Economic development around trans-port corridors in Africa

Analyzing the impacts of 21 road and rail projects

M.J. Kooistra

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Economic development around transport corridors in Africa

Analyzing the impacts of 21 road and rail projects

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M.J. Kooistra

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Thesis committee:	Prof. dr. ir. L. A. Tavasszy,	TU Delft, chairman
	dr. ir. J. Verschuur,	TU Delft, supervisor
	Prof. dr. C. P. van Beers,	TU Delft, supervisor

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TU Delft

Preface

After seven years of studying, this thesis document marks the end of my time as a student at the TU Delft. This thesis is part of finalizing the MSc Transport, Infrastructure, Logistics, where I enjoyed working on the transport-related subjects and had the opportunity to expand my scientific knowledge further.

I would like to thank the committee members who guided me over the past 6 months, during which I worked on my thesis. I was intrigued by the topic of African transport corridors due to the interesting combination of large-scale transport infrastructure within the context of developing countries. Throughout the process, I tried several approaches to find as many interesting results as possible, given the 6 months I had to work on this research. With advice from my committee, I chose to compare multiple corridor projects instead of focusing on just a few, and the result was the discovery of interesting associations between economic development and the corridors. Through this research, I learned to work with GIS and difference-in-differences modeling to capture large economic effects, which was new for me, but I enjoyed trying out this approach, and I am overall satisfied with the final thesis document.

I want to thank Jasper for supervising me throughout the project during our two-weekly meetings. I want to thank Lóri for his valuable input, which helped me a lot to steer the research in a direction that resulted in interesting outcomes. I want to thank Cees for his expertise in economic modeling and knowledge about Africa. During my research, I had contact with Charles and Bernard from the World Bank, with whom we discussed the research topic. I would like to thank them both for their valuable insights.

Delft, October 2025
Martin Kooistra

Summary

Highlights

- The economic development around 21 road and rail corridors constructed between 2003 and 2013 is analyzed with nighttime light data
- Up to 2023, all areas around the corridors are associated with positive economic growth since its construction
- Most economic development around the corridors occurs in urban settings close to ports
- Along new built corridor routes in landlocked countries, the nighttime lights are turned off

Introduction and literature review

Africa has seen major investments in its infrastructure over the last decades. Over 400 projects were completed from 2012 to 2020 that could benefit regional and continental development (PIDA, 2023). Infrastructure development can lead to increased access to economic markets, education, and health services. The continent has a history of underinvestment. In 2022, only a third of Africa's rural population had access to paved roads, and only 1% of the world's rail network was located in Africa. With the African population expected to grow by 60% up to 2060, there is a huge potential in economic development.

Infrastructure projects in Africa target large areas with transport corridors. In these projects, investments target infrastructure, such as roads, rails, or ports. Often these corridors are complemented with investments in electricity networks, last-mile connections, or soft investments in trade or customs. These investments could help accommodate the growing demand in African transportation, leading to economic development by increasing labor markets and trade access. However, these economic impacts remain insufficiently indicated and attributed to transport corridors. Most research on transport investments focuses on middle- and high-income countries. Existing examples of African corridors indicate mostly heterogeneous effects in case studies. Corridors in Africa could have long-term positive economic effects through improved market access; however, there are also characteristics that could hinder this development. First, Africa has the highest share of landlocked countries, so continent-wide effects are less obvious than in regions oriented around coastal economic zones. Infrastructure is linked to cross-country growth in employment and distributional gains in developing countries, but these are higher-level relationships and do not establish a direct corridor-level causal link (Calderón et al., 2008). Second, Africa has a large rural population, greater distances between urban areas, and the lowest road and rail density worldwide. These features suggest that realizing economic development from transport corridor investments may be less automatic in Africa than elsewhere. To address this matter, this research aims to answer the following research question:

To what extent do investments in transport corridors have economic impact in Africa?

Methodology

To answer this question, a quantitative approach is maintained where the economic impact is expressed in numerical data. To capture economic development, nighttime light data is used as an indicator. The idea is that when access to electricity increases, the economic status in those areas changes because companies and households have access to the electricity network. When higher nighttime light intensities are measured, this could be a strong indication that economic development increases. To attribute the effects to the corridor, areas directly affected by the investments are compared with those that are not. In both areas, the annual nighttime light measurements are taken. When the affected area increases faster than the unaffected area after the project's construction begins, the changes in

nighttime lights can be attributed to the transport corridor. The analysis examines the characteristics of the corridor, as well as whether corridors with that characteristic exhibit different growth patterns. The tested characteristics are related to the project (brownfield or greenfield investment, road or railway, and involvement of a Multilateral Development Bank), or to the geographic context (urban or rural, and landlocked or non-landlocked). To test the effect of the characteristics, the corridors are divided into parts of 50 kilometers. The outcomes show which parts of the corridors are associated with more development than others. This way, the heterogeneity between the corridors can be addressed. Only corridors are selected with notable constructions (>100 km of infrastructure) between 2003 and 2013. The routes were selected from the African Development Corridor Database created by Thorn et al., 2022. The data source for nighttime light is obtained from the simulated VIIRS satellite dataset from Chen et al., 2024. This nighttime light data is annual available from 1992 to 2023.

Results

21 corridors were indicated with construction between 2003 and 2013. Testing the average effect across all 21 corridors reveals the short-term effects of the anticipation effect immediately after the start of corridor construction. This is the moment when nighttime lights begin to develop more rapidly in areas near the corridor than in areas further away. This effect becomes more prominent from the eighth year. This could be evidence that it takes time for firms and households to adapt to the new infrastructure. Comparing the local area around the corridor with areas further away reveals that areas within 50 kilometers develop more closely with the local area after the corridor is constructed. This could be an indication that at that reach, corridor effects are still felt.

All corridors have experienced positive economic development since their construction. This is tested by comparing the local area of 10 kilometers on both sides of the corridors with unaffected areas at 80 to 110 kilometer distance. On average, 2% more annual growth is measured in the local areas. Some corridors have almost no noteworthy development (4% growth after 10 years) whereas other show significant growth up to 120% more nighttime light in the local area compared to a control area. A suggestion could be made about 3 different types of corridor outcomes. The first type is characterized by almost no notable growth between the treatment and control groups. These are projects where not enough complementary context is available to create economic development. For example, poor road connections or the absence of an initial economic baseline. The fact that little development has taken place after more than 10 years at these locations could be a sign that billion-dollar investments in hard infrastructure do not yield local economic benefits when no complementary investments accompany the projects. The second group aligns with steady growth around the corridors, mostly associated with 20% to 40% growth after more than 10 years. The third group has exceptional growth related to an existing economic structure around ports. New infrastructure seems to be a trigger to enable economic development. Before the start of the corridor construction, the areas around the corridor had already experienced increasing development compared to the unaffected areas that are compared in the analysis. Therefore, the results are nuanced: the economic effect is associated with the corridor and is not a clean causal effect.

That there are varying impacts associated with the corridors can be explained by testing the project characteristics and the geographic setting over the corridor segments. These results, where the corridors have been analyzed as part of an infrastructure of 50 kilometers each, reveal more about where and when economic development occurs. As seen for the highest corridor development effects, an initial economic baseline is associated with enabling economic activities. That segments with brownfield investments are associated with most growth is, therefore, not a surprise: these segments are former roads and rails that already existed at locations with initial economic development. The economic development that is linked to nighttime lights mostly occurs in urban settings. This is where most lights are turned on after building new roads and rails. But the growth also occurs in rural areas. Especially around brownfield investments. Nighttime light as an indicator for rural development has been prone to debate because it does not accurately represent the economic activities that happen in the countryside. However, the fact that nighttime light has an effect could still indicate that new forms of economic activity are being added to what is already happening. It is possible that local communities, often with an agricultural background, diversify activities with commercialized ones. Other effects suggest that rural

areas are also experiencing less development. This happens in landlocked countries, where the effect shows that in greenfield projects, control areas develop more than treatment areas. This suggests that economic activities are reallocated, most likely closer to urban areas.

The main takeaway of these results is that they explain more about the corridor settings where and when economic development happens. Brownfield and urban segments emphasize the importance of an already existing economic baseline. Distance to ports, as a key indicator, is mostly proven by landlocked areas scoring low. Also, projects selected by MDBs are associated with more growth. These effects explain the heterogeneity that have been found previously in the full corridor sample.

Discussion and conclusion

Across 21 African corridor projects started between 2003 and 2013, areas within 10 km of the routes show more nighttime light intensity than comparable unaffected areas, with average equivalent annual gains around 2% and substantial heterogeneity. The affected and unaffected areas show different patterns. This reveals that the measurements in economic growth need to be nuanced as associations with the corridor: already initial development exists in the local corridor area. Still, post-construction growth of corridors persists across the area difference, and strengthens from about the eight year, consistent with commissioning lags and slow agglomeration. Spillovers are detectable within 20–80 km, after which average effects stabilize; an 80–110 km control area therefore serves as a balanced main control area. The strongest gains occur where corridors reinforce dense, port-linked market structures, while minimal gains are observed in contexts of weak complements or adverse conditions (e.g., poor last-mile connections in landlocked interiors). Segment analysis clarifies where development concentrates: urban segments dominate, brownfield upgrades outperform greenfield, and MDB projects are located in regions with substantially more growth in development. In contrast, rural, landlocked, greenfield segments can experience slower development in treatment than in the control. It is an effect of relocating economic activities to urban areas. Taken together, the results map a coherent geography of where corridor-specific development is most likely to occur.

These patterns come with important caveats and implications. Nighttime lights understate agricultural activity in rural areas and may over-represent urban change. Moreover, complementary investments in ports, trade facilitation, and local road networks are not explicitly modeled, and distributional outcomes (who benefits) remain unobserved. Policy practice should, therefore, bundle hard corridor investments with soft investments in trade/customs policies and last-mile connectivity in dense markets; screen projects for baseline economic potential (especially in landlocked settings); evaluate success over longer time periods rather than immediately post-commissioning; and prevent that rural development is slowed down with targeted local investments. Future research can tighten interpretation by linking lights to household- and firm-level outcomes and by extending the sample beyond 2013, applying alternative control area designs and tracing dynamic effects for longer time periods. Even with these limitations, the consistent spatial and temporal patterns indicate a clear message: corridors tend to enable durable gains where they connect existing economic baselines. In particular near ports. In contrast, impacts are far less automatic in rural or landlocked contexts without the right complements.

Acronyms

- **AfDB** African Development Bank
- **ATT** Average Treatment Effect on the Treated
- **AU** African Union
- **BRI** Belt and Road Initiative
- **CRS** Coordinate Reference System
- **DiD** Difference-in-differences
- **DMSP** Defense Meteorological Satellite Program
- **EU** European Union
- **LAPSSET** Lamu Port and Lamu–Southern Sudan–Ethiopia Transport Corridor
- **LULC** Land Use Land Cover
- **MDB** Multilateral Development Bank
- **PIDA** Program Infrastructure Development for Africa
- **SOL** Sum Of Light
- **TWFE** Two-Way Fixed Effects
- **VIIRS** Visible Infrared Imaging Radiometer Suite
- **WB** World Bank
- **WEB** Wider Economic Benefit

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1 Introduction

The introduction of this thesis document will explain what transport corridors are and how investing in those could lead to economic development in Africa. This is explained as the background information in section 1.1. Scientific research has been done before on this topic, but what will be contributed in this research is discussed further in section 1.2. section 1.3 gives the related research questions and section 1.4 narrows down the research space. The structure of the thesis document is explained in section 1.5.

1.1. Background

Africa has seen major investments in infrastructure projects in recent years. Between 2012 and 2020, the African Union, in collaboration with the African Development Bank, targeted infrastructure development through the Programme for Infrastructure Development in Africa (PIDA), which executed over 400 projects with a focus on regional and continental development (PIDA, 2023). This is done after long periods of underinvestment. Just 1% of the world's rail is located in Africa, and a third of the rural population has access to paved roads (Thorn et al., 2022). New infrastructure could enable economic development by lowering the costs for moving persons and goods (Storeygard, 2016). These improvements in connectivity could attract firms and expand economic activities. The activities tend to cluster in industrial regions, leading to an agglomeration effect where economic zones are growing (Lebrand, 2021) (Rosenthal & Strange, 2004). These regions could experience several economic benefits, including new access to jobs and higher household incomes. In the short run, directly after the construction of new infrastructure, corridor investments could enable firms to meet the demand for the movement of goods. In the long run, more firms could be reallocated to the economic clusters by mobilizing workers to relocate to the cluster. This could be a reinforcing system where the labor markets and firms continue to expand (Redding & Turner, 2015). This effect can be significant in economies that underperform their potential (IMF, 2025). The rapid growth of the African population, with predictions of up to 60% growth between 2025 and 2060, could lead to a substantial increase in demand for infrastructure (Thorn et al., 2022). In the new PIDA for 2021-2030, 25 new transport projects are planned. The investments have strong relations with Multilateral Development Banks (MDBs) such as the African Development Bank (AfDB) and the World Bank (WB). Additionally, foreign banks, such as the Chinese Investment Bank, are investing significantly in Africa's infrastructure. As an example, in the Chinese Belt and Road Initiative, an investment of 39 billion US dollars in infrastructure projects has been made in 2025 from January to June (Nedopil, 2025).

Infrastructure projects in Africa are targeted with a transport corridor approach. These investments target large spatial areas where roads, railways, waterways, or pipelines are built or rehabilitated. Also, industrial hubs such as ports and airports are targeted with these investments. They are specifically developed to increase connectivity and enhance national transport backbones (Quium, 2019). This could meet the demand of the increasing African population, allowing them to move more easily and resulting in economic benefits such as access to jobs, education, or healthcare. The scope of these corridors can reach large, transnational geographical areas. Over time, they are not only an infrastruc-

ture program anymore, but serve multiple societal and economic objectives by clustering logistics and incorporating market integrations (Bignoli et al., 2024). The term 'development corridor' is maintained for these larger investment programs, and the term 'transport corridor' is defined as its simplest manifestation. The transport corridor can be an investment within larger development corridor programs. In these programs, investments in electricity networks and innovations in governing policies are combined with investments in transport infrastructure. This could enhance the economic opportunities (Melecky et al., 2018). An example is the Abidjan–Lagos Trade & Transport Facilitation Project, which not only includes hard infrastructure investments, but also targets customs policies and additional trade regulations (Bank, 2010). Another example is the Lamu Port–South Sudan–Ethiopia Transport (LAPSSET) corridor, which aims to open new trade routes in Northern Kenya. The project has estimations up to 23 billion dollar investments, it still in the making, and subject to scientific debate (Aalders et al., 2021).

Examples in other developing or previously developing countries are known where infrastructure programs played an important role in significant economic transformations. Large upgrades in Chinese road infrastructure have led to increased economic activity that clusters in economic zones (Faber, 2014). In India, old colonial railway routes have been upgraded, and economic development around these revived routes has been significantly attributed to those upgrades (Donaldson, 2018). These effects can lead to significant population reallocations in the long run. Therefore, it appears that investments in large-scale infrastructure projects are a powerful tool for transforming and improving economies. In Africa, already 79 transport corridors exist that target development (Thorn et al., 2022). With increasing new investments over the following years, it is relevant to discuss whether these projects will lead to more economic opportunities.

1.2. Problem statement

The developments in large investments in African infrastructure could yield ambitious economic development across the continent; however, the causal economic impacts of African transport corridors remain insufficiently established at the corridor level. Most research on transport investments focuses on middle- and high-income countries, leaving state-of-the-art evidence for low-income settings scarce (Jedwab & Moradi, 2016). Existing work documents heterogeneous effects, with corridors fostering development in specific settings (Jedwab & Storeygard, 2022), but these studies mostly emphasize short-term impacts directly after installation (Alam et al., 2022). Comparative studies with multiple projects in Africa suggest long-term development related to infrastructure via network-wide market-access elasticities over 30 years (Jedwab & Moradi, 2016). Yet this literature speaks more to network-level adjustment than to local, corridor-specific development over the long run.

As mentioned in section 1.1, evidence from other developing countries shows that transport investments can have long-run local effects through improved market access and economic clustering. Similar effects could be expected in Africa; however, Africa also has distinctive characteristics that may hinder development. First, Africa has the highest share of landlocked countries, so continent-wide effects are less obvious than in regions oriented around coastal economic zones. Infrastructure is linked to cross-country growth in employment and distributional gains in developing countries, but these are higher-level relationships and do not establish a direct corridor-level causal link (Calderón et al., 2008). Second, Africa has a large rural population, greater distances between urban areas, and the lowest road and rail density worldwide. These features suggest that realizing economic development from transport corridor investments may be less automatic in Africa than elsewhere.

To conclude, more corridor-level evidence is needed to determine whether transport corridor investments generate long-term economic impacts in surrounding areas, beyond their requires more explicit explanationshort-term effects. The currently observed heterogeneity in corridor impacts also needs to be explained more explicitly. The main contribution of this thesis is (i) to detect wider economic effects around corridors and (ii) to identify the settings and investment characteristics associated with stronger development responses.

1.3. Research questions

The focus of this thesis will be on the economic impact of the transport corridors on large spatial scales in Africa. The local effects around the corridors will be analyzed, and the associations of the investment characteristics with that development will be tested. The primary research question is as follows:

To what extent do investments in transport corridors have economic impact in Africa?

To address this question, several aspects need to be considered separately to comprehensively answer the main research question. To do so, the following sub-questions are formulated:

1. **To what extent does the economic development in Africa differ in areas targeted by transport corridor investments and comparable areas without transport corridor investments?** This sub-question taims to determine whether there is a difference in economic development between areas directly exposed to the impacts of corridor investments and thosenot directly affected by the investments. This way, the local effects of the corridors can be tested. Comparing with similar regions that are not targeted by the investment makes it possible to isolate the corridor effect.

2. **What geographic characteristics of transport corridors could explain differences in economic development?**
   The geographic context could be an important indicator tof why economic development varies byregion. By characterizing the corridors based on itheirgeographic location, these differences can be measured and compared.

3. **What project characteristics could explain differences in economic development?**
   When the impact of a transport corridor investment can be associated with economic development, the different project characteristics need to be considered to explain whether a certain project leads to a greater economic impact than others.

1.4. Scope

To effectively answer the research questions, the research space is further specified and narrowed down. The focus of the research is road and rail projects in Africa that can be related to corridor projects. The reason for analyzing road and rail data only is that it makes it easier to compare large geographic areas for which sufficient data is available. Data about canals and oil pipelines is also available, but there are not enough projects to create a comparable analysis. The transport corridor routes are selected from the African Development Corridor Database developed by Thorn et al., 2022. Only projects in the database that are related to corridor programs are included.

To measure the impacts of the corridors beyond the short-term effects, projects between 2003 and 2013 are selected. This leads to more than 10 years of analysis to examine the developments. An approach is chosen in which numerical data are analyzed to measure the effects. The corridor effects can also be described using a qualitative data approach; however, numerical evidence provides a more detailed understanding of the magnitudes of certain impacts.

1.5. Document structure

This thesis document is structured in 6 chapters. chapter 1 introduces the subject and addresses the knowledge gap in this chapter. chapter 2 adds on to the scientific literature of the subject. chapter 3 describes what methods were used to answer the research questions of this chapter. The results are shown in chapter 4 and further discussed in chapter 5. The conclusions are stated in chapter 6. A scientific paper is included about the thesis in Appendix A.

2

Literature review

This chapter contains a review of the literature on transport corridors in Africa and their economic impacts on the surrounding regions. The review is conducted by using scientific papers and reports that cover the topic of transport corridors with a focus on Africa. The section 2.1 gives an introduction to African transport corridors. section 2.2 outlines the economic mechanisms associated with the corridors. How economic development could be enabled specifically for Africa is discussed in section 2.3. The measurement of economic growth in previous studies is explained in section 2.4. The chapter ends with what needs to be studied more and what the intended contribution is of this thesis (section 2.5).

2.1. Transport corridor development in Africa

To explain corridors in Africa, it is necessary to discuss the current state of infrastructure needs in the context. Afterward, the definition of transport corridors is further examined to clarify what they are and how they are present in Africa. Infrastructure development needs to be discussed.

2.1.1. African infrastructure development

Africa suffers from a lack of investment and inadequate maintenance of its infrastructure, including roads, railways, waterways, and pipelines. This leads to high logistics costs and low transportation reliability. Although Africa has some of the fastest-growing economies, it has a history of under-investments, with currently 1% of the world's railways and a third of the rural population with access to paved roads (Thorn et al., 2022). To put this in perspective, 2.5 kilometers of railway is distributed per thousand square kilometers, whereas in Europe this is 50 kilometers per thousand square kilometers (Lamarque & Nugent, 2022). Additionally, railway density is unevenly distributed, as most railway networks are concentrated in Southern Africa. For road density, 3.4 kilometers can be allocated to approximately 1,000 people. This is far below the global average, and even reduced to one-fifth if only paved roads are considered (Lamarque & Nugent, 2022). However, the population is predicted to grow by 60% from 2025 to 2060, making the continent interesting for foreign investment, opening significant opportunities for economic growth (IMF, 2025). The African Union estimated that an annual investment of $ 93 billion US dollars would be needed to cope with the transport demand resulting from this growth (Cervigni et al., 2022). Likewise, the AfCFTA emphasizes the need for improved connectivity, as without these upgrades, trade benefits could be missed (Corporation, 2024). At the same time, transport prices remain high, creating trade barriers, while efficient upgrades are lacking (Teravaninthorn & Raballand, 2008). To lower these costs, an integrated approach is employed under the new PIDA program, which runs until 2030, as opposed to the rehabilitation-only approach used prior to 2021. Under the new PIDA program, the infrastructure projects have a stronger focus on integration with trade facilities and complementary utilities (AU, 2020). An example is the addition of multiple one-stop border posts in East Africa, resulting in reduced travel times and cost savings for companies and households (Ayele et al., 2023). In recent decades, African infrastructure projects have often been targeted with corridor programs. In these programs, cross-border connections can be improved and the accessibility of landlocked countries can be increased (Lebrand, 2021). Examples of the corridor approach have been known since 1980, and since 2010, it has been further institutionalized as the main strategy of the

African Union (AUDANEPAD, 2023).

2.1.2. Transport corridors: definition, history, and Worldwide Phenomena

Corridor programs target large, spatial areas aimed at economic development by improving the transportation system (Alam et al., 2022). Therefore, these investments often target road or rail infrastructure, inland waterways, or pipelines, as well as improvements to port and airport connections. Investments can target outdated infrastructure and brownfield upgrades, but can also focus on the construction of new infrastructure. This can lead to an increase in transport commodities between industrial clusters, e.g., trucks and passenger freight (Quium, 2019). These projects are useful for national governments' economic strategies to increase national income and industrial sector exports (Keser, 2015). The transport corridor can span over a large geographic scope targeting multiple regions or countries (Bignoli et al., 2024).

The transport corridor is often referred to in scientific literature as a first manifestation of what later becomes a development corridor. Firstly, the transport corridors are focusing on substantial investments that cover the physical infrastructure being built. Next installments of the corridors can include programming multiple societal and economic objectives, clustering logistics and market integration linked to national spatial development initiatives (Bignoli et al., 2024). The corridor evolves into a development corridor by incorporating these objectives, resulting in a broader economic impact. The transport corridors can be viewed within the context of a network where several corridor programs exist, each with distinct characteristics in terms of scale, transport modes used, and price and service quality (Lamarque & Nugent, 2022).

The transport corridor has been a worldwide phenomenon during the last centuries, fostering strategic connections to expand trade, power, and territorial integration. During the 19th century, railways and canals served as transportation corridors that facilitated industrialization (Jedwab & Moradi, 2016). These corridors were complemented by institutional innovations in customs authorities and the establishment of new government bodies. Examples are British Railways located in India and the Chinese Silk Road Economic Belt (Nedopil, 2025). These projects were instruments to enhance geopolitical power and economic development in the areas.

2.1.3. Corridor investments in Africa

In Africa, the first large-scale road and rail initiatives were initiated due to its colonial heritage. The main function of these projects was to transport raw materials from inland to ports. These old colonial routes can be found in Western and Eastern African countries, serving inland mining excavation (Lamarque & Nugent, 2022). Over the last decades, these routes have seen several reconstructions. They have been targeted in development corridor projects, which involve redeveloping outdated infrastructure connections, with a new focus on regional integration, in addition to the extractive export of raw materials (Jedwab & Moradi, 2016). Examples of these projects are the Maputo Development Corridor and the reconstruction of the Tanzania-Zambia Railway (Lamarque & Nugent, 2022). The former colonial routes were not necessarily built to foster inland connections between countries, as their primary target was to ease transportation in the colonizer's area of influence. Since colonizers mostly operated within their own areas and did not cooperate with other colonizers, there was little need for larger-scale connections between African countries (Calderón et al., 2008). Recent corridors focus more on these connections over a larger geographic scope. An example of this is the Trans-African Highway network, which spans over the entire continent.

African examples of transport corridors include, for example, the Central Corridor and the Northern Corridor in Eastern Africa. These are large-scale projects that involve multi-modal surface transport, incorporating roads, rail, and waterways (Imaniranzi, 2025). They span over multiple countries and came into being through multilateral agreements (Rweyendela, 2024). The target of these projects is to ease cross-border trade flows and multilateral cooperation (Bignoli et al., 2024). These are examples of further mature transport corridors, i.e., development corridors, with multiple programs designed to enhance market access. Other examples of corridors in Africa are the several instances of the Trans-African highways. These are long roads spanning various African countries and are not all associated with additional programs for economic development; however, following the definition, they are consid-

ered transport corridors.

The implementation of transport corridor programs in Africa typically involves a wide range of organizations, often involving a mix of multiple national governments, international organizations, and international partnerships (Bignoli et al., 2024). The governance structure can vary, ranging from designated corridor authorities to public-private platforms, such as the Walvis Bay Corridor Group. These structures provide monitoring, coordination, and stakeholder management. Funding of projects often occurs in a hybrid form, combining budgets from national governments and development banks with bilateral loans and investments. The role of the state in many African cases differs from that in other continents. The corridors in Africa have a significant presence of the private sector, as there has been a shift from state capital to private capital, following neoliberal strategies (Lamarque & Nugent, 2022). This has led to increased foreign investments in the 2000s. Unilateral investments often lead to increases in the national debt. According to the World Bank, the average public debt increased from 40% to 59% of GDP. Of the overall debt, 20% is attributed to China (Lamarque & Nugent, 2022).

Two major banks active in Africa are the World Bank and the African Development Bank. During the last decades, the Chinese Investment Bank has provided several large loans to transport corridor projects in Africa as part of the Belt and Road Initiative (BRI) (Chai & Tang, 2023). Other notable investments are made by the EU (Global Gateway) and the G7 (Partnership for Global Infrastructure). Construction of the physical infrastructure is often done by private African companies. Corridor programs also encompass last-mile connections and procedures to ease trade and customs processes at borders. These examples of soft investments are associated with improved reliability, trade connections, and inclusive economic impacts (Enns, 2018).

2.2. How transport corridors enable economic development

Transport corridors can be associated with economic development in their surrounding areas. This economic development can be characterized by an increase in economic activities, including growth in job opportunities, new trade flows, and higher incomes (Krantz, n.d.). Firstly, transport corridors aim to reduce travel times and friction. The first effect is that markets become more accessible: firms and households are brought closer together. In the long run, this change in accessibility needs to create a new equilibrium where markets cluster. This is called the agglomeration effect. Both mechanisms will be discussed in this part. In addition to market access and agglomeration effects, the corridors can have a significant impact on ecology and society beyond economic development. This will be reviewed as well.

2.2.1. Improved market access

An impact of transport corridors is to ease access to markets. When infrastructure projects are specifically targeting road and rail connections, it is possible for firms and households to reach destinations in a shorter period of time at lower costs. Improved connectivity enlarges the effective size of markets, allowing producers to reach consumers who were previously inaccessible due to logistical constraints (Melecky et al., 2018). For agricultural producers in particular, corridors facilitate a shift from subsistence farming to more commercially oriented production, as surplus output can be reliably delivered to urban centers and export markets (Jedwab & Moradi, 2016). Last-mile connections are therefore crucial: when new roads and railways are built through the region, the necessary infrastructure must be in place to connect these markets with the roads and rails (Lebrand, 2021). The distance from the infrastructure to the markets is therefore crucial in enabling the markets and their structure. When the markets are concentrated in densely populated areas, it is easier to mobilize them: a larger population results in larger market demands for the customer side. On the consumer side, increased competition and lower transaction costs often result in lower prices and more diverse product offerings (Storeygard, 2016). Another factor that could increase customers' demand is investment in ports. Ports with larger outputs can meet the demands of countries worldwide, which often require foreign products. The other way around, products from foreign countries can be shipped to the port, leading to variations in products and new market demands (UNCTAD, 2024).

In Africa, the market structures will be denser over time. Currently, Africa has the highest urbanization

rate among all regions worldwide (AU, 2024). This reduces economic distances and opens up possibilities for new markets to become competitive. Still, the distances from markets to infrastructure such as road, rails, or ports are much larger compared to other continents. These distances are located 13 % further than the world's average and even 50 % compared to Europe (Lamarque & Nugent, 2022). This large economic distance has to do with described situation in section 2.1 where the road and rail density is much lower compared to other continents.

2.2.2. Agglomeration effect

Transport corridors also contribute to the formation of agglomeration effects, whereby economic activity clusters around hubs of improved connectivity (Rosenthal & Strange, 2004). This can be triggered by improved market access, as lower transport costs expand local demand and increase supplier reach. The result is that firms start to share inputs, leading to thicker labor markets where workers share knowledge and can be employed more efficiently (Duranton & Puga, 2003). The expansion of markets results in a demand for workers, which can mobilize them to cluster in the same economic zones. In the short run, corridors can enable this anticipation, leading to reallocation of firms (Faber, 2014). Over the longer run, improved market access leads to advantages through self-reinforcing dynamics: the denser market structure raises productivity and wages, attracting more firms and workers and increasing land values (Redding & Turner, 2015). In developing country settings, this mechanism is visible in decades-long shifts of population and economic activity toward cities with improved road or rail access (Donaldson, 2018).

Therefore, the pre-existence of roads and rails leads to path-dependent economic development along these routes. In developing countries, historical routes are often the regions where economic activity is clustered. Evidence of economic growth along historical routes has been found in China, where brownfield investments of these routes are associated with most development (A. Banerjee et al., 2020). Greenfield projects are more related to the full marginal accessibility effects between places that were not initially connected. Therefore, large-scale economic development around greenfield projects could take much longer because no initial economic baseline exists. In China, the effects of the highway network that has been developed improve the economy, resulting in reallocation of firms and economic activities (P. Banerjee, 2017). It shows agglomeration effects spanning over multiple decades (Faber, 2014). Evidence from other areas illustrates how corridors have supported industrial development and urbanization. For example, the Delhi–Mumbai Industrial Corridor in India has fostered industrial clustering and increased foreign investment inflows (Williams et al., 2023). Firms relocated closer to the roads of the corridor. The result was that more workers were needed, who moved toward the region. The investments in former colonial rail networks in India are strongly related to the increasing incomes over multiple decades (Donaldson, 2018). Already, an initial economic baseline existed in those areas. The upgrades improved the connectivity, triggering this economic baseline. Similarly, rail networks in Europe are associated with the same effect, where regional innovation is clustered and labor mobility increased, resulting in agglomeration (Vickerman, 2018). There is, however, a risk that agglomeration effects may lead to the impoverishment of rural areas. Although the average impact could lead to positive economic development over the full area, it becomes easier for people and capital to move from rural areas to urbanized areas (A. Banerjee et al., 2020).

The impact of transport corridors can extend far beyond the targeted area. Additionally, effects that were not accounted for in the first place could manifest as external effects of the corridors. Literature often describes spillover effects related to infrastructure, which is an impact that extends beyond directly connected hubs into areas further away through deeper supply chains, new labor mobility, or lower transport prices. Because of these effects, the impact of the corridors can extend far beyond the initially targeted areas for investment. An example is India's Golden Quadrilateral highway upgrades, which increased access to manufacturing and productivity, not only on the corridor but also in nearby districts that gained easier access to hubs (Ghani et al., 2014). Spillover effects are often considered external effects of the projects and are, therefore, unplanned. Additionally, not all effects on the reallocation of rural populations due to the new Chinese highway infrastructure were initially expected (Faber, 2014).

2.2.3. Complementary investments

Whether transport corridors lead to economic impact can be related to much more complementary channels that trigger development. The hard infrastructure could be a strong trigger for new markets, but trade is also facilitated through trade unions, multilateral collaborations, and other investments that can ease the trade process. Additionally, the unwanted effects of corridors can be mitigated in this way. Negative externalities can concern ecological impacts. Improved access could lead to opportunities in illegal wood logging, deforestation around feeder roads, or could add to the global emissions of greenhouse gases (Laurance et al., 2014). Additionally, determining the best ways to implement corridors based on governance, project execution, and maintenance is also related to the economic reach of the investments. The World Bank mentions multiple complementary investments alongside hard infrastructure to facilitate broader economic development. This could target investments in electricity networks or measures to involve rural populations in the corridor process (Enns, 2018) (Bignoli et al., 2024). The literature presents numerous best practices and frameworks for sustainable corridor development, which are not discussed in this review; however, the key mechanisms for development are largely discussed and mentioned at this point.

2.3. Factors for economic development around African corridors

The ways that corridors have triggered economic development could be possible in Africa as well. This part of the literature review will discuss in more detail what factors are playing a role to enable this development. A closer look to the differences with other countries and continents is added. In Africa, corridors within the context of a development program is often raised as a best practice to induce wider benefits. But also the geographic context and the differences between types of infrastructure influence how economic development is enabled.

2.3.1. Corridors as a development program

Comparable studies of corridors are mostly based on projects undertaken by international organizations, such as the World Bank or the African Development Bank (Alam et al., 2022). For these projects, it is well-documented what type of assessment reports are used and which complementary projects are considered in combination with the physical infrastructure. Several studies suggest that soft investments can be as important as hard investments. When programs integrate customs policies, regulate markets, and establish corridor authorities adjacent to the actual constructions of the corridor, the economic impacts can be larger because trade is regulated more efficiently and supply chains can operate more deeply in areas surrounding the corridors (Lebrand, 2021).

The role of private investments is significant for African cases. The private investors have a strong influence on where and how the projects are built. Therefore, the objective of projects is closely related to the most optimal transportation of goods from A to B and less to the overall, local economic development. Furthermore, examples are known where private investments are used for prioritizing political objectives at the expense of evaluating technical and economic feasibility. The Addis Ababa-Djibouti Railway, commissioned in 2018, has faced major operational and technical challenges. Additionally, markets were not well-reached because last-mile connectivity was not adequately considered (Lamarque & Nugent, 2022). The investment was implemented too hastily and was not located in areas with the necessary requirements for strong market connections. The outcomes of the investments seem to differ between private and foreign investors, compared to international development institutes. The projects selected by the World Bank are often integrated into larger development programs with complementary investments. The study of (Chai & Tang, 2023) compares projects of the World Bank with Chinese funded projects. It specifically mentions that Chinese-funded projects are more focused on the hard infrastructure and less on complementary investments. The results of the Chinese projects, however, are associated with more economic development, as expressed in nighttime lights. It acknowledges that hard infrastructure can lead to a faster economic response and that projects from the World Bank may take longer to have a significant impact on wider regional development.

2.3.2. Geographic setting

Africa has a diverse landscape with the Sahara Desert and rainforests. Distances between economic clusters and populations can cover extremely long distances. Therefore, when corridors are upgraded,

these distances remain obstacles to trade between clusters (ICA, 2009). Road networks and railway networks are often upgraded from old colonial networks. According to Chinese evidence, economic development tends to follow these historical routes (A. Banerjee et al., 2020). These routes would not necessarily lead to the most development, as they were built primarily for the economic benefits of the colonizers and were not strategically located to benefit the population. The ideal road network in Africa would look different (Krantz, n.d.). The colonial infrastructure projects had the primary objective of connecting the ports to the land and mines for the transportation of minerals. Populations inland could benefit from improved port connections, as markets can serve demand from international trade. The other way around, the goods that come into the ports can serve the demand from the population. Africa has 16 landlocked countries that are not directly linked to ports. Other countries, such as the Democratic Republic of the Congo, are almost completely landlocked (Lamarque & Nugent, 2022). Being landlocked has great consequences for logistic costs and supply chain reliability (Frederic et al., 2021). These countries could largely benefit from transport corridors. Projects with a large geographic scope spanning multiple countries could have a positive impact on economic development (Alam et al., 2022). As discussed in subsection 2.3.1, to unlock this cross-border development, complementary programs on customs and transnational trade are key.

It is tempting to extrapolate the scientific research on the discussed agglomeration effects in China and India to the African context. Over the last few decades, they have been transforming from developing countries to developed countries, and they have a history of being subject to foreign imperialism. African economic development closely follows the patterns of colonial roads and rails (Jedwab et al., 2017), similar to India and China; however, some nuances need to be added to this comparison. The most obvious difference, namely that Africa is a continent, calls for cooperation among countries and forms of multilateral governance. Africa has a supranational political union, similar to the European Union, known as the African Union, which fosters cooperation. A part of the Union is the African Continental Free Trade Area (AfCFTA) that works on free-trade between the countries, but this is not at an integrated level as its European counterpart. 16 of the 55 African countries are landlocked, which is the highest number in the world, and they don't benefit enough from the free trade (Arvis et al., n.d.). Landlocked countries and large geographic distances between cities can hinder large-scale economic development. Research of Storeygard, 2016 found that most economic development enabled by oil price increases between 2002 and 2008 concentrated to cities close to ports. People are expected to move to such urban areas when increased market accessibility has led to new economic opportunities (Jedwab et al., 2017). The transport corridors are associated with local shifts in economic activities; however, causal evidence of large-scale mobilization across Africa due to the corridors is limited. The strongest findings suggest distance-decay effects but effects on demographic mobilization are mostly heterogeneous (Storeygard, 2016). The study by (Jedwab & Storeygard, 2022) compares the market access of African infrastructures over a 30-year period. It found that market access is improved, but it does not give conclusions on the local effects of agglomeration as it follows a more network-focused approach.

In Africa, the urban and rural distribution differs from that of a continent like Europe, and countries such as India and China, with large cities closer to each other. Africa has fewer large cities and they are mostly located in coastal areas (OECD, 2020). Roads and railways that traverse Africa, connecting economic nodes, pass through rural areas with low populations and cross landscapes such as savannas, deserts, or forests. The long distances between the economic nodes prevent starting an economic demand and supply chain because decent infrastructure is lacking, and transportation costs would be high. This effect is larger in landlocked countries than in coastal countries. It makes it difficult for rural areas to develop economically at the same rate as other urbanized regions. However, this will change because, as explained in subsection 2.1.1, the population in Africa is growing and experiences the fastest urbanization growth rate of the world.

2.3.3. Characteristics of infrastructure

Roads generally lead to higher connectivity in the last miles because more routes can be directly connected, whereas railways require additional stops (Laurance et al., 2014). Railways could be cheaper and more sustainable than roads: to users it could offer lower transportation costs when car-ownership is not needed, and car-emissions could be prevented. Lamarque and Nugent, 2022 mentions two fun-

damental reasons why, in Africa, railways are less desired. First, the fixed costs are really high for rails. As most financial constructions in Africa are based on loans, the increase in debt is passed on to railway users, resulting in higher ticket prices. Secondly, the road and railway discussion is strongly political, where politicians tend to prefer trucking over roads. Both investments in roads, rails, and waterways could lead to economic development. In Africa, they often are combined when full development corridor programs target large areas, resulting in varying impacts and trade-offs (Roberts et al., 2020). Roads can enhance last-mile connectivity for freight, facilitating easier trade. Brownfield could improve this connectivity as well, whereas greenfield investments could open new markets because new connections are made (Jedwab & Storeygard, 2022).

2.4. How economic impact is quantified

Studies by the World Bank aim to measure the impact by using the concept of wider economic benefits (WEBs). Melecky et al., 2018 states that WEBs go beyond savings in travel time and operating costs, and that they ensure market access that exploits both small and big companies. The WEBs refer to effects such as increased access to education or jobs. Therefore, WEBs can be measured using indicators such as wages, consumption, or employment rates, and can also encompass equity or ecological indicators (Roberts et al., 2020).

An indicator that is often used to capture economic effects or WEBs in scientific research is nightlight level development. Because the emitted light during night is associated with human-designed electrified constructions, it is assumed that the intensity of a pixel, representing how strong the nightlight level is at a given area, effectively reflects the level of economic activity (Alam et al., 2022). Nightlight level closely aligns with indicators of economic development. Examples are known of strong correlations with GDP per capita (Chang et al., 2020) and spatial clustering (Henderson et al., 2012), as well as GDP (Roberts et al., 2020). Whereas in developing countries, nighttime light development could indicate reallocation of populations and agglomeration effects, in Africa, this is not necessarily the case. Compared to other continents, Africa has far fewer people who are connected to electricity grids. Therefore, when an increase in nighttime light is indicated, it does not immediately mean that persons are moving, but that the already existing population starts to economically develop.

Another way to capture economic development is by mapping the change in land use and land cover (LULC change) around transport corridors. An example is the paper by (Navalkar et al., 2023), which shows how railways led to a decrease in agricultural land cover and an increase in industrial space. The method provides explanatory insights into how economic change influences other land use. Therefore, it focuses more on the ecological aspects of WEBs. This method is also useful to explain economic effects on smaller scales. In cities, it can be used to capture land use and land cover change with new transit developments (Yildirim & Akin, 2023).

2.5. Research gaps and contribution

The current studies of African transport corridors are mostly case studies and limited to specific examples. Also, the few studies that cover multiple corridors mostly discover heterogeneous effects. Firstly, there is a lack of convincing evidence on whether economic development in Africa is caused by these corridor investments. It can take a considerable amount of time before the effects of the corridors lead to economic development. Most studies examine the effects up to 5 years; however, in the long run, it is unknown how regions surrounding corridors develop. Investments in roads and railways could trigger market access and agglomeration effects, but because the average distance from roads to markets is higher in Africa compared to other regions, and because Africa has larger distances between urban areas, large transport corridor projects might not lead to promising economic development as was the case in other regions.

If local markets are not easily accessible and trade between economic clusters is difficult to unlock, the population will not directly benefit from new transport corridors that span long distances to connect economic clusters. Therefore, this research intends to find evidence whether these large, transport corridors have proven to trigger economic development. This could be the case for urban areas, but also in rural areas where not much initial economic development exists, it could be an interesting take

to see whether economic activity is created by the corridors. Than the next question would be if other types of investment would be more suitable to trigger development. Therefore, this research aims to find evidence if transport corridors have a wide effect on the economic development of the surrounding areas, and tries to formulate in what settings the corridors will have a notable effect on economic development.

3

Methods and data

This chapter contains the methods that are employed to answer the research questions and explains what data is used. section 3.1 discusses the approach of this research and why it is a logical strategy to properly address the research questions. section 3.2 discusses the modeling approach. The data that is used is discussed in section 3.3.

3.1. Research strategy

This thesis aims to indicate whether investments in transport corridors in Africa lead to economic development. The transport corridor could lead to new economic opportunities and changes in demographics in the long term (Storeygard, 2016) (Faber, 2014). To research this, a quantitative approach is maintained where the economic development is expressed in numerical data. The economic impact of corridors over long periods can also be assessed using qualitative data. Typical examples include conducting interviews or surveys to capture perspectives on the relationship between investments and their economic impact. However, this would not lead to strong conclusions on the magnitude of the effect, as no numerical evidence would accompany the claims. Economic development is measured using a proxy indicator that can be observed along the corridors. To compare affected and unaffected areas of the corridors, a difference-in-differences approach is followed.

3.1.1. A proxy indicator for economic development

The proxy indicator is nighttime light data. This data is worldwide available for every year (Chen et al., 2024) (Li et al., 2020) and strongly correlates with economic indicators such as wealth indices (Jhamb et al., 2025) or GDP (Ivan et al., 2020). The theory for this is that increasing nighttime lights indicate growing access to electricity for households and growing industrialization (Alam et al., 2022). This can be related to the theories of market access and agglomeration effects of the transport corridors: when the nighttime lights around corridor routes are measured over the years, it is possible to see where and when the agglomeration effect as expressed in nighttime lights occurred. Whether nighttime light data is a good indicator for development in developing countries is still subject to inconclusive debate. The study of Pérez-Sindín et al., 2021 tested nighttime lights and the relation with the Gross Domestic Product, Regional Domestic Product, and the Global Urban Footprint. Tested on different population sizes in Colombia, they showed strong correlations and concluded that the indicator is valuable to estimate economic patterns. In rural areas, however, the correlation with economic activity is less strong, which is also suggested by World Bank research (Jhamb et al., 2025). This has to do with rural, often agricultural, activities that do not directly lead to more nighttime lights and have less reliable access to electricity (Mellander et al., 2015). Because Africa has a lot of rural areas, it is possible that increased agricultural activities are not properly captured with nighttime lights. On the other hand, when nighttime light development in rural Africa is indicated, it could indicate economic growth and diversification of the economic activities that are taken place. To account for differences in economic activities in Africa, this research indicates both rural and urban areas. A way to overcome the rural-

urban difference is to look at land use and land cover change (LULC). This is possible with satellite imagery (Navalkar et al., 2023). In that case, the areas around the corridors can be divided in land use types and distinguish between agricultural land and industrial land use. This could be an interesting next step to explain why the nighttime light developments around the corridors.

3.1.2. Difference-in-differences

When economic development is measured using nighttime lights, an analysis needs to be conducted to determine whether the development can be attributed to the impact of transport corridor investment. To do this, a difference-in-differences approach is employed. The idea is that two areas are measured: a treatment area and a control area. In this research, the treatment area refers to the area targeted by the corridor investment, while the control area is the unaffected area. The areas need to share similar characteristics and parallel trends over time, but differ in infrastructure investments. When the nighttime lights in both areas are measured, but the only difference is the corridor investment, the development can be attributed to the investments and considered as the economic impact of the corridor. The difference-in-differences approach uses an event-year: in this context, the year that a corridor is constructed. By comparing the trend in nighttime light development before and after the event, the break in the trend after the event between the treatment and control areas can be attributed to the corridor. To test if the trend is parallel in the pre-event years, an event study is done. The average trend over all corridors is calculated to check whether the development pre-event follows the same pattern. The event study can also provide insight into corridor dynamics, such as anticipation effects and the impact once corridors become operational.

In the analysis, corridors constructed between 2003 and 2013 are considered. With this time frame, for every project, there are at least 10 years after the event. This way, long-run economic effects can be captured. Choosing projects before 2003 would not yield enough pre-event years, as accurate satellite imagery became unavailable around 1993 (Chen et al., 2024). 10 years would be enough to estimate pre-event trends.

For every corridor, a treatment area of 10 kilometers is selected on both sides of the route. This captures the direct, local effect of the corridor. The control has multiple specifications based on the distance to the corridor route. The effects of transport infrastructure can reach up to 100 kilometers (Graham, 2007). Therefore, control areas are tested up to 200 kilometers to ensure that no direct effect is expected over the long term of the corridors in the control areas. Difference-in-differences is a commonly used method to measure the impact of infrastructure. The same approach is used in the study by Alam et al. (2022), which utilizes control areas located on both sides of a corridor route, at a distance of 80 to 100 kilometers.

Part of the research involves finding answers to whether different characteristics of corridor investments lead to differences in economic development. To do this, the corridor routes are divided into segments of 50 kilometers. By doing this, parts of the corridor can be characterized. For example, some parts of the corridor are located in densely populated areas, whereas others are not. The different parts can now be compared to see if the nighttime light development is different. Segmenting also creates a bigger sample. When there are not enough corridor projects available, it becomes difficult to find sufficient variation to test characteristics such as road or rail differences. By dividing into parts of 50 kilometers, the analysis is no longer directly at the corridor level, but rather at the 50-kilometer infrastructure level. The disadvantage is that the segments are next to each other and are not standalone projects: they are affected within the context of a corridor. However, this is a common method for testing heterogeneity within the corridor sample. The 50-kilometer distance is based on the study by Laurance et al., 2015, but it is possible that outcomes might change slightly for other distances (Faber, 2014). This research will not do robustness tests on different segment sizes, but it could be an interesting addition.

3.1.3. Step-by-step approach

The overall strategy can be divided into four sequential steps. For the first tests, multiple control areas are tested for parallel trends and the spatial reach of corridor effects. The testing tells a lot about the corridor effect, but is also a type of robustness testing: from these analyses, a suitable control area

can be indicated. The control area is used for calculating the nighttime light developments.

1. *Test parallel trends with event study*
   To test the causal effect between transport corridors and economic impact, an event study is done for different specifications of the control areas. The trend line shows the relative growth difference between the treatment and control areas. It can be used to test whether ,before the construction of the corridor, the treatment and control had the same relation in nighttime light development. The event study shows a line representing the trend, which also explains how the development in the treatment area behaves over time.

2. *Test spatial reach of corridors*
   To test how far the effects of the corridors reach, different specifications of the control areas are tested with an average DiD-estimate over all corridors. It could be expected that areas closer to the corridor also benefit from the corridor. When the area closer to the corridor has a lower average DiD-estimate compared to areas further away, this effect can be indicated.

3. *Calculate corridor DiD-estimates*
   A control area is selected and the DiD-estimates are calculated for each corridors. The corridors are compared based on how large the DiD-effect is.

4. *Calculate DiD-estimates for project characteristics* The corridors are divided into segments of 50 kilometers. DiD-estimates are calculated over all segments. The result is that DiD-estimates can be attributed to segments with certain characteristics. This leads to associations of each characteristic with a magnitude in nighttime light development, which could explain heterogeneous effects in the corridor sample. The segments are divided and tested over 3 samples, namely, the full sample, a rural-segments-only sample, and an urban-segments-only sample.

3.2. Empirical strategy

This section of the method outlines the empirical strategy of the research. It involves specifying the regression models used in the difference-in-differences modeling. It models are implemented in Python to process the calculations. The specification of this code is shown in Appendix B.

3.2.1. Regression models

The difference-in-differences approach is a comparison between two regions: the treatment region and the control region. The regions can be specified by creating grids in QGIS that follow the corridor routes. The grids are a set of cells of 5 by 5 kilometers. A grid of 10 kilometers on both sides of the corridor routes is the treatment area, and the control areas are grids from 20 to 50, 50 to 80, 80 to 110, 110 to 140, 140 to 170, and 170 to 200 kilometers.

For each cell, the sum of light (SOL), i.e., the sum of the pixel values of the nighttime lights on the grid cell, is calculated. The logarithm of 1 + SOL is used because the value distribution of nighttime light has many zero values and a significant number of outlier values, resulting in a right-skewed distribution. The logarithm provides a more uniform distribution over the residuals, thereby reducing outlier sensitivity. Let i be a cell and t be the year, then the outcome would be as follows:

$$y_{it} = ln(1 + SOL_{it}) \tag{3.1}$$

Every cell is linked to a corridor or segment and an event-year, indicating when construction started. A binary indicator for the post-event-years (=1 when year > event-year), is used for the difference-in-differences-regressor group x post (DiD-regressor). With the regressor and y_{it}, a Two-Way Fixed-Effect regression formula is created. Because the data can be structured in a wide-format panel for cells and years, it is possible to estimate fixed effects. In the model, time-invariant differences and yearly shocks are captured across the grid cells through these effects. By indicating these effects, the bias of unobserved constant factors is removed. This is valuable for the robustness of the analysis as it overcomes problematic shocks that could lead to spontaneous changes in nighttime light development. Reasons this could happen, including, for example, the COVID-19 pandemic or natural disasters. For each corridor, given a cell i and year t, the equation would be as follows:

$$y_{it} = \alpha_i + \tau_t + \beta(g_i \cdot post_{it}) + \epsilon_{it} \tag{3.2}$$

Let α_i be the fixed effect over the grid cells and τ_t the fixed effect for the years. $g_i \in \{0,1\}$ is 1 if a cell belongs to treatment and 0 if it belongs to control. $post_{it} \in \{0,1\}$ is 1 if cell i in year t is after the start of construction of the project. ϵ_{it} is an error term. The difference-in-differences coefficient β is the estimate on the DiD-regressor, measuring how the nighttime light intensity in treated cells developed faster than the control cells, next to the fixed differences in cell and year trends.

To test how the project characteristics are associated with the difference-in-differences coefficients, a pooled TWFE model is estimated. In this model, the corridors are divided in segments of 50 kilometers and added in one regression instead of separate regressions. The result is that the parts of the corridors become comparable where the characteristics can be related to DiD-estimations. Let s be a segment, i a grid cell, t the year, and k a characteristic in the set $k \in K$, than the following equation can be formulated:

$$y_{sit} = \alpha_{si} + \tau_t + \beta(g_s \cdot post_{st}) + \sum_{k \in K} \gamma_k (g_s \cdot post_{sit} \cdot Z_s^k) + \epsilon_{sit} \tag{3.3}$$

This model estimates DiD-coefficients as well for each segment, and interacts the effects with $g_i \cdot post_{it}$ and Z_s^k. $Z_s^k \in \{0,1\}$ is 1 if a segment s has characteristic k, and 0 when this is not the case. This model accounts for fixed effects as well. This model estimates a baseline DiD-effect for which all characteristics have the value 0, i.e., segments that don't share any of the characteristics (thus, all $k \in K$ are 0). Difference-in-differences literature refers to this baseline effect as the Average Treatment effect on the Treated (ATT). The γ_k is the effect above the ATT. Thus, for every characteristic k, an additional DiD-coefficient γ_k is estimated as the average over all segments in the sample. With these estimates, it is possible to calculate the average nighttime light impacts associated with the corridor segments that have a certain combination of characteristics $k \in K$.

The β and the γ_k are estimated on a logarithmic scale because of the specification of y_{it}. To make the coefficients easier to interpret, they are converted to percentages. For β this is done with $(e^{\beta}-1)\cdot 100\%$. For γ_k this is done with $(e^{\sum \gamma_k} - 1) \cdot 100\%$. The β is also expressed as an equivalent annual rate: the yearly rate of the DiD-coefficient for every post-event year. Because the corridors have different post-event years, the corridor effects become more comparable. The equivalent annual rate is calculated as $(e^{\beta / n_{post}} - 1) \cdot 100\%$ with n_{post} being the number of post-event years. Note that this is a summary measure under constant compounding; it does not imply that the treatment effect actually grew at a constant rate each year.

3.2.2. Event study and spatial reach

To test the parallel trends and the spatial reach of the corridors, the pooled variant of the TWFE model is used over the corridor sample. The objective for these analyses is not to test for heterogeneous effects for each corridor in the sample, but to indicate average effects over the full sample, namely, for the parallel trends and for the effect of the control area specifications. The pooled model puts all corridors in one sample and calculates an ATT, which is a representation of the average effect over all corridors. Let c be the corridor, i a cell, and t the year, then the equation would be as follows:

$$y_{cit} = \alpha_{ci} + \tau_t + \beta(g_c \cdot post_{cit}) + \epsilon_{cit} \tag{3.4}$$

The event study calculates the annual ATT for every year k. k is the event year, indicating the start of the corridor construction. The event year k is different for every corridor, which means that k is not a fixed year. The ATT is the average difference between the treatment and the control area over all corridors in the sample. This difference is calculated between the year k and the year k - 1, leading to the estimation below:

$$\mathrm{ATT}_k = \left(\overline{y}_{T,k} - \overline{y}_{T,k-1}\right) - \left(\overline{y}_{C,k} - \overline{y}_{C,k-1}\right) \tag{3.5}$$

$\overline{y}_{T,k}$ is the annual outcome expressed in nighttime light for the treatment cells T in year k, and $\overline{y}_{C,k-1}$ is the annual outcome for the control cells C in year k. The ATT is calculated for the pre-event years before k, and the post-event years after k, resulting in a trend-line with annual development of the ATT. Because $y_{it} = ln(1 + SOL)$, the ATT is also estimated as a log-coefficient and therefore converted to a percentage for easier interpretation.

The ATT for testing the spatial reach of the corridors is tested the same way. The average difference of the treatment and control areas is calculated, yet not based on event year k, but based the full post-event period and after-event period. Therefore, the ATT is calculated as formulated below:

$$\text{ATT} = \left(\overline{y}_{T,\text{post}} - \overline{y}_{T,\text{pre}}\right) - \left(\overline{y}_{C,\text{post}} - \overline{y}_{C,\text{pre}}\right) \tag{3.6}$$

3.3. Data collection and processing

This part of the chapter discusses the data that is used in the difference-in-differences modeling. In subsection 3.3.1, the process of selecting African corridors is described. subsection 3.3.2 explains how the characteristics of each corridor are mapped and processed. The data source of the nighttime light data is mentioned in subsection 3.3.3.

3.3.1. Selecting corridor routes and areas

An overview of all transport (development) corridor projects in Africa can be found in the Development Corridor Database of (Thorn et al., 2022). All existing and planned corridor investments are compiled, and data on the various corridors is collected. The routes can be of 3 types of infrastructure: roads, railways, and pipelines. The projects are only included when they have a clear link with the corresponding corridor program. Thus, international roads, as part of a corridor strategy, are included; however, standalone airport projects unrelated to corridor strategies are not included. The database contains several characteristics of the corridor investments, in addition to their infrastructure type, including investors, launch year, geographic scope, and investment costs. The database has been utilized in various applications, including policy analysis of protected areas by the African Knowledge Platform (AKP, 2023). Peer-reviewed, scientific literature referenced the dataset in a broader evaluation of global infrastructure (Simkins et al., 2023). The database also covers hubs in development corridors. These include, for example, ports, airports, and industrial hubs. Examples of billion-dollar investments are well-known and can have a significant impact on various areas. However, this research focuses solely on roads and railways, as the research strategy enables the comparison of large, spatial areas to capture economic impacts from comparable projects. For the same reason, inland waterways and pipelines are also excluded because insufficient information on these projects is available in the database to make them comparable.

In the database, not all launch years of the investments correspond with the actual start of construction and the commissioning. Therefore, additional data is collected to indicate on every route where and when construction happened. Various data sources have been used to obtain the data, such as World Bank reports and the African Union reports. Along the corridor routes, other major investments outside the scope of the World Bank have been completed during this time period by foreign investments from countries such as Germany, Japan, and, in particular, China. Projects with corresponding routes of the Chinese investment bank can be obtained from AIDDATA. An overview of the data sources of each project can be found in Appendix C. Only projects with routes longer than 100 kilometers of new construction have been selected. With this search criteria, it is easier to narrow down the selection along the corridor routes in the database. The selection process is shown in the figure below. Figure 3.1a shows all corridors in the database. The figure in the middle shows the corridors with construction between 2003 and 2013 that are analyzed. Figure 3.1c shows the routes in segments of 50 kilometers.

(a) All corridors (b) Selected corridors (c) Corridor segments

The areas close to the corridors and the areas further away are created in QGIS. This is achieved by spanning a grid over Africa with cells of 5 km by 5 km. This grid is placed over buffers next to the corridors. A buffer of 10 kilometers on both sides of the route is used as the area directly targeted by the investments. Buffers further away have been created on 20-50, 50-80, 80-110, 110-140, 140-170, and 170-200 kilometer distances. Cells that overlap with oceans or lakes are removed from the analysis. An example of these areas is shown in Figure 3.2. The red cells follow the route of one of the corridors in the analysis as part of the treatment area, and the orange cells follow the area that is unaffected by the investment as part of the control area.

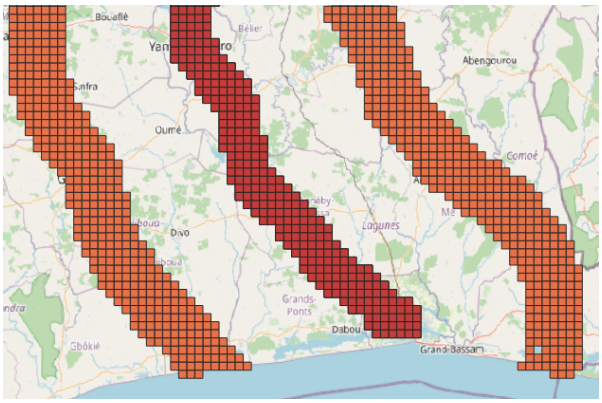


Figure 3.2: Treatment and control areas

3.3.2. Indicating project characteristics and geographic context

To test the effect of varying characteristics of the corridors, a novel dataset is created with the selected corridors and their characteristics. The dataset contains the segments of the corridors and the characteristics represented with dummy coding. For every segment, whether a characteristic is true or untrue is based on binary coding, where 1 indicates true and 0 indicates untrue. For example, a segment can get the value 1 for road and 0 for not-road. The binary coding makes it possible to vary the characteristics in the pooled TWFE model (subsection 3.2.1). The characteristics of the infrastructure are derived from the project data obtained from the reports (Appendix C). The Development Corridor Database mentions project characteristics as well (Thorn et al., 2022). The data is about the type of investment, e.g., whether it is greenfield or brownfield, or whether the infrastructure is road or rail. Also, the involvement of an MDB is added as one of the characteristics.

The geographic context is also processed with dummy coding. An important geographic characteristic that could explain nighttime light development is whether a region is urban or rural. To make this distinction for regions where the corridors are located, the Global Human Settlement Layer developed by the European Union is used. The dataset uses satellite data and population counts of countries worldwide to build a map of the world that indicates the absolute number of people in a spatial unit. The spatial units are pixels with a resolution of 250m x 250m on a WGS84 projected grid. Typically,

the data is represented with 0 to 30 values, for which higher values indicate dense, urban populations and lower rural populations. Visually, values above 20 are bright white and below are black or grey, as shown in the picture. The data is available for a period from 1975 to 2030 (future years are based on extrapolated data). The data is available in time steps of 5 years. The rural and urban distinction is done with this separate dataset because it accurately displays how large populations are in certain regions. Other datasets, such as nighttime lights or Google Earth imagery, could be used as well, but some large African populations don't have much access to electricity, and Google Earth imagery is difficult to distinguish between rural and urban based on numerical data.

(a) Nile region

(b) Nile region settlements

Figure 3.3: GHSL settlements for the Nile region.

Another geographic characteristic is whether a segment of the corridor is located in a landlocked country or not. A landlocked country is a country that is completely surrounded by land and has, therefore, no connection with the coast. Landlocked countries in Africa are, e.g., Ethiopia, Zimbabwe, and Mali. Segments that are in both landlocked and non-landlocked countries are assigned to the country with the most kilometers of the segment.

3.3.3. Measuring economic development

The proxy indicator for economic development is nighttime light data based on DMSP and VIIRS satellites from (Chen et al., 2024). VIIRS has been used since 2012 and captures strong imagery of nighttime lights. Before 2012, DMSP satellite imagery was the common way of capturing this, but the global annual simulated VIIRS nighttime light dataset overcomes the differences between the satellites by harmonizing DMSP data between 1992 and 2013 to comparable VIIRS data with a U-Net super-resolution model (NTLSRU-Net). VIIRS data is less saturated than raw DMSP data and, therefore, can describe nighttime light more accurately. The data is projected on WGS84 based on a linear longitudinal – latitudinal grid of 15 arcseconds, i.e., 463 x 463 meters at the equator, which is the pixel area. The grid values are the radiances in nW cm(-2) sr(-1). This concerns positive values on a continuous scale. For illustration, typical values between 1 and 5 are small villages, 5 and 30 are urban zones, and larger values than 30 indicate strong nighttime light areas. For this last category, think of cities such as London or New York. This classification, however, is not hard cases but rather an indication of the scale values on the continuum.

Before 2023, the indicator needed to overcome the satellite differences manually with advanced normalization and harmonization techniques to make the data as comparable as possible. This data set removes this obstacle and makes research on nighttime light development more accessible because,

with limited means, the satellite data can be analyzed. No applications with the dataset testing large economic cases are available because the data became available in 2024. Therefore, this research is one of the first applications of this dataset. The raw data representing the nighttime lights is placed over the grids around the corridors. For every cell in the grid, the pixel values can be calculated. The outcome is an indicator of economic activity in the grid cell.

4

Results

The results of the research are discussed in this chapter. The economic development around the corridors is discussed in section 4.1. How the project characteristics are associated with the economic development, is explained in section 4.2.

4.1. Economic development around corridors

To capture the economic development of the corridors, the TWFE model is used, as explained in subsection 3.2.1. An event study is performed to test the trends in the treatment and control area in subsection 4.1.1. The spatial reach of the corridors is tested in subsection 4.1.2 by analyzing several specifications of the control areas. Afterward, the economic impact that is associated with the corridors is shown in subsection 4.1.3.

In the data processing, 21 infrastructure projects in Africa were selected with notable constructions between 2003 and 2013. In Table 4.1, the number of corridors in the sample is shown, together with counts of how many projects are in the set that are road, rail, greenfield, etc.

Table 4.1: Sample size corridor dataset

	Sample size
Corridors	21
Greenfield investment	6
Brownfield investment	15
Road project	15
Rail project	6
MDB involvement	9
No MDB involvement	12

4.1.1. Parallel trends of treatment and control areas

The event study is conducted to measure the difference between the treatment and control areas around the years of construction (i.e., around the event year). The objective is to indicate if a pre-trend exists and to measure the development post-trend after construction. The treatment area of the corridors is 10 kilometers on both sides of the corridors. Control areas around the treatment area could vary in nighttime light development. The treatment area could be in a region where an economic baseline already exists. This may be particularly true for brownfield projects. The economic baseline could span the closer control regions. The impact of the corridor could target these areas as well.

Figure 4.1 shows a visualization of the trend lines for the specifications of the control areas (the buffers). The full event study can be found in Appendix D. The x-axis shows the event time k, which is the event-year when the construction of the corridor started. The analysis is conducted for all corridors with varying event-years. Therefore, k is not a fixed year but represents multiple years depending on

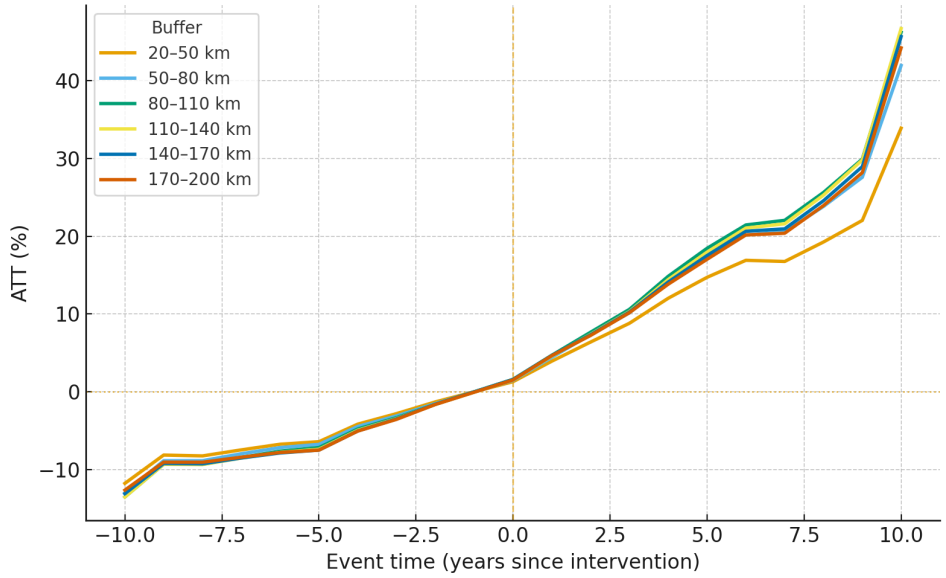


Figure 4.1: Event study

the corridor. The years before k indicate the period before the construction of the corridor, and the years after k the post-treatment years. The y-axis shows the difference between the treatment and control areas in year k. Therefore, the line illustrates the difference in nighttime lights between the treatment and control cells. In the study, the line represents the value of the ATT which is the Average Treatment Effect on the Treated: the average difference of the treatment and the control areas over all corridors in event-year k. The ATT is calculated on cell-level but weighted over all corridors such that every corridor has the same weight in the analysis. Otherwise, corridors that have more treatment cells would add more explanatory power than other corridors. To assume parallel trends, the line post-treatment, the years before k, need to approximate an ATT of zero. The graph shows before the construction of the projects (k<01) that the treatment group is running in on the control group. This indicates that there are no strict parallel trends between areas. In the figure this is clearly indicated because before the event-year (k<0), the ATT is not approximately 0. The pre-trend is significant for every ATT in the study (Appendix D). Consequently, the DiD-coefficients should be interpreted as associations of the corridor impacts rather than clean causal effects. They still document stronger post-intervention growth in treated areas relative to controls, but part of the effect may reflect pre-existing trends. The DiD-approach of Alam et al., 2022) did not account for pre-trends as well and emphasizes the results as associations of corridors. In the same spirit, the DiD coefficients in this research are best read as correlation patterns linked to the corridors, not as fully identified causal effects. Interestingly, all the specifications of the control area show a similar trend till k>0. This indicates that the areas around the corridor from 20 to 200 kilometers share the same economic characteristics that can be expressed in nighttime light. The only control area that changes after the event-year is the buffer from 20 to 50 kilometer. The most obvious explanation for this is that is benefits more from increased economic opportunities that could be associated with the corridors.

A deviation from the trend is seen 5 years before k when the slope of the pre-trends approximates the slope post-intervention. In that period, the faster development in the control areas follows a consistent trend. 5 years before the intervention, this difference in development between the groups becomes smaller. An explanation for this could be that the announcement of the infrastructure projects triggers anticipation effects. As soon as the projects launches and the funding or procurement is underway, activities on land can start years before the actual start of construction. Another explanation could be the investments are located in selected areas that are experiencing development. Targeting areas for investments that are already experiences economic development could be a valid reason to start new infrastructure projects because the new economic growth could result in a demand for roads or rails. Furthermore, the graph shows that at k>-1 the treatment areas have structural more nighttime light

development than the control area. From k>3 the slope becomes steeper which could indicate that at that point the projects are commissioned and the real effects start. The average commissioning of the projects is 4.5 years after the start of the construction. That the local development around the corridor is increasing 3 years after the event-year, can be explained because the first projects are commissioned. At k=6, the effect shortly slows down before growing again. An explanation could be that in the first years after commissioning, there are strong effects in economic opportunity, but this slows down a few years later. At k>8, the local development increases again. This is an indication that impacts of the corridor may take a while before they actually increase nighttime lights. It would take some time after commissioning to relocate firms and connect markets. The event study is not showing more years than 10 post-years: one project in the sample has 10 post-years only so after k>10 the trend-line follows an incomplete corridor sample.

4.1.2. Spatial reach of corridor effects

The economic development could be triggered when new infrastructure is built, and when markets become more easily accessible. Because transportation costs and travel times are lowered, firms expand their market reach, trade intensifies, and productivity rises through better matching of inputs and customers. Markets tend to cluster in industrial areas leading to agglomerations of industry. These mechanisms related to infrastructure can work through on large distances from the corridors (Jedwab & Moradi, 2016). The test measures how far the spatial effects of the corridors can reach, and the treatment areas are compared with different specifications of the control areas. The results are shown in Figure 4.2. The complete overview of all DiD-coefficients can be found in Appendix E. The size of the control areas is indicated on the x-axis, based on the size of the control buffers. Just as in the event study, the corridors are weighted on their treatment cells to prevent large corridors from being the main explanatory variable. Therefore, the ATT per buffer shows the average treatment effect compared to the control groups, for the average corridor.

The first two tested control areas, from 20 to 50 km and from 50 to 80 km, can still experience the effects of the corridor investments. Within this distance, markets can still be addressed (Rothengatter, 2017). The ATTs of these control areas show that the treatment areas develop respectively 23.2 and 27.9 percent faster than the corresponding control areas. The control areas show around 30 percent growth. The lower ATTs for buffers below 80 kilometers could indicate that the effects of the corridor work through up to that distance. When the corridors trigger economic development in the control areas closer to the treatment areas, the DiD-coefficients become smaller as the difference in economic trend is narrowed. The same effect is suggested in the event study for the control area at a distance of 20 to 50 kilometers. The difference between the pre-years and the post-years is smaller compared to buffers further away. In this graph, the control area at a distance of 50 to 80 kilometers has a lower value before the line becomes constant. This is not directly shown in the event study. This suggests that corridor effects may also have spillovers beyond 50 kilometers. The nighttime light development becomes larger at post-year k>8. The years further away than 10 post-years are not shown in the event study. It is possible that the 50 to 80 kilometer trend starts to deviate from the other control areas at that point.

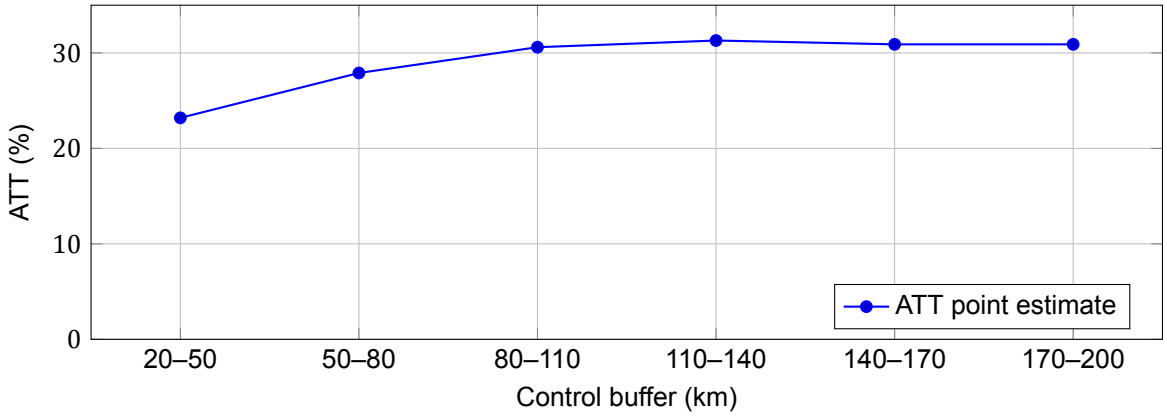


Figure 4.2: ATT by control buffer distance (corridor-level, TWFE).

The graph suggests that from control areas farther away than 80 kilometers, the effects of the corridors are not felt much anymore. At that moment, the area could be considered unaffected by the corridor. The other analyses in the research are based on the control area from 80 to 110 kilometers. This is a similar buffer as used in the corridor research of Alam et al., 2022 in which the corridors are compared with ring buffer control areas with a distance from 80 to 100 kilometers. Buffers farther away than 110 kilometers could make the differences between the treatment and control areas too large. At that moment, the risk of control areas being in other economic zones could make the areas incomparable. Within 80 kilometers distance, the effects of road and rails can still be found (Ghani et al., 2014). Even further away than 80 at that distance.

4.1.3. Economic impact of corridors

The economic impact of the corridors is estimated with DiD-percentages per corridor. As explained, the buffer of 80 to 110 kilometers is used because at that distance, the control areas show similar development, which could indicate that the effects of the corridor are no longer felt. The objective is to indicate similarities between the corridors and account for outliers. The results are shown in Table 4.2. The DiD-percentage shows how the treatment areas have developed differently compared to the control areas over the years after the corridor construction, compared to the period before the intervention. The annual DiD-percentage is equivalent to this. Using an annual percentage equivalent to the DiD-percentage over the growth percentage makes the corridors comparable but the corridors differ in investment type, infrastructure, and size.

The complete overview of the DiD-coefficients can be found in Table 4.2. The objective is to indicate similarities between the corridors and account for outliers. Using an annual growth percentage equivalent to the DiD-coefficient makes the corridors comparable, but the corridors differ in investment type, infrastructure, size, and MDB involvement.

Table 4.2: Difference-in-differences percentages

Project	Annual DiD (%)	DiD (%)	Infrastructure	Investment	MDB involvement
Mtwara Development Corridor Mtwara-Mbamba Bay Road (2004)	0.2%	4.2%	Road	Greenfield	Yes
Limpopo Road Corridor (2011)	0.4%	4.7%	Road	Brownfield	No
Djibouti-N'Djamena Highway (2003)	0.6%	13.2%	Road	Brownfield	Yes
Cairo–Gaborone-Cape Town Road (2009)	0.9%	12.8%	Road	Brownfield	No
Benguela Railway (2006)	1.0%	17.8%	Rail	Greenfield	Yes
Moanda-Kinshasa Road (2005)	1.1%	20.7%	Road	Brownfield	No
Nacala Road Corridor (2010)	1.3%	17.6%	Road	Brownfield	Yes
Namibe Road (2003)	1.7%	39.4%	Road	Greenfield	No
Nacala Railway Corridor (2012)	1.8%	22.2%	Rail	Brownfield	Yes
Tema-Ouagadougou Road (2008)	2.0%	34.7%	Road	Brownfield	Yes
Lagos-Kano-Jibiya Road (2009)	2.0%	32.7%	Road	Brownfield	No
Juba-Port Sudan Road (2007)	2.0%	36.9%	Road	Brownfield	No
Abidjan-Bamako Road (2008)	2.1%	37.2%	Road	Brownfield	Yes
Zambia-Malawi-Mozambique Railway (2012)	2.1%	26.3%	Rail	Greenfield	No
Addis–Djibouti Transport Railway (2011)	2.4%	33.4%	Rail	Greenfield	No
Luanda-Cabinda Road (2007)	2.5%	48.3%	Road	Brownfield	No
Mombasa-Nairobi Standard Gauge Railway (Phase 1) (2013)	2.6%	29.4%	Rail	Greenfield	No
Cairo-Dakar Highway (2010)	4.1%	67.8%	Road	Brownfield	No
Northern Corridor Transportation Improvement Road (2008)	4.5%	94.0%	Road	Brownfield	Yes
Malange Road (2005)	5.0%	138.9%	Road	Brownfield	Yes
Brazzaville-Pointe Noire Road (2007)	5.1%	120.6%	Road	Brownfield	No

The analysis of the 21 African corridors show that in all cases areas along corridors grow faster in nighttime lights than the control areas. On average, this amounts to 2.16% with annual growth equivalent to the full difference-in-differences effect. The median value is 2.0%. Most projects in the sample show slow but study growth where the equivalent annual rate is between 1% and 3%. But there are also effects that are heterogeneous: there are large gains in nighttime light developments in treatment areas (e.g., Malange Road +138.9%, Brazzaville–Pointe Noire +120.6%, Northern Corridor +94.0%, Cairo–Dakar +67.8%), while others have almost no notable gain (Mtwara–Mbamba Bay +4.2%, Limpopo +4.7%). This fits in the literature that mostly has indicated heterogeneous effects on the short term (Alam et al., 2022) but also on the longer term (Jedwab & Storeygard, 2022).

The cases with low nighttime light development are associated with several explanations. The Mtwara Development Corridor has experienced 4.2% growth in its treatment area over 19 years since the start of construction. The issue was that the package of investments was incomplete and did not effectively connect ports and energy complementarities (Hobbs & Bignoli, n.d.). The Djibouti–N'Djamena Highway follows a route through landlocked countries. The main issue along this route is the poor road conditions that need to be improved to provide the last-mile connections along the corridor route (OIC, 2012). The thing all four outliers with the most development have in common is that they improve connections with ports. They are located in regions with dense economic market structures that are strongly triggered once the connection with the ports is improved. This effect is strongest when complementary investments in the ports are implemented, resulting in larger port outputs. Worldwide trade and the global economy play an important role here, just as does the economic potential of the African country. The development of Malange Road is largely attributed to the booming oil industry, which began in 2004 following the end of the civil war (Henderson et al., 2012). This paper also suggests a point that will be discussed in the next section regarding project characteristics: nighttime lights appear to cluster around urban regions where the actual agglomeration effect occurs. For rural areas, no clear evidence is found.

Road seems to exhibit higher effects than rail, but this is also a reflection of the sample composition, where rail projects are more often greenfield. That brownfield investments are associated with more growth is consistent with the idea that an existing economic baseline amplifies the economic outcomes. For both projects with MDB involvement and those without, there are outliers with almost no effect on nighttime light development and those with significant development.

4.1.4. Key findings

The short-term effects of the corridors align with the previous research, where an anticipation effect led to some economic development before and directly after the start of the corridor construction. This is the moment when nighttime lights begin to develop more rapidly in treatment areas than in control areas. The trend from the eighth year onward shows that the effect becomes more prominent: treatment develops faster on the corridor average. This could be evidence that it takes time for firms and households to adapt to the new infrastructure, which delays the process of agglomeration around corridors and results in a slower increase in nighttime light.

Comparing the local area around the corridor with areas further away reveals that areas within 50 kilometers develop more closely with the local area after the corridor is constructed. This could be an indication that at that reach, corridor effects are still felt. The idea that this effect is only related to the similarity in the economic zone is rejected: in the pre-trend, all control buffers show identical behavior, which changes in the post-trend.

There are some interesting takeaways that tell something about the different effects of the 21 corridor projects. A first suggestion could be made about 3 different types of corridor outcomes. The first type is characterized by almost no notable growth between the treatment and control groups. These are projects where not enough complementary context is available to create economic development. E.g., poor road connections or no initial economic baseline that exists. The fact that not much development took place after more than 10 years at these locations could be a sign that billion-dollar investments in hard infrastructure do not lead to local economic outputs when no complementary investments accompany the projects. The second group aligns with steady growth around the corridors, mostly associated with 20% to 40% growth after more than 10 years. The third group has exceptional growth related to an existing economic structure around ports. New infrastructure seems to be a trigger to enable economic development, as expressed in nighttime light growth. The findings need to be nuanced because of the existing pre-trends: corridors are associated with economic development and are not a clean causal effect that explains the development.

4.2. Project characteristics

This part of the results discusses what characteristics of the projects are associated with a change in economic development. The first part discusses the impacts of the transport corridors in rural and urban settings (subsection 4.2.1). The second part discusses the other project characteristics and the economic development associated with these specifications (subsection 4.2.2). The impacts of the projects are tested with the pooled TWFE model, as explained in subsection 3.2.1, where the effects are dummy coded and estimated as interaction effects with the DiD-regressor. The effects of the project characteristics are tested in an univariate model, where every effect is tested separately, and in a multivariate model with all characteristics. The models are estimated with segments of 50 kilometers from the 21 corridors database. This resulted in 3 samples: one with all segments, and sub-samples for rural segments and for urban segments. An overview of the samples and counts of the segments per characteristic are shown below.

Table 4.3: Sample size corridor segments

	Full	Rural	Urban
Segments	240	174	66
Road project	164	114	50
Rail project	76	60	16
Greenfield investment	75	59	16
Brownfield investment	165	115	50
MDB involvement	99	66	33
No MDB involvement	141	108	33
Landlocked country	44	24	20
No landlocked country	196	150	46
Urban	66		
Rural	174		

The segments are binary-coded based on the characteristics they possess. The coding is shown in Table 4.4. That the sample is divided into urban and rural is done based on the binary-coding. Other characteristics chosen are road or rail, greenfield or brownfield, landlocked or non-landlocked, and MDB or non-MDB. Whether a project has involvement with a Multilateral Development Bank is decided based on whether a project is supported by the World Bank or the African Development Bank. The differences between projects that are MDB or non-MDB related have been the subject of multiple studies (Chai & Tang, 2023). Their approaches to infrastructure development are different, which makes the subject interesting. The other characteristics are chosen because they can explain heterogeneity in the projects: brownfield and landlocked are strong explanatory indicators for the existence of initial economic development around corridor areas.

Table 4.4: coding project characteristics

Variable	Coding
Road	0 = railway project, 1 = road project
Greenfield	0 = brownfield investment, 1 = greenfield investment
MDB	0 = no MDB involvement, 1 = MDB involvement
Landlocked	0 = no landlocked country, 1 = landlocked country
Urban	0 = rural, 1 = urban

4.2.1. Impacts in rural and urban contexts

The first model that is tested is the multivariate model over the full sample of 240 segments, where all interaction effects are included. These effects are: road or rail, greenfield or brownfield, MDB or non-MDB, landlocked (LL) or non-landlocked (non-LL), and rural or urban. The objective is to indicate what project characteristics are associated with a change in economic development. The multivariate model makes the characteristics conditional on each other to test if the effect per characteristic differs between settings. The results of the model are shown in Figure 4.3. In section F.3, the table with the log-coefficient that is used to calculate the percentages in the figure is shown. The percentages indicate how much the treatment group, given its characteristics, grows differently compared to its control group. The control groups are selected from the grid cells in the control buffer at distances of 80 to 110 kilometers from the corridor.

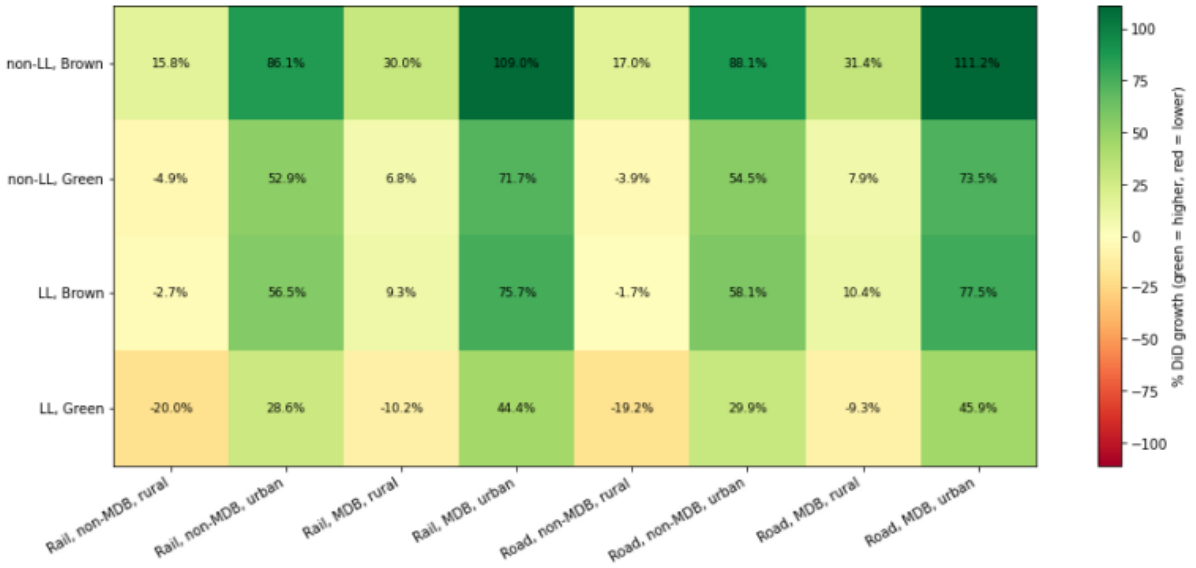


Figure 4.3: DiD-estimates (%) by characteristic segments

The results shows examples of project characteristics that had an average, positive DiD-effect after the construction of the corridors. The largest percentages can be found in urban segments with brownfield investments. Percentages above 100 percent can be expected: some treatment areas and control areas had barely any nighttime lights, but when the corridor is constructed, the sum of lights go from zero to something leading to large, growth effects. The model suggests negative DiD-effects as well where control develops faster than treatment. Negative DiD-effects could indicate that in certain areas the transport corridors are slowing down economic development. This effect exists in landlocked segments in rural areas, and also in greenfield segments. An explanation for this negative effect could be that populations are moving to urban areas when travel barriers are removed because of new connections. This corresponds with the theory of agglomeration effects. There are DiD-coefficients of segments that show this effect. Figure 4.4 shows the segments of the Northern corridor road project of 2008. Every square represents a segment of 50 kilometers. The segments follow a sequential order. The percentages represent the nighttime light growth of the DiD-coefficient, and the star indicates when a segment is urban. This corridor shows that urban segments are associated with large economic growth when treatment and control are compared, and shows an example of a negative relation. The negative effect is a rural area between urban areas: an indication of the agglomeration effect. All DiD-coefficient growth percentages are added in Appendix G where more examples of the effect can be found.

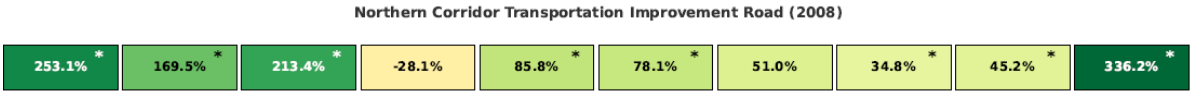


Figure 4.4: DiD-estimates (%) of Northern corridor road segments

But before hasty conclusions are claimed about the impacts associated with the project characteristics, Figure 4.3 shows that the effect of rural and urban is by far the most important characteristic of the corridor. Urban areas uplift every combination with each characteristic. The estimated DiD-coefficients of each characteristic in section F.3 suggest that the effect is the same in every setting, e.g., the effect of road in rural areas is the same as in urban areas. However, the impacts of new infrastructure can work differently for rural and urban settings. Urban areas have denser populations, with the result that new roads target a higher market accessibility compared to low-populated areas. The high DiD-coefficient for urban areas indicates this heterogeneity. Therefore, the presented multivariate model is too heavily influenced by the heterogeneous effects of the urban and rural contexts of the segments that it would be better to estimate the other effects associated with the project characteristics in a rural-only setting and an urban-only setting. The sample sizes are large enough to test these effects.

4.2.2. Economic impacts of project characteristics

To get an idea of the economic effects of the characteristics, univariate effects are tested as shown in Figure 4.5. It are average effects of the characteristics, unconditional to the other characteristics. The DiD-coefficients as log values can be found in section F.2. By dividing the sample in rural and urban, it becomes clear how much more nighttime lights are observed in urban than in rural for every characteristic.

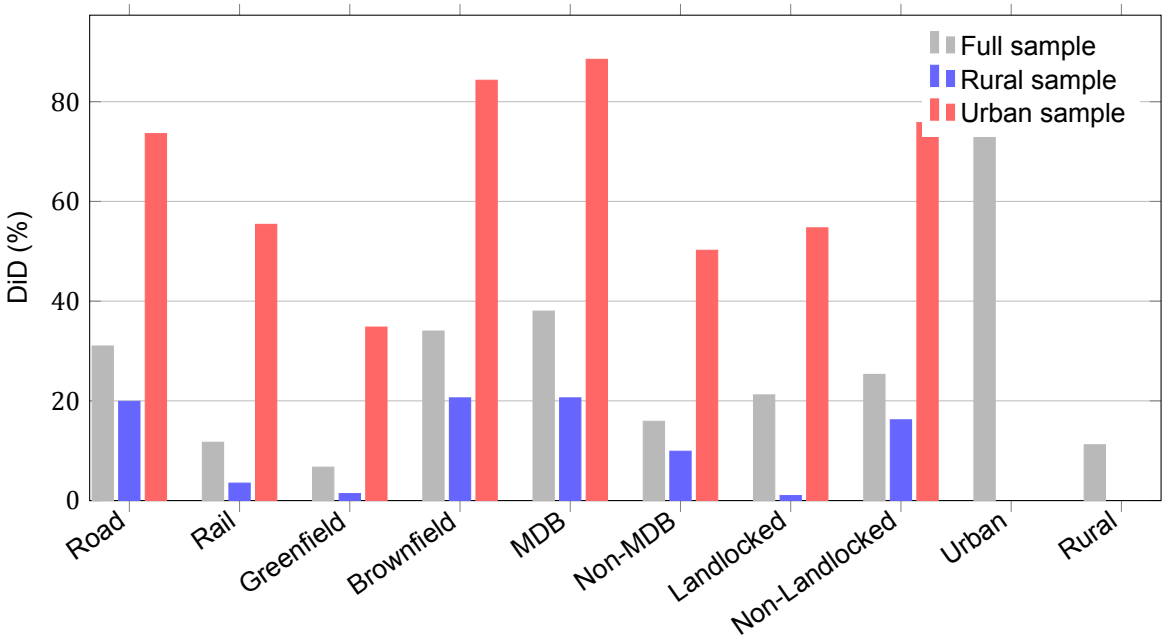
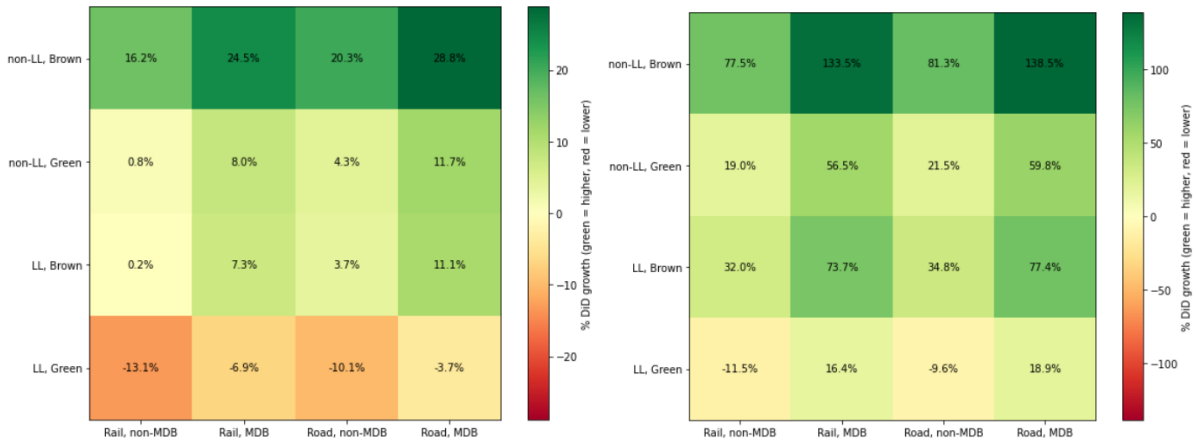


Figure 4.5: DiD-estimates (%) by characteristic (Full, Rural, Urban).

Overall, only positive DiD-growth percentages can be indicated from the bar chart although the characteristics can be negative conditional on the other characteristics. The urban segments substantially uplift the impacts. In both subsamples, greenfield projects underperform brownfield investments. A plausible explanation could be that most growth is created along routes with pre-existing economic activity—where economies of agglomeration can be leveraged. For instance, building a large new railway, e.g., the Benguela railway, across low-populated areas with little initial economic activity is unlikely to result in new industrial clustering, even in ten years after construction begins, as in this model. MDB-related projects overperform in comparison to projects without development banks' involvement. In particular, the effect in an urban context is strong and suggests that the projects target the agglomeration effects in a better way. An explanation could be that the conditions for which projects are selected have stricter requirements compared to non-MDB-related projects. Furthermore, segments that are located in landlocked countries experience, on average, less economic growth. The reason for this could be that without direct connections with the port, fewer economic opportunities are enabled compared to non-landlocked countries. The corridors in the sample mostly run through multiple countries. Therefore, it could be the case that economic mobilization starts to occur in landlocked countries as well. The research of Jedwab and Storeygard, 2022 found that cities further inland experience growth as well when economic opportunities start to increase, but that the effect is less compared to cities closer to ports. This effect seems to be similar in the urban context; however, for rural areas, this is not the case. The percentage for road is insignificant in the urban sample, so no conclusions can be attributed to that effect.

Testing the multivariate models in rural and urban settings shows the strongest explanation of the corridor-heterogeneity. As expected, most development is clustered in urban areas where the percentages are higher in every setting. The idea that most economic development occurs in countries with coasts and an existing economic baseline is supported by the high percentages for segments that are non-landlocked and brownfield. The corridors still experience positive growth in nighttime light in a

landlocked setting around brownfield upgrades. Every corridor has overall positive growth, so no strong negative values were expected. There are negative associations nonetheless: greenfield investments in landlocked countries are associated with slower development in the treatment areas than the control areas. This is in line with the idea that economic activities are pulled away from rural areas and are relocated to urban areas. The road and rail differences in the rural sample are not that varied. The road and rail difference in the urban sample is insignificant: no statistical difference exists. Therefore, heterogeneity of the corridor effects could not properly be addressed with road and rail in this research.



(a) DiD-estimates (%) rural

(b) DiD-estimates (%) urban

Figure 4.6: DiD-estimates (%) by characteristics (rural and urban)

4.2.3. Key findings

These results, where the corridors have been analyzed as being parts of infrastructure of 50 kilometers each, tell something more about where and when economic development occurs. As seen for the highest corridor development effects, an initial economic baseline is associated with enabling economic activities. That segments with brownfield investments are associated with most growth is, therefore, not a surprise: these segments are former roads and rails that already existed at locations with initial economic development.

The economic development that is linked to nighttime lights mostly occurs in urban settings. This is where most lights are turned on after building new roads and rails. But the growth also occurs in rural areas. Especially around brownfield investments. Nighttime light as an indicator for rural development has been prone to debate because it does not accurately represent the economic activities that happen in the countryside. However, the fact that nighttime light has an effect could still indicate that new forms of economic activity are being added to what is already happening. It is possible that local communities, often with an agricultural background, diversify activities with commercialized ones. Other effects suggest that rural areas are also experiencing less development. This happens in landlocked countries, where the effect shows that in greenfield projects, control areas develop more than treatment areas. This suggests that economic activities are reallocated, most likely closer to urban areas.

The main takeaway of these results is that they explain more about the corridor settings where and when economic development happens. Brownfield and urban segments emphasizes the importance of an already existing economic baseline. Distance to ports as a key indicator is mostly proven with landlocked areas scoring low. Also projects selected by MDBs are associated with more growth. These effects explain the heterogeneity that have been found previously in the full corridor sample.

5

Discussion

In this chapter, the findings from the difference-in-differences analysis are discussed and related to the existing body of scientific research on corridor development. This is done for every sub-question. The limitations of the research are mentioned as well.

5.1. Discussion on results

To what extent does the economic development in Africa differ in areas targeted by transport corridor investments and comparable areas without transport corridor investments?
In this thesis, the areas that are targeted by transport corridors are local areas spanning 10 kilometers on both sides of the corridor route. This is compared with control areas of 20 to 50 kilometers, up to 170 to 200 kilometers. A treatment area of 10 kilometers around the corridor captures a more local impact of the corridor, similar to other studies (Ghani et al., 2014) (Faber, 2014). In contrast, other studies, e.g., Alam et al., 2022, use treatment areas of 20 kilometers or more. The economic development has been measured for over 10 years. It is possible that the impacts span further than 10 kilometers, which could lead to higher DiD-estimates, especially in urban areas where most nighttime lights are increasing. Evidence for this is provided by this research by testing the spatial reach of the corridor for different control areas. Control areas between 20 and 80 kilometers from the corridors show that the average nighttime light development is more similar than that further away, beyond 80 kilometers, where the difference becomes constant. The indication of spatial decay, the farther away from the corridor, aligns with the theory of agglomeration effects, for which empirical work shows that the effects become less significant at distances of 50 to 100 kilometers (Graham, 2007). Still, the effect of the corridor is felt to some extent on these distances because spillover effects in the long run can work through distances far away (Donaldson, 2018). People move for economic opportunities closer to corridors where market access is increased. Within the closer control areas, this could lead to a shift where people move closer to the corridor. If this were the case, it could be that closer control areas have a larger DiD-effect than areas further away. This is not supported by the results, which strengthens the assumption that the corridor effect has a wider impact than concentrating solely on a 10-kilometer treatment area.

The dynamics of economic development between treatment and control areas are explained using an event study. The study shows a significant pre-trend: treatment areas were developing faster than the control areas, already before the start of the corridor construction. This indicates that, on average, the 21 corridors in the sample are located in areas that already experience economic development. Not all studies account test for parallel trend violation (Alam et al., 2022) (Chang et al., 2020) but the study of Chai and Tang, 2023 does use a variant of DiD on smaller scales around development projects. Ghani et al., 2014, Faber, 2014, and Datta, 2012 all use pre-trends to analyze effects, but they are mostly used to calculate differences between control areas or explain structures around transport infrastructure areas. DiD is often a quasi-experimental method that is used for associations with corridors, but rarely can parallel trends over such large areas be indicated. The results of the event study can be used for nuance: the post-effect could be overestimated. To estimate a clean causal effect, the pre-trend between the areas needs to be parallel, which is not the case (Rambachan & Roth,

2023). The event study shows that around the construction of the corridor, the treatment area starts to grow faster than the control area: this trend starts a few years before the construction, increases more after the start, and even more after commissioning. This is a similar response as seen in Indian road investments, where the industry immediately reacted to new infrastructure (Datta, 2012). African studies of infrastructure projects mention heterogeneous effects, with immediate short-term impacts, and corridor overviews emphasize similar dynamics (Alam et al., 2022).

The nighttime light development share calculated for a control area from 80 to 110 kilometers, i.e., the distance where average ATT becomes constant. It is possible that effects are felt at this distance (Donaldson, 2018), but the further away the control buffer is chosen, the more it is disconnected with the economic and regional comparability of the treatment areas. Also, at 80 kilometer distance, control areas could be located in other countries with other economic zones. It could be the case that the impact of the corridor in the control areas would therefore be different than in the treatment areas. Besides violation of the parallel trends assumption, this is also a remark to lay nuance on an implied causal effect. The analysis has a sample of 21 transport corridors in Africa that are road or rail. They were constructed between 2003 and 2013 and compared with the control areas till the year 2023. The result is that every treatment area of the corridor has seen more growth in nighttime lights than the control areas. Annual growth rates equivalent to the DiD-percentage over all post-event years are significant and have a mean of 2.16% and median of 2.0%. Positive overall effects indicate that on the long run, new infrastructure can be associated with economic growth. Evidence in Ethiopia suggests that the effects are heterogeneous based on initial development (Alder et al., 2022). For some corridors, the larger effects can be attributed to a colonial baseline and initial economic setting, where projects lead to more development in the long run. A similar effect is also observed along colonial routes in China (A. Banerjee et al., 2020) and India (Datta, 2012). Besides the large, heterogeneous effects, most corridors follow a steady growth over the long-run where annual growth is equivalent between 2% to 4%. This is in line with the magnitudes reported in Jedwab and Storeygard, 2022, which also show a similar average growth across multiple African infrastructure projects. However, this study measures development with market access and economic elasticities. The long-term effects of nighttime light on multiple transport corridors in Africa have not been previously compared, but the effects that gradually emerge after more than 10 years show similarities with the study of highways in India by Ghani et al., 2014. The developments grow gradually and mostly further away than 10 years after the start of construction, similar to the findings of the event study in this research. The study acknowledges heterogeneity for locations with initial economic development. The cause of heterogeneity in Africa, however, differs due to the presence of landlocked countries and the larger distances between economic clusters.

What geographic characteristics of transport corridors could explain differences in economic development?

The research indicates that there is a clear difference in the nighttime light development in rural and urban areas. The urban areas are associated with much faster growth in nighttime lights compared to their control areas, unlike the rural areas. Most growth in nighttime light in Africa is set in areas with initial access to electricity grids and with an existing economic baseline, according to Jiang et al., 2021. This could be more the case for urban areas than for rural explaining the differences in growth. The fact that urban effects grow stronger is in line with the literature, which suggests that denser economic areas exhibit stronger elasticity for agglomeration compared to rural areas with lower economic densities (Rosenthal & Strange, 2004). Urban areas encompass more clusters of labor markets and supplier markets, making it easier to put costs in the market through reduced access barriers (Donaldson, 2018). Other studies find similar effects, where nighttime lights are mostly clustered around cities. Storeygard, 2016 mentions that two-thirds of the nighttime light development in sub-Saharan Africa is clustered around urban areas, and Henderson et al., 2012 sees nighttime light development as something typical of cities. The research found indications that rural areas are also developing fewer nighttime lights compared to their control areas when they are between urban areas. It is possible that people move away from rural areas when urban areas are more accessible. Instead of a corridor impact, it could also be a direct effect of the ongoing urbanization in Africa. The heterogeneous effects of slowing down rural development have been indicated by Jedwab and Storeygard, 2022 for African infrastructure investments. Evidence of this rural-urban migration has been indicated for Chinese highway projects as well (Faber, 2014).

Another effect can be found in landlocked segments of corridors. Landlocked segments underperform compared to non-landlocked segments. Structurally higher transportation costs and no port-related growth are drivers to explain this difference (Arvis et al., n.d.). The thesis finds that landlocked segments can have slower treatment area development compared to it's control areas when the project is a greenfield investment. This effect is evident in both rural and urban settings. No causal evidence exists that the corridor investments lead to the mobilization of populations directly to non-landlocked countries. Current research suggests that this mobilization occurs mostly within countries, rather than between them (Jedwab & Moradi, 2016). The fact that greenfield investments in landlocked countries are associated with slow economic development aligns with the literature, which suggests that most development occurs in urban areas connected to African ports. In those areas, the effects of improved market access are felt most (Jedwab & Moradi, 2016).

What project characteristics could explain differences in economic development?
The results reveal positive nighttime light developments for both brownfield investments and greenfield investments. This effect becomes stronger in urban settings. Prior findings reported heterogeneous WEBs across corridors that often indicated larger short-run effects for greenfield investments, especially on a larger geographic scope (Alam et al., 2022). In this thesis, for both settings, brownfield would outperform greenfield. The difference is that this research analyzes longer periods over more than 10 years after the start of construction. It could be the case that greenfield triggers faster development in the first year of the project, but does not hold this development as much as brownfield projects do. The brownfield projects are strongly related to initial economic development, whereas greenfield projects are located in areas where the economic development is not yet fully enabled, which could explain this difference. This research did not find noteworthy results for road and rail differences that could explain heterogeneity between the corridors. What is interesting is the involvement of an MDB. These are associated with more nighttime light development. On first view, this would contradict the findings of Chai and Tang, 2023: Chinese projects lead to more nighttime light than WB projects. The explanation: Chinese projects focus more on hard infrastructure, which is a stronger trigger for nighttime light. This also relates to the study of Alam et al., 2022 where greenfield investments trigger development. Two ideas could explain why this thesis associates MDB-involvement with more development. First, it could be the case that MDBs select projects with more promising potential for economic growth than Chinese. Second, the largest DiD-effects are found further away than 8 years after corridor construction. This reaches further than the other studies. It could be the case that MDB-projects take longer to enable economic development.

5.2. limitations

Rural economic impact
It is already mentioned, but measuring economic activity in Africa with nighttime light can be difficult to create a good representation. Especially in rural areas, economic activities are not fully related to nighttime light. It can be the case that the corridors have resulted in large gains for agriculture, but this has not been indicated.

Wider trend in urbanization
In Africa, a wider trend of population growth and urbanization is leading to more economic activity. This thesis does discuss mechanisms (control area testing, fixed effects, trend-lines) that partly account for this, however, how much of the associated DiD-effects are accurately attributed to the corridor and how much is already the logical growth of Africa's growing population?

Complementary investments of corridors
Corridors combined with investments in ports are associated with large growth. However, this is not explicitly tested in this thesis. Also, other investments that could improve trade or improve customs could explain impacts.

Distribution and inclusion
The research show where and when economic development occurs, however, it does not tell to who. It does not explain how this development is distributed based on gender, age, or the population in

general. Economic development can be really beneficial for the one who is running a large firm, but this does not immediately mean that all workers benefit. Especially in rural areas, there are indications of dimming nighttime lights. Could this mean that people are left behind?

Associations and causal effect
This research appears to offer explanations for heterogeneous effects, particularly for MDB involvement and investment types. However, these are associations and have not been verified as a causal effect. Verifying this could be difficult because the data sample needs to be extended and some data could be difficult to obtain or simply not exist. Also, no matching is used with treatment and control. Especially for segmenting, it is possible that rural control areas are assigned to urban segments. This could overestimate the impacts for urban areas.

6

Conclusion

6.1. Key findings

This thesis analyzes economic development along 21 African transport corridors by comparing treatment areas adjacent to the corridors with nearby control areas. The projects started between 2003 and 2013 with an average construction time of ≈ 4.5 years. The effects are measured with nighttime lights. This data is available till 2023, so most of the effects show impacts on the long-run of the corridor investments. When considering entire corridor routes, the results show statistically significant positive effects on nighttime lights. The magnitudes are heterogeneous: several corridors exhibit large increases that align with the literature's expectation of context-dependent impacts, while others show little to no growth. A large part of the corridors in the sample have gradual, economic development, equivalent to 2% to 4% growth.

At the same time, the parallel-trends assumption is not fully satisfied. Although control areas behave similarly across control areas in the pre-event period, treatment areas display differential pre-trends relative to controls. As a result, the post-event differences should be interpreted as associations rather than clean causal effects. Notably, the treatment–control gap becomes larger roughly eight years after the start of construction, suggesting that corridor-related development intensifies over a long horizon rather than in the short-term, immediately after the commissioning.

To explain heterogeneity, the corridor routes are divided into segments of 50 kilometers. The segments are characterized: road or rail, greenfield or brownfield, MDB or non-MDB, landlocked or non-landlocked, and urban or rural. Urban segments show the strongest growth in nighttime lights, consistent with the hypothesis that corridors amplify activity where an initial economic baseline is present. Brownfield upgrades are associated with stronger gains than greenfield segments, pointing to the role of pre-existing networks and complementary infrastructure. In contrast, segments in landlocked countries experience lower development, with negative DiD-estimates for greenfield investments. There are indications of declining economic activities in rural areas that are in between urban areas. These patterns align with research emphasizing port access and market-density: non-landlocked urban areas are better positioned to translate corridor investments into economic opportunity.

Finally, MDB involvement is associated with larger nighttime light increases than non-MDB projects. One plausible interpretation is selection: MDBs chooses locations with an economic potential. Another explanation could be that the MDB-approach is less focused on short-term effects and focus more on the long-run.

Overall, the findings indicate that corridor-adjacent regions tend to develop more strongly than comparable areas over the long run, but that impacts are uneven, shaped by urbanization, existing infrastructure, and port accessibility. While violations of parallel trends limit strict causal claims, the consistent patterns across space, time, and subgroups provide a coherent narrative of where and when corridor investments are most likely to yield durable gains.

6.2. Recommendations for future research

Explain nighttime lights
A next step could indicate what nighttime light actually is representing. This could be an increase in households or an increase in firms. Additionally, nighttime lights in rural areas may indicate the onset of industrialization. An interesting approach could be an LULC change analysis that discusses how land use has been transformed around the corridors.

Time span and spatial reach for analyzing corridors
The results indicate that the effects of corridors can span over more than 10 years before actual large developments are happening. So, besides the short-term effect, long-term effects could be as interesting to focus on. Also, the effects further away than the targeted local areas can benefit from the corridors. Spillovers can reach up to 80 kilometers distance from the corridor route.

Test complementary investments
The effect of complementaty investments in ports or in trade could benefit corridor impacts. This thesis find the largest effects by ports but does not discuss parallel port investments that could explain these large impacts. Other investments could focus on last-mile connectivity of roads around corridors or investments in customs.

Predictions under increased urbanization
The results of this research are based on the context of Africa from 1993 to 2023, based on the available nighttime light data. Africa will continue to urbanize and to grow in population next decades. This could change the rural character of the continent and the market densities. Future research should focus on how transport corridors in Africa would behave in settings where markets are denser.

Extension of the current research
This thesis uses a database of 21 corridor projects. The sample could be bigger when projects after 2013 are added as well. Also, other types of investments such as ports and oil pipelines can be added.

6.3. Recommendations for practice

Bundle hard and soft investments where it matters most
The largest gains are identified along urban areas with links to ports. The corridors with the largest impacts were combined with investments in ports and in trade. Therefore, a combination of hard infrastructure investments, while accounting for soft investments in trade, could lead to large results in development.

Indicate if an area has enough economic potential
Examples of corridors that have led to almost no development in nighttime lights do not have a strong pre-existing economic baseline that could mitigate the effects of the corridors. For example, a lack of paved roads that connect the corridor or excessively large distances between economic clusters. This also depends on the function of the corridor. If the only function is to transport goods from landlocked countries to ports, local economic development might not be valued as important. But at some moment it could be the case that local development starts to increase, which could affect the performance of the corridor.

Declare successes over longer time periods
When the success of a corridor is represented by measuring as much economic impact as possible, a success or failure indication should be done 10 years after the start of the project. The first years after commissioning of the project are a strong indicator as well, but the effects are increasing rapidly in later years.

Accounting for rural economic development
New transport corridor investments should not lead to a decay in economic activity in rural areas. Complementary measures should be taken that prevent impoverishment of rural areas

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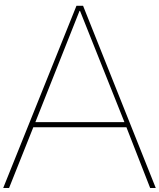

Scientific paper

Economic development around transport corridors in Africa: analyzing the impacts of 21 road and rail projects

Martin Kooistra[a]

[a]*Delft University of Technology, The Netherlands*

Abstract

This paper discusses the economic developments around 21 road and rail corridor projects in Africa. These projects were funded by development banks or by foreign investors and were built between 2003 and 2013. The paper employs a difference-in-differences modeling approach to compare local regions around the corridor areas, as well as those further away that are not directly targeted by the corridor investments. The projects are analyzed for more than 10 years after the start of construction. Projects that are built in regions with an existing economic baseline are associated with the most growth. Newly built projects that are in landlocked countries are associated with less growth.

Keywords: transport corridors, Africa, infrastructure, road, rail

Highlights

- The economic development around 21 road and rail corridors constructed between 2003 and 2013 is analyzed with nighttime light data
- Up to 2023, all areas around the corridors are associated with positive economic growth since its construction
- Most economic development around the corridors occurs in urban settings close to ports
- Along new built corridor routes in landlocked countries, the nighttime lights are turned off

1. Introduction

Africa has seen major infrastructure investment in recent years. Between 2012 and 2020, the African Union, in collaboration with the African Development Bank, advanced the Programme for Infrastructure Development in Africa (PIDA), which executed more than 400 projects with a regional and continental focus (PIDA, 2023). These efforts follow long periods of underinvestment: only 1% of the world's rail is located in Africa, and just a third of the rural population has access to paved roads (Thorn et al., 2022). New transport infrastructure reduces the costs of moving people and goods (Storeygard, 2016), can attract firms, and can expand activity that clusters in industrial regions, generating agglomeration effects where economic zones grow (Lebrand, 2021; Rosenthal and Strange, 2004). In the short run, corridor investments ease logistics bottlenecks and help firms meet demand; in the long run, reallocation of firms and workers toward emerging clusters can reinforce growth through market access and scale economies (Redding and Turner, 2015). These dynamics may be particularly consequential where economies underperform to their potential (IMF, 2025). With Africa's population projected to grow by 60% between 2025 and 2060 (Thorn et al., 2022), demand for infrastructure expected to rise further. In the new PIDA (2021–2030), 25 transport projects are planned, backed by Multilateral Development Banks (AfDB, World Bank) and foreign investors.

A salient feature of recent practice is the transport corridor approach. Corridors target large spatial areas where roads, railways, waterways, or pipelines are built or rehabilitated, and they often include hub investments such as ports and airports to strengthen national backbones and cross-border connectivity (Quium, 2019). Over time, many programs evolve beyond hard infrastructure into broader "development corridors" that improve last-mile logistics, integrate markets, and coordinate complementary policies and network upgrades (Bignoli et al., 2024; Melecky et al., 2018). In such programs, investments in electricity, customs reforms, and regulatory modernization are bundled with transport spending to unlock wider economic opportunity. The Abidjan–Lagos Trade & Transport Facilitation Project exemplifies this broadened scope by combining corridor infrastructure with trade and customs measures (Bank, 2010). Another example is Kenya's Lamu Port–South Sudan–Ethiopia Transport (LAPSSET) corridor: a still-evolving, debated initiative aiming to open northern trade routes, with investment needs estimated up to USD 23 billion (Aalders et al., 2021).

Lessons from other developing or once-developing contexts suggest that large transport programs can catalyze structural change. In China, major road upgrades increased economic activity concentrated in zones (Faber, 2014); in India, the revival of colonial railway routes has been linked to substantial local development (Donaldson, 2018). Such

investments can trigger long-run reallocation of population and firms as access improves and markets integrate. Africa already counts 79 development-oriented transport corridors (Thorn et al., 2022). With new investments accelerating, a central question is whether—and under what conditions—corridors translate into broader economic opportunity in surrounding areas.

Despite growing interest, the causal economic impacts of African transport corridors remain insufficiently established at the corridor level. Much of the evidence comes from middle- and high-income countries (Jedwab and Moradi, 2016). Existing work documents heterogeneous effects in Africa—often highlighting short-run outcomes following installation (Alam et al., 2022; Jedwab and Storeygard, 2022). Comparative studies with multiple projects suggest long-term development associated with infrastructure via network-wide market-access elasticities over three decades (Jedwab and Moradi, 2016); however, these results speak more to network adjustment than to persistent, local, corridor-specific change. In other words, we know relatively more about how national networks reshape market access over time than about how particular corridors reshape nearby economic activity and household welfare.

Similar long-run local effects could be expected in Africa, but several Africa-specific characteristics may dampen or condition the gains. First, the continent has the highest share of landlocked countries, which can mute continent-wide effects relative to regions oriented around coastal economic hubs. Cross-country evidence links infrastructure to growth in employment and distributional gains in developing countries (Calderón et al., 2008), yet such evidence operates on the network level and does not by itself establish corridor-level causality. Second, Africa's settlements have large rural populations, greater distances between urban centers, and the world's lowest road and rail density, implying that development from corridor investments may be less automatic and more context dependent than elsewhere. These considerations motivate a corridor-level analysis that looks to economic responses beyond short-term impacts.

This research contributes new corridor-level evidence on the long-run economic impacts of transport corridors in Africa and aims to explain heterogeneity in their impacts. Specifically, it (i) detects wider economic effects around corridors at large spatial scales and (ii) identifies settings and investment characteristics associated with stronger development responses. The primary research question is:

To what extent do investments in transport corridors have economic impact in Africa?

2. Methodoloy

This study assesses whether African transport corridors are associated with local economic development over the long run. A quantitative design with satellite-based proxies and difference-in-differences (DiD) models is made that compares areas next to corridors to comparison areas.

2.1. Outcome and measurement

Nighttime lights serve as the proxy indicator representing economic development. These outcomes represent annual global data of which is known that is strongly correlates with economic activity such as GDP and wealth indices (Ivan et al., 2020). Conceptually, brighter lights reflect expanding electrification and industrial activity (Alam et al., 2022). This research projects a data source that has aggregated, harmonized DMSP/VIIRS satellite imagery (Chen et al., 2024), to a 5×5 km grid, and computes the *sum of lights* (SOL) per cell-year. To handle zeros and heavy right tails, the outcome is

$$y_{it} = \ln\left(1 + \mathrm{SOL}_{it}\right). \tag{1}$$

The research tests samples divided into rural-only settings and urban-only settings. Nighttime lights are interpreted differently in a rural context as it is a weaker proxy for agricultural development and other rural activities (Mellander et al., 2015) (Pérez-Sindín et al., 2021). Consequently, an increase or decrease in rural nighttime light can tell something different from that in an urban context: diversification of economic activity. The distinction between rural and urban is done with the Global Human Settlement Layer of the European Union. This database shows how densely-populated the areas around the corridors are.

2.2. Treatment and control areas

The study analyzes 21 corridor projects (road/rail) with construction starts between 2003 and 2013, tracking outcomes through 2023. The routes are selected from the African Development Corridor Database created by Thorn et al. (2022). The database consists of 79 corridor and over 100 investment projects that are linked to these corridors. Various reports from the World Bank and from AidData were used additionaly to the database to indicate the exact routes where construction occured between 2003 and 2013. This window yields at least ten post-construction years and sufficient pre-period coverage (Chen et al., 2024). The unit of observation is a 5×5 km grid cell i observed annually t. Each cell is linked to a corridor (or a 50 km segment; see heterogeneity) and an event year indicating the construction start. The areas surrounding the corridor comprise the treatment region of the corridor and consist of cells within 10 km on either side of a corridor route. The treatment region is compared with a control region. Candidate controls are regions within distances at 20–50, 50–80, 80–110, 110–140, 140–170, and 170–200 km. Varying the control distance serves two roles: (i) indicating spatial decay and spillovers (Graham, 2007) and (ii) selecting a control that is unaffected by the impact of the corridor investment.

2.3. Model and estimation

In the analysis two-way fixed-effects DiD models are estimated at the cell-year level with cell (α_i) and year (τ_t) fixed effects:

$$y_{it} = \alpha_i + \tau_t + \beta\,(g_i \cdot post_{it}) + \varepsilon_{it}, \tag{2}$$

where g_i indicates treatment status and $post_{it}$ indicates post-construction years for the associated corridor. β is reported as a percent effect via $(e^{\beta}–1)\times100\%$ and as an equivalent annual rate $(e^{\beta/n_{post}} - 1) \times 100\%$ (a summary under constant compounding). The dynamics of the average over all corridors in the sample is tested with an event study, encompassing pre-trends, anticipation, and commissioning profiles.

2.4. Heterogeneity design

To identify settings and features associated with stronger development, each corridor is divided into contiguous 50 km segments s and analyzed in pooled DiD models. In these models, interacting the treatment effect with segment characteristics $Z_s^k \in \{0, 1\}$ (e.g., road vs. rail, greenfield vs. brownfield, MDB involvement, landlocked status, and an urban/rural dummy derived from GHSL), results in DiD-estimations that are associated with the characteristics. Because urbanization strongly shapes light responses, models are also estimated within rural-only and urban-only subsamples.

2.5. Workflow

The workflow is an empirical strategy wherein four sequential steps can be distinguished. This works as follows:

1. *Test parallel trends with event study*
   To test the causal effect between transport corridors and economic impact, an event study is done for different specifications of the control areas. The trend line shows the relative growth difference between the treatment and control areas. It can be used to test whether ,before the construction of the corridor, the treatment and control had the same relation in nighttime light development. The event study shows a line representing the trend, which also explains how the development in the treatment area behaves over time.
2. *Test spatial reach of corridors*
   To test how far the effects of the corridors reach, different specifications of the control areas are tested with an average DiD-estimate over all corridors. It could be expected that areas closer to the corridor also benefit from the corridor. When the area closer to the corridor has a lower average DiD-estimate compared to areas further away, this effect can be indicated.
3. *Calculate corridor DiD-estimates*
   A control area is selected and the DiD-estimates are calculated for each corridor. The corridors are compared based on how large the DiD-effect is.
4. *Calculate DiD-estimates for project characteristics* The corridors are divided into segments of 50 kilometers. DiD-estimates are calculated over all segments. The result is that DiD-estimates can be attributed to segments with certain characteristics. This leads to associations of each characteristic with a magnitude in nighttime light development, which could explain heterogeneous effects in the corridor sample. The segments are divided and tested over 3 samples, namely, the full sample, a rural-segments-only sample, and an urban-segments-only sample.

3. Results

3.1. Economic development around corridors

After careful selection from routes in the corridor database of Thorn et al. (2022), 21 corridor routes were indicated with constructions between 2003 and 2013. This led to the data sample as shown in table 1. A distinction is made between projects that are supported by Multilateral Development Banks such as the World Bank, and project without involvement. The differences between these investors has been discussed in recent literature because they have alternating approaches for infrastructure development. Projects from MDBs are associated with additional societal programs and projects from private actors and foreign investment bank are associated with hard investments in infrastructure (Chai and Tang, 2023).

Table 1: Sample size corridor dataset

	Sample size
Corridors	21
Greenfield investment	6
Brownfield investment	15
Road project	15
Rail project	6
MDB involvement	9
No MDB involvement	12

The event study is conducted to measure the difference between the treatment and control areas around the years of construction (i.e., around the event year). The objective is to indicate if a pre-trend exists and to measure the development post-trend after construction. The treatment area of the corridors is 10 kilometers on both sides of the corridors. Control areas around the treatment area could vary in nighttime light development. The treatment area could be in a region where an economic baseline already exists. This may be particularly true for brownfield projects. The economic baseline could span the closer control regions. The impact of the corridor could target these areas as well.

Figure 1 shows a visualization of the trend lines for the specifications of the control areas (the buffers). The x-axis shows the event time k, which is the event-year when the construction of the corridor started. The analysis is conducted for all corridors with varying event-years. Therefore, k is not a fixed year but represents multiple years depending on the corridor. The years before k indicate the period before the construction of the corridor, and the years after k the post-treatment years. The y-axis shows the difference between the treatment and control areas in year k. Therefore, the line illustrates the difference in nighttime lights between the treatment and control cells. In the study, the line represents the value of the ATT which is the Average Treatment Effect on the Treated: the average difference of the treatment and the control areas over all corridors in event-year k. The graph shows before the construction of the projects (k<01) that the treatment group is running in on the control group. This indicates that there are no

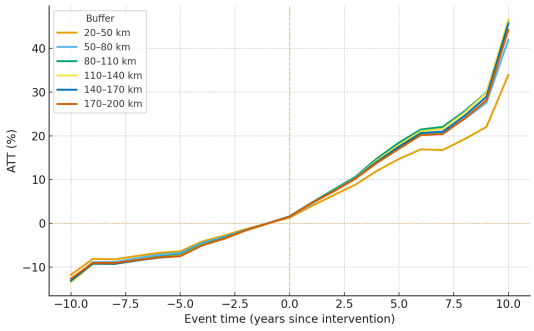

Figure 1: Event study (ATT in event time).

strict parallel trends between areas. In the figure this is clearly indicated because before the event-year (k<0), the ATT is not approximately 0. Consequently, the DiD-coefficients should be interpreted as associations of the corridor impacts rather than clean causal effects. A deviation from the trend is seen 5 years before k when the slope of the pre-trends approximates the slope post-intervention. In that period, the faster development in the control areas follows a consistent trend. 5 years before the intervention, this difference in development between the groups becomes smaller. An explanation for this could be that the announcement of the infrastructure projects triggers anticipation effects. As soon as the projects launches and the funding or procurement is underway, activities on land can start years before the actual start of construction. Another explanation could be the investments are located in selected areas that are experiencing development. Targeting areas for investments that are already experiences economic development could be a valid reason to start new infrastructure projects because the new economic growth could result in a demand for roads or rails. Furthermore, the graph shows that at k>-1 the treatment areas have structural more nighttime light development than the control area. From k>3 the slope becomes steeper which could indicate that at that point the projects are commissioned and the real effects start. The average commissioning of the projects is 4.5 years after the start of the construction. That the local development around the corridor is increasing 3 years after the event-year, can be explained because the first projects are commissioned. At k=6, the effect shortly slows down before growing again. An explanation could be that in the first years after commissioning, there are strong effects in economic opportunity, but this slows down a few years later. At k>8, the local development increases again. This is an indication that impacts of the corridor may take a while before they actually increase nighttime lights. It would take some time after commissioning to relocate firms and connect markets.

The economic impact of the corridors is estimated with DiD-percentages per corridor. The buffer of 80 to 110 kilometers is used because at that distance, the risk of spillover effects by the corridor is limited. The objective is to indicate similarities between the corridors and account for outliers. The results are shown in table 2. The DiD-percentage shows how the treatment areas have developed differently compared to the control areas over the years after the corridor construction, compared to the period before the intervention. The annual DiD-percentage is equivalent to this. Using an annual percentage equivalent to the DiD-percentage over the growth percentage makes the corridors comparable but the corridors differ in investment type, infrastructure, and size.

There are some interesting takeaways that tell something about the different effects of the 21 corridor projects. A first suggestion could be made about 3 different types of corridor outcomes. The first type is characterized by almost no notable growth between the treatment and control groups. These are projects where insufficient complementary context is available to facilitate economic development. For example, poor road connections or the absence of an initial economic baseline. The fact that little development has taken place after more than 10 years at these locations could be a sign that billion-dollar investments in hard infrastructure do not yield local economic benefits when no complementary investments accompany the projects. The second group aligns with steady growth around the corridors, mostly associated with 20% to 40% growth after more than 10 years. The third group has exceptional growth

Table 2: Difference-in-differences percentages

Project	**Annual DiD (%)**	**DiD (%)**
Mtwara Development Corridor Mtwara–Mbamba Bay Road (2004)	0.2%	4.2%
Limpopo Road Corridor (2011)	0.4%	4.7%
Djibouti–N'Djamena Highway (2003)	0.6%	13.2%
Cairo–Gaborone–Cape Town Road (2009)	0.9%	12.8%
Benguela Railway (2006)	1.0%	17.8%
Moanda–Kinshasa Road (2005)	1.1%	20.7%
Nacala Road Corridor (2010)	1.3%	17.6%
Namibe Road (2003)	1.7%	39.4%
Nacala Railway Corridor (2012)	1.8%	22.2%
Tema–Ouagadougou Road (2008)	2.0%	34.7%
Lagos–Kano–Jibiya Road (2009)	2.0%	32.7%
Juba–Port Sudan Road (2007)	2.0%	36.9%
Abidjan–Bamako Road (2008)	2.1%	37.2%
Zambia–Malawi–Mozambique Railway (2012)	2.1%	26.3%
Addis–Djibouti Transport Railway (2011)	2.4%	33.4%
Luanda–Cabinda Road (2007)	2.5%	48.3%
Mombasa–Nairobi Standard Gauge Railway (Phase 1) (2013)	2.6%	29.4%
Cairo–Dakar Highway (2010)	4.1%	67.8%
Northern Corridor Transportation Improvement Road (2008)	4.5%	94.0%
Malange Road (2005)	5.0%	138.9%
Brazzaville–Pointe Noire Road (2007)	5.1%	120.6%

related to an existing economic structure around ports. New infrastructure appears to be a catalyst for enabling economic development, as evidenced by nighttime light growth. The findings need to be nuanced due to the existing pre-trends: corridors are associated with economic development, but this is not a clean causal effect that explains the development.

3.2. Project characteristics

The corridor-heterogeneity is tested with corridor segments of 50 km. This is tested for rural and urban settings wherein the effects are varied. This resulted in DiD-estimates, represented as percentages, that are associated with a set of characteristics. The results of the rural setting are shown in figure 2 and of the urban setting in figure 3.

Testing the multivariate models in rural and urban settings shows the strongest explanation of the corridor-heterogeneity. As expected, most development is clustered in urban areas where the percentages are higher in every setting. The idea that most economic development occurs in countries with coasts and an existing economic baseline is supported by the high percentages for segments that are non-landlocked and brownfield. The corridors continue to experience positive growth in nighttime light in a landlocked setting surrounding brownfield upgrades. Every corridor has overall positive growth, so no strong negative values were expected. There are

Figure 2: DiD growth by segment characteristics (multivariate model, full sample).

negative associations nonetheless: greenfield investments in landlocked countries are associated with slower development in the treatment areas than the control areas. This aligns with the notion that economic activities are increasingly being drawn away from rural areas and relocated to urban areas. The differences in road and rail access in the rural sample are not particularly varied. The difference between the road and rail samples in the urban sample is insignificant, indicating no statistical difference exists. Therefore, the heterogeneity of the corridor effects could not be properly addressed with road and rail in this research.

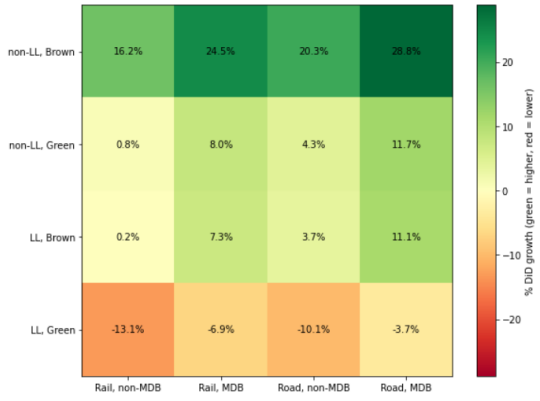

Figure 3: DiD growth by segment characteristics (multivariate model, full sample).

4. Discussion and Conclusion

Across 21 African corridor projects started between 2003 and 2013, areas within 10 km of the routes show more nighttime light intensity than comparable control areas, with average equivalent annual gains around 2% and substantial heterogeneity. Event-time patterns show clear non-parallel pre-trends—treatment areas were already improving before construction—so estimates are best read as associations with corridor timing rather than clean causal effects. Still, post-construction growth of corridors persists across the treatment-control difference, and strengthens from about k+8, consistent with commissioning lags and slow agglomeration. Spillovers are detectable within 20–80 km, after which average effects stabilize; an 80–110 km control area therefore serves as a balanced main control area. The strongest gains appear where corridors reinforce dense, port-linked market structures, while minimal gains coincide with weak complements or adverse context (e.g., poor last-mile connections in landlocked interiors). Segment analysis clarifies where development concentrates: urban segments dominate, brownfield upgrades outperform greenfield, and MDB projects are located in regions with substantially more growth in development. Contrary, rural landlocked greenfield segments can experience slower development in treatment than control. It is an effect of relocating economic activities to urban areas. Taken together, the results map a coherent geography of where corridor-specific development is most likely to occur.

These patterns come with important caveats and implications. Nighttime lights understate agricultural/rural activity and may over-represent urban change; identification is challenged by non-parallel pre-trends, potential spillovers into near controls, and imperfect segment-level matching. Moreover, complementary investments in ports, trade facilitation, and local road networks are not explicitly modeled, and distributional outcomes (who benefits) remain unobserved. Policy practice should therefore bundle hard corridor works with soft investments in trade/customs policies and last-mile connectivity in dense markets; screen projects for baseline

economic potential (especially in landlocked settings); evaluate success over longer time periods rather than immediately post-commissioning; and prevent that rural development is slowed down with targeted local investments. Future research can tighten interpretation by linking lights to household- and firm-level outcomes and by extending the sample beyond 2013, applying matching/alternative control designs and tracing dynamic effects further into the post period. Even with these limitations, the consistent spatial and temporal patterns indicate a clear message: corridors tend to enable durable gains where they connect existing economic baselines. In particular near ports. In contrast, impacts are far less automatic in rural or landlocked contexts without the right complements.

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B

Code specification

B.1. TWFE model

```
#imports
import geopandas as gpd
import pandas as pd
import numpy as np
from pathlib import Path
import rasterio
from rasterio.features import geometry_window, geometry_mask
import statsmodels.formula.api as smf
from linearmodels.panel import PanelOLS

#paths
corridor_path  =
treatment_path =
control_path   =
tif_folder     =

#constants
TARGET_CRS = "ESRI:102022"
years      = list(range(1993, 2024))
intervention_years = {
    11:2007, 12:2013, 16:2004, 21:2003, 29:2008, 35:2005, 37:2010, 39:2010,
    44:2003, 45:2011, 49:2006, 55:2009, 57:2003, 58:2003, 59:2012, 61:2012,
    62:2008, 63:2005, 71:2009, 72:2011, 73:2008, 75:2007, 81:2007
}

#helpers
def read_to_target(path: Path, crs: str) -> gpd.GeoDataFrame:
    g = gpd.read_file(path)
    g = g.set_crs(crs, allow_override=True) if g.crs is None else g.to_crs(crs)
    return g

def pick(gdf, names):
    for n in names:
        if n in gdf.columns: return n
    cl = {c.lower(): c for c in gdf.columns}
    for n in names:
        if n.lower() in cl: return cl[n.lower()]
    return None

def zonal_stat_sum(image_path: Path, gdf: gpd.GeoDataFrame, geom_col="geometry")
    -> np.ndarray:
```

```
    with rasterio.open(image_path) as src:
        g = gdf.to_crs(src.crs)
        out = np.full(len(g), np.nan, dtype="float64")
        for i, geom in enumerate(g[geom_col].values):
            try:
                win = geometry_window(src, [geom], north_up=True, rotated=False)
            except Exception:
                continue
            data = src.read(1, window=win, masked=True)
            mask = geometry_mask([geom], out_shape=data.shape,
                                 transform=src.window_transform(win), invert=True)
            arr = np.ma.array(data, mask=(~mask) | data.mask)
            if arr.count() > 0:
                out[i] = float(arr.sum())
        return out

def to_pct(b):
    return (np.exp(b)-1)*100 if (b is not None) and np.isfinite(b)

#read data and set CRS
corr = read_to_target(corridor_path, TARGET_CRS)
treat = read_to_target(treatment_path, TARGET_CRS)
ctrl  = read_to_target(control_path,   TARGET_CRS)

#assign treatment and control
t_assign = treat[['cell_id','fid','geometry']].copy(); t_assign['group'] = 1
c_assign = ctrl [['cell_id','fid','geometry']].copy(); c_assign['group'] = 0
assign   = pd.concat([t_assign, c_assign], ignore_index=True).drop_duplicates(['
    cell_id','fid','group'])
assign   = (assign.sort_values(['cell_id','fid','group'], ascending=[True,True,
    False])
                  .drop_duplicates(['cell_id','fid'])
                  .reset_index(drop=True))
assign   = gpd.GeoDataFrame(assign, geometry='geometry', crs=TARGET_CRS)

#create a cell panel
uniq_cells = assign[['cell_id','geometry']].drop_duplicates('cell_id').reset_index
    (drop=True)
rows = []
for y in years:
    tif = tif_folder / f"SRUNet_Nightlight_RAW_{y}.tif"
    vals = zonal_stat_sum(tif, uniq_cells)
    sol  = dict(zip(uniq_cells['cell_id'], vals))
    df_y = assign[['cell_id','fid','group']].copy()
    df_y['year'] = y
    df_y['sol']  = df_y['cell_id'].map(sol)
    rows.append(df_y)

panel = (pd.concat(rows, ignore_index=True)
           .dropna(subset=['sol'])
           .assign(ln_sol=lambda d: np.log1p(d['sol'])))

#create the DiD regressor
panel['intervention_year'] = panel['fid'].map(intervention_years).fillna(2013).
    astype(int)
panel['post'] = (panel['year'].astype(int) > panel['intervention_year']).astype(
    int)
panel['gp']   = panel['group'] * panel['post']

#TWFE on cell level
panel['year_i'] = panel['year'].astype(int)
```

```
panel['entity'] = panel['cell_id'].astype(str)

panel_lm = panel.set_index(['entity','year_i']).sort_index()
y = panel_lm['ln_sol']
X = panel_lm[['gp']]

clusters_fid = (panel[['entity','year_i','fid']]
                .set_index(['entity','year_i'])['fid'].astype(str))

res = PanelOLS(
        y, X,
        entity_effects=True,
        time_effects=True
     ).fit(
        cov_type='clustered',
        clusters=clusters_fid
     )

print(res.summary)

att_b = res.params.get('gp', np.nan)
att_p = res.pvalues.get('gp', np.nan)
att_pct = to_pct(att_b)

#create a results dataframe
# A) set counts
counts = (panel.groupby(['fid','group'])['cell_id']
               .nunique()
               .unstack(fill_value=0)
               .rename(columns={0:'n_ctrl', 1:'n_treat'}))

# B) aggregate to fid x group x year
agg = (panel
       .groupby(['fid','group','year'], as_index=False)
       .agg(ln_mean=('ln_sol','mean')))

# C) set intervention and post
agg['intervention_year'] = agg['fid'].map(intervention_years).fillna(2013).astype(
    int)
agg['post'] = (agg['year'].astype(int) > agg['intervention_year']).astype(int)

# D) DiD-coeff and % for each corridor
rows = []
for fid_val, sub in agg.groupby('fid'):
    sub = sub.copy()
    okay = (sub['group'].nunique() == 2) and (sub['post'].nunique() == 2)
    cells = counts.loc[fid_val] if fid_val in counts.index else pd.Series({'n_ctrl
        ':0,'n_treat':0})
    iy = int(sub['intervention_year'].iloc[0])

    if not okay:
        rows.append({'fid': int(fid_val),
                     'did_coef': np.nan,
                     'did_pct': np.nan,
                     'p_value': np.nan,
                     'n_ctrl': int(cells.get('n_ctrl',0)),
                     'n_treat': int(cells.get('n_treat',0)),
                     'avg_annual_growth_treat_pct': np.nan,
                     'avg_annual_diff_growth_pct': np.nan,
                     'intervention_year': iy})
        continue
```

```
    sub['year_fe'] = sub['year'].astype(int)
    m = smf.ols('ln_mean ~ group:post + C(group) + C(year_fe)', data=sub).fit(
        cov_type='HC1')
    b = m.params.get('group:post', np.nan)
    p = m.pvalues.get('group:post', np.nan)

    post_treat = sub[(sub['group']==1) & (sub['year'] > iy)]
    post_ctrl  = sub[(sub['group']==0) & (sub['year'] > iy)]

    def annual_growth_ln(df):
        if df.shape[0] < 2 or df['year'].nunique() < 2:
            return np.nan
        yv = df['ln_mean'].values
        xv = df['year'].values.astype(float)
        xv = xv - xv.mean()
        beta = np.dot(xv, yv) / np.dot(xv, xv)
        return to_pct(beta)

    g_treat = annual_growth_ln(post_treat)
    g_ctrl  = annual_growth_ln(post_ctrl)
    g_diff  = g_treat - g_ctrl if (np.isfinite(g_treat) and np.isfinite(g_ctrl))
        else np.nan

    rows.append({'fid': int(fid_val),
                 'did_coef': b,
                 'did_pct': to_pct(b),
                 'p_value': p,
                 'n_ctrl': int(cells.get('n_ctrl',0)),
                 'n_treat': int(cells.get('n_treat',0)),
                 'avg_annual_growth_treat_pct': g_treat,
                 'avg_annual_diff_growth_pct': g_diff,
                 'intervention_year': iy})

results_df = pd.DataFrame(rows)

round_cols = ['did_coef','did_pct','p_value',
              'avg_annual_growth_treat_pct','avg_annual_diff_growth_pct']
for c in round_cols:
    results_df[c] = results_df[c].round(3)

results_df = results_df.sort_values('did_pct', ascending=False).reset_index(drop=
    True)
```

```
#Event study
import numpy as np
import pandas as pd
from linearmodels.panel import PanelOLS
import matplotlib.pyplot as plt


MAX_LEAD = 10
```

```
MAX_LAG  = 10

ev = panel.copy()
ev['event_time'] = ev['year'].astype(int) - ev['intervention_year'].astype(int)
ev['event_time_clip'] = ev['event_time'].clip(lower=-MAX_LEAD, upper=MAX_LAG)

cats = [k for k in range(-MAX_LEAD, MAX_LAG+1) if k != -1]
for k in cats:
    ev[f'et_{k}'] = ((ev['event_time_clip'] == k).astype(int) * ev['group'].astype
        (int))

fid_cells = (ev[['fid','cell_id']].drop_duplicates()
               .groupby('fid').size().rename('n_cells'))
ev = ev.merge(fid_cells, on='fid', how='left')
ev['w_eq_fid'] = 1.0 / ev['n_cells'].astype(float)

ev['entity'] = ev['cell_id'].astype(str)
ev['year_i'] = ev['year'].astype(int)
ev_idx = ev.set_index(['entity','year_i']).sort_index()

Y = ev_idx['ln_sol']
Xcols = [f'et_{k}' for k in cats if ev_idx.get(f'et_{k}', pd.Series()).var() > 0]
X = ev_idx[Xcols]

weights  = ev_idx['w_eq_fid']
clusters = ev_idx['fid'].astype(str)

res_ev = PanelOLS(
    Y, X, entity_effects=True, time_effects=True, weights=weights
).fit(cov_type='clustered', clusters=clusters)

print(res_ev.summary)

rows = []
for k in cats:
    name = f'et_{k}'
    if name in res_ev.params.index:
        b  = float(res_ev.params[name])
        se = float(res_ev.std_errors[name])
        rows.append({'k': k, 'beta': b, 'lo': b - 1.96*se, 'hi': b + 1.96*se})
event_df = pd.DataFrame(rows).sort_values('k')

fig, ax = plt.subplots(figsize=(7,4))
ax.axvline(0, ls='--', lw=1, alpha=0.6)
ax.axhline(0, ls=':',  lw=1, alpha=0.6)

ax.plot(event_df['k'], event_df['beta'], lw=2, label='Event-time DiD (avg)')
ax.fill_between(event_df['k'], event_df['lo'], event_df['hi'], alpha=0.2, label='
    95% CI')

ax.set_xlabel('Event time (years since intervention year k)')
ax.set_ylabel('Log DiD')
ax.legend()
plt.tight_layout()
plt.show()

def to_pct(x):
    return (np.exp(x) - 1) * 100

rows = []
for k in cats:
```

```
    name = f'et_{k}'
    if name in res_ev.params.index:
        b  = float(res_ev.params[name])
        se = float(res_ev.std_errors[name])
        lo = b - 1.96*se
        hi = b + 1.96*se
        rows.append({
            'k': k,
            'beta_pct': to_pct(b),
            'lo_pct': to_pct(lo),
            'hi_pct': to_pct(hi)
        })

event_df = pd.DataFrame(rows).sort_values('k')

fig, ax = plt.subplots(figsize=(7,4))
ax.axvline(0, ls='--', lw=1, alpha=0.6)
ax.axhline(0, ls=':',  lw=1, alpha=0.6)

ax.plot(event_df['k'], event_df['beta_pct'], lw=2, label='ATT (%)')
ax.fill_between(event_df['k'], event_df['lo_pct'], event_df['hi_pct'], alpha=0.2,
    label='95% CI')

ax.set_xlabel('Event time (years since intervention year k)')
ax.set_ylabel('ATT (%)')
ax.legend()
plt.tight_layout()
plt.show()
```

B.2. Pooled TWFE model

```
#imports
import geopandas as gpd
import pandas as pd
import numpy as np
from pathlib import Path
import rasterio
from rasterio.features import geometry_window, geometry_mask
import statsmodels.formula.api as smf
from linearmodels.panel import PanelOLS

#paths
corridor_path  =
treatment_path =
control_path   =
tif_folder     =

#constants
TARGET_CRS = "ESRI:102022"
years      = list(range(1993, 2024))
intervention_years = {
    11:2007, 12:2013, 16:2004, 21:2003, 29:2008, 35:2005, 37:2010, 39:2010,
    44:2003, 45:2011, 49:2006, 55:2009, 57:2003, 58:2003, 59:2012, 61:2012,
    62:2008, 63:2005, 71:2009, 72:2011, 73:2008, 75:2007, 81:2007
}

#set thresholds for minumum number of cells in treatment and control
MIN_CTRL_CELLS  = 50
MIN_TREAT_CELLS = 20
```

```
#helpers
def read_to_target(path: Path, crs: str) -> gpd.GeoDataFrame:
    g = gpd.read_file(path)
    g = g.set_crs(crs, allow_override=True) if g.crs is None else g.to_crs(crs)
    return g

def pick(gdf, names):
    for n in names:
        if n in gdf.columns: return n
    cl = {c.lower(): c for c in gdf.columns}
    for n in names:
        if n.lower() in cl: return cl[n.lower()]
    return None

def zonal_stat_sum(image_path: Path, gdf: gpd.GeoDataFrame, geom_col="geometry")
    -> np.ndarray:
    with rasterio.open(image_path) as src:
        g = gdf.to_crs(src.crs)
        out = np.full(len(g), np.nan, dtype="float64")
        for i, geom in enumerate(g[geom_col].values):
            try:
                win = geometry_window(src, [geom], north_up=True, rotated=False)
            except Exception:
                continue
            data = src.read(1, window=win, masked=True)
            mask = geometry_mask([geom], out_shape=data.shape,
                                 transform=src.window_transform(win), invert=True)
            arr = np.ma.array(data, mask=(~mask) | data.mask)
            if arr.count() > 0:
                out[i] = float(arr.sum())
        return out

to_pct = lambda b: (np.exp(b)-1)*100 if (b is not None) and np.isfinite(b)

#read data and set CRS
corr = read_to_target(corridor_path, TARGET_CRS)
treat = read_to_target(treatment_path, TARGET_CRS)
ctrl  = read_to_target(control_path,   TARGET_CRS)

#set columns
corr['fid']     = corr['fid'].astype(int)
corr['seg_key'] = corr[seg_col].astype(str).str.strip()

name_col = 'Project_na' if 'Project_na' in corr.columns else None
bin_vars = [c for c in ['Is_Landl_1','Is_Green_1', 'Is_Road', 'Is_WB', 'Is_Settl_1
    '] if c in corr.columns]

#assign treatment and control based on segment key
t_assign = treat[['cell_id','seg_key','geometry']].copy(); t_assign['group'] = 1
c_assign = ctrl [['cell_id','seg_key','geometry']].copy(); c_assign['group'] = 0
assign   = pd.concat([t_assign, c_assign], ignore_index=True).drop_duplicates(['
    cell_id','seg_key','group'])
assign   = (assign.sort_values(['cell_id','seg_key','group'], ascending=[True,True
    ,False])
                  .drop_duplicates(['cell_id','seg_key'])
                  .reset_index(drop=True))
assign   = gpd.GeoDataFrame(assign, geometry='geometry', crs=TARGET_CRS)

#unique cells per group
seg_counts = (assign.groupby(['seg_key','group'])['cell_id']
                    .nunique()
```

```
                    .unstack(fill_value=0)
                    .rename(columns={0:'n_ctrl', 1:'n_treat'}))
seg_counts['n_total'] = seg_counts['n_ctrl'] + seg_counts['n_treat']

eligible_idx = seg_counts.index
if MIN_CTRL_CELLS is not None:
    eligible_idx = eligible_idx.intersection(seg_counts.index[seg_counts['n_ctrl']
        >= MIN_CTRL_CELLS])
if MIN_TREAT_CELLS is not None:
    eligible_idx = eligible_idx.intersection(seg_counts.index[seg_counts['n_treat'
        ] >= MIN_TREAT_CELLS])
if MIN_TOTAL_CELLS is not None:
    eligible_idx = eligible_idx.intersection(seg_counts.index[seg_counts['n_total'
        ] >= MIN_TOTAL_CELLS])

n_before = assign['seg_key'].nunique()
assign = assign[assign['seg_key'].isin(eligible_idx)].copy()
n_after  = assign['seg_key'].nunique()

#check if its working
print(f"[INFO] links: rows={len(assign)}, cells={assign['cell_id'].nunique()}, "
      f"segs_kept={n_after}/{n_before}, T-links={(assign['group']==1).sum()}, C-
          links={(assign['group']==0).sum()}")

#create a cell panel
uniq_cells = assign[['cell_id','geometry']].drop_duplicates('cell_id').reset_index
    (drop=True)
rows = []
for y in years:
    tif = tif_folder / f"SRUNet_Nightlight_RAW_{y}.tif"
    vals = zonal_stat_sum(tif, uniq_cells)
    sol  = dict(zip(uniq_cells['cell_id'], vals))
    df_y = assign[['cell_id','seg_key','group']].copy()
    df_y['year'] = y
    df_y['sol']  = df_y['cell_id'].map(sol)
    rows.append(df_y)

panel = (pd.concat(rows, ignore_index=True)
           .dropna(subset=['sol'])
           .assign(ln_sol=lambda d: np.log1p(d['sol'])))

#meta regression
meta_cols = ['seg_key','fid'] + ([name_col] if name_col else []) + bin_vars
corr_meta = corr[meta_cols].drop_duplicates()
panel = panel.merge(corr_meta, on='seg_key', how='left')

panel['intervention_year'] = panel['fid'].map(intervention_years).fillna(2013).
    astype(int)
panel['post'] = (panel['year'].astype(int) > panel['intervention_year']).astype(
    int)

#set binary columns
for v in bin_vars:
    if v in panel.columns:
        panel[v] = panel[v].fillna(0).astype(int)

#pooled TWFE model
seg_n = (panel[['seg_key','cell_id']].drop_duplicates()
         .groupby('seg_key').size().rename('n_cells').reset_index())
panel = panel.merge(seg_n, on='seg_key', how='left')
panel['w_seg_eq'] = 1.0 / panel['n_cells'].astype(float)
```

```
# A) set interactions
panel['gp'] = panel['group'] * panel['post']
for v in bin_vars:
    panel[f'gp_{v}'] = panel['gp'] * panel[v]

# C) set fixed effects: cell × segment; time = year
panel['year_i'] = panel['year'].astype(int)
panel['entity'] = panel['cell_id'].astype(str) + '|' + panel['seg_key']

panel_lm = panel.set_index(['entity','year_i']).sort_index()
y = panel_lm['ln_sol']
X = panel_lm[['gp'] + [f'gp_{v}' for v in bin_vars if f'gp_{v}' in panel_lm.
    columns]]
X = X.loc[:, X.var() > 0]

#cluster on segment keys
clusters_seg = (
    panel[['entity','year_i','seg_key']]
    .set_index(['entity','year_i'])['seg_key']
    .astype(str)
)

res = PanelOLS(
        y, X,
        entity_effects=True,
        time_effects=True,
        weights=panel_lm['w_seg_eq']
     ).fit(
        cov_type='clustered',
        clusters=clusters_seg
     )

print(res.summary)

for v in bin_vars:
    key = f'gp_{v}'
    if key in X.columns and key in res.params.index:
        print(f'Extra bij {v}=1:', round(to_pct(res.params[key]), 1),
              '| p =', round(res.pvalues[key], 3))

# DiD over all segments keys
agg = (panel
       .groupby(['seg_key','group','year'], as_index=False)
       .agg(ln_mean=('ln_sol','mean'),
            sol_mean=('sol','mean')))

agg = agg.merge(corr_meta, on='seg_key', how='left')
agg['intervention_year'] = agg['fid'].map(intervention_years).fillna(2013).astype(
    int)
agg['post'] = (agg['year'].astype(int) > agg['intervention_year']).astype(int)

# create a results dataframe
results = []
for seg_key, sub in agg.groupby('seg_key'):
    sub = sub.copy()
    if sub['group'].nunique()<2 or sub['post'].nunique()<2:
        results.append({'seg_key':seg_key,'did_coef':np.nan,'p_value':np.nan,
                        'growth_pct':np.nan,'did_abs':np.nan})
        continue
    ct = sub.groupby(['group','post']).size()
```

```
    if not all(k in ct.index for k in [(0,0),(0,1),(1,0),(1,1)]):
        results.append({'seg_key':seg_key,'did_coef':np.nan,'p_value':np.nan,
                        'growth_pct':np.nan,'did_abs':np.nan})
        continue

    sub['year_fe'] = sub['year'].astype(int)
    try:
        m = smf.ols('ln_mean ~ group:post + C(group) + C(year_fe)', data=sub)\
               .fit(cov_type='HC1')
        b = m.params.get('group:post', np.nan)
        p = m.pvalues.get('group:post', np.nan)
    except Exception:
        b = p = np.nan

    g = sub.groupby(['group','post']).agg(sol_mean=('sol_mean','mean'))
    did_abs = (g.loc[(1,1),'sol_mean'] - g.loc[(1,0),'sol_mean']) - \
              (g.loc[(0,1),'sol_mean'] - g.loc[(0,0),'sol_mean'])

    results.append({'seg_key': seg_key,
                    'did_coef': b,
                    'p_value': p,
                    'growth_pct': to_pct(b) if pd.notna(b) else np.nan,
                    'did_abs': did_abs})

results_df = pd.DataFrame(results).merge(corr_meta, on='seg_key', how='left')
if name_col:
    results_df = results_df.rename(columns={name_col: 'project_name'})

results_df['intervention_year'] = results_df['fid'].map(intervention_years).astype
    ('Int64')

cell_counts_after = (panel.groupby(['seg_key','group'])['cell_id']
                          .nunique()
                          .unstack(fill_value=0)
                          .rename(columns={0:'n_ctrl', 1:'n_treat'}))
results_df = results_df.merge(cell_counts_after.reset_index(), on='seg_key', how='
    left')

results_df['p_value'] = pd.to_numeric(results_df['p_value'], errors='coerce').
    fillna(1.0)

STEP = 0.005
def round_to_step(s, step=STEP):
    s = pd.to_numeric(s, errors='coerce')
    return np.round(s / step) * step

for col in ['did_coef','growth_pct','p_value','did_abs']:
    results_df[col] = round_to_step(results_df[col], STEP)

results_df = results_df.sort_values('growth_pct', ascending=False).reset_index(
    drop=True)
```

C

Selected corridors

Table C.1: Selected corridors

Project	Year of construction	Year of commissioning	Data source
Luanda-Cabinda Road	2007	2016	AidData, n.d.-c
Mombasa-Nairobi Standard Gauge Railway Project (Phase 1)	2013	2017	World Bank, 2014b
Mtwara Development Corridor Mtwara-Mbamba Bay Road	2004	2010	DCP, 2022
Abidjan-Bamako Road	2008	2012	World Bank, 2008
Moanda-Kinshasa Road	2005	2007	World Bank, 2010a
Cairo-Dakar Highway	2010	2011	World Bank, 2010b
Nacala Road Corridor	2010	2017	ANE, 2011
Djibouti-N'Djamena Highway	2003	2004	World Bank, 2003
Addis–Djibouti Transport Railway	2011	2016	World Bank, 2012
Benguela Railway	2006	2017	AidData, n.d.-b
Cairo–Gaborone-Cape Town Road	2009	2011	COMESA–EAC–SADC, 2012
Namibe Road	2003	2004	European Commission, 2008
Nacala Railway Corridor	2012	2016	African Development Bank, 2015
Zambia-Malawi-Mozambique Railway	2012	2013	JICA, 2012
Tema-Ouagadougou Road	2008	2015	World Bank, 2018
Malange Road	2005	2008	World Bank, 2004
Lagos-Kano-Jibiya Road	2009	2013	FMPWH, 2019
Limpopo Road Corridor	2011	2014	PRISE, 2014
Northern Corridor Transportation Improvement Road	2008	2013	World Bank, 2014a
Juba-Port Sudan Road	2007	2016	AidData, n.d.-a
Brazzaville-Pointe Noire Road	2007	2011	AidData, n.d.-d

D

Event study results

The event study shows the trend line over the years pre-event and post-event. The event in this context is the start of the corridor construction. The log-ATT is calculated for different specifications of the control areas. The results for each event time et are shown in Table D.1. All values are significant, thus, the suggested pre-trends and post-trends can't be rejected.

Event-time	20 - 50 km	50 - 80 km	80 - 110 km	110 - 140 km	140 - 170 km	170 - 200 km
et_-10	-0.1250	-0.1389	-0.1450	-0.1451	-0.1402	-0.1349
et_-9	-0.0846	-0.0925	-0.0975	-0.0977	-0.0965	-0.0946
et_-8	-0.0858	-0.0925	-0.0977	-0.0980	-0.0970	-0.0947
et_-7	-0.0774	-0.0828	-0.0879	-0.0888	-0.0887	-0.0876
et_-6	-0.0696	-0.0742	-0.0792	-0.0809	-0.0817	-0.0810
et_-5	-0.0661	-0.0698	-0.0742	-0.0765	-0.0777	-0.0778
et_-4	-0.0423	-0.0454	-0.0488	-0.0505	-0.0515	-0.0517
et_-3	-0.0283	-0.0313	-0.0337	-0.0348	-0.0353	-0.0359
et_-2	-0.0129	-0.0151	-0.0160	-0.0162	-0.0160	-0.0163
et_0	0.0130	0.0146	0.0160	0.0152	0.0158	0.0152
et_1	0.0387	0.0434	0.0460	0.0450	0.0458	0.0455
et_2	0.0621	0.0712	0.0739	0.0714	0.0708	0.0700
et_3	0.0845	0.0967	0.1008	0.0983	0.0976	0.0969
et_4	0.1136	0.1326	0.1385	0.1348	0.1321	0.1296
et_5	0.1373	0.1606	0.1693	0.1651	0.1614	0.1573
et_6	0.1562	0.1836	0.1943	0.1910	0.1876	0.1837
et_7	0.1549	0.1871	0.1992	0.1955	0.1902	0.1855
et_8	0.1761	0.2137	0.2281	0.2254	0.2196	0.2146
et_9	0.1991	0.2435	0.2617	0.2608	0.2542	0.2482
et_10	0.2918	0.3502	0.3798	0.3831	0.3760	0.3660

Table D.1: Event study results

E

Spatial reach results

The ATT for every control area buffer is calculated based on the cell-level of the weighted corridors. The DiD-estimates are shown in Table E.1 The estimates are log-coefficients. The values are significant. The DiD-estimates of all control buffers are shown in Table E.2. They are represented as percentages. The year column indicates the start of construction.

Table E.1: ATTs by control area distance

Buffer (km)	**ATT (DiD-coef)**
20–50	0.209
50–80	0.246
80–110	0.267
110–140	0.272
140–170	0.269
170–200	0.269

Table E.2: DiD-estimates (%) by control buffer distance

		Buffer (km)					
Project	**Year**	**20–50**	**50–80**	**80–110**	**110–140**	**140–170**	**170–200**
Luanda-Cabinda Road	2007	37.443	46.560	48.330	50.283	48.199	16.608
Mombasa-Nairobi Standard Gauge Railway Project (Phase 1)	2013	19.653	28.203	29.422	30.854	27.432	31.698
Mtwara Development Corridor Mtwara-Mbamba Bay Road	2004	4.818	4.714	4.156	4.845	4.270	4.278
Abidjan-Bamako Road	2008	25.392	30.526	37.215	45.132	49.481	49.613
Moanda-Kinshasa Road	2005	5.386	18.140	20.703	21.996	21.871	21.806
Cairo-Dakar Highway	2010	36.401	65.632	67.818	68.846	63.299	87.370
Nacala Road Corridor	2010	21.309	21.513	17.578	19.712	19.152	10.237
Djibouti-N'Djamena Highway	2003	10.955	11.222	13.241	13.081	13.372	12.858
Addis–Djibouti Transport Railway	2011	24.837	30.941	33.357	34.201	34.476	35.334
Benguela Railway	2006	16.760	17.413	17.761	17.175	16.760	17.635
Cairo–Gaborone–Cape Town Road	2009	9.770	9.870	12.765	14.226	14.705	13.582
Namibe Road	2003	38.748	40.291	39.395	38.029	38.544	40.414
Nacala Railway Corridor	2012	21.303	20.492	22.156	21.805	18.885	17.783
Zambia-Malawi-Mozambique Railway	2012	19.451	25.050	26.281	29.135	32.058	32.369
Tema–Ouagadougou Road	2008	29.406	31.098	34.733	42.310	46.771	40.875
Malange Road	2005	113.184	121.823	138.903	135.778	141.250	135.719
Lagos–Kano–Jibiya Road	2009	23.705	29.028	32.745	34.311	33.328	34.657
Limpopo Road Corridor	2011	5.939	3.887	4.663	-12.352	-21.584	-19.648
Northern Corridor Transportation Improvement Road	2008	51.015	69.618	94.039	99.983	110.908	107.588
Juba–Port Sudan Road	2007	26.669	35.286	36.877	35.944	35.739	35.858
Brazzaville–Pointe Noire Road	2007	103.248	117.263	120.624	127.647	128.347	128.475

F

TWFE model results

The routes of the corridors in the analysis are selected in QGIS with the database of Thorn et al., 2022. The routes are numbered with ID (Figure F.1). The results represented in DiD coefficients are presented in Table F.1.

F.1. Results TWFE model

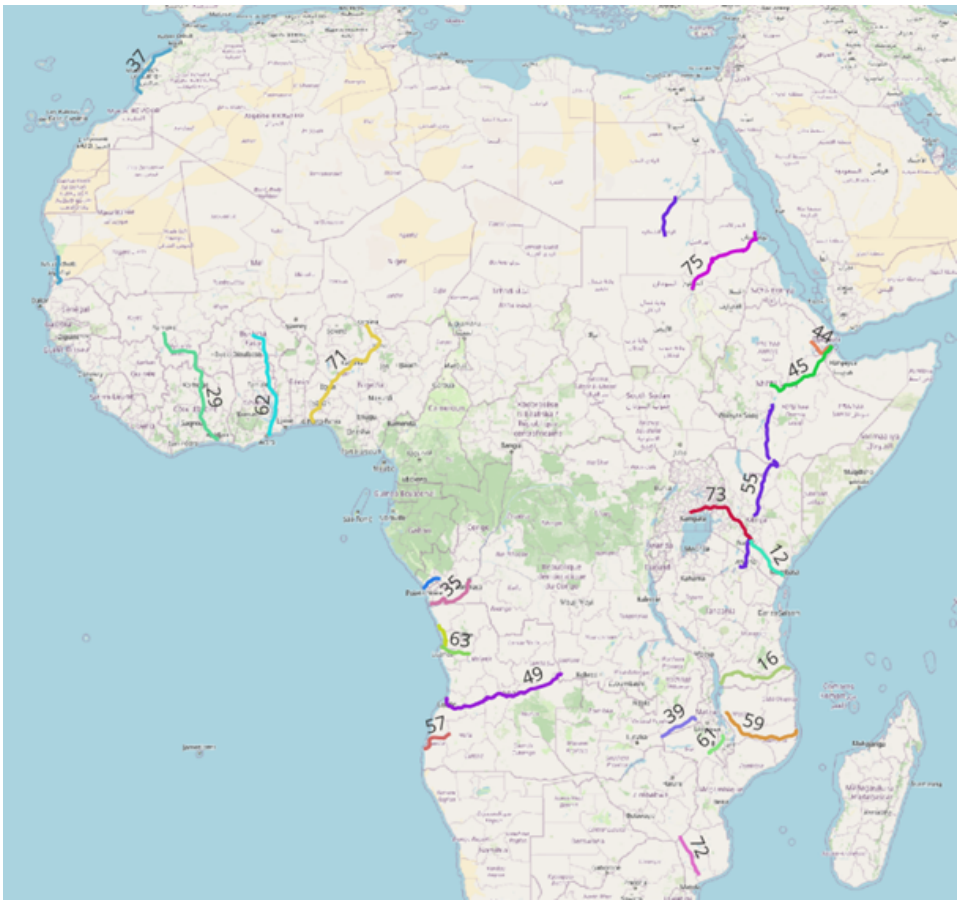


Figure F.1: Corridor locations

Table F.1: Difference-in-differences coefficients

ID	Project	Construction year	DiD coef	DiD (%)	Annual DiD (%)
11	Luanda-Cabinda Road	2007	0.394	48.3%	2.5%
12	Mombasa-Nairobi Standard Gauge Railway Project (Phase 1)	2013	0.258	29.4%	2.6%
16	Mtwara Development Corridor Mtwara-Mbamba Bay Road	2004	0.041	4.2%	0.2%
29	Abidjan-Bamako Road	2008	0.316	37.2%	2.1%
35	Moanda-Kinshasa Road	2005	0.188	20.7%	1.1%
37	Cairo-Dakar Highway	2010	0.518	67.8%	4.1%
39	Nacala Road Corridor	2010	0.162	17.6%	1.3%
44	Djibouti-N'Djamena Highway	2003	0.124	13.2%	0.6%
45	Addis–Djibouti Transport Railway	2011	0.288	33.4%	2.4%
49	Benguela Railway	2006	0.163	17.8%	1.0%
55	Cairo–Gaborone-Cape Town Road	2009	0.120	12.8%	0.9%
57	Namibe Road	2003	0.332	39.4%	1.7%
59	Nacala Railway Corridor	2012	0.200	22.2%	1.8%
61	Zambia-Malawi-Mozambique Railway	2012	0.233	26.3%	2.1%
62	Tema-Ouagadougou Road	2008	0.298	34.7%	2.0%
63	Malange Road	2005	0.871	138.9%	5.0%
71	Lagos-Kano-Jibiya Road	2009	0.283	32.7%	2.0%
72	Limpopo Road Corridor	2011	0.046	4.7%	0.4%
73	Northern Corridor Transportation Improvement Road	2008	0.663	94.0%	4.5%
75	Juba-Port Sudan Road	2007	0.314	36.9%	2.0%
81	Brazzaville-Pointe Noire Road	2007	0.791	120.6%	5.1%

F.2. Univariate interaction effects

Table F.2: Univariate interaction effects, * = p<0.05

	DiD-coeff.
ATT	0.110* (11.7%)
Road	0.160* (17.5%)
ATT	0.292* (34.0%)
Greenfield	-0.227* (-20.3%)
ATT	0.148* (15.9%)
WB	0.174* (19.0%)
ATT	0.226* (25.3%)
Landlocked	-0.034* (-3.3%)
ATT	0.106* (11.2%)
Urban	0.472* (60.3%)

F.3. Multivariate interaction effects

Table F.3: Multivariate interaction effects of full sample, * = p<0.05

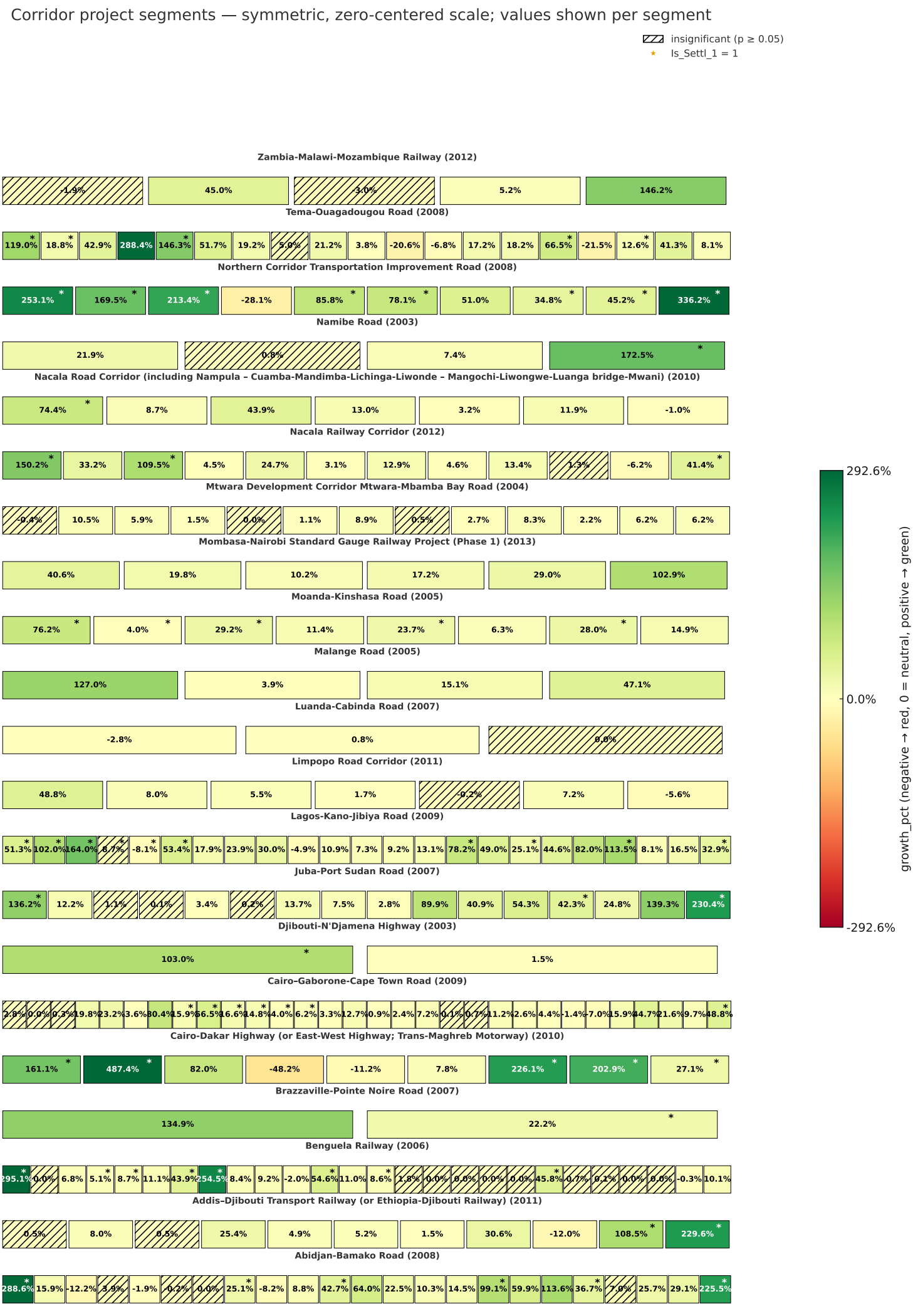
	Estimate
ATT	0.147 *
Road	0.010
Greenfield	-0.196*
WB	0.116*
Landlocked	-0.174*
Urban	0.475*

Table F.4: Multivariate interaction effects of rural and urban sample, * = p<0.05

	Rural	**Urban**
ATT	0.150*	0.574*
Road	-0.034*	0.021
Greenfield	-0.142*	-0.400*
WB	0.069*	0.274*
Landlocked	-0.148*	-0.296*

G

DiD-estimates of segments


Corridor project segments — symmetric, zero-centered scale; values shown per segment
insignificant (p ≥ 0.05)
Is_Settl_1 = 1
Zambia-Malawi-Mozambique Railway (2012)
-1.9%
45.0%
3.0%
5.2%
146.2%
Tema-Ouagadougou Road (2008)
119.0% 18.8% 42.9% 288.4% 146.3% 51.7% 19.2% 5.0% 21.2% 3.8% -20.6% -6.8% 17.2% 18.2% 66.5% -21.5% 12.6% 41.3% 8.1%
Northern Corridor Transportation Improvement Road (2008)
253.1% 169.5% 213.4% -28.1% 85.8% 78.1% 51.0% 34.8% 45.2% 336.2%
Namibe Road (2003)
21.9%
0.8%
7.4%
172.5%
Nacala Road Corridor (including Nampula – Cuamba-Mandimba-Lichinga-Liwonde – Mangochi-Liwongwe-Luanga bridge-Mwani) (2010)
74.4% 8.7% 43.9% 13.0% 3.2% 11.9% -1.0%
Nacala Railway Corridor (2012)
150.2% 33.2% 109.5% 4.5% 24.7% 3.1% 12.9% 4.6% 13.4% 1.3% -6.2% 41.4%
Mtwara Development Corridor Mtwara-Mbamba Bay Road (2004)
-0.4% 10.5% 5.9% 1.5% 0.0% 1.1% 8.9% 0.5% 2.7% 8.3% 2.2% 6.2% 6.2%
Mombasa-Nairobi Standard Gauge Railway Project (Phase 1) (2013)
40.6% 19.8% 10.2% 17.2% 29.0% 102.9%
Moanda-Kinshasa Road (2005)
76.2% 4.0% 29.2% 11.4% 23.7% 6.3% 28.0% 14.9%
Malange Road (2005)
127.0% 3.9% 15.1% 47.1%
Luanda-Cabinda Road (2007)
-2.8% 0.8% 0.0%
Limpopo Road Corridor (2011)
48.8% 8.0% 5.5% 1.7% -0.2% 7.2% -5.6%
Lagos-Kano-Jibiya Road (2009)
51.3% 102.0% 164.0% 8.7% -8.1% 53.4% 17.9% 23.9% 30.0% -4.9% 10.9% 7.3% 9.2% 13.1% 78.2% 49.0% 25.1% 44.6% 82.0% 113.5% 8.1% 16.5% 32.9%
Juba-Port Sudan Road (2007)
136.2% 12.2% 1.1% 0.1% 3.4% 0.2% 13.7% 7.5% 2.8% 89.9% 40.9% 54.3% 42.3% 24.8% 139.3% 230.4%
Djibouti-N'Djamena Highway (2003)
103.0%
1.5%
Cairo–Gaborone-Cape Town Road (2009)
2.8% 0.0% 0.3% 19.8% 23.2% 3.6% 30.4% 15.9% 66.5% 16.6% 14.8% 4.0% 6.2% 3.3% 12.7% 0.9% 2.4% 7.2% 0.1% 0.7% 11.2% 2.6% 4.4% -1.4% -7.0% 15.9% 44.7% 21.6% 9.7% 48.8%
Cairo-Dakar Highway (or East-West Highway; Trans-Maghreb Motorway) (2010)
161.1% 487.4% 82.0% -48.2% -11.2% 7.8% 226.1% 202.9% 27.1%
Brazzaville-Pointe Noire Road (2007)
134.9%
22.2%
Benguela Railway (2006)
295.1% 0.0% 6.8% 5.1% 8.7% 11.1% 43.9% 254.5% 8.4% 9.2% -2.0% 54.6% 11.0% 8.6% 1.8% 0.0% 8.0% 0.0% 0.0% 45.8% 0.7% 0.1% 0.0% 0.0% -0.3% 10.1%
Addis–Djibouti Transport Railway (or Ethiopia-Djibouti Railway) (2011)
0.5% 8.0% 0.5% 25.4% 4.9% 5.2% 1.5% 30.6% -12.0% 108.5% 229.6%
Abidjan-Bamako Road (2008)
288.6% 15.9% -12.2% 3.9% -1.9% -0.2% 0.0% 25.1% -8.2% 8.8% 42.7% 64.0% 22.5% 10.3% 14.5% 99.1% 59.9% 113.6% 36.7% 7.0% 25.7% 29.1% 225.5%
292.6%
0.0%
-292.6%
growth_pct (negative → red, 0 = neutral, positive → green)