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# Roads and jobs in Ethiopia

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**Abstract:** We look at how improving roads can affect jobs and structural transformation. We use a novel geocoded dataset covering the universe of Ethiopian roads and match this information with individual data to identify the effects of improvements in road infrastructure on the creation, quality, and sectoral distribution of jobs over the period 1994–2013. We find that, at the district level, higher market potential due to better roads contributes to the creation of new jobs, reduces the share of agricultural workers, and increases that of workers in the services sector but not in manufacturing. The latter experiences a relative increase in the share of informal workers. Finally, investigating the underlying mechanisms, we show that patterns of internal migration and changes in economic opportunities can help to rationalize our findings.

**Keywords:** Ethiopia, roads, structural transformation, transport infrastructure

**JEL classification:** L16, O18, O55, R4

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## 1 Introduction

Transport infrastructures matter for economic development. Greater transport connectivity can improve the lives of individuals, widening their work and educational opportunities and fostering transition to more productive activities. In addition, improving domestic transport infrastructures can relax some of the key constraints that affect the private sector in many low-income countries, by allowing firms to better connect to local and international markets, improve efficiency, and provide better jobs. Understanding whether policies supporting the construction of transport infrastructures can affect jobs in low-income countries is therefore of high policy relevance. Yet, partially due to limited availability of time series data on transport infrastructures in low-income countries, this topic remains relatively under-investigated in the academic literature. In this paper we look at the effects of developments in road infrastructure on the number and quality of jobs in Ethiopia.

We take advantage of the collection of very granular information on a recent large-scale programme, the Road Sector Development Programme (RSDP). The RSDP started in 1997 with the aim of improving connectivity across the country through the rehabilitation of existing roads and the construction of new ones.[1] In the space of just a decade, improvements due to the RSDP have been remarkable. Road density rose from 24.1 per 1,000 km$^2$ when the programme started to 44.4 per 1,000 km$^2$ in 2010 (when an evaluation of the first three rounds of the programme was completed; Ethiopian Road Authority 2011). Over the same period, the proportion of the total road network in good condition improved from 22 per cent to 56 per cent. In this paper we use geolocalized information on the Ethiopian road network, for which we track road-segment-specific improvements recorded under the RSDP. We match information on the road network with information at the level of individuals taken from the 1994 Population Census and the Ethiopian National Labour (NLF) survey, a representative survey of Ethiopian workers, available for the years 1999, 2005, and 2013. We use the district (or woreda, the third-level administrative units in Ethiopia) as the unit of analysis. To better explore how transport infrastructures affect labour demand, we further combine road data with additional information on the activity of manufacturing and services firms.

The case of Ethiopia is particularly relevant for our purposes. Industrialization and structural transformation are at the core of the Ethiopian national development strategies. Beginning with the agricultural development-led industrialization (ADLI) strategy in 1995, and following with the most recent growth and transformation plans (I and II), a large emphasis has been placed on structural transformation (Schmidt et al. 2018). This policy agenda focused on the development of some targeted industries (those with more linkages to the agricultural sector), but it also more generally promoted diversification into highly productive activities and entrepreneurship, and supported investment, especially from abroad. Improving connectivity both within the country (rural–urban and urban–urban) and with external markets is a related effort in the pursuit of structural transformation and economic upgrading (Ali 2019).[2] Existing evidence from Ethiopia shows how high transport costs have so far represented high barriers to market integration (Atkin and Donaldson 2015; Gunning et al. 2018) and labour supply (Franklin 2018).

We study the impact of road infrastructures using a market potential indicator. Grounded on the work by Harris (1954) and theoretically founded in gravity adaptations of the new economic geography (NEG) model, a measure of market potential allows us to account for the direct and indirect effects of roads investment that took place all over the country under the RSDP. We expect that improvements in mar-

[1] Note that roads represent the exclusive means of transport in Ethiopia over the period covered in our analysis. The railway, connecting Addis to Dijibuti, was in fact re-established in 2017.

[2] The recent efforts to develop industrial parks in the country are consistent with the idea that both employment creation in non-agricultural sectors and structural transformation are indeed dependent on a reliable infrastructure network.

ket potential will have implications for the number and quality of jobs in Ethiopia.[3] However, the sign of these effects is theoretically ambiguous (Asher and Novosad 2018; Baum-Snow et al. 2018). Especially for countries at earlier stages of development (and high transport costs to start with), improvements in market potential shape the distribution of economic activities, with central locations initially growing faster compared to more peripheral ones (Brulhart et al. 2019). Changes in market potential alter the economic environment for both firms and workers.[4] Better roads can affect firms in various ways. Improvements in road infrastructures reduce firms' transport costs, increasing market opportunities while lowering the costs of sourcing inputs. This can trigger private sector development through more entry and higher performance, and ultimately generate an increase in labour demand. However, better roads also increase competitive pressures faced by firms with potentially opposite implications on labour demand. On the supply side, roads can contribute to pushing workers out of agriculture (Asher and Novosad 2018), which is still the prevalent sector in the country. This happens primarily through improvements in farms' productivity (due to, for instance, greater access to new and imported inputs). Recent evidence provides support to the link between improvements in connectivity under the RSDP and increases in agricultural productivity (Adamopoulus 2018).

Lower transport costs also reduce constraints on migration choices (Morten and Oliveira 2017). According to a report of the recently established Ethiopian Jobs Commission (Jobs Creation Commission Ethiopia 2019), recent increases in migration (mostly rural–urban) do exert a huge pressure on urban labour markets, with likely consequences for wages, unemployment, and the size of the informal sector. Understanding how labour demand and supply interact in the Ethiopian context and the effects on the size and composition of local employment is therefore an empirical question that we try to analyse in the paper.

A key issue for our analysis is that the high costs and potentially large benefits of investment in road infrastructures might imply a correlation between the placement of new roads and both the economic and political characteristics of each district. Note that an advantage of using a market potential approach, compared for instance to measures of local road density, is that its value is influenced by improvements recorded elsewhere in the country. This should, in turn, reduce some of the common concerns related to endogenous road placement (Donaldson and Hornbeck 2016). Our identification strategy relies on exploiting the time series dimension of improvements in roads within each district, running a panel regression that includes granular district fixed effects together with region–time fixed effects. To further minimize endogeneity concerns we add an appropriate battery of controls varying at the time–district level that allow us to isolate changes in market potential that are orthogonal to investments in local road infrastructure. In addition, we exploit the fact that market potential in a district is determined by changes not only in nearby districts' road segments, but also in any other part of the national road network. Therefore, by controlling for improvements to roads within the district we restrict the variation in the market potential measure to reflect improvements in the road network which are arguably exogenous to other districts' characteristics. Note that this is also, to the best of our knowledge, the strategy adopted to tackle the endogeneity of market potential by most papers using similar measures to ours

[3] Following Gollin and Rogerson (2014), in developing countries it is hard to undertake structural transformation without first reducing transport costs.

[4] There is indeed evidence showing that improvements in within-country market potential are linked with more trade, income, and population (for instance, see Alder 2019; Chiovelli et al. 2019; Eberhard-Ruiz and Moradi 2019; Storeygard 2016).

For the case of Ethiopia, Fiorini et al. (2019) show that improvements in market access due to the RSDP are a necessary condition for firms to experience productivity gains from trade liberalization.

in a panel setting (for example, see Donaldson and Hornbeck 2016; Storeygard 2016; Storeygard and Jedwab 2018).[5]

Our results show that there is a link between improvements in connectivity, jobs, and their composition in the context of Ethiopia. We find that improvements in market potential contribute to the creation of jobs. An improvement from the 25th to the 75th percentile of the distribution of market potential in our estimation sample would imply, for an average district, an increase of about 19.6 per cent in the number of jobs, which corresponds on average to roughly 8,600 additional persons employed. In addition, we find evidence that improvements in roads are associated with changes in the sectoral composition of the workforce within the same district. This happens through a reduction in the number of agricultural workers and an increase in the number of workers in the services sector, but not in manufacturing. We show, therefore, that improvements in roads seem to contribute to setting up a pattern of structural transformation without manufacturing, which is consistent with findings of other studies looking at the dynamics of structural transformation in the African continent (Hjort and Poulsen 2019; Hohmann 2018; Rodrik 2016). By investigating the effects of road infrastructures at a disaggregated sectoral level, we show that the increasing share of services employment that can be attributed to improvements in roads is mostly accounted for by low-value-added activities, including private household services and retail trade.

Next, we shed light on the effects of infrastructural reforms on informal jobs across sectors. To do this, we exploit information available from the NLF surveys (but not from the 1994 census) covering both the formal and informal nature of the organizations in which workers are employed and the self-employment status of workers. Overall, we do not find strong evidence of an increase in informal jobs. A notable exception is the manufacturing sector, for which we show relative increases in the share of informal jobs following improvements in market potential.[6]

We extend our analysis and make two additional points. First, we identify some gender-specific patterns. Evidence on the relative increase of workers in services is significant for women but not for men, a result that confirms some previous evidence on the gender-specific benefits of improvements in transport (e.g. Lei et al. 2019). Second, we show also evidence of an increase in the working-age population with higher education (diploma and higher degrees) in districts where investment in road infrastructure determined higher market potential. This finding supports the result of higher returns to schooling in well-connected locations (as in Adukia et al. (2019) for the case of India). Importantly, our results remain qualitatively robust to alternative definitions of the variables of interest as well as to different cuts in the data.

Finally, we investigate some of the potential economic mechanisms that can help to rationalize our results. Following the existing literature, it can be argued that the effects of road infrastructure on jobs are driven by reduced costs of internal migration, on the one hand (Morten and Oliveira 2017), and by increased economic activity, on the other (Hjort and Poulsen 2019).[7] We show that increases in market potential through improved roads are indeed correlated with higher domestic migration to urban areas. Moreover, we find support for the hypothesis that the effects of roads on jobs are also driven by an increase in the demand for workers in districts with better market potential. Using data on both formal

[5] Most of the papers that have so far instrumented for road improvements or market access have done so by adopting time-invariant instruments, including, for instance, planned or historic routes, or the geophysical conditions of the terrain (Redding and Turner 2015).

[6] To some extent, this looks consistent with experimental evidence provided by Blattman and Dercon (2017), who showed how Ethiopian workers in the manufacturing sector do not have clear preferences for a formal rather than informal nature of jobs (and even seem to prefer the latter if this eases capital constraints).

[7] An additional mechanism has to do with improvements in connectivity leading to agricultural productivity. This channel has already been explored by Adamopoulus (2018) using comparable data for Ethiopia and therefore is not directly addressed in our study.

and informal manufacturing firms, we find that the response of formal and informal manufacturing firms includes improvements in productivity, as well as a relative increase in the number of non-production workers and in their wages. Given that this employment category includes high-skilled workers, we interpret this finding as explaining how individuals in locations with higher market potential are most likely to invest in education in view of more rewarding job opportunities in the future. Firms operating in trade-related services (i.e. wholesalers and retailers), on the other hand, experience an increase in the number of jobs but a reduction in their productivity.

Our work speaks to different strands of the literature. First, it contributes to a growing body of evidence employing detailed micro-data to investigate the drivers and patterns of job creation and structural transformation in developing countries. Some recent works by Bustos et al. (2016, 2017) focus on push factors, and show how technological shocks affecting agricultural productivity have driven structural changes in Brazil. Erten and Leight (2019) and Hohmann (2018) look at pull factors, including openness to trade and exogenous changes in international prices of natural resources to explain changes in the composition of the workforce in China and several other developing countries. Most related to the content of this paper are the works by Hjort and Poulsen (2019) Asher and Novosad (2018), and Adukia et al. (2019). These authors look at how connection to infrastructures can affect structural transformation. Hjort and Poulsen (2019) relate the connection to fast internet cables along the coasts of some African countries to an increase in job opportunities. Similarly to our findings, they show that this effect is likely to be driven by the rise of a more dynamic private sector in treated locations. Asher and Novosad (2018) and Adukia et al. (2019) exploit rich information on the construction of roads in rural villages in India. They offer a more nuanced set of results. Investment in roads does stimulate reallocation of workers out of agriculture and higher investment in education, but does not significantly increase local economic activities in treated areas. Differently from their work, our paper captures not only the construction of new roads, but also improvements (e.g. rehabilitation, expansion) made to all types of roads. In addition, while they focus on rural India, our work looks at both rural and urban areas in Ethiopia.

By exploring the relation between roads and informal employment we add to the study of the causes of informality in developing countries. For instance, the trade literature has some contrasting findings about the potential drivers of informal activity following liberalization episodes (Dix-Carneiro and Kovak 2017; McCaig and Pavcnik 2018; McMillan and McCaig 2019). We contribute to this body of research by arguing that informal jobs can also react to changes in the costs of trading domestically. More specifically, we show that, especially in the manufacturing sector, higher competition following improvements in market potential can push firms and workers to more informal jobs.

We contribute more generally to a growing literature looking at the effects of transport infrastructures on several dimensions of local economic development in low-income countries (for a review of the recent evidence see, for instance, Berg et al. 2017; Redding and Turner 2015). Donaldson (2018) and Storeygard (2016), among others, demonstrate high returns to infrastructural investments in several developing countries. Jedwab and Moradi (2016), Baum-Snow et al. (2018), and Storeygard and Jedwab (2018) show that infrastructures have persistent effects on urbanization and the distribution of economic activities across space. Other works point to second-order advantages related to, for instance, removing costs of migration (Bryan and Morten 2018), which are especially important for rural areas (Adam et al. 2018; Asher and Novosad 2018).

There is a small but growing literature looking at the consequences of infrastructural investments in Ethiopia, especially under the RSDP. Shiferaw et al. (2015) and Fiorini et al. (2019) find some evidence for the benefits of the RSDP on business dynamics and firms' productivity, respectively. Importantly, and consistent with our overall story, a recent work of Adamopoulus (2018) provides evidence supporting the link between improvements in connectivity under the RSDP and increases in agricultural productivity using a panel of Ethiopian woreda over the period 1996–2014.[8] None of this work looks specifically at the capacity of roads to generate jobs. Closer to the spirit of our work is that of Moneke (2019), who looks at the effects of infrastructural investments (in roads and electrification) on structural transformation and welfare in Ethiopia. Similarly to our work, he finds that investment in roads promotes structural transformation away from agriculture and towards services, but not in manufacturing. Rather, the analysis by Moneke (2019) shows that manufacturing jobs are supported by investment in roads in those areas of the country that also received investment in electrification.

The rest of the paper is organized as follows. Section 2 presents the main data employed in the paper. Section 3 describes the identification strategy, while Section 4 introduces the core results on the effects of road connectivity on structural transformation. Section 6 presents an empirical investigation into the mechanisms driving our findings. Section 7 concludes.

# 2 Data

## 2.1 Individuals

Individual-level data are obtained after merging two sources that provide complementary information. The first is the Ethiopian NLF survey. This is a representative survey of both urban and rural areas administered by the Central Statistical Agency (CSA) with the objective of monitoring the economic and social conditions of the economically active population. Information provided in the survey includes the demographic characteristics of the individuals, their education, and their working conditions. Questions include whether the interviewee has changed residence in the previous five years, allowing identification of internal migrants; there are also questions regarding the formal or informal nature of individuals' current jobs. We use all the existing waves of the NLF, covering the years 1999, 2005, and 2013.[9]

A limitation of the NLF surveys is that they do not cover the period preceding the start of the RSDP. To address this issue we combine the NLF with the 1994 population census. The 1994 edition of the census has most of the information that is also present in the NLF, including on the working conditions and educational attainments of the survey respondents. Crucially, the 1994 census provides details on the distribution of workers across industrial sectors.[10] Once the two datasets have been cleaned and made homogeneous to account for different definitions of the areas over time,[11] we have collapsed all the information at the district–year level using sample weights to recover information on the underlying population.

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[8] Also Iimi et al. (2017) report some evidence on the effects of improved infrastructures on agricultural productivity in Ethiopia. The focus of their work is on railways, not roads.

[9] The NLF surveys are nationally representative. They cover all urban and rural areas of the country, except the non-sedentary areas in the Somali region. The sampling frame to select the enumerator areas is provided by the population census (the 1994 census for the 1999 and 2005 NLF, and the 2007 census for the 2013 NLF). All the relevant information on the sampling procedures, coverage, and full descriptive statistics are available from the survey reports published by the CSA (2004, 2006, 2014).

[10] This is not trivial, since the 2007 census no longer includes this information. Note that while the 1994 census reports most of the relevant questions that are included in all the NLF surveys, it does not ask the individuals who work whether their job is in the formal or informal sector.

[11] NLF survey data are not geocoded, but provide identification codes for each location, including the region, zone, and district. To combine the different waves of data we have used the definition of district (woreda) provided by IPUMS that matches districts using their names when the geographic definition of borders differed between the 1994 and 2007 censuses. The 1994 census does not provide disaggregated information on the woredas belonging to the Addis Ababa region, so woredas in Addis are covered only for the three successive periods. Overall, the sample on which we run our empirical analysis covers on average about 80 per cent of the estimated total population in each wave considered.

Table 1 shows the distribution of labour shares over the 1994–2013 period, computed at the national level. While numbers of jobs are rising, there is also some general evidence on the process of structural transformation occurring in the country as economic growth occurs. Notably, there is some evidence that workers move away from agriculture in favour of services. Little change is recorded in the manufacturing sector, which is consistent with related evidence pointing to a lack of industrialization in the country.[12] When we observe the distribution of workers across industries within the service sector, we do not find evidence of any relevant shifts towards either high-value-added industries (real estate, business services, or finance) or jobs in public administration. Rather, we observe some rapid improvements in a few industries, namely trade-related services (which move from 2 to about 5 per cent of total jobs from 1994 to 2013), private services to households (rising from nearly 0.7 to about 3.4 per cent during the sample period), and other uncategorized services, which grew to 6.3 per cent in 2013.

Data show also that, over time, the relative position of women in the labour market has improved (women represented about 46 per cent of total workers in 2013, up from 43 per cent in 1994). This relative improvement seems to be driven by an increase in women employed in the services sector. While men dominate employment in the agricultural sector, women represents a larger share of employment in both manufacturing and services.

Table 1: Sector composition of employment (%)

| Year | Agriculture | Manufacturing | Construction | Services |
|---|---|---|---|---|
| 1994 | 89.71 | 1.78 | 0.29 | 8.21 |
| 1999 | 80.68 | 4.50 | 0.93 | 13.90 |
| 2005 | 83.64 | 4.41 | 1.28 | 10.67 |
| 2013 | 75.36 | 4.17 | 1.79 | 18.68 |

Notes: all values represent the share of sectoral workers from the total number of employed persons in the specific year. Following the NLF report, a worker is defined as a person who declared at least one hour of work during the week preceding the interview. All data have been weighted before collapsing information at the woreda–year level.

Source: authors' elaboration on CSA data.

Information on the informal sector is only available from the NLF surveys. The NLF provides a fairly detailed definition of informal sector employment. An informal worker is so defined if two criteria are met: first, the worker is not employed in government, government development organizations, NGOs (non-governmental organizations), or as members of cooperatives; second, those that do not fit the first criterion are considered informal workers if the enterprise for which they work has neither a book of account or a licence.[13] Following the existing literature (McCaig and Pavcnik 2018; McMillan and McCaig 2019), a definition based on the status of the firm in which the worker is employed provides a better account of informality compared to those based on the worker's registration status within formal firms, especially in countries in which the informal sector represents a large share of employment. The data show large discrepancies in the number of informal jobs and share of informal work between 1999 and other years. This is because since 2005 the question was asked only of the employed population, excluding people engaged in subsistence farming and those who work in private households (see CSA 2006, 2014). For this reason, the focus of our analysis is restricted to informal employment in the modern sectors. The number of informal jobs have been rising in these two sectors, though they represent a declining share of the total. Still, almost 50 per cent of manufacturing jobs are in the informal sector. To overcome some of the above-mentioned limitations of the data on the informal sector, we also use information on self-employment, a proxy that is most commonly used in empirical works on informality. This information is available for all sectors. Self-employment represented 38.6 per cent of total jobs in

[12] This pattern of transformation, known as 'premature deindustrialization' (Rodrik 2016), is common in many developing countries, especially in Africa.

[13] These feature are asked directly of the person being interviewed in separate questions. A worker is defined as informal if her response to both questions is negative, and formal otherwise.

2013, about 7 percentage points lower than in 1999. The agricultural sector hosts the majority of self-employed persons. Shares of self-employment in the total number of jobs are in line with those reported for the informal sector, confirming the complementarity of the two definitions.

### 2.2 Firms

To dig into more specific mechanisms, we will combine road data with three different datasets on Ethiopian firms.

The first is the annual census of large and medium manufacturing establishments, published by the CSA. The data cover all firms with at least 10 persons engaged and that use electricity in their production process.[14] All firms need to comply with the CSA requirements, and the census therefore reports information on the universe of more structured and formal firms in the country. The dataset includes detailed information on the characteristics of each establishment that are needed to estimate production functions, as well as detailed information on the size and composition (including by skills and gender) of the workers. Firms in this survey belong to the manufacturing sector, and their industry is defined at the four-digit level according to the ISIC Rev. 3 classification.

The second dataset is the Small-Scale Manufacturing Industries Survey (SSIS). This is a representative survey that covers small (those engaging fewer than 10 persons) and informal firms in the manufacturing sector. Over 95 per cent of the firms surveyed in the different waves of the SSIS do not keep a book of the account (or declare keeping it incompletely). We combine the existing five waves of the survey (covering the years 2002, 2006, 2008, 2010, and 2014), collapsing the information at the woreda level.

As per our data (Table 2), small and informal firms represent the large majority of manufacturing establishments, more than half of total manufacturing employment and about one-third of the value-added produced in the sector.

Table 2: Share (percentage of total) of the informal manufacturing sector

| Year | *N* firms | Employment | Value-added |
|---|---|---|---|
| 2006 | 97.14% | 51.42% | 38.77% |
| 2008 | 96.74% | 59.64% | 31.06% |

Notes: all values represent the share of informal manufacturing firms of the total values. The latter is given by the sum of informal and formal firms' annual totals. Information on the informal firms is calculated using weights. We report the information only for the two years in which both the SSIS and the firm census were run simultaneously. Value-added is computed as the total value of production net of production costs.

Source: authors' elaboration on CSA data.

Unfortunately, there is no equivalent information for firms in the services sector. The only information that we could recover on such firms is based on the Ethiopian Distributive Trade Survey (DST), which covers service firms in trade-related activities (i.e. retailers and wholesalers). Note that the survey is not representative at the national level, given that it covers only the urban areas of the country.[15] This is a cross-sectional survey, available for the years 2003, 2009, and 2011. Crucially, it includes information on the districts in which these firms are located, as well as other basic information on their activity, such as their size, wages, sales, and investments.

[14] The number of persons engaged refers to employees as well as working owners. This means that the total number of employees of these firms could also be lower than 10.

[15] This corresponds to 15 major urban centres (regional capitals and other major towns) and 106 other towns.

### 2.3 Roads

The main source of information on Ethiopian road infrastructure is a proprietary geospatial database consisting of coded documents by the Ethiopian Road Authority (ERA), reporting on all road construction sites that were opened in the context of the first three phases of the RSDP. The resulting database is a time series of shapefiles of the Ethiopian road network, where for each geolocalized road segment two main attributes are registered: the type of road surface and the road's condition.[16]

Figure 1a presents the network of federal and regional roads in 1996 by type of surface. Figure 1b shows the network of federal and regional roads in 2014, distinguishing between road segments that existed in 1996 and were not rehabilitated by 2014 (light grey segments on the map) and roads that were either newly constructed or rehabilitated during the first three phases of the RSDP. A visual inspection of the two maps shows a substantial expansion of the road network between 1996 and 2014. Importantly, this expansion does not appear to be geographically concentrated, but spans different administrative areas across the country. These data on road improvements can be aggregated to compute the average travel speed for each road segment at each point in time. This is done in accordance with the speed matrix proposed by the ERA and reported in Table 3.[17]

Table 3: The ERA travel speed matrix

| Surface | Condition | |
|---|---|---|
| | Not rehabilitated | Rehabilitated or new |
| Asphalt | 50 | 70 |
| Major gravel | 35 | 50 |
| Minor gravel | 25 | 45 |
| Earth | 20 | 30 |

Notes: the table reports average travel speed as a function of the surface and condition of the road segment. Speed is measured in kilometres per hour.

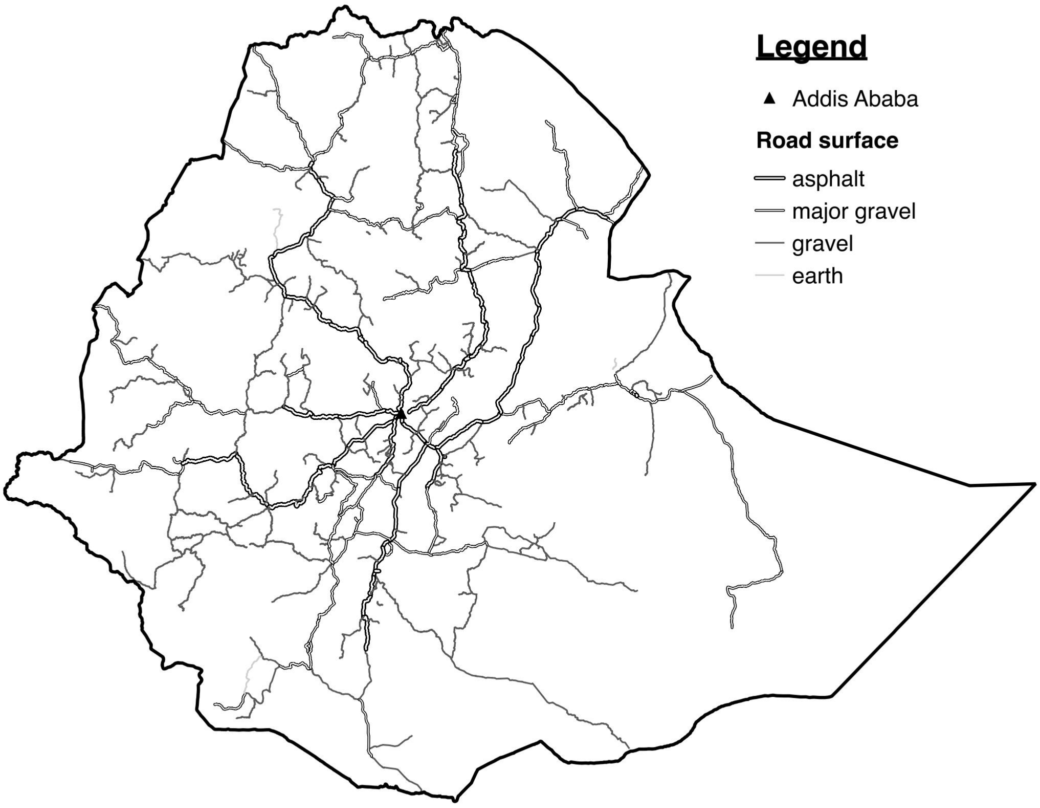
Source: authors' own calculations.

[16] There are four types of road surfaces in the data: earth surface, minor gravel (which identifies regional rural roads with a gravel surface), major gravel (federal gravel roads), and asphalt. The database distinguishes road conditions between two categories: not rehabilitated and new or rehabilitated.

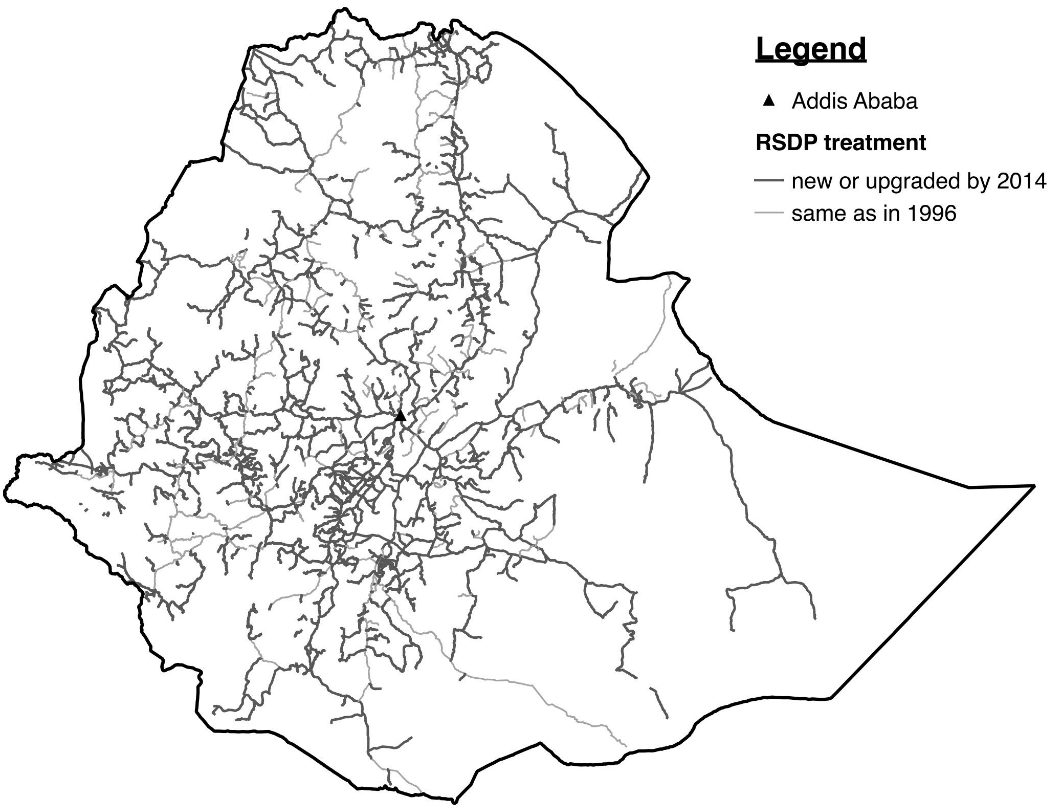
[17] The same speed matrix has been used by Shiferaw et al. (2015) and Storeygard and Jedwab (2018).

Figure 1: Federal roads, regional roads, and the RSDP: (a) RSDP roads in 1996 by surface type; (b) New and upgraded RSDP roads from 1996 to 2014

(a)




(b)




Source: authors' creation based on proprietary data.

We employ an indicator of market potential á la Harris (1954). This and alternative versions of the market potential indicator have been used in the seminal contribution by Donaldson and Hornbeck (2016) to measure the economic effects of infrastructural developments in the context of a formal structural gravity trade model. In the context of the present paper and similarly to Storeygard (2016), market potential captures the structure of road connections between a geographically defined area and all other markets in the country weighted by the intensity of their economic activity.

Formally, we define the indicator $\text{Roads}_{rt}$ for each district $i$ at time $t$ as follows:

$$\text{Roads}_{it} = \log\left(\sum_{z \neq i} D_{iz,t}^{-1} L_z\right)$$

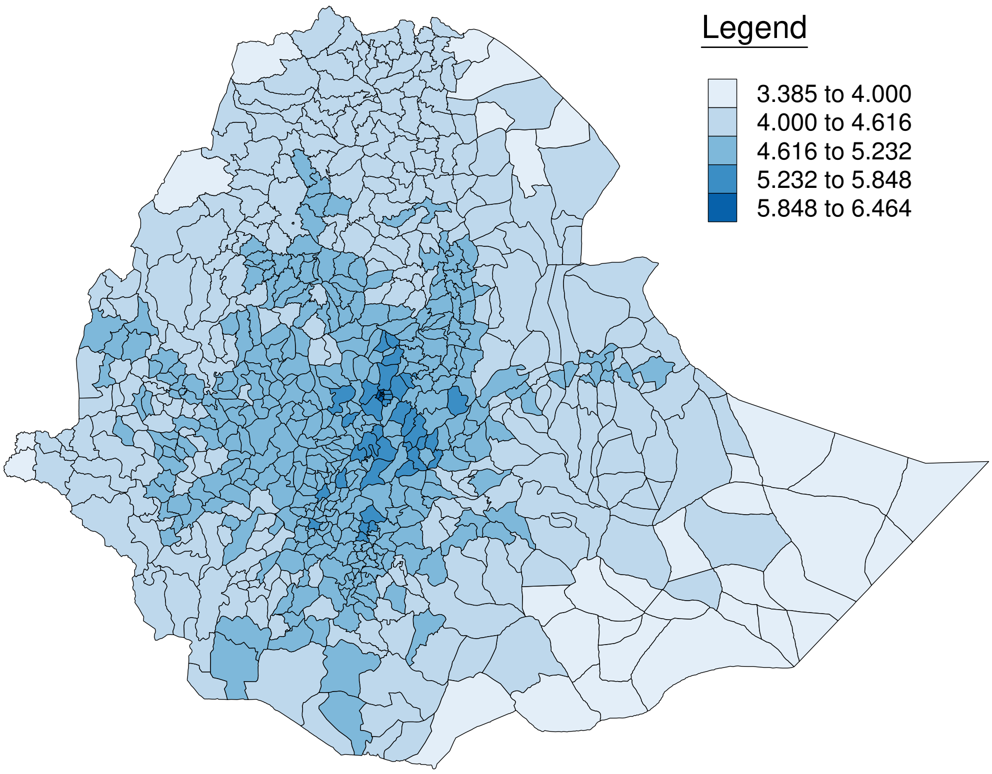
where $D_{iz,t}$ is the minimum distance in hours of travel between district $i$ and district $z$, given the road network in place at $t$, and $L_z$ is an indicator of the economic activity based on night-time light intensity in $z$ provided by NOAA (2018) over 0.86km$^2$ grid cells within the district. We fix the weight at the beginning of the sample period (1996) to exclude potential correlation between changes in destinations' economic activity and our outcomes.[18] Bilateral distances in travel hours are computed by applying the Dijkstra algorithm on the whole network of Ethiopian districts connected by federal and regional Ethiopian roads (links). This means that the time variation in $\text{Roads}_{it}$ solely reflects the rehabilitation, upgrading, and construction of new roads undertaken during the RSDP.

Figure 2a plots the value of the market potential indicator at the beginning of our baseline estimation sample (1996) for all Ethiopian districts. Figure 2b shows the change in market potential between 1996 and 2014 for each woreda, formally $\text{Roads}_{r,2014} - \text{Roads}_{r,1996}$. Focusing on Figure 2a, dark blue woredas near the centre of the country close to Addis reveal higher market potential in this area of the country. Light blue districts away from the centre indicate lower market potential for these areas. Figure 2b shows a large increase in market potential for less connected districts away from the centre, suggesting that they saw improvements in road infrastructure over the time period of our analysis.

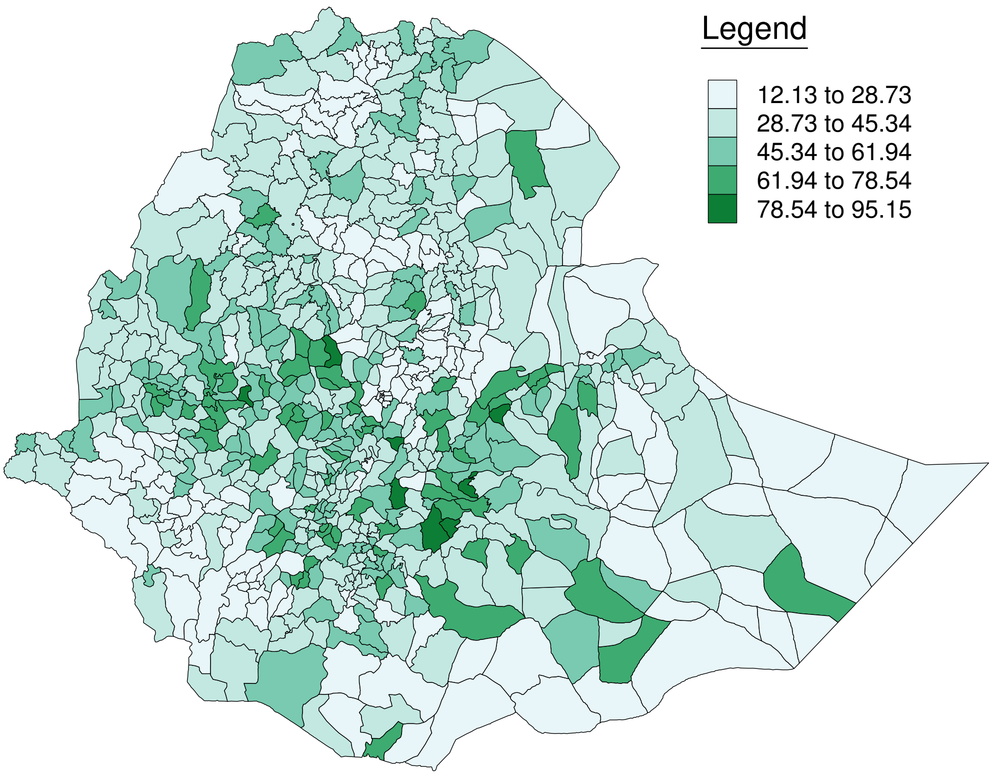
[18] While many papers, including Donaldson and Hornbeck (2016), use population data in the computation of market potential, we employ night-time light intensity data as in Storeygard (2016) and Chiovelli et al. (2019). This is particularly appropriate given our interest in supply-side economic activity. Note that other works (e.g. Alder 2019) use a market potential computed with beginning-of-sample weights as an instrumental variable for the market potential using time-varying night-time light density weights.

Figure 2: Market potential: starting point and change by woreda (a) $\text{Roads}_{r,1996}$; (b) $\text{Roads}_{r,2014} - \text{Roads}_{r,1996}$

(a)




(b)




Source: authors' creation based on proprietary data.

## 3 Empirical model

The objective of our empirical analysis is to link improvements in connectivity, which we measure through market potential, to outcomes related to the labour market at the district level in Ethiopia. Our baseline specification is:

$$y_{it} = \beta_1 \text{ Roads}_{it} + \beta_2 \text{ X}_{it} + \theta_i + \varphi_{rt} + \varepsilon_{it} \quad (1)$$

where $y$ measures one of the outcomes that we can track for each Ethiopian district $i$ over time $t$. The term $\text{Roads}_{it}$ is market potential, which also varies across district $i$ and over time $t$. Each specification includes district and region–time fixed effects. District fixed effects $\theta_i$ are important to control for all the time-invariant characteristics of the district (e.g. geophysical ones, such as soil quality and elevation) that can affect the decision to invest in roads. Region-specific time trends $\varphi_{rt}$ account for common shocks (e.g. policies) that can confound the relations between the outcomes and the treatment. Standard errors are clustered at the level of the district. $\text{X}_{it}$ includes some controls that vary over time at the level of the district. One is the night-time light intensity, which is a commonly adopted proxy for the level of economic activity at the sub-national level.[19] We also account for the intensity of conflicts, measured as the number of conflicts occurring in each district on a yearly basis.[20] Last, we include total population, which is calculated directly using weights from census and NLF data.

Our estimation sample is based on 1,573 observations covering 506 different woredas. Taken together, these observations account for over 80 per cent of total population and total jobs in the country. Table 4 reports descriptive statistics of our outcomes of interest and the main controls.

Table 4: Summary statistics

| Variable | Mean | Std dev. | Min. | Max. | Obs. |
|---|---|---|---|---|---|
| Jobs (log) | 10.92 | 0.7870 | 5.567 | 12.76 | 1,573 |
| Agr. share | 0.8052 | 0.2092 | 0 | 1 | 1,573 |
| Manuf. share | 0.0365 | 0.0561 | 0 | 0.6123 | 1,573 |
| Const. share | 0.0111 | 0.0272 | 0 | 0.3143 | 1,573 |
| Services share | 0.1449 | 0.1654 | 0 | 0.9855 | 1,573 |
| Informal manuf. | 0.0211 | 0.0399 | 0 | 0.3729 | 1,573 |
| Informal constr. | 0.0029 | 0.0112 | 0 | 0.2514 | 1,573 |
| Informal services | 0.0502 | 0.0788 | 0 | 0.7826 | 1,573 |
| Roads | 4.846 | 0.4027 | 3.418 | 6.575 | 1,573 |
| Local roads | 12.03 | 5.225 | 0 | 16.57 | 1,573 |
| NTL (log) | 1.475 | 0.3481 | 1.098 | 4.158 | 1,573 |
| Conflict | 0.0415 | 0.4565 | 0 | 9.832 | 1,573 |
| Population (log) | 11.47 | 0.7335 | 6.347 | 13.99 | 1,573 |

Source: authors' own calculations.

### 3.1 Identification

A potential threat to identification in our empirical setting is the endogeneity of our key variable of interest. Note that, by construction, changes in market potential can be due to road investment occurring in other districts. This means that our specification is not only identified by changes occurring in district $i$. Some robustness checks are nevertheless needed to exclude issues related to omitted variable bias or to reverse causality (i.e. decisions on which investments in roads to prioritize may be anticipated by the characteristics of the district). It is possible that investments in road improvements were allocated systematically across districts in a way that introduces non-random treatment with respect to our

[19] Data are provided by the NOAA (2018) over 0.86 $\text{km}^2$ grid cells within the area corresponding to the districts. Following Eberhard-Ruiz and Moradi (2019), we use scores from raw satellite images instead of processed images with stable night-time lights as these are more reliable proxies of economic activity in small and medium-sized African towns.

[20] Data are provided by Aiddata geoquery, and originally sourced from ACLED Conflict Events.

outcomes of interest. Indeed, the improvement of the road network across districts may be driven by the spatial distribution of economic activities. For instance, geographic areas with a relatively larger (smaller) agricultural or services sector might be systematically more successful in attracting infrastructural investment. Hence, in a first exercise, we try to exclude the potential concern of an anticipation effect by running the following regressions:

$$\Delta \text{ Roads}_i = \beta_1 X_i + \varphi_i + \varepsilon_i \tag{2}$$

in which the dependent variable is the change in the coefficient of market potential calculated between 1996 (i.e. one year before the beginning of the RSDP) and 2013 and $X$ is a vector of initial characteristics of district $i$. This includes our main outcomes (i.e. initial employment) as well as the shares of agriculture, manufacturing, and services in total jobs. Initial characteristics are computed using information included in the 1994 census. Results of this preliminary exercise, reported in Table A1 in the Appendix, show that there is no evidence of initial conditions driving subsequent investment in the road sector.

The literature on the effects of transport infrastructures has proposed some solutions to address endogeneity (for a review of the methods adopted, see Redding and Turner 2015).[21] In the rest of the paper, we rely on the identification strategy originally proposed by Donaldson and Hornbeck (2016) and adopted in various guises by other papers using market potential as their measure of infrastructural improvements (including, for instance, Storeygard and Jedwab 2018). More precisely, we exploit the fact that variation in each district's market potential is determined by improvements to the whole road network in the country. In this way we can partial out the changes in local roads, which are the key source of the endogeneity concerns. We capture the district-level infrastructural developments through a weighted sum of the distance covered by each road segment within the district area, with weights equal to the speed allowed by the type of surface and the road condition.

## 4 Results: roads and jobs

Our analysis links improvements in the road sector, measured through the market potential approach, with a set of measures accounting for changes in the size and composition of the workforce over time. In the following subsections we provide a set of results looking at the effect of market potential on jobs, structural transformation, and informality.

### 4.1 Jobs

We start by introducing a set of results linking market potential to jobs in Ethiopian districts. The first column of Table 5 reports a cross-sectional comparison across districts with different levels of treatment, including region–year fixed effects and the district-specific controls. It shows that districts with higher levels of market potential have higher employment rates than others. Next, we ask whether this finding survives to our more demanding identification strategy. Table 5 reports the same results after controlling for district-specific effects, region time trends, and time-varying controls at the district level. In the last column we also add a measure of local improvements in connectivity, which is essential to correctly identify the effects of market potential on the outcomes, as discussed in Section 3. So, we account specifically for within-district changes over time in market potential that can be attributed to the improvements in the quality of roads. There is a difference in both the size and the precision of the estimated coefficient, which can be attributed to the inclusion of the local improvements in connectivity.

[21] Yet, most of the solutions based on the use of instrumental variable strategies ground on the construction of time-invariant instruments, such as the placement of planned or historic roads, which we cannot replicate in this paper.

The larger point estimate (as well as the gains in precision) reported in column 3 might therefore reflect the omitted variable bias of the estimates in column 2.[22]

The results are not only statistically, but also economically relevant. An improvement allowing a district to move from the 25th to the 75th percentile of the distribution of market potential in our estimation sample would imply an increase of about 19.24 per cent in the total number of jobs in that district, which corresponds on average to roughly 8,600 additional jobs.

Table 5: Roads and jobs

| | Cross-Section | Main (no local roads) | Main |
|---|---|---|---|
| | (1) | (2) | (3) |
| Roads | 0.0516** | 0.111 | 0.166** |
| | (0.0243) | (0.0778) | (0.0829) |
| Constant | –0.558*** | –1.300*** | –1.498*** |
| | (0.161) | (0.467) | (0.475) |
| Observations | 1,573 | 1,573 | 1,573 |
| R-squared | 0.936 | 0.961 | 0.962 |
| Controls | YES | YES | YES |
| District FE | NO | YES | YES |
| Region–year FE | YES | YES | YES |

Notes: the dependent variable in all regressions measures the log number of jobs in each district. The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, and the log of total population. In column 3 we add a measure of local roads improvements, as described in Section 3.1 Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

## 4.2 Sectoral composition of jobs

In this section, we present results linking market potential to the composition of the workforce across broadly defined sectors. Table 6 reports the results. We find that there seems to be a role for improvements in market potential on the typical outcomes of a process of structural transformation. There is evidence of a reduction in the share of agricultural workers that is due to improvements in connectivity. This seems to happen mostly in favour of the services sector rather than manufacturing. A pattern like this is not uncommon in low-income countries. It echoes existing evidence on the direction of structural change, including in Ethiopia, that sees a reallocation of workers out of agriculture in favour of services. We add that changes in market potential due to road investment does play a role in driving workers out of agriculture and attracting them to the services sector. Also in this case, the relation is economically relevant. Taking again an improvement from the 25th to the 75th percentile of market potential, this would imply (a) a reduction of about 14 percentage points down from their sample average (80.52 per cent) in the share of agricultural workers; and (b) an increase of about 2 percentage points from their sample average (14.5 per cent) in the share of workers employed in services.

As such, we cannot derive any clear implications in terms of growth potential of these districts. Due to the heterogeneous nature of services, we do not know whether this improvement is driven by the rise of high- or low-productive activities. While one should expect that workers move from low- to high-productivity industries, this is not a given, especially in the African context. For instance, Barrett et al. (2017) argue that typically episodes of structural transformation in the continent have brought workers into low-productive services in urban areas. This is, in turn, consistent with the evidence on the emergence of consumption cities (Gollin et al. 2016) and premature deindustrialization (Rodrik 2016).

[22] Another common source of bias is due to measurement error of market potential. Without an instrument we can do little on that, however.

Table 6: Roads and the composition of jobs

| | Agriculture | Manufacturing | Construction | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Roads | –0.149** | 0.0134 | 0.00884 | 0.118* |
| | (0.0715) | (0.0203) | (0.0102) | (0.0604) |
| Constant | 0.768* | –0.0694 | –0.126** | 0.453 |
| | (0.414) | (0.153) | (0.0533) | (0.351) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.675 | 0.512 | 0.558 | 0.651 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the share from total employment of agricultural workers (Agriculture), manufacturing workers (Manufacturing), construction workers (Construction), and service workers. The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local roads improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Hence, a related question that we ask is which specific activities are mostly affected by roads, with respect to those included within the services sector.[23] Table A2 provides a summary of our results by collating information from several regressions run at the (two-digit) industry level. Within services, improvements in market potential mainly bring higher shares of workers into low-productive activities, including the provision of personal services and retail trade. We also find significant increases in financial services.

### 4.3 Informality

In this section we look at another important dimension related to the sectoral composition of jobs in Ethiopia by exploring the link between market potential and informality. Remember that information on informality is only available from the NLF surveys, so the time coverage of this specific part of the analysis is limited to the 1999–2013 period. Also, data based on the informal nature of the organizations in which workers are based is most reliable for the modern sectors. In what follows we report our estimates covering manufacturing and services sectors' shares of informality from the total number of jobs. Results are reported in Table 7, and show some evidence of an increase in the share of informal jobs as far as the manufacturing sector is concerned.

Due to the difficulties properly defining the informal sectors across the board, and also providing a definition that is consistent across different contexts, as in McMillan and McCaig (2019) we also focus on self-employment as a proxy for informality. This time the data cover all sectors and allow us to give a broad indicator of the share of informal (self-employed) workers in the total. The results, presented in Table A3, are fully consistent with the previous ones as far as the manufacturing and service sectors are concerned. Moreover, they show that there is no effect of roads on the overall share of informal workers over the period considered.

[23] We have run this analysis only within services, as there is more cross-industry variation compared to the manufacturing sector. The latter represents about 4 per cent of employed persons, and none of the industries within that go over 1 per cent. In this respect, it has to be noted that our analysis covers a period during which industrial parks (such as the one at Hawassa) had not yet started their activities.

Table 7: Roads and informality

| | Manufacturing | Construction | Services |
|---|---|---|---|
| | (1) | (2) | (3) |
| Roads | 0.0352* | 0.00289 | –0.0418 |
| | (0.0196) | (0.00537) | (0.0448) |
| Constant | –0.325*** | –0.0686* | 0.693*** |
| | (0.113) | (0.0351) | (0.255) |
| Observations | 1,086 | 1,086 | 1,086 |
| R-squared | 0.497 | 0.490 | 0.622 |
| Controls | YES | YES | YES |
| District FE | YES | YES | YES |
| Region–year FE | YES | YES | YES |

Notes: the dependent variables measure, respectively, the share from total employment of informal workers in manufacturing (Manufacturing), construction (Construction), and services (Services). The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local roads improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

## 5 Extensions and robustness

In this section we provide some additional analysis that serves the double purpose of adding additional dimensions of heterogeneity to our main set of results and testing their robustness. Thus, in the first part of this section we extend our results in two main directions. First, we disaggregate information on workers across their gender to check for heterogeneous responses to improvements in market potential. Second, we use educational attainment as an additional outcome to check whether incentives to invest in education are affected by roads. The rest of the section presents a number of different set of robustness checks, based on different definitions of the variables of interest and some cuts to the data.

### 5.1 Gender

In this section we check for potential heterogeneous responses to improvements in connectivity by disaggregating our main results according to the gender of respondents. The results, reported in Table A4, show that the patterns described in the previous section are mostly confirmed even after disaggregating our outcomes by gender. The effect of an improvement of market potential is particularly pronounced for women in the case of the total number of jobs (column 1). A major result of this exercise is, however, that increases in the number of service-sector jobs due to improvements in connectivity is different from zero only for women. This is an important finding, which is also consistent with the evidence reported in Table A2, in which we show that household services, generally performed by women, are among those that drive the overall increase in the share of service-related jobs. Evidence from developing countries shows that women more friction in the labour market compared to men, and are disproportionately affected by infrastructural bottlenecks. Improving connectivity can reduce some of these constraints, allowing women to save time to spend in unpaid activities, reducing discrimination, and allowing women to look for opportunities beyond their local communities (Lei et al. 2019).

### 5.2 Education

Table A6 reports results linking improvements in market potential to a number of indicators catching education-related outcomes. Educational indicators cover information on the highest grade completed.[24]

[24] Data on the educational indicators are reported in Table A5.

Despite data on educational attainment being originally collected for each person aged five years and above, we follow the same approach adopted by the CSA in their NLF reports (CSA 2014) and calculate the information for all individuals older than 10 years. Over time the number of individuals with some level of education has been growing consistently. Still, only a very small fraction of individuals report levels of education higher than primary school (grades 1 to 8). Overall, improvements in connectivity have an effect on both educational enrolment and attainment. This is true especially as far as higher levels of schooling are concerned. Individuals living in districts that improve their connectivity over time are likely to invest more in education, possibly in anticipation of more remunerative employment. These findings suggest evidence of higher returns to education in better-connected places, and are consistent with recent work by Adukia et al. (2019), linking investment in roads to educational outcomes in rural India.

### 5.3 Robustness checks

In this section we introduce a number of additional tests we made in order to check for the robustness of our main findings.

First, we use different definitions of the proxy for local roads that we have introduced to strengthen our identification strategy, as discussed in Section 3.1. Including local roads allows us to isolate changes in market potential that are orthogonal to changes in each district's own roads. Our main definition of local roads, the total (weighted) length of all roads within the borders of the district, may not necessarily identify investments that are developed far away. To address this measurement issue we augment our baseline specification by controlling for improvements in all roads within buffers of 10–50 km (both one after the other and all together in the same regression) constructed around the districts' borders. The estimated coefficient of market access is unaffected, and remains economically and statistically significant (Table A8).

Second, the results may be affected by the way we construct the market potential variable measuring roads. We use an alternative measure of market access that draws on the model-based formula derived in Donaldson and Hornbeck (2016) and applied to the East African context by Eberhard-Ruiz and Moradi (2019) (henceforth ERM). Using the night-time light intensity variable $L$ and bilateral travel times $D$, the model-based formula of market access for district $i$ can be written as $\sum_{z \neq i} L_z / \exp\{\sigma D_{iz,t}\}$, where $\sigma$ is a distance decay parameter and captures the non-linear impact of distance on trade. We follow the parametrization in ERM where $\sigma$ is the product of trade elasticity—fixed at 8.4—and the average per unit cost of transporting a good for one hour over the road network relative to the good's overall value. The value of this latter parameter has been estimated by ERM at 0.005 using monthly petrol prices for seven Ugandan cities. We plug the resulting value (0.042) of the distance decay parameter $\sigma$ into the market access formula and take the log. The results, reported in Table A9, show that coefficients remain consistent, though there is no significant effect of the model base proxy for market access on jobs (column 1).

Third, we drop potential growth hubs from the sample. This approach follows Faber (2014) and Storeygard and Jedwab (2018) and is motivated by the fact that growth in hubs might have driven the locations of road construction. We first drop the woredas included in the Addis special administrative division (six in total). Next, we also exclude the districts where regional capitals are located.[25] Finally, we run our analysis excluding all the districts belonging to the Tigray region, which hosts the majority of the Tigrayan ethnic group that was in political power until 2018. This test is motivated by a political economy argument according to which co-ethnicity can drive public investment choices (Burgess et al.

[25] The capital of the Oromia region was moved to Addis in 2005. Still, for the purpose of this exercise we used the old capital, Adema. As in the case of Addis, we also included all the districts (two in total) belonging to the special administrative zone of Dire Dawa.

2015). The results, summarized in Table A10, show that our main findings hold for all the different cuts to the data, with the coefficients of interest generally getting smaller in terms of magnitudes, but remaining statistically significant.

Fourth, we check whether the possible presence of spatial correlation in the residuals can affect the results. To do this, we run our model again by introducing a spatial HAC (heteroscedasticity- and autocorrelation-consistent) correction of standard errors based on the Conley method using the code given by Hsiang et al. (2011). We impose no constraints on the temporal decay to the weights and test the robustness of our specification to different lengths of the radius (respectively, from 100 km to 500 km) for the spatial kernel. Standard errors get generally smaller with higher distances (especially in the specifications on services), and there are no changes to the substance of our results.[26]

## 6 Mechanisms

Our main results point to a nexus between improved market potential with an increase in the number of jobs, a process of structural transformation towards services (especially for women), and a relative surge of informality in manufacturing. In this section we try to reconcile all these pieces of evidence by dealing with some of the potential mechanisms underlying these relations. There are several ways in which improvements in market potential can support changes in the size and composition of the workforce: directly by lowering transport costs and therefore reducing some of the typical frictions that characterize the labour market in developing countries; and indirectly by levelling the playing field and increasing economic opportunities, as well as competition, in the treated locations.

### 6.1 Internal migration

First, we ask whether improvements in connectivity, driving down transportation costs, have a direct effect on the cost of moving people. While this is intuitive, there is very little evidence supporting this relation empirically. An exception is the recent work by Morten and Oliveira (2017), who show how improvements in roads in Brazil had large effects on abating migration costs. We check whether improvements in roads are conducive to more migration in treated districts. Information available in both census and NLF data allow us to track changes in the place of residence of people before the interview. An individual is classified as a migrant in the year of the survey if her birthplace is different from the place where she currently lives.[27] Note that for this exercise we can only track migrants at the destination and not at the origin, as information on the former is only available at a highly disaggregated geographic level (the zone). We focus on migration towards urban areas only. The results are reported in Table A7. Overall, they confirm that locations with higher levels of infrastructures are likely to host a larger number of migrants. The results are statistically significant only in a specification focusing on an across-districts comparison, which is consistent with the data showing that a large share of migrants is directed towards a few areas (especially to Addis and, to a lesser extent, the regional capitals).

### 6.2 Economic opportunities

In this subsection we provide some evidence supporting a demand mechanism. To do this we match our road data with firm-level data covering the manufacturing sector and the trade services. The census of

[26] Results of these specifications are not included for reasons of space, but are available upon request from the authors.

[27] The NLF considers (return) migrants as individuals who were born in the survey town and have returned to that town after having resided in another place.

manufacturing firms collects information on several indicators, including the location of firms.[28] Our data cover the 1998–2009 period, thus ending a few years earlier than our main analysis, but it has the advantage of providing a firm-specific panel setting. We use these data to explore whether improvements in market potential in a firm's location have an impact on the dynamism of the private sector and on several dimensions of firms' performance. In all regressions we control for firm and region–time fixed effects. The results are presented in Table A11. First, after collapsing the data at the location–year level, we show whether there is any significant effect on firms' dynamics. We find that improving infrastructure has no effect on firms' entry, but is particularly relevant for attracting foreign firms. The latter is an important finding since it is demonstrated that foreign investors normally generate more skilled jobs, pay higher salaries, and create more linkages with local firms (including in the services sector).[29] Moving to the firm-specific changes, we show that firms in locations that have improved their market potential have experienced gains in several dimensions, including some suggesting upgrading (e.g. by increasing their productivity). We also find evidence of a compositional shift towards non-production workers, whose real per capita wages are also positively affected by an increase in market potential.

Next, we try to replicate the previous set of results using data on informal manufacturing firms. This is an important part of the story, since as far as manufacturing is concerned these firms represent the large majority in terms of number of firms, as well as being a (slight) majority of the sector's employment (see Table 2). The possibility of replicating exactly the same analysis is constrained by the lack of a panel dimension in the SSIS data. Thus, we run our analysis using district and region–year fixed effects to get a sense of how aggregate and average firm indicators have changed over time within the same district under differential changes in market potential. The results, reported in Table A12, resemble those of the formal firms. Thus, they seem to confirm that improvements in market potential affect informal firms' productivity, a shift towards non-production workers, and an increase in their wages.

Last, we try to replicate some of the previous analysis on the basis of information available from the survey of trade services firms. Note that the information provided by this survey is much more limited compared to that on manufacturing firms. In addition to covering only some of the services firms, the survey is not representative of rural areas and provides only limited information on firms' accounts. This being said, we show that firms in districts experiencing improvements in market potential do experience increases in their average size, there is no effect on wages, and they see a reduction in their levels of labour productivity. In spite of data limitations, this is still helpful to interpret some of our key findings as they seem to point out an increase in employment in low-value-added service activities (consistent with findings reported in Table A13) and a reduction in average productivity that could be due to increased competition in the sector that can be attributed to higher market potential.

## 7 Conclusions

In this paper we have analysed the consequences of an improvement in market potential on the size and composition of jobs in Ethiopian districts. We have taken advantage of novel geocoded information covering the universe of Ethiopian roads, which we combined with individual information from population censuses and nationally representative labour force surveys. Our results provide a mixed picture. We show that districts that have experienced increases in market potential due to road improvements have generally recorded an increase in the number of jobs, as well as a process of structural transformation

[28] Information on the location of manufacturing firms is slightly more precise than that we use in this paper, so we have computed our market potential at the level of the (urban) town rather than at the district level.

[29] Looking at the local impact of foreign direct investment (FDI) in Ethiopia, a recent work by Abebe et al. (2019) provides sound evidence that the entry of FDI generates high spill-overs on domestic firms and workers.

characterized by a reduction in the share of agricultural workers in favour of services. We do not find evidence of improvements in market potential leading to more jobs in the manufacturing sector. Rather, we show that within manufacturing roads lead to a (slight) compositional shift towards the informal sector. We show also that such changes are most likely to benefit women rather than men, and that roads lead to a potential upgrading of the labour force through more investment in education. Our results show that higher economic activity induced by road investment stimulates both the demand from firms—through increases in productivity—and supply from workers, who are more likely to migrate towards parts of the country with higher market potential.

All in all, our results show that investment in roads under the RSDP can support the process of job creation and structural transformation since it can contribute to reducing some of the typical frictions affecting the labour market in Ethiopia, while also spurring demand. Yet, the lack of effect of roads on the manufacturing sector is disappointing, especially in view of the country's high political focus on industrialization. Having said that, it is important to highlight that our analysis does not cover the most recent years, when most of the industrial parks (e.g. the one established in Hawassa) have started their activities at scale and for which it is well known that infrastructural investments are key. Further research is therefore needed in this area to improve understanding of the dynamics through which the nexus between market potential and industrialization in low-income countries happens.

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## Appendix

Table A1: Endogeneity of roads

| Dep. var.: delta roads | Total | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | –0.0124 | 0.0617 | –0.191 | –0.0748 |
| | (0.0147) | (0.0600) | (0.221) | (0.0776) |
| Constant | 0.491*** | 0.301*** | 0.361*** | 0.363*** |
| | (0.159) | (0.0554) | (0.00756) | (0.00870) |
| Observations | 363 | 363 | 363 | 363 |
| R-squared | 0.176 | 0.176 | 0.175 | 0.176 |
| Region FE | YES | YES | YES | YES |

Notes: the dependent variable measures changes in market potential between 2013 and 1996. The independent variables are baseline levels of the (log of) jobs (Total); the share of agriculture on total jobs (Agriculture); the share of manufacturing on total jobs (Manufacturing); the share of services on total jobs (Services). Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A2: Sectoral results

| Sectors | Coefficient | Standard error |
|---|---|---|
| Utilities | 0.00801 | (0.00855) |
| Wholesale | –0.0384*** | (0.0142) |
| Retail | 0.0434** | (0.0184) |
| Hotels & restaurants | –0.00282 | (0.0155) |
| Transport | 0.00208 | (0.00321) |
| Financial | 0.00342* | (0.00190) |
| Estate | –4.80e–05 | (0.000722) |
| Public admin | 0.00600 | (0.00550) |
| Education | 0.000447 | (0.00588) |
| Health | –0.00556 | (0.00676) |
| Other services | 0.0673** | (0.0287) |
| Private HH services | 0.0382** | (0.0191) |
| N.C. services | 0.000426 | (0.000309) |

Notes: the coefficients and standard errors reported are derived from individual regressions using the share of individuals employed in each sub-sector on total jobs. Industries are classified according to the ISIC classification. Some harmonization using concordance tables has necessary, given that different waves of data reported sectors classified according to different revisions of the ISIC codes (3, 3.1, and 4). The number of observations is 1,573 for all specifications. All regressions include a full set of controls, district fixed effects, and region–year fixed effects. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A3: Roads and self-employment

| Informal jobs | Total | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Roads | –0.0667 | –0.0814 | 0.0311* | –0.0213 |
| | (0.0694) | (0.0669) | (0.0162) | (0.0494) |
| Constant | 0.789** | 0.549 | –0.220** | 0.600** |
| | (0.387) | (0.382) | (0.0854) | (0.272) |
| Observations | 1,086 | 1,086 | 1,086 | 1,086 |
| R-squared | 0.556 | 0.600 | 0.497 | 0.574 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the share of self-employed workers on total jobs (Total); the share of informal workers in agriculture on total jobs (Agriculture); the share of self-employed workers in manufacturing on total jobs (Manufacturing); the share of self-employed workers in services on total jobs (Services). The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local roads improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A4: Employment and gender

| Employment | Total | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Panel A: females** | | | | |
| Roads | 0.256* | –0.0743 | 0.00389 | 0.0869* |
| | (0.144) | (0.0456) | (0.0149) | (0.0414) |
| Constant | –2.768*** | 0.355 | –0.0632 | 0.175 |
| | (0.842) | (0.260) | (0.0900) | (0.231) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.898 | 0.598 | 0.449 | 0.612 |
| **Panel B: males** | | | | |
| Roads | 0.124 | –0.0744 | 0.00953 | 0.0316 |
| | (0.0759) | (0.0485) | (0.0120) | (0.0260) |
| Constant | –2.110*** | 0.413 | –0.00620 | 0.278* |
| | (0.423) | (0.276) | (0.106) | (0.156) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.972 | 0.649 | 0.577 | 0.653 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the log number of employed persons (Total); the share of agricultural workers on total (Agriculture); the share of manufacturing workers on total (Manufacturing); the share of services workers on total (Services). The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local roads improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A5: Educational attainment (%)

| Year | Grade 1–8 | Grade 9–12 | Diploma | Degree |
|---|---|---|---|---|
| 1994 | 15.95 | 3.91 | 0.17 | 0.10 |
| 1999 | 22.83 | 3.91 | 0.31 | 0.11 |
| 2005 | 31.86 | 4.40 | 0.50 | 0.15 |
| 2013 | 46.74 | 7.19 | 1.89 | 1.04 |

Notes: all values represent the share of individuals with different levels of education from the total number of individuals aged 10 and above. This is to maintain consistency with the NLF reports. All data have been weighted before collapsing information at the woreda–year level.

Source: authors' elaboration on CSA data.

Table A6: Roads and education

| Variables | Grade 1–8 | Grade 9–12 | Diploma | Degree |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Roads | 0.00392 | 0.00934 | 0.0127** | 0.00985** |
| | (0.00978) | (0.00569) | (0.00596) | (0.00413) |
| Constant | –0.0105 | 0.0214 | –0.0525 | –0.0511* |
| | (0.0510) | (0.0366) | (0.0377) | (0.0277) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.662 | 0.800 | 0.618 | 0.643 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure the share of individuals with completed grades 1–8, 9–12, diploma, and degree on the total number of individuals aged 10 and above. The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local road improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A7: Internal migration

| Variables | Urban migration | Urban migration |
|---|---|---|
| | (1) | (2) |
| Roads | 0.0110** | 0.0177 |
| | (0.00436) | (0.0159) |
| Constant | –0.0282 | –0.0488 |
| | (0.0491) | (0.0761) |
| Observations | 1,573 | 1,573 |
| R-squared | 0.285 | 0.609 |
| Controls | YES | YES |
| District FE | NO | YES |
| Region–year FE | YES | YES |

Notes: te dependent variables measure the share of migrants in the total population in the urban areas of the district. The main control (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local road improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A8: Robustness: additional local roads

| Employment | Jobs | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Roads | 0.148* | -0.156** | 0.0115 | 0.131** |
| | (0.0849) | (0.0739) | (0.0215) | (0.0622) |
| Constant | –1.404*** | 0.797* | –0.0576 | 0.395 |
| | (0.478) | (0.425) | (0.158) | (0.358) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.962 | 0.675 | 0.512 | 0.652 |
| Controls | YES | YES | YES | YES |
| Local roads outside border | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the log number of jobs (Jobs); the share of agricultural workers on total (Agriculture); the share of manufacturing workers on total (Manufacturing); the share of services workers on total (Services). The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local road improvements, as described in Section 3.1. All equations include measures proxying local road improvements happening outside the border of the district (at 10, 20, 30, 40, and 50 km). Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A9: Robustness: market Access

| Employment | Jobs | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Market access | 0.0528 | –0.231*** | –0.00617 | 0.220*** |
| | (0.105) | (0.0883) | (0.0217) | (0.0754) |
| Constant | –1.052 | 1.621*** | 0.0380 | –0.472 |
| | (0.769) | (0.620) | (0.183) | (0.537) |
| Observations | 1,573 | 1,573 | 1,573 | 1,573 |
| R-squared | 0.961 | 0.675 | 0.511 | 0.652 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the log number of jobs (Jobs); the share of agricultural workers on total (Agriculture); the share of manufacturing workers on total (Manufacturing); the share of services workers on total (Services). The regressor of interest (Market access) measures the log of market access computed according to the approach of Eberhard-Ruiz and Moradi (2019). Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local road improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A10: Robustness: cuts to the data

| Employment: | Jobs | Agriculture | Manufacturing | Services |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| **Panel A: Excluding Addis** | | | | |
| Roads | 0.165** | –0.149** | 0.0136 | 0.118* |
| | (0.0828) | (0.0714) | (0.0203) | (0.0602) |
| Constant | –1.469*** | 0.809* | –0.0315 | 0.381 |
| | (0.488) | (0.418) | (0.151) | (0.350) |
| Observations | 1,547 | 1,547 | 1,547 | 1,547 |
| R-squared | 0.961 | 0.576 | 0.456 | 0.575 |
| **Panel B: Excluding regional capitals** | | | | |
| Roads | 0.159* | –0.141** | 0.0122 | 0.112* |
| | (0.0832) | (0.0712) | (0.0202) | (0.0599) |
| Constant | –1.239** | 0.882** | –0.0834 | 0.358 |
| | (0.505) | (0.437) | (0.149) | (0.368) |
| Observations | 1,518 | 1,518 | 1,518 | 1,518 |
| R-squared | 0.961 | 0.550 | 0.455 | 0.555 |
| **Panel C: Excluding Tigray** | | | | |
| Roads | 0.150* | –0.148** | 0.0149 | 0.120* |
| | (0.0839) | (0.0728) | (0.0210) | (0.0614) |
| Constant | –1.383*** | 0.773* | –0.0742 | 0.431 |
| | (0.488) | (0.427) | (0.161) | (0.360) |
| Observations | 1,445 | 1,445 | 1,445 | 1,445 |
| R-squared | 0.963 | 0.687 | 0.517 | 0.665 |
| Controls | YES | YES | YES | YES |
| District FE | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the log number of employed persons (Total); the share of agricultural workers on total (Agriculture); the share of manufacturing workers on total (Manufacturing); the share of services workers on total (Services). The regressor of interest (Roads) measures the log of market potential. Controls include the log of night-time light density, the log number of conflicts, the log of total population, and a measure of local road improvements, as described in Section 3.1. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A11: Manufacturing firms

| Variables | Entry | Foreign_ entry | Productivity | Empl | Non production emp | Wage | Wage non-prod | Wage prod. |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Roads | 0.00775 | 0.00266* | 0.160*** | 0.0166 | 0.0565* | 0.00948 | 0.0806* | 0.00832 |
| | (0.0155) | (0.00155) | (0.0577) | (0.0318) | (0.0333) | (0.0329) | (0.0453) | (0.0299) |
| Constant | –0.321 | 0.0914 | 10.28*** | 4.064*** | –1.954*** | 7.806*** | 7.749*** | 7.460*** |
| | (0.559) | (0.0595) | (1.041) | (0.510) | (0.537) | (0.497) | (0.729) | (0.491) |
| Observations | 604 | 604 | 8,478 | 10,130 | 8,758 | 10,120 | 9,198 | 9,566 |
| R-squared | 0.537 | 0.406 | 0.697 | 0.906 | 0.632 | 0.790 | 0.737 | 0.686 |
| Firm FE | NO | NO | YES | YES | YES | YES | YES | YES |
| TOWN FE | YES | YES | NO | NO | NO | NO | NO | NO |
| Region–year FE | YES | YES | YES | YES | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, the entry rate, measured as the share of new firms at $t$ on the total number of firms at $t-1$ in each town (Entry); the entry rate of foreign-owned firms (Foreign_entry); firms' labour productivity, measured as value-added on employment (Productivity); firms' (log of) total employment (Empl); firms' share of non-production workers (Non production emp); the (log of) per capita wages for all employees (Wage), and for production (Wage prod.) and non-production workers (Wage non-prod.). The main control (Roads) measures the log of market potential. Standard errors are clustered at the town level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A12: Informal manufacturing firms

| Variables | Empl | Productivity | Non production empl | Wage | Wage prod | Wage non-prod |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Roads | –0.341 | 0.471** | 0.0222 | –0.0242 | 0.0858 | 5.777* |
| | (0.213) | (0.205) | (0.0347) | (1.390) | (0.414) | (3.160) |
| Constant | 0.210 | –0.0601 | –0.184 | 1.717 | 6.146*** | –19.73 |
| | (1.065) | (1.029) | (0.172) | (7.092) | (2.079) | (14.09) |
| Observations | 10,604 | 10,069 | 10,604 | 7,417 | 5,600 | 970 |
| R-squared | 0.345 | 0.707 | 0.143 | 0.292 | 0.333 | 0.334 |
| District FE | YES | YES | YES | YES | YES | YES |
| Region–year FE | YES | YES | YES | YES | YES | YES |

Notes: the dependent variables measure, respectively, firms' (log of) total employment (Empl); firms' labour productivity, measured as value-added on employment (Productivity); Firms' share of non-production workers (non production empl); the (log of) per capita wages for all employees (Wage), and for production (Wage prod) and non-production workers (Wage non-prod). The main control (Roads) measures the log of market potential. All the regressions include firm-specific controls (the age, total size, and the status of importer and exporter), as well as a measure of local road improvements. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.

Table A13: Trade services

| Variables | Employment | Wages | Productivity |
|---|---|---|---|
| | (1) | (2) | (3) |
| Roads | 2.021** | –1.640 | –11.81*** |
| | (0.798) | (9.705) | (3.545) |
| Constant | –9.081** | 81.08* | 70.04*** |
| | (4.097) | (45.78) | (17.94) |
| Observations | 10,582 | 3,609 | 10,490 |
| R-squared | 0.134 | 0.311 | 0.360 |
| District FE | YES | YES | YES |
| Region–year FE | YES | YES | YES |

Notes: the dependent variables measure, respectively, the (log) number of employees (Employment); the (log of) wage per capita (Wages); the (log of) sales of employees (Productivity), all computed at the firm level. All variables have been deflated using the GDP deflator from the IMF. The main control (Roads) measures the log of market potential. All the regressions include a measure of local road improvements. Standard errors are clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: authors' own calculations.