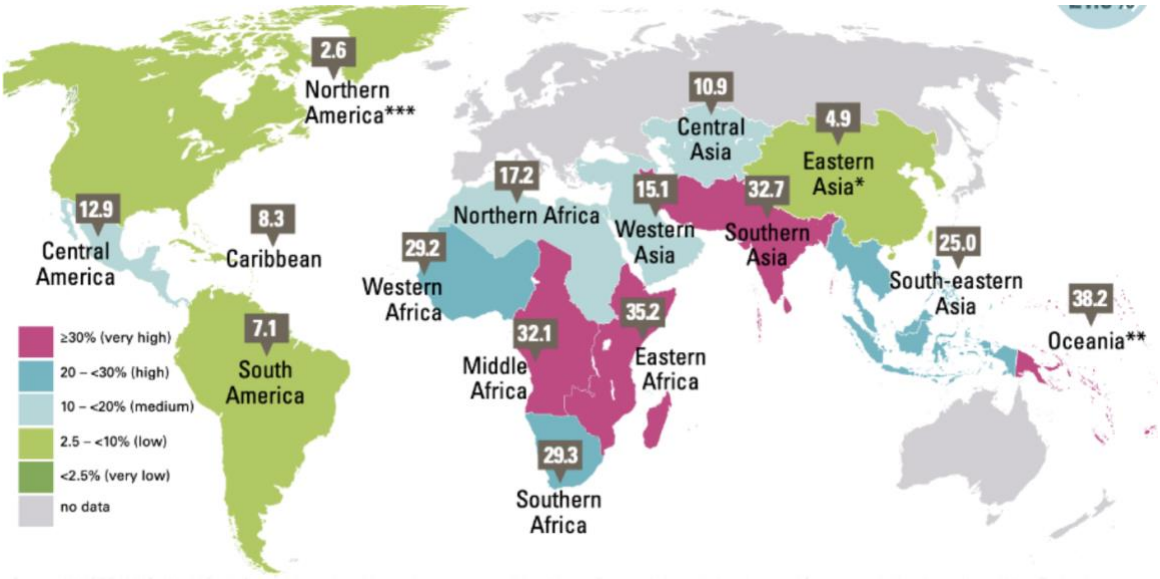

Figure 2.1 Percentage of Stunted Children under 5
Source: UNICEF, WHO, World Bank Joint Child Malnutrition dataset, March 2019 edition

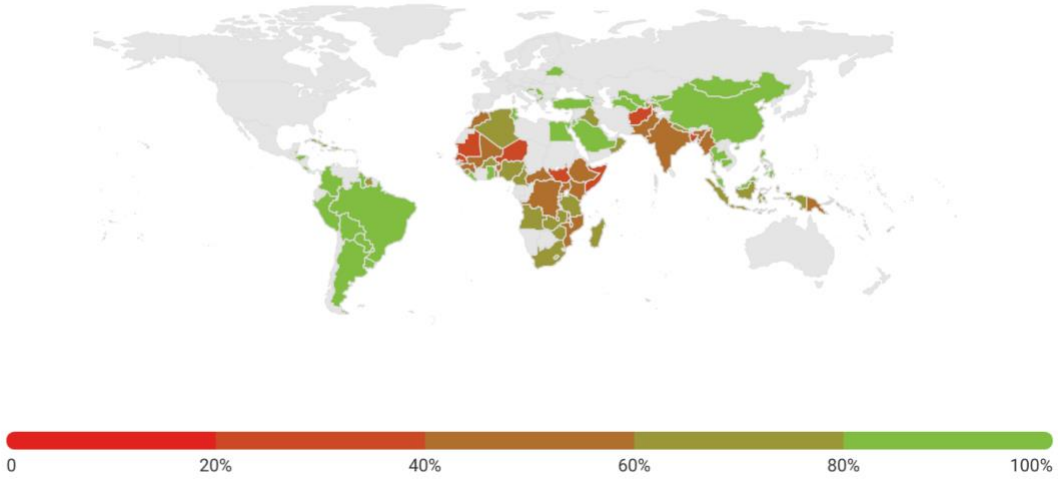

Figure 2.2 Percentage of women aged 15-49 attended by any provider at least four times during pregnancy
Source: UNICEF global databases, 2023, of antenatal care, based on MICS, DHS and other nationally representative household survey data

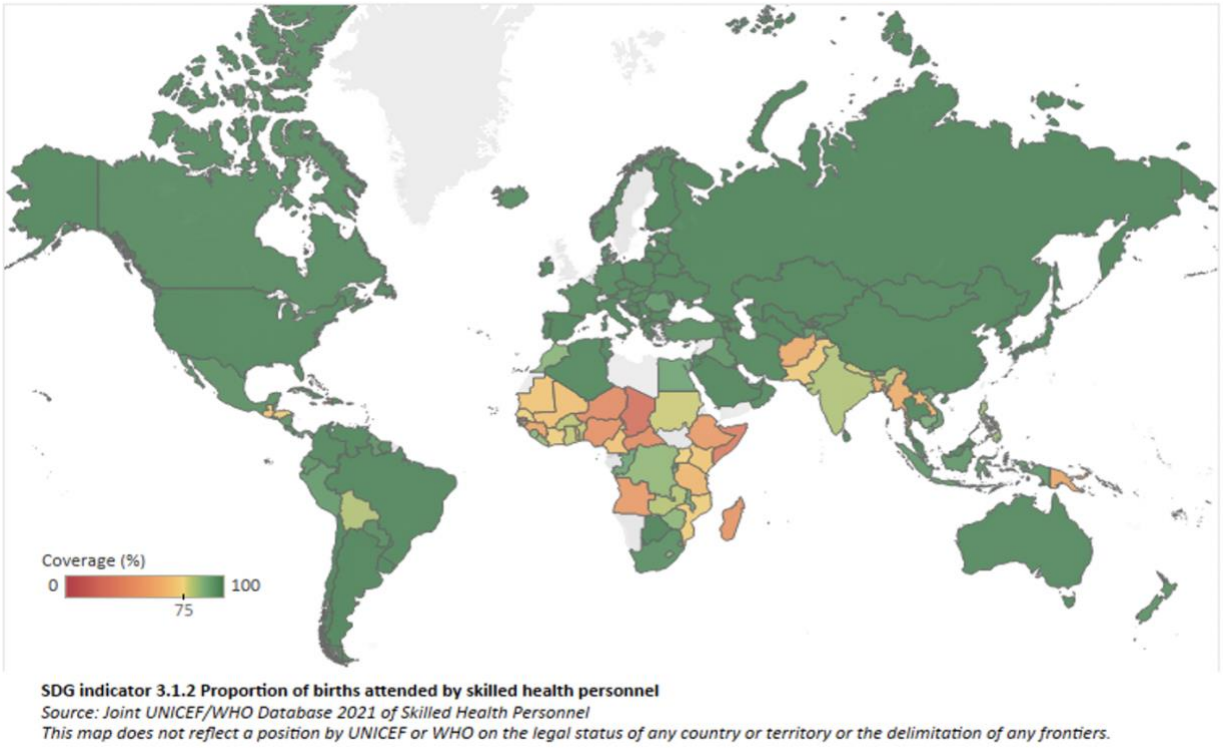

Figure 2.3 Proportions of births attended by skilled health personnel

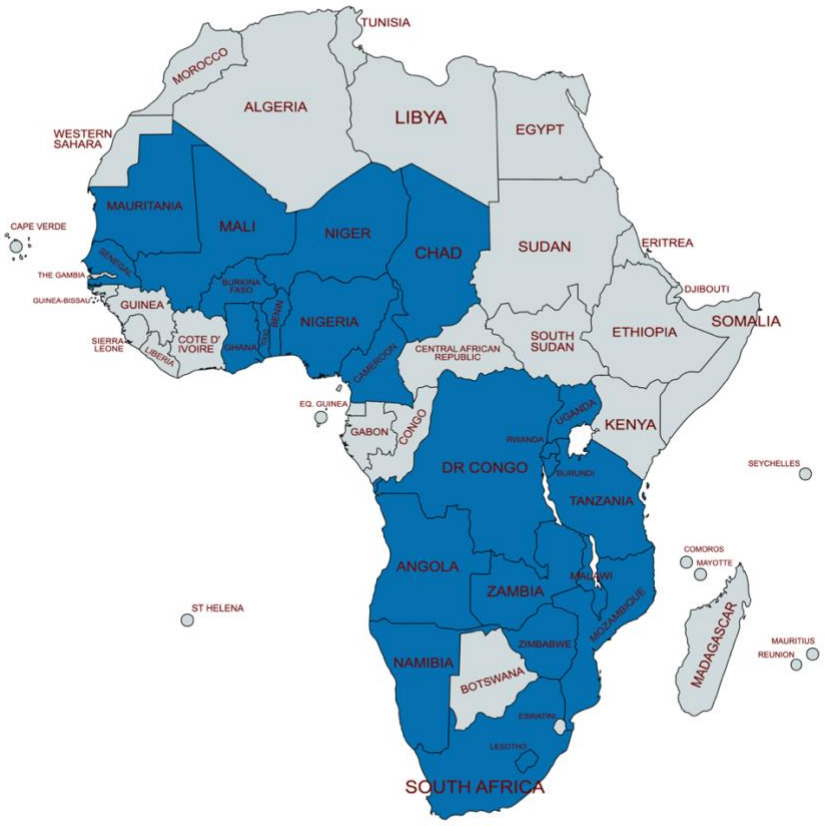

Figure 2.4 DHS Coverage Map

Table 2.1 Countries and Years Utilized in Sample

Country	Years Available							
Angola	2015							
Burkina Faso	1993	1999	2003	2010				
Benin	1996	2001	2012	2017				
Burundi	2010	2016						
Republic of the Congo	2007	2013						
Côte d'Ivoire	1994	1998	2012					
Cameroon	1991	2004	2011					
Ghana	1993	1998	2003	2008	2014			
Guinea	1999	2005	2012	2018				
Kenya	2003	2008	2014					
Liberia	1986	2007	2013					
Lesotho	2004	2009	2014					
Mali	1996	2001	2006	2012	2018			
Malawi	2000	2004	2010	2015				
Mozambique	2011							
Nigeria	1990	2003	2008	2013	2018			
Niger	1992	1998						
Namibia	2000	2006	2013					
Rwanda	2005	2008	2010	2014				
						2015	2016	2017
Senegal	1993	1997	2005	2010	2012			
Chad	2014							
Tanzania	1999	2010	2015					
Uganda	2000	2006	2011	2016				
Zambia	2007	2013	2018					
Zimbabwe	1999	2005	2010	2015				

Table 2.2 Constructing a panel dataset from a repeated cross-sectional dataset

Mother	Birth Year	Delivery Outcome
Woman 1	Child 1's Birth Year	Child 1's Delivery Outcome
Woman 1	Child 2's Birth Year	Child 2's Delivery Outcome
Woman 1	Child 3's Birth Year	Child 3's Delivery Outcome
Woman 2	Child 1's Birth Year	Child 1's Delivery Outcome
Woman 2	Child 2's Birth Year	Child 2's Delivery Outcome

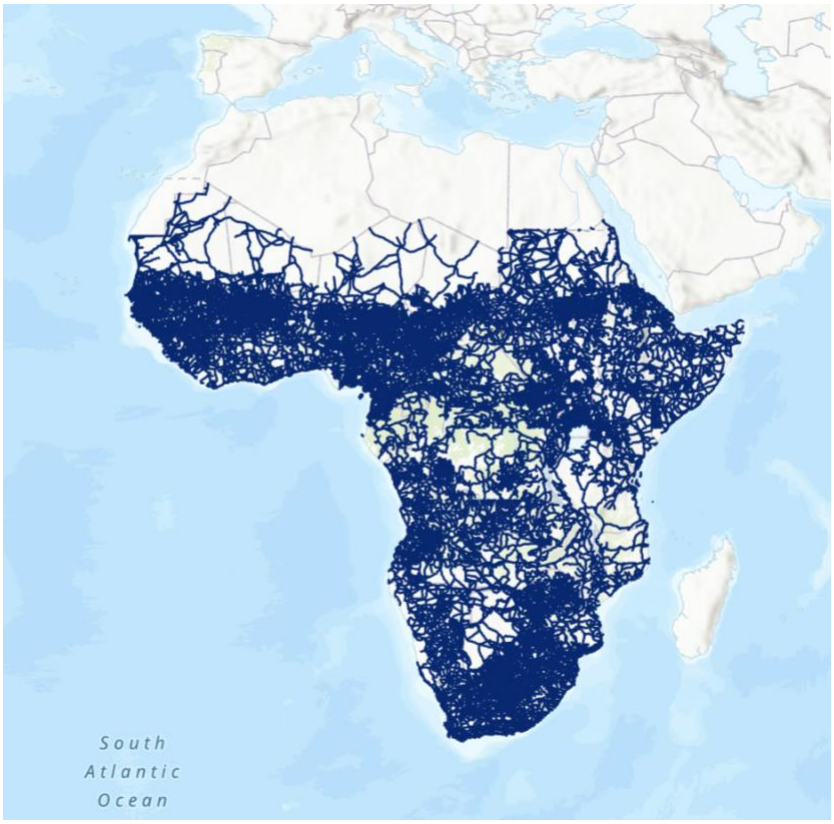

Figure 2.5 Roads in sub-Saharan Africa

Figure 2.6 Road improvement in Kolda, Senegal

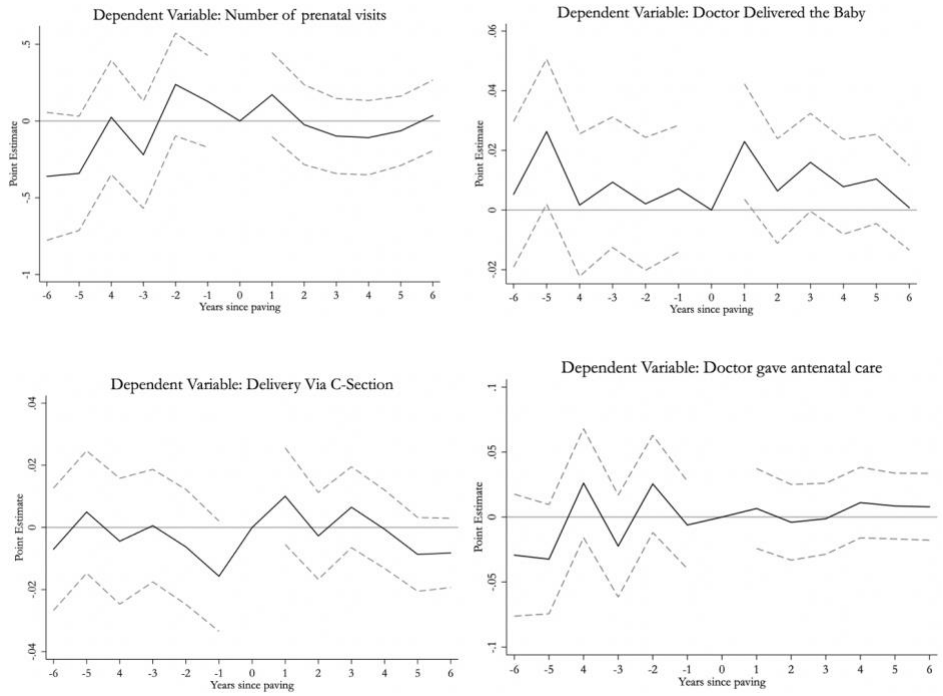

Figure 2.7 Maternal Outcomes – Trends

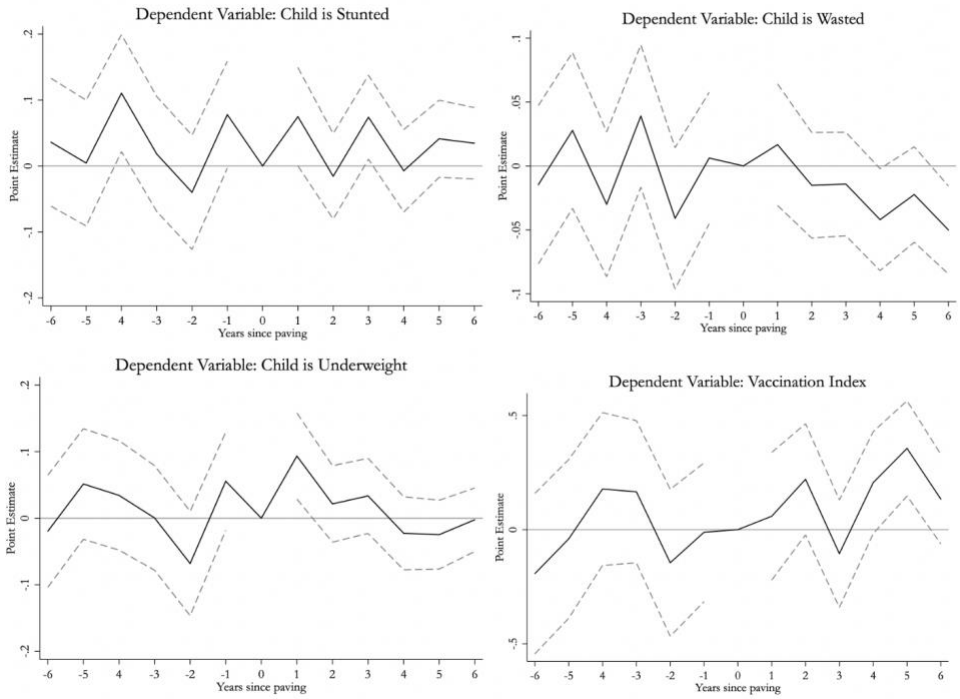

Figure 2.8 Early Childhood Outcomes – Trends

Table 2.3 Summary Statistics

	Frequency	Percent
Age in 5-year groups		
15-19	3,229	1.99
20-24	15,677	9.68
25-29	29,598	18.28
30-34	34,220	21.13
35-39	33,090	20.44
40-44	26,133	16.14
45-49	19,973	12.33
Highest Educational Level		
No Education	74,364	45.93
Primary	62,191	38.41
Secondary	23,194	14.32
Higher	2,169	1.34
Household wealth quintile		
Poorest	33,812	23.15
Poorer	32,351	22.15
Middle	30,269	20.72
Richer	28,126	19.25
Richest	21,524	14.73
Residence		
Rural	121,619	75.11
Urban	40,301	24.89
Status of nearest road		
Dirt	31,237	19.29
Paved	68,929	42.57
Improved	61,755	38.14

Table 2.4 Means differences across paved and unpaved roads

	Unpaved	Paved/Improved	P-Value
Age	28.54852	28.31674	0
HH Head Age	45.30748	44.5713	0
Wealth Index Quantile	2.6898	3.3161	0
Share Urban	0.224	0.4274	0
Completed years of education	3.62	5.37	0
Partner's Completed years of education	3.85761	5.8331	0
Total Number of Household Members	7.6653	7.0472	0
Total Number of Children Ever Born	3.3311	2.8126	0
Total Number of Children under 5	1.6348	1.3518	0
Distance to Nearest Hospital	24,509.69	23,334.39	0
Travel Time the Closest 50,000 (in Minutes)	109.6753	47.717	0

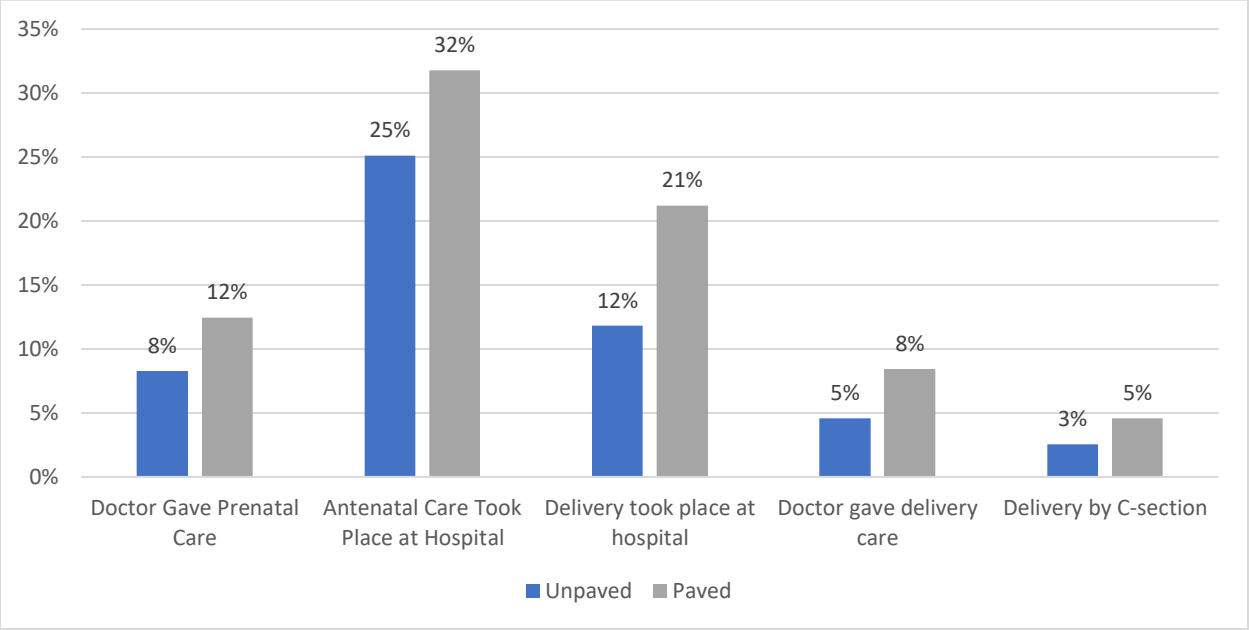

Figure 2.9 Means differences in Delivery and Prenatal Outcomes

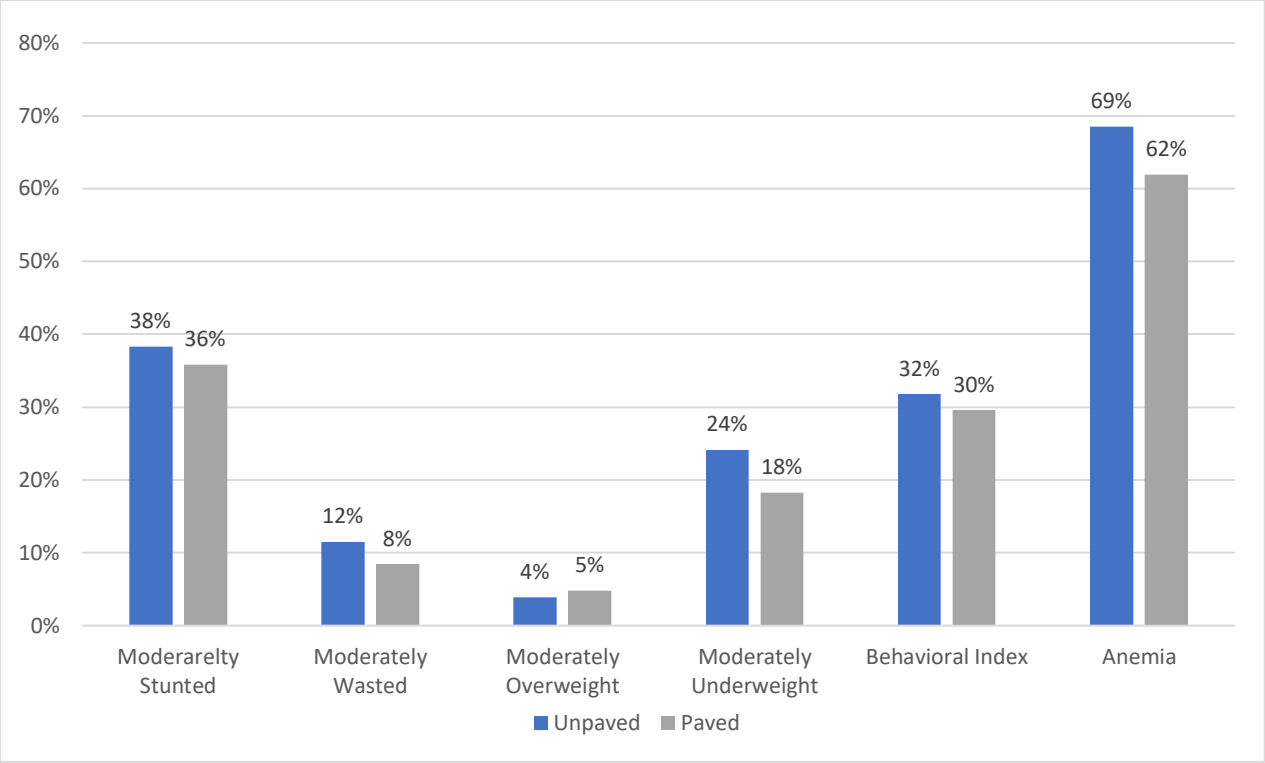

Figure 2.10 Means differences in Early Childhood Outcomes

Table 2.5 Delivery Outcome using Binary Measure of Road Paving

VARIABLES	Doctor gave prenatal care	Number of antenatal visits during the pregnancy	Antenatal care took place at hospital	Delivery took place at hospital	Doctor gave delivery care	Delivery by c-section
Road is Paved/Improved	0.0103	0.0221	0.0150	-0.00635	0.00378	0.00628
	(0.00877)	(0.0780)	(0.0496)	(0.00722)	(0.00513)	(0.00411)
Baseline Mean	8%	3.21 Visits	25%	12%	5%	3%
Observations	477,020	524,371	333,375	760,164	671,064	742,047
R-squared	0.934	0.948	0.958	0.858	0.840	0.828

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
The table displays results from regressions using a difference in differences estimation method, with two-way fixed effects. We use household and birth year fixed effects. I control for parents' age and educational levels and birth order dummies. With the exception of columns 2 and 3, the outcome variables are binary. For instance, the variable 'Doctor gave prenatal care' takes the value 1 if, when asked about a given birth, the mother reports that a professional doctor administered prenatal care. It takes the value 0 otherwise.

Table 2.6 Hospital Delivery Substitutes

VARIABLES	Nurse/Midwife Gave Delivery	Auxiliary Midwife Gave Delivery Care	Traditional Birth Attendant Gave Delivery Care	Trained Traditional Birth Attendant Gave Delivery Care	Relative Gave Delivery Care
Road is Paved/Improved	0.000336	0.0333***	-0.000370	-0.00859	0.0155
	(0.0116)	(0.0120)	(0.00770)	(0.0100)	(0.0100)
Baseline Mean	36%	11%	23%	16%	24%
Observations	677,405	191,743	746,155	240,130	596,282
R-squared	0.848	0.863	0.847	0.792	0.829

VARIABLES	Other Person Gave Delivery Care	No One Gave Delivery Care	Deli at health Center	Delivery Care at Home	Delivery Care at Private Center
Road is Paved/Improved	-0.00102	-0.00357	-0.00598	0.000555	-0.00696***
	(0.00366)	(0.00541)	(0.00561)	(0.00582)	(0.00246)
Baseline Mean	3%	8%	24%	45%	4%
Observations	757,103	757,105	893,922	893,922	893,922
R-squared	0.774	0.809	0.789	0.805	0.820

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The table displays results from regressions using a difference in differences estimation method, with two-way fixed effects. We use household and birth year fixed effects. I control for parents' age and educational levels and birth order dummies. The outcome variables are binary. For instance, the variable 'Doctor gave prenatal care' takes the value 1 if, when asked about a given birth, the mother reports that a professional doctor administered prenatal care. It takes the value 0 otherwise.

Table 2.7 Intensity of Treatment

VARIABLES	Doctor Gave Prenatal Care	Number Of Antenatal Visits During the Pregnancy	Antenatal Care Took Place at Hospital	Delivery Took Place at Hospital	Doctor Gave Delivery Care	Delivery By C-Section
Log years improved/paved	0.00347	-0.00126	0.0117	-0.00299	-0.000459	0.000843
	(0.00282)	(0.0250)	(0.0112)	(0.00215)	(0.00153)	(0.00122)
Baseline Mean	8%	3.21 Visits	25%	12%	5%	3%
Observations	477,020	524,371	333,375	760,164	671,064	742,047
R-squared	0.934	0.948	0.958	0.858	0.840	0.828

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table displays results from regressions using a difference in differences estimation method, with two-way fixed effects. We use household and birth year fixed effects. I control for parents' age and educational levels and birth order dummies. With the exception of column 2, the outcome variables are binary. For instance, the variable 'Doctor gave prenatal care' takes the value 1 if, when asked about a given birth, the mother reports that a professional doctor administered prenatal care. It takes the value 0 otherwise.

Table 2.8 Child Malnutrition outcomes

VARIABLES	Child is Moderately to Severely Stunted	Child is Moderately to Severely Wasted	Child is Moderately Overweight	Child is Moderately to Severely Underweight	Vaccination Index	Child is Anemic
Fraction of life paved	-0.140***	0.00411	-0.0257**	-0.0411*	-1.707***	-0.0408
	(0.0247)	(0.0159)	(0.0112)	(0.0210)	(0.0916)	(0.0457)
Baseline Mean	38%	12%	4%	24%	32%	69%
Observations	355,493	355,679	355,679	350,575	602,545	148,595
R-squared	0.744	0.722	0.743	0.733	0.771	0.778

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The table displays results from regressions using a difference in differences estimation method, with two-way fixed effects. We use household and birth year fixed effects. I control for parents' age, and educational levels and birth order dummies. The variables take the value 1 if the child is reportedly stunted, wasted, underweight, or anemic during survey collection and 0, otherwise. The vaccination index takes values between 0 and 9 and the behavioral index takes values between 0 and 10.

APPENDIX C. CHAPTER 3 FIGURES AND TABLES

Figure 3.1 The BRT in Cape Town
Source: (The Next 48 Hours, 2014)

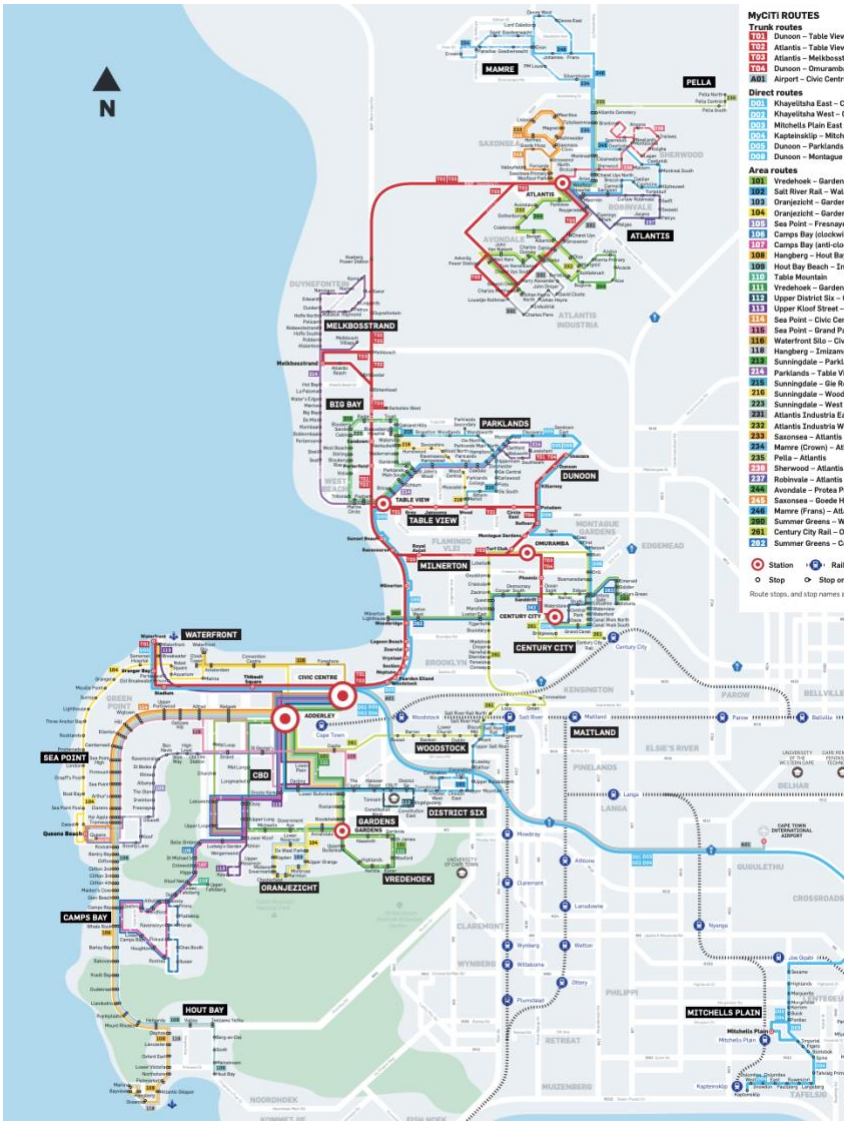

Figure 3.2 Cape Town's MyCity

Source: City of Cape Town

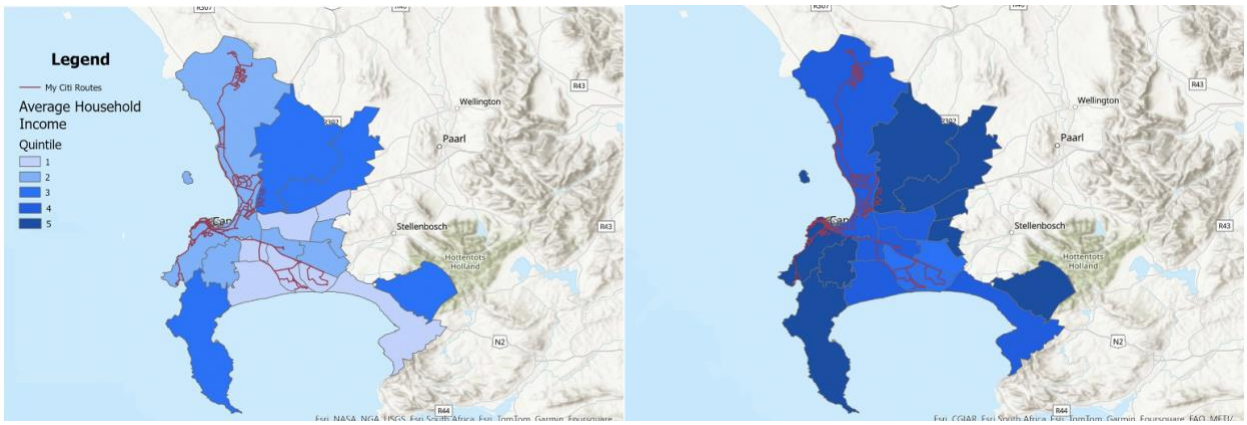

Figure 3.3 Travel Analysis Zones and BRT routes and average income

Table 3.1 Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Min	Max
Household Income	21,324	20472.5	29151.24	0	350840
Personal Income	8,154	7232.188	10531.12	18	350000
Household Size	14,136	4.41511	2.173873	1	16
Respondent has access to the BRT (2003)	8,870	0	0	0	0
Respondent has access to the BRT (2013)	9,752	0.0193806	0.1378658	0	1
Respondent has access to the BRT (2020)	4,384	0.0992245	0.2989972	0	1
Respondent lives less than 15 minutes away from a BRT Station (2003)	8,870	0	0	0	0
Respondent lives less than 15 minutes away from a BRT Station (2013)	9,752	0.0139459	0.1172722	0	1
Respondent lives less than 15 minutes away from a BRT Station (2020)	4,384	0.0412865	0.1989748	0	1
Respondent is Employed	23,006	0.6858646	0.4641807	0	1
Age	22,995	34.47345	19.08703	0	99
Male Dummy	23,001	0.4761097	0.4994398	0	1
Highest Level of Education Attained	12,904	11.00767	4.724989	0	29

Table 3.2 Baseline Results

VARIABLES	Highest Level of Education Attained	Highest Level of Education Attained	Respondent is Employed	Respondent is Employed
Respondent has access to the BRT	-0.380*	-0.547***	-0.0141	-0.0153
	(0.219)	(0.206)	(0.0133)	(0.0133)
Constant	9.433***	8.752***	0.658***	0.608***
	(0.194)	(0.225)	(0.0120)	(0.0142)
Observations	13,036	13,023	23,508	23,490
R-squared	0.115	0.212	0.361	0.367
TAZ Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

VARIABLES	Household Income	Household Income	Personal Income	Personal Income
Respondent has access to the BRT	2,479***	1,899***	2,269***	1,482**
	(577.1)	(571.1)	(745.2)	(714.7)
Constant	17,884***	15,713***	4,580***	-1,429*
	(522.9)	(613.6)	(604.1)	(740.3)
Observations	21,826	21,819	8,301	8,299
R-squared	0.718	0.724	0.123	0.197
TAZ Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

Table 3.3 Household Income, By Race

	Black	Black	Coloured	Coloured	White	White
VARIABLES	Household Income	Household Income	Household Income	Household Income	Household Income	Household Income
Respondent has access to the BRT	1,502	1,501	4,457***	4,458***	-1,980	-1,895
	(942.6)	(942.8)	(791.9)	(791.9)	(1,579)	(1,556)
Constant	20,008***	19,694***	16,758***	16,429***	19,995***	27,544***
	(1,333)	(1,386)	(572.3)	(644.6)	(1,755)	(1,938)
Observations	6,355	6,353	11,947	11,946	3,323	3,322
R-squared	0.801	0.801	0.752	0.752	0.539	0.553
TAZ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes

Table 3.4 Personal Income, By Race

	Black	Black	Coloured	Coloured	White	White
VARIABLES	Personal Income	Personal Income	Personal Income	Personal Income	Personal Income	Personal Income
Respondent has access to the BRT	2,166	2,145	-103.8	-204.7	165.8	648.6
	-1,773	-1,773	-912.8	-902.7	-2,357	-2,273
Constant	3,331**	2,036	3,241***	224.9	12,073***	1,203
	-1,561	-1,755	-434.4	-549.6	-2,042	-2,293
Observations	2,226	2,225	4,322	4,322	1,529	1,529
R-squared	0.054	0.056	0.079	0.1	0.091	0.157
TAZ Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes

Table 3.5 Living within 15 minutes of a BRT station

VARIABLES	Highest Level of Education Attained	Highest Level of Education Attained	Respondent is Employed	Respondent is Employed
BRT is within a 15-minute walk	-1.515***	-1.417***	-0.0216	-0.0211
	-0.365	-0.345	-0.0224	-0.0223
Constant	9.317***	8.746***	0.657***	0.605***
	-0.197	-0.228	-0.0122	-0.0144
Observations	12,904	12,891	23,006	22,988
R-squared	0.115	0.213	0.357	0.363
TAZ Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

VARIABLES	Household Income	Household Income	Personal Income	Personal Income
BRT is within a 15-minute walk	-1,245	-1,443*	2,477**	2,323**
	-858.8	-846	-1,103	-1,043
Constant	17,742***	15,720***	4,559***	-1,200*
	-468.8	-548.3	-540.9	-657.2
Observations	21,324	21,317	8,154	8,152
R-squared	0.764	0.771	0.151	0.241
TAZ Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

Table 3.6 Compositional Change

VARIABLES	Age	Household Size	Highest Level of Education Attained
Respondent has access to the BRT	1.574**	-0.0649	-0.380*
	(0.671)	(0.0789)	(0.219)
Constant	37.02***	4.123***	9.433***
	(0.605)	(0.0712)	(0.194)
Observations	23,497	23,508	13,036
R-squared	0.049	0.073	0.115
TAZ Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
Controls	No	No	No

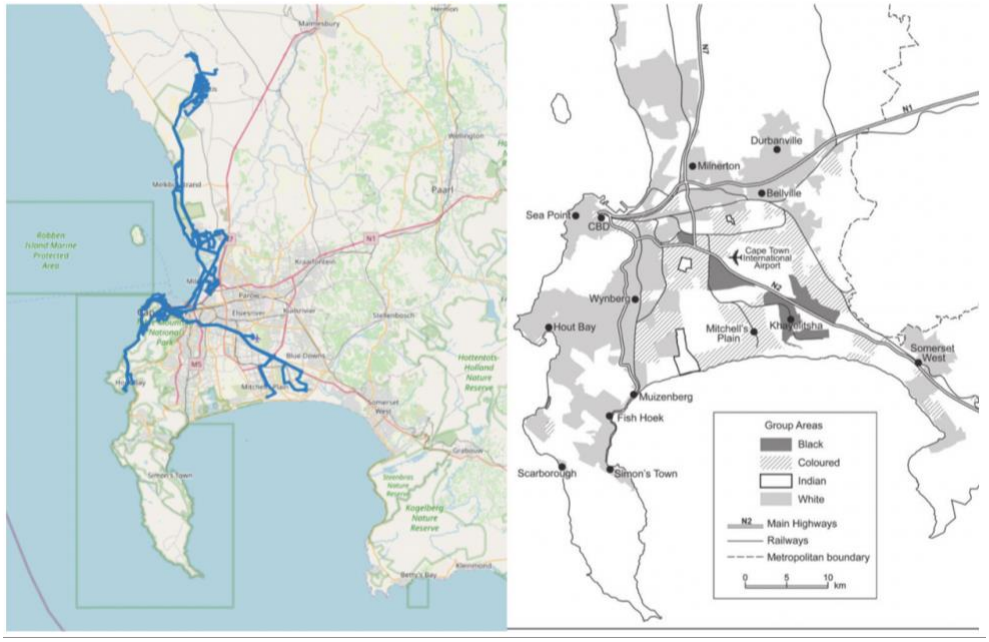

Figure 3.4 BRT Lines and Apartheid Zoning

Source: City of Cape Town 2024; Crankshaw, 2012