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Impact Evaluation of Transport Corridors: Approach from the ieConnect Portfolio

Transport infrastructure has the potential to bolster economic development by connecting several pillars of a nation's economy. Several studies have independently documented the gains and losses from investments in transport infrastructure, such as direct and indirect outcomes, wider economic benefits, and complementary measures. This article presents a programmatic approach for evaluating the impact of transport infrastructure investments with respect to their short and long run goals. It builds on existing data and reviews newly available high-frequency geospatial data and innovations on outcome measurements. The program exposition is substantiated with examples of projects currently evaluated under the ieConnect for Impact program at the World Bank.[1]

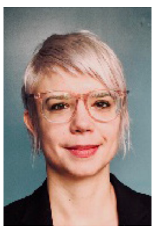
WORLD BANK GROUP
Transport

1 In addition to the authors, this article covers the contributions of several former and current ieConnect and DIME team members, in particular Sveta Milusheva, Théophile Bougna, Rob Marty, Kevin Croke, John Loeser, Florence Kondylis, and Maria Jones. The authors thank the ieConnect and DIME teams and management for their support and advice. More information on ieConnect's projects can be found here.

Introduction

About the Authors

Advitha Arun is a Research Assistant at the World Bank.



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Improved access to roads can increase output, reduce costs, and foster economic growth. During the fiscal year 2022, the World Bank listed 176 active transport projects, with US$35.33 billion in commitments. Given the magnitude and pervasiveness of transport investment across the developing world, it becomes essential to evaluate the benefits of such investments. Impact evaluation helps in understanding the return on investment (ROI) and helps policy makers design future corridor investments as well as complementary interventions. However, policy makers and academics seeking to address this question often find themselves impeded by challenges, such as data availability and choosing the appropriate indicator based on the context for statistical analyses.

Traditionally, transport appraisal plans estimate short-term outcomes ex ante, such as reduction in travel time and savings in terms of vehicle operating costs. The highway development and management model (HDM-4) is a widely used system for transport infrastructure investment appraisal and decision making. HDM-4 takes as inputs road conditions, vehicle speeds, traffic volume, and vehicle operating costs, among others. The outputs of the model include road user costs, sensitivity analysis, and a simplified economic evaluation of roads.

However, beyond the immediate benefits, such as reduced travel time and vehicle operating costs, infrastructure investments also aim at generating benefits for households and firms, thereby leading to economic growth and development.

Therefore, measurement of immediate outcomes is a necessary—though not a sufficient—measure of evaluating the impact of roads in developing countries. Monitoring informs the policy makers of the pace and progress of transport infrastructure investment. However, impact evaluation is necessary to understand the reasons for the apparent success of construction of roads in a particular context, if any. In this way, monitoring and impact evaluation complement each other in addressing questions of evaluating transport infrastructure and throwing light on complementary measures that could further increase the benefits of constructing corridors.

Despite their importance, impact evaluations of transport projects accounted for less than 1 percent of all impact evaluation studies globally between 1981 and 2012 (Cameron, Mishra, and Brown 2016). To bridge the knowledge gap, the World Bank's ieConnect for Impact program has undertaken several studies for improving the evidence base for policy making.

Rapid technological advancement during the past decade has enabled data collection using remote sensing technologies at relatively low cost. This advent of geospatial data has provided an opportunity for researchers in policy as well as academia to employ publicly available high-quality data in their research on topics ranging from economic activity, agricultural productivity and pollution to urban development. A key advantage of geospatial data is its availability at large geographic scale for repeated periods, at relatively low cost. Measurement of these variables would be prohibitively expensive without remote sensing.

While the academic literature on impact evaluation of transport infrastructure has been effectively using these novel data sources, there is scope for the policy makers to tap into these. By reviewing a subset of work done in this space by the ieConnect team, this article seeks to systematically present methods for approaching questions in evaluating transport infrastructure. Though the review is not exhaustive, the article lays out a barebones structure policy makers can use to reproduce similar work in their respective contexts and contribute to growing international evidence in this area.

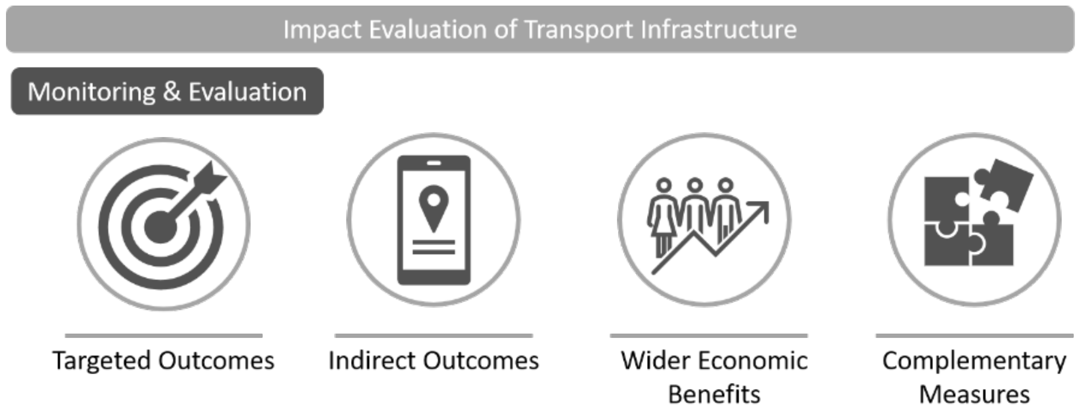
Challenges in Evaluation

Evaluation Beyond Monitoring

Metrics used by multilateral development banks (MDBs) for measuring the success of a transport infrastructure investment are often outputs. This is usually captured in the monitoring and evaluation, or M&E. The challenge posed by evaluating the benefits of transport infrastructure is that these investments are not implemented in a vacuum. Other factors might affect the success of a locality close to the road or intended beneficiaries, such as local industries or other government programs. The challenge that impact evaluations aim to address is to get at the causal effect of the transport infrastructure on the outcomes of interest.

Figure 1 shows the essential difference between impact evaluation and M&E. The role played by complementary policies in amplifying the economic benefits of transport corridors is also important to understand and mitigate the existence of relative “winners” and “losers.” Roberts et al. (2020) finds detrimental effects on environmental quality outcomes in some regions and increased spatial inequality, despite overall positive average impact. Evidence-based policy making requires understanding the effectiveness and efficiency of “place-based” policy choices with respect to transport infrastructure (Duranton and Venables 2021).

Figure 1. Impact Evaluation of Transport Infrastructure



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Measuring Causal Impact

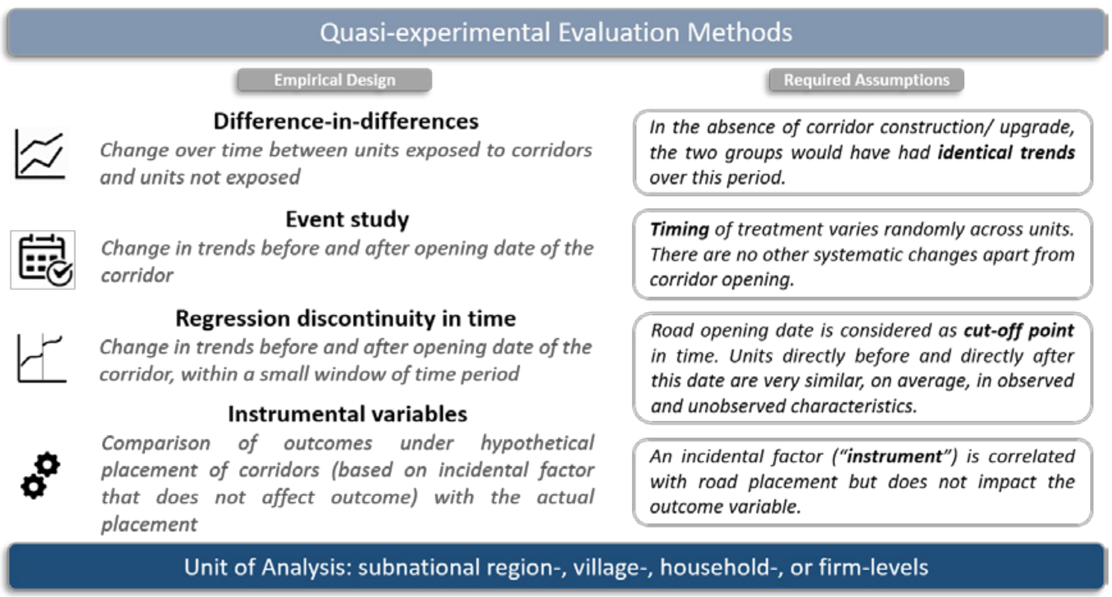
Traditional impact evaluations are based on an experimental design. A key feature of randomized experiments is that they enable comparison of statistically identical groups of individuals, which gives a precise estimate of the intended effect. However, it is impossible to randomize costly highways and roads placement in a geographic space. Policy makers prioritize transport investment in the areas that exhibit specific characteristics or would support a specific growth strategy. Additionally, investment in transport infrastructure could induce relocation of economic activity between places. This movement could not only result in gains in one location at the cost of another, but also makes comparison of outcome indicators between targeted and nontargeted locations insufficient.

Given these constraints, the economics literature has relied on other methods to arrive at the causal effect of the roads. These rely on examination of locations directly targeted by the project, the "in-between" locations along the corridors incidentally served and locations truly unaffected by the transport corridor. Locations affected by corridors, either directly or indirectly due to proximity, are classified as "treatment" units, whereas those completely unaffected are termed as "control" units.

Redding and Turner (2015) note that the recent literature has developed methods such as instrumental variables, difference-in-differences, regression discontinuity designs, matching, and event studies. These methods require larger sample sizes and more assumptions than experimental methods to provide valid and unbiased estimates of the causal impacts, as seen in **figure 2**.

Differences-in-differences compare outcome variables of units exposed to the roads' interventions with those units—villages not exposed but that have similar trends in outcomes ex ante. The change over time in the two groups quantifies the impact of the constructed infrastructure. Instrumental variables, instead, consider the placement of roads to be correlated with an incidental factor that does not impact the outcome variable. Event studies are a flexible form of difference-in-differences, giving estimates for each time period.

Figure 2. Quasi-Experimental Methods for Transport Infrastructure Impact Evaluation



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Inputs in Impact Evaluations

Sound evaluation of transport infrastructure depends not only on the methodological rigor of the proposed evaluation, but also on data quality and availability at high frequency. This is especially true in the case of low- and middle-income countries (LMICs), which have a dire need for both. Advances in technology have enabled the use of novel data sources to answer questions in traditional economics. Data from satellite imagery, aggregated mobile phone and crowdsourced data from social media are used by the ieConnect team. These granular datasets are available at high frequency with high geographic coverage. Combining these data sources with existing administrative data helps in evidence-based decision making for transport infrastructure investments, especially in development research (Donaldson and Storeygard (2016).[2]

2 Among others, Bleakley and Lin (2012) and Henderson, Storeygard, and Weil (2011; 2012) use nighttime lights data to show agglomeration in areas surrounding portage sites and agricultural regions. Storeygard (2016) estimates the transport costs for cities in Sub-Saharan Africa and Alder (2016) studied the impact of the Golden Quadrilateral in India.

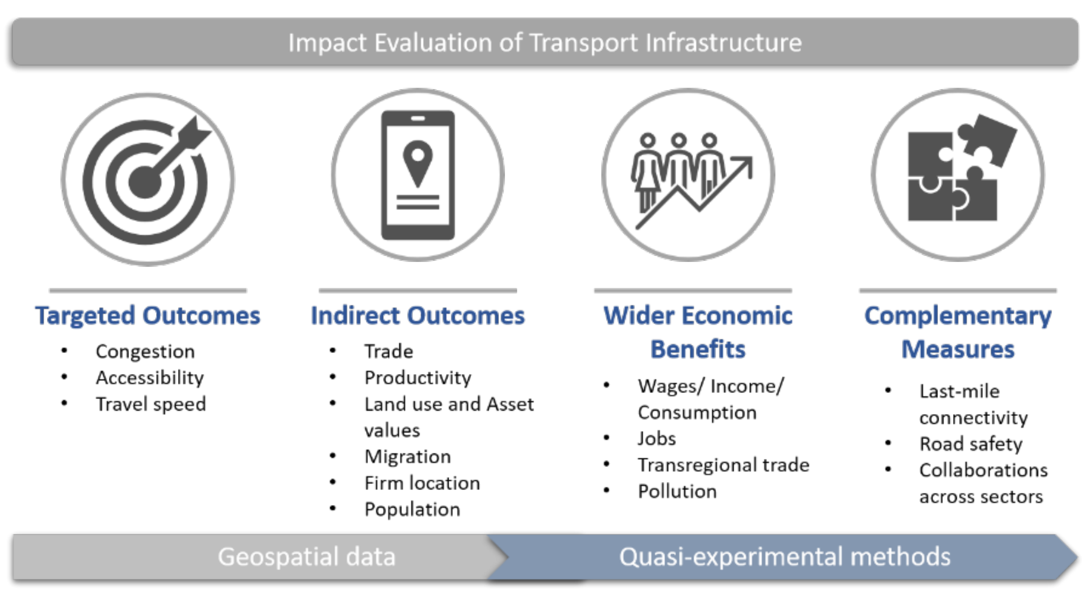
Proposed Approach to Evaluate Corridors Projects

We explain the proposed approach to impact evaluation of corridors in four sections, based on corridor projects, well-defined theory of change derived from policy and research questions and outcomes of interest:

1. Intervention-targeted outcomes
2. Indirect outcomes
3. Wider economic benefits
4. Complementary measures

This framework seeks to bring new and existing data sources together to answer questions in this space, as summarized in **figure 3**. It builds on the project appraisal objectives of transport infrastructure investments, which focus on reduced travel time to measure congestion and accessibility. As the effects of the corridors spill over, we can expect changes in land use and relocation of firms and workers—potentially resulting in urbanization and increased trade in the medium term. Over time, transport infrastructure improvements could induce increased economic activity, job creation, increased household income, and higher firm productivity. Further, the success of a transport corridor in catalyzing economic development depends on complementary measures that enable implementation, such as simplifying border processes for traders, last mile connectivity, or road safety.

Figure 3. Framework for Transport Infrastructure Impact Evaluation



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Intervention-Targeted Outcome: Accessibility

Providing accessibility is essential for public service delivery and matching people to jobs. In this way, transport infrastructure paves the path for achieving more than half of the Sustainable Development Goals, or SDGs (Cook et al. 2017) . Target 9.1 of the SDGs aims at developing reliable and sustainable infrastructure, to provide equitable economic opportunities and well-being for all. In developing countries, improving the connection of firms and farmers to national and global markets is crucial for job creation and economic growth. Policy makers often define "accessibility" as the ability and the ease with which people can reach their destinations.[3]

Accessibility in data-poor environments: Example of Tunisia corridors

The challenge of measuring accessibility then becomes that of finding the appropriate data for measuring population density. While this might be relatively easy to obtain in urban areas (using administrative data from municipalities, for example), measuring population precisely in remote and far-reaching rural areas is not usually so. Survey methods have provided a potential solution to the measurement of population density. For example, the Rural Access Index (RAI) designed and used by the World Bank provides a basis for estimating the proportion of rural population with access to the transport system by undertaking a locally representative household survey (Roberts, KC, and Rastogi 2006). In addition to being expensive, the survey method has the disadvantage of being inconsistent across areas, districts, and countries (World Bank 2016). Geospatial data provides a suitable alternative for measuring accessibility. For instance, high-resolution population distribution data by WorldPop, digitized road network data, and mobility data platforms (including navigation apps such as Google Maps). Focusing on population density measures accessibility through a "travel demand" approach alone. In contrast, according to Mehndiratta and Peralta Quiros (2015), combining granular geospatial data helps to link qualities of the transport system (road network, speed, costs) with those of the land-use system (distribution of activities).

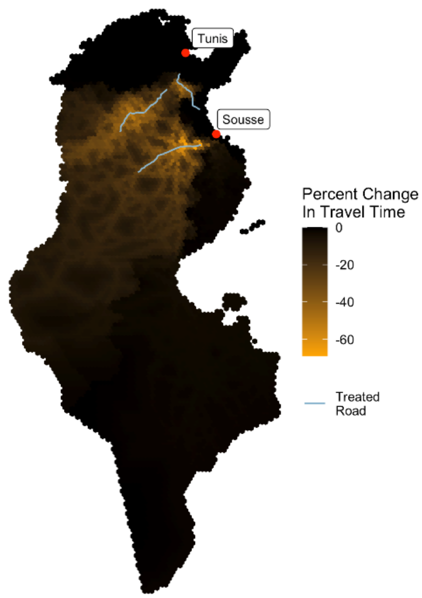
The challenge of measuring accessibility then becomes that of finding the appropriate data for measuring population density.

To address the poor traffic conditions on roads to and from Tunis, the government of Tunisia is working to improve the connections between the coastal economic hubs and the lagging interior regions by expanding the capacity of three road segments in the cental west region of the country. These upgrades seek to reduce travel times, improve road safety, and enable the access of interior regions to the main economic centers and international ports.

3 SDG Target 9.1.1, hence, measures the proportion of rural population who live within 2km of an all-seasoned road.

The targeted outcomes of the project include road upgrades to increase lane capacity for over 146 kilometers of the three road segments and increase the speed limit from 70 to 90 kilometers per hour (kph). To measure progress in these stated outcomes, the ieConnect team collected real-time data from Google Maps and Mapbox on travel times at regular time intervals (for example, every hour) between select locations. This provides useful information about how congestion has changed since the construction started. Using Google Maps API, or application programming interface, also has the advantage of tracking real-time road speed for roads with different traffic conditions, which enables real-time tracking of road congestion.

Figure 4. Accessibility in Tunisia



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Since the intervention aims at better connection of interior regions in the country to the coastal cities of Tunis and Sousse, we consider these to be the origin locations for measuring accessibility. We then calculate the shortest distance to Tunis and Sousse for each pixel[4] on the map of Tunisia, and the time to travel that shortest distance. Repeating the process to derive the travel time under the improved corridor system, gives us the predicted change in travel time post corridor construction. Using these two measures of travel time, we build an accessibility map, as shown in **figure 4**.

4 A pixel measures an area of 750 meters x 750 meters on the Earth's surface.

Indirect Outcomes: Economic Activity and Land Use Changes

Transport corridor systems are typically planned and constructed with the objective of reducing travel time for people and enabling better connection. However, while this ensures greater mobility, it might not always guarantee better economic opportunities. Often, the aim of the projects is also to bring growth to relatively remote or less advanced areas by improving access to market and inputs for producers, and access to jobs for the population living in relatively remote urban areas. Transport infrastructure can result in improved access to markets through two ways; first is through reduced travel time to existing markets, and the second is through inducing relocation of markets. On the one hand, construction of transport infrastructure reduces travel time and costs for firms and consumers, as explained previously. This implies that inputs to production and finished goods can be transported across space at relatively less, albeit at some, cost—known in the academic literature as transport costs. A potential way to circumvent these transport costs is for the firms to geographically fragment the production process by setting up small local plants (Ottaviano 2008). On the other hand, however, fragmentation comes at the cost of decreased efficiency and increasing returns to scale at the plant level. Firms are also able to enjoy the benefits of "scale economies" such as access to specialized business-to-business services and knowledge spillovers or idea flows (Fujita and Thisse 2002; Duranton and Puga 2004).

In this section, we explore ways to evaluate the impact of transport corridors on this trade-off between transport costs and scale economies via its impact on land use, densification and economic activity using geospatial data.

While rarely targeted by policymakers, land use changes might happen because of the new infrastructure.

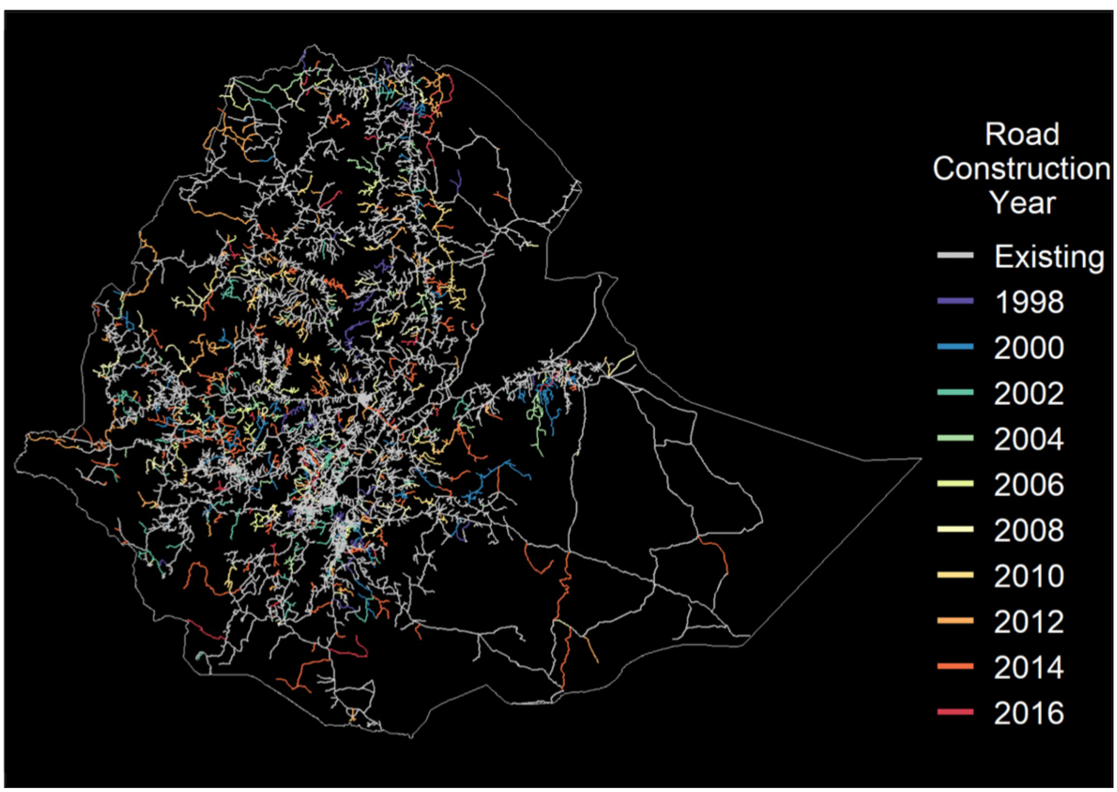
Land-use changes: Example from the Ethiopia road sector development program

While rarely targeted by policy makers, land-use changes might happen because of the new infrastructure. In economic theory, the impact of transport corridors on land-use changes is a priori ambiguous: while it aims at allowing economic activity to flourish in remote areas, it can also lead to greater specialization, such that agricultural zones see more intensive agriculture take place while urban and periurban areas grow. That is, as transport costs fall, roads could either facilitate migration to periurban and urban areas and specialization of rural economies in agriculture, or lower transport costs could cause emergence and expansion of rural economic activities. Evidence in this area is mixed. For instance, in Peru Escobal and Ponce (2002) find that rehabilitated road access enhances nonagricultural income opportunities, whereas Ethiopia (Gebressilasse 2023) and China (Qin and Zhang 2016) show access to roads is strongly associated with specialization, while road connections improve household agricultural income. This stresses the importance of evaluations that can uncover the magnitude of impact along sectoral and spatial variations.

However, a key challenge in measuring such outcomes is the availability of reliable granular data. Traditionally, studies have analyzed long-term trends using administrative data or surveys on number of new firms and household income levels. These data sources are available ex post at relatively larger geographic coverage and aggregated over time periods. In the context of developing countries, the issue could be further complicated by potential manipulation of key statistical information. The advent of remote sensing data presents the opportunity to evaluate progress along these measures at granular geographic coverage and higher temporal frequency.

To contribute to this strand of literature, the ieConnect research team has undertaken a study to measure the impact of building roads on urbanization in Ethiopia (Alder et al. 2022). The study combines remote sensing data with administrative data from the government of Ethiopia to study the road sector development program from 1996 to 2016 (**figure 5**). The aim of the program was to improve the sparse network of roads to support agricultural value chains, light manufacturing, and growth in Ethiopia.

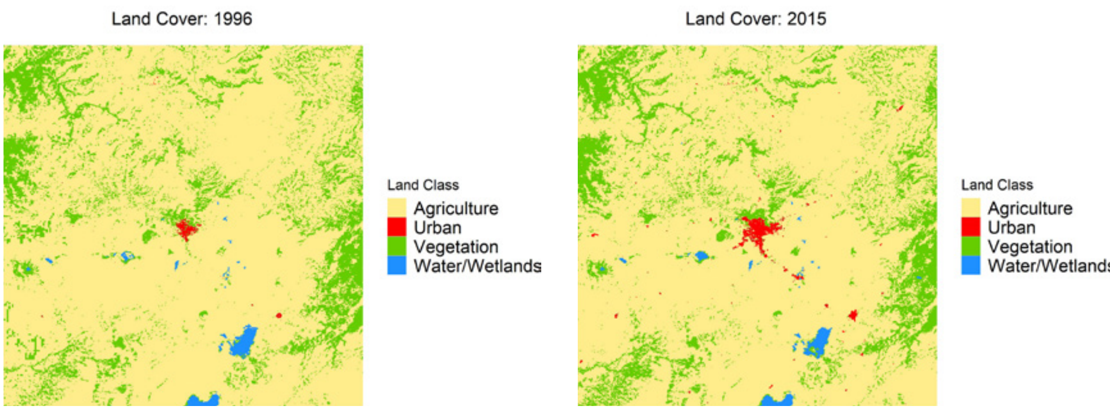
Figure 5. Ethiopa Road Sector Development Program (RSDP)



Source: Alder et al. 2022.

The study is based on an instrumental variable design and a differences-in-differences design. The empirical approaches address the fact that roads are not built at random; the places benefitting from an upgraded road might already have characteristics that lead them to have higher economic growth, or a different trend in employment. The instrumental variable approach addresses this issue by creating an instrument linked to the objectives of the program yet independent from local conditions. Specifically, following an approach from (Faber 2014), the team constructed a hypothetical network in a way that minimizes construction costs proxied by elevation change and existing land cover. To measure urbanization, the team used land cover data[5] (shown in a **figure 6**).

Figure 6. Urbanization in Ethiopia Based on Changes in Land Cover from 1992 to 2018



Source: Alder et al. 2022.

Economic activity through nighttime lights: example from Iraq corridors

Transport corridors are constructed with the objective of bringing economic growth at the national and subnational levels, consequently leading to overall economic prosperity. MDBs aim to stimulate intraregional and global trade and foster market integration through corridor investments. These objectives by planners are guided by economic theory about the distributional effects of transport infrastructure. According to this theory, regions have fixed factor endowments and differing productivity levels. A new road link between two of these regions would lower their bilateral trade costs, thereby allowing consumers to buy goods from the most affordable regions and producers to sell more of what they are best at producing. Hence, increased access to markets through transport corridors could benefit all regions, though in an inequal manner (Donaldson and Storeygard 2016).

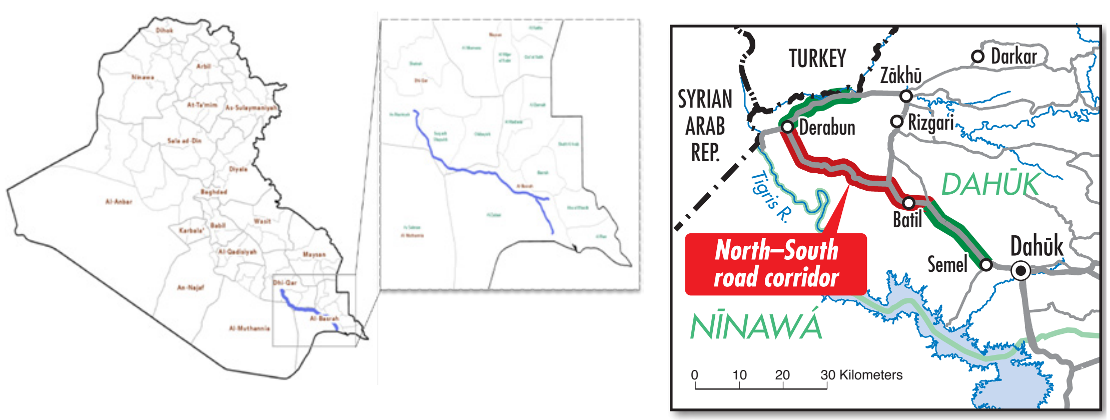
5 Available annually since 1992. Land cover data comes from European Space Agency (Globcover dataset).

The key challenge of impact evaluation along these objectives is that it necessitates reliable and granular economic data at subnational levels. While some studies have focused on using survey on wages, employment, and consumption (Small and Verhoef 2007) or administrative data on firms (Banerjee, Duflo, and Qian 2020), data availability is still an issue for LMICs.

Recent advances in technology and data availability have provided a partial solution to this issue. A key advantage of nightlights data is that it is available at higher spatial resolution, and is also available for regions that may not have official data because of lack of statistical capacity or conflict. For example, the ieConnect team is using geospatial impact evaluation in the fragile context of Iraq (DIME 2019) to evaluate the country's transport corridor. Iraq has sought to address the problem of a weak and underdeveloped infrastructure sector. Most of the population is inadequately serviced by unpaved roads with the impact falling disproportionately on low-income groups. The government of Iraq prepared its national development plan (NDP), where improving transport infrastructure is expected to play a key role.

The corridor project in Iraq aims at rehabilitating a 257-kilometer segment of Expressway 1 and constructing of a 23-kilometer segment of the north–south transport corridor near Turkey and Syria, as shown in **figure 7**.

Figure 7. Expressway Rehabilitation and Construction in Iraq

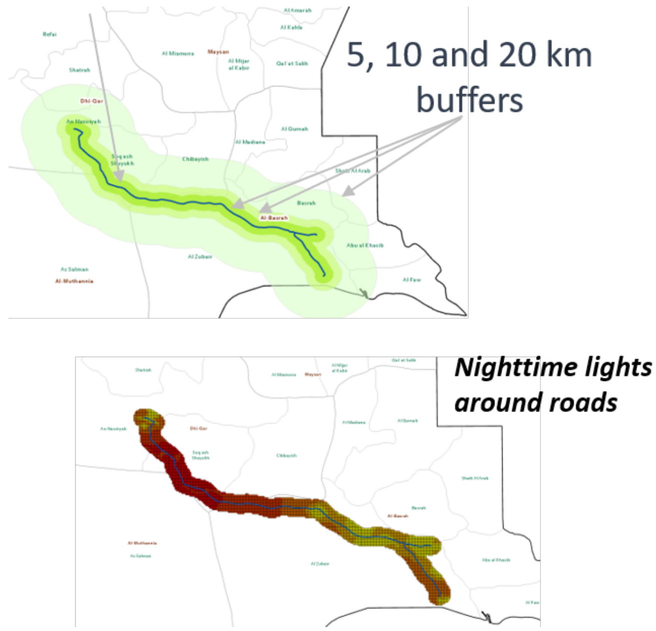


Source: DIME 2019. Map produced by the World Bank Cartography Unit (IBRD 40249).

To estimate the impact of the interventions on local economic development, the ieConnect study relies on a combination of data from satellite imagery as well as administrative data[6] at a monthly frequency. A pixel is "treated" if it lies within 10 kilometers of the improved roads. **Figure 8** shows luminosity surrounding the project roads.

6 In the case of Iraq, survey data such as Iraq Household Socioeconomic Survey (IHSES). and Continuous Household Survey (CHS) are georeferenced.

Figure 8. Nighttime Lights near Project Roads



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Wider Economic Benefits and Social Costs

In addition to direct and indirect outcomes, investment in transport infrastructure is also aimed at providing wider economic benefits in the long run, such as increase in intra-national trade, increase in economic activity, and changes in land-use valuation. This is especially relevant in the context of developing countries, where roads pave the path to eliminating extreme poverty.

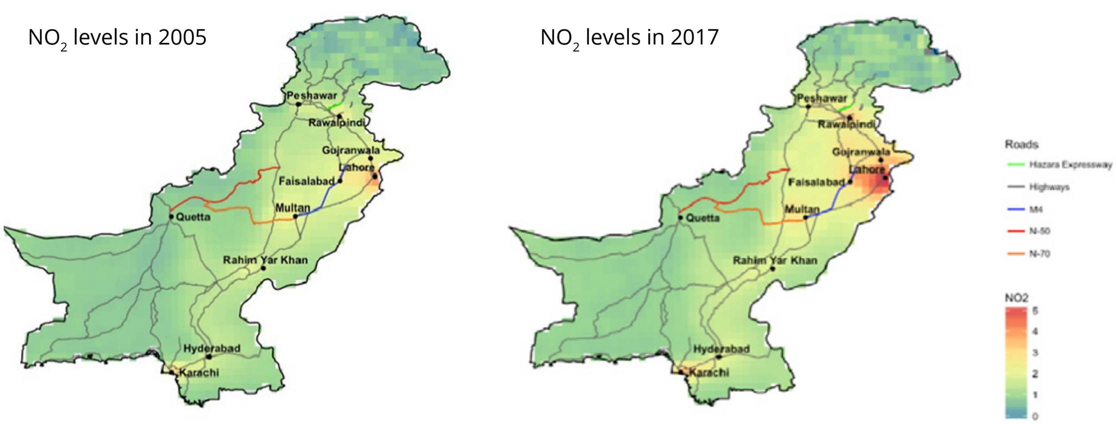
Literature evaluating the impact of transport infrastructure has focused less on the wider economic benefits than on the indirect economic impacts and choice of firm location (Redding and Turner 2015). As travel time and vehicle operating cost reduce, other benefits from the transport infrastructure arise. First, in very disconnected countries, prices of similar goods might differ significantly from city to city. One of the aims of the transport corridors is thus improving national integration by reducing this difference in prices (known as trade costs) between cities and improving arbitrage possibilities for inhabitants. Second, increasing the volume of road users might have consequences on the newly crossed territories and on the environment. The approaches to the latter two question are discussed below.

Social cost of transport corridors – Example from air pollution in Pakistan

Policy makers are concerned with the social costs of constructing transport infrastructure, in addition to the economic costs and benefits. Reduction in travel time should lead to reduction in emissions and air pollution. On the other hand, however, the fundamental law of congestion states that traffic increases proportional to the increase in road capacity. Reduced air pollution will contribute to SDG 3. SDG target 11.6 measures the air quality in cities while target 11.2 measures access to sustainable transport. These emissions generated have adverse health consequences, according to reports by the Asian Development Bank (ADB) and World Health Organization (WHO) (Qui et al. 2017; WHO 2011). A World Bank study in 2000 found that road transport was the largest source of nitrogen oxide (NO_x) emissions, over 40 percent (Lvovsky et al. 2000). Recent studies suggest that reducing congestion reduces nitrogen dioxide (NO_2) and NO_x (Gendron-Carrier et al. 2018) and reduces particulate matter, while Hilboll, Richter, and Burrows (2017) find that rapid growth experienced by India translated into higher concentration in pollutants.

Research by ieConnect in Pakistan focuses on uncovering the effect of intercity transport infrastructure on air pollution. Unfortunately, data on particulate matter and pollutants on the ground have been irregularly released in the past. The NO_2 levels in Peshawar, Islamabad, Lahore, and Karachi were found to be greater than the WHO guidelines in 2014 and it was estimated that 85 percent of the particulate matter of less than 2.5 microns is linked to road transportation (Sánchez-Triana et al. 2014). **Figure 9** shows the change in yearly average of NO_2 levels over the years.[7] The more industrialized areas of Sindh, especially Lahore, have seen their level of NO_2 increase between 2005 and 2017.

Figure 9. Air Pollution in Pakistan



Values are tropospheric NO_2 10^{15} molec/cm^2.

Source: Original figure produced for this publication.

7 Values above $5x10^{15}$ molecules per square centimeter (cm_2) are generally considered polluted and values above $1x10^{16}$ are considered highly polluted.

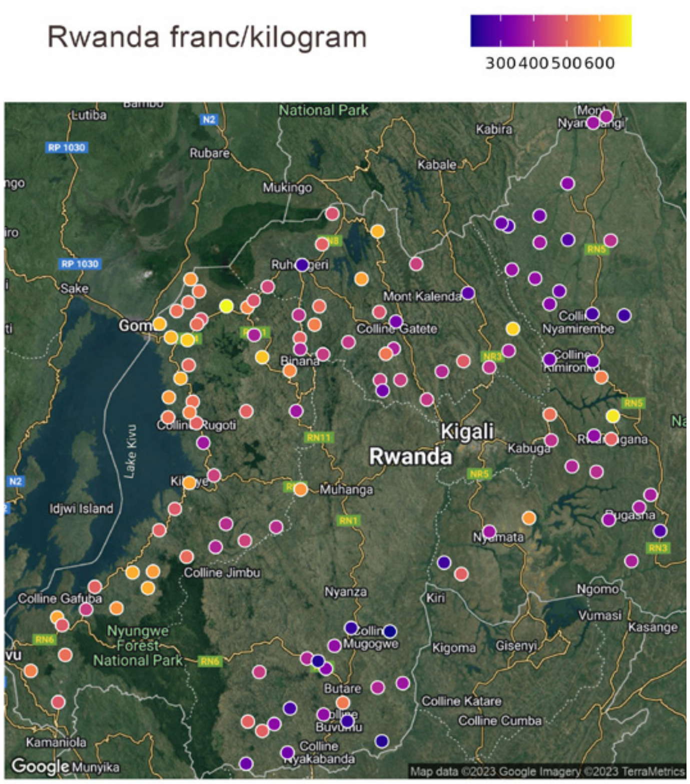
Complementary Measures: Enhancing the Benefits of Infrastructure Investments

Facilitating trade across borders along the corridor: Example from Malawi

As direct transport costs are part of a wider array of trade costs, it is important to identify their relative importance to prioritize intervention and enhance the impact of hard infrastructure (WTO 2015). This impact evaluation studies an ongoing standard trade facilitation intervention in Malawi aiming at simplifying border crossing by streamlining the steps for clearance and final authorization to cross the border by connecting agencies to the customs database and reducing the number of agencies present at the border. The intervention evaluated is part of a larger package of hard and soft infrastructure to enhance connectivity in Southern Africa. The analysis is based on extracts from customs data and trader surveys to have a measure of the relative importance of border crossing-related costs, transport costs, and bribes among the total trade costs and evaluate the impact of the intervention on trade cost and customs' revenue collection.

Last-mile connectivity: Example from Rwanda

Figure 10. Rwanda: Market Prices for Tomatoes and Feeder Roads in Q4 2019



Source: Original figure produced for this publication by the DIME Rwanda research team.

Several countries in the developing world have seen massive amounts of investment in large transport infrastructure projects. Despite these efforts, connectivity remains a primary issue in rural and remote areas. For instance, 40 percent of the rural population in Africa lives within 2 kilometers of an all-season road (Gwilliam et al. 2008). In such a scenario, last-mile connectivity between the national road system and remote areas is a pressing development challenge. Though investment in large corridor projects is undertaken with the aim to increase economic benefits, their individual impact can vary across population groups and locations. Complementary reforms have the potential to catalyze economic growth and development across locations and population groups.

For example, the government of Rwanda is rehabilitating feeder roads to reduce travel times and increase access to markets. The DIME study uses administrative, survey, market prices, and remote sensing data to study the impact of the feeder roads (**figure 10**).

The team finds that remote villages have 23.1 percent lower household income than more connected villages, and that feeder road rehabilitation increases short-run household income in remote villages by 23.4 percent, representing a full catch-up of income.

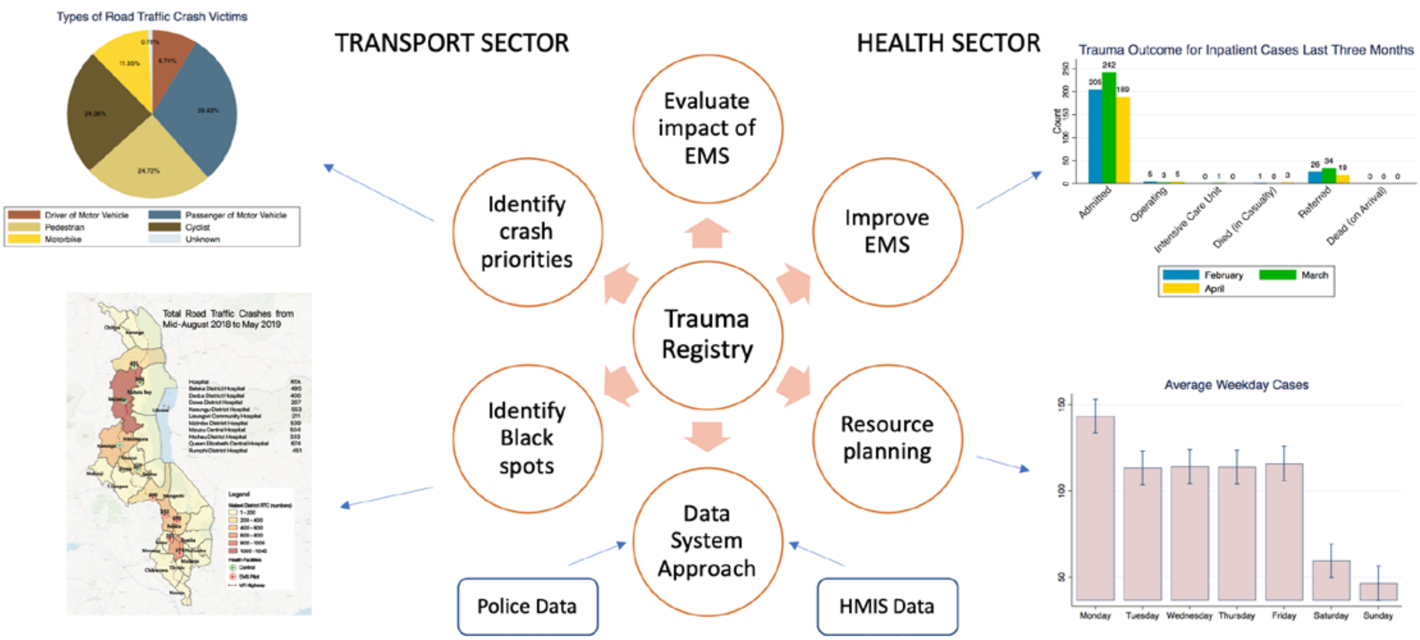
Road safety and cross-sectoral collaboration

Fatalities and injuries from road traffic crashes represent a significant social cost, particularly along major trade corridors. Africa has one of the highest road traffic death rates in the world, with 26.6 deaths per 100,000 people (WHO 2015).

Road safety will only continue to grow as a problem if it is not addressed. As more resources are channeled toward improving corridors, these upgrades often lead to higher road speeds, which can increase the number of injuries and deaths from motor vehicle crashes (Job, Soames, and Sakashita 2016). Yet, achieving the SDG target for reduction in road deaths could add 15 to 22 percent of GDP growth over 24 years (World Bank 2017). Therefore, when evaluating the economic impacts of new transport corridors, it is important to factor in the impacts that this infrastructure could have on road safety. Evidence on the effectiveness of such cross-sectoral interventions between agencies in charge of transport, health and law enforcement, among other agencies, is limited. A key challenge for policy makers looking to evaluate the impact of such cross-sectoral reforms on road safety is the paucity of data on road traffic crashes and outcomes. Significant gaps exist in administrative records on crashes and post-crash medical data in LMICs. As with other outcomes, identifying relevant data sources and strengthening data collection from different institutions is critical.

One example of the addition of a complementary road safety intervention is a pilot program in Malawi, illustrated in **figure 11**. This program is focused on a cross-sectoral collaboration focusing on first responders and trauma center improvements as part of the larger Southern Africa Trade and Transport Facilitation Program (SATTFP). Research by the ieConnect team involved pooling high frequency data from four primary sources to create a data system that can be used for evaluating the complementary reforms and planning future transport infrastructure projects (Croke et al. 2020).

Figure 11. Building Data Systems through Cross-Sectoral Collaborations in Malawi



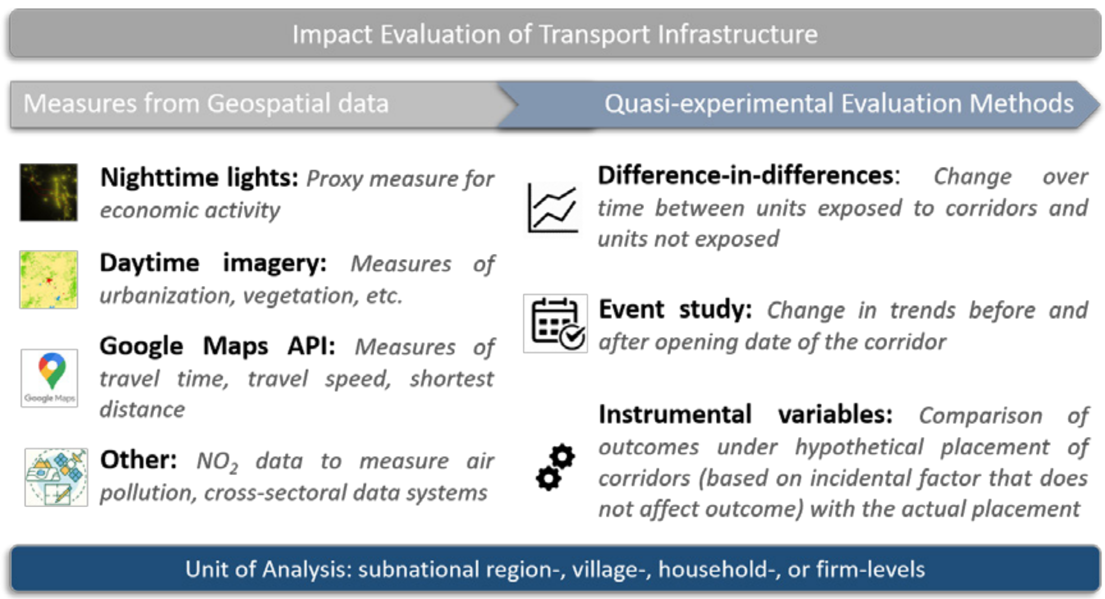
Source: Original figure produced for this publication, by the ieConnect team.

Path Forward

This article presents a framework that can be used by policy makers to understand the wider socioeconomic impacts of transport infrastructure projects. Given the large financial investment and the potential for wide economic benefits of transport corridors, their impact evaluation is essential for evidence-based policy making. The key challenges faced by policy makers and researchers in this area are availability of data and the use of relevant methodology for deriving precise estimates.

With respect to data availability, this article suggests combining geospatial data with the available administrative data in data-poor environments. Advances in technology have enabled the use of remote sensing and satellite imagery, which are used as proxy measures in the economics literature for measures such as local economic activity, travel time, accessibility and land use. Remote sensing data provides granular geographic coverage and higher frequency at lower cost. Cross-sector collaborations (across transport, trade health, and other sectors) can be used to build a comprehensive data system that tracks real-time outputs.

Figure 12. Proposed Framework for Impact Evaluation of Transport Corridors



Source: Original figure produced for this publication.

Given the strategic placement of corridors and the impossibility of randomizing end-users, reliance on quasi-experimental methods is suggested. Further, use of geospatial data provides the additional advantage of verifying long-term trends in unobservable factors such as quality of roads and mode of transportation, which are essential for the methods such as difference-in-differences, event study, and instrumental variables, as summarized in **figure 12**.

In addition to the targeted outputs and economic outcomes, this article highlights the importance of evaluating the impact of wider economic benefits as well as complementary reforms. There is a large scope for policy makers and researchers to evaluate the effects of corridors on equity and environmental welfare, as corridors materialize and their benefits spillover. Complementary policies can help amplify the benefits of transport corridors, and hence evaluating their impact helps the design of an optimal corridor package.

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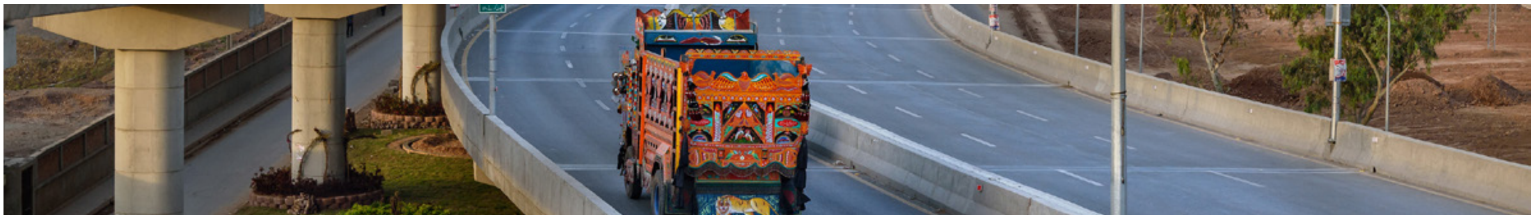

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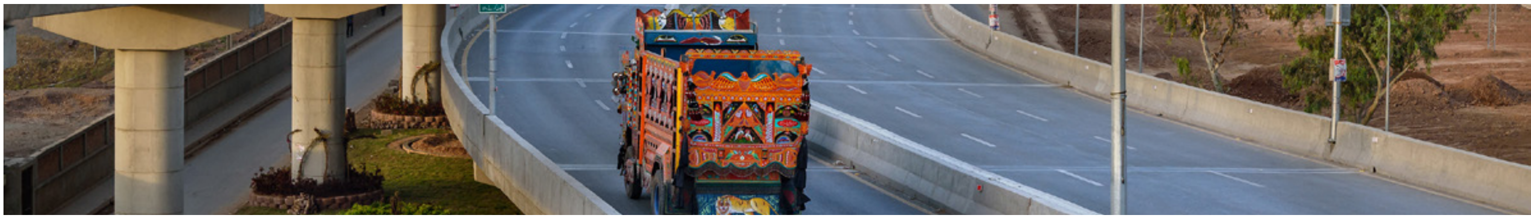

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