Foreign Direct Investment, Roads, and Markups: the case of Ethiopia*

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Abstract

Ethiopia has received substantial amounts of foreign direct investment (FDI) in its manufacturing sector over the last decade, and at the same time it experienced a major improvement in the domestic road network. We study the effect of these investments using a model of internal trade with variable markups. The model allows us to disentangle the various channels through which this policy can affect welfare, including changes in the allocative efficiency. We calibrate the model and find substantial gains from the presence of foreign firms, even though the presence of these foreign firms resulted in a modest worsening of allocative efficiency. We also find that large-scale road improvement projects had positive effects on real income, including positive effects on allocative efficiency. These findings are bolstered by evidence from empirical analysis that leverages micro data on manufacturing firms, information on FDI projects and geospatial data on improvements in the road network.

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1 Introduction

Governments around the world compete to attract foreign direct investments (FDI) on the presumption that foreign firms, thanks to their superior technologies and international experience, will contribute to improve local wellbeing (Javorcik, 2019; Alfaro, 2017). Most existing empirical studies on FDI focus on estimating spillovers that can arise if foreign firms establish supply chain linkages with local firms, such as the transfer of technologies and knowledge (e.g. Setzler and Tintelnot, 2021; Alfaro-Urena, Manelici and Vasquez, 2020). Little work has studied how the entry of foreign firms affects competition in the local market through changing markups, and the resulting effect on welfare.[1] For example, the entry of foreign firms may force local firms to reduce markups in a way that is beneficial to the country's welfare. Measuring these effects is especially useful, as this type of market failure may provide a rationale for governments to subsidize the entry of foreign firms.

In order to study these issues, we use the case of Ethiopian manufacturing. The Ethiopian government incentivized the entry of foreign investors in the manufacturing sector through the use of generous subsidies, such as tax exemptions. This sector has subsequently received substantial amounts of FDI and by the year 2016, foreign-owned firms accounted for 21 percent of manufacturing value added. As a part of the government's overall growth strategy, also known as the Growth and Transformation Plans (GTP), Ethiopia embarked additionally on a road infrastructure development programme called the Road Sector Development Program (RSDP). The RSDP started in 1997 with the aim of improving connectivity across the country through rehabilitation of existing roads and the construction of new ones[2]. The country saw large investments in road improvements during this period: for example, between 2010 and 2016, the number of kilometers of paved roads in the country doubled. The Ethiopian setting thus allows us to study the complementarity between FDI and improvements in road infrastructure, both policies targeted at boosting the competitiveness of the industrial sector.

We explore the effects of FDI using a quantitative trade model that allows us to distinguish among multiple channels that can affect welfare. By incorporating transport costs into the model, meaning that it is costly to ship goods between regions, we are able to examine the role played by road infrastructure in determining

[1] Exceptions include the paper by Atkin, Faber and Gonzales-Navarro (2018), who looks at the retail sector, or the work by Blalock and Gertler (2008), who however looks at the effect of FDI entry on competition in the input market.

[2] Note that roads represent the main transport infrastructure in Ethiopia over the period covered in our analysis. The railway, connecting Addis to Dijibuti, was in fact reestablished in 2017.

these effects. A key channel that we emphasize is the effect of FDI on the allocative efficiency of the economy. Thus, we examine how FDI affects the allocation of resources across firms in the economy and hence, aggregate gains. We augment the quantitative model with a reduced-form empirical analysis that leverages detailed micro data on manufacturing firms and the Ethiopian road network.

Our quantitative trade model is based on Atkeson and Burstein (2008) in which all of the regions of Ethiopia trade with each other. Firms compete oligopolistically, which implies that firms charge variable markups depending on the level of competition in a market. This framework is useful to study the effects of foreign-owned firms on the allocative efficiency of the economy. The reason is that firms with high markups are inefficiently small relative to firms with low markups. The presence of foreign firms, by affecting the pattern of spatial competition across the country, will thus impact the distribution of markups and allocative efficiency.

To discipline the parameters of our model, we use detailed micro data on manufacturing firms and the road network. Firm level information comes from the annual census of large and medium establishment published by the Central Statistical Agency (CSA). Though including mostly formal firms, which are a minority in the country, firms in the census account for about 50% of total employment and more than 70% of value added (Diao et al., 2021). Census data also include information on the share of capital held by foreign nationals, information that allows us to identify foreign-owned firms. Following a surge in FDI inflows into the country, foreign firms accounted for over 21% of manufacturing value added by 2016 (from 5.6% in 1996) and more than 13% (from just about 1% in 1996) of employment.

In addition, we take advantage of granular information on roads. In the space of a decade, improvements due to the RSDP have been remarkable. Road density rose from 24.1 per 1000 sq. km when the programme started to 44.4 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 rose from 22% to 56%. Our analysis uses geolocalized information on the Ethiopian road network, for which we track road-segment specific improvements under the RSDP. This information is then matched with firm data using the district (*woreda*), the third administrative unit of the country as the unit of analysis.

We first calculate the benefit from the presence of FDI by supressing foreign-owned firms in the calibrated model and comparing the results. We find that there are large aggregate gains in real income in the manufacturing sector of 10.20 percent to Ethiopians from FDI. Note that the model is static and thus these gains accrue to the economy on an annual basis. These gains are calculated based on increases in Gross National Product (GNP), which captures gains accruing to Ethiopian nationals. We find that increases in total real income, a calculation based on Gross Domestic Product (GDP), are 16.62 percent. Thus, we find that approxiamately 1/3 of the gains accrue to GDP, but not GNP.

Next, we decompose the welfare gains into different components using the theoretical result developed by Holmes, Hsu and Lee (2014) (herein after, HHL). The Ricardian component is simply the gains in real income if all firms charged their marginal cost. This component maps back to welfare in models in which all firms operate in perfect competition. The allocative efficiency component relates to the welfare loss resulting from misallocation, arising due to heterogeneous markups charged by firms. Finally, the markups terms of trade (ToT) component compares the average markup of the goods sold with the average markup of the goods purchased by a district. Regions with high markups on the goods that they sell relative to the goods that they buy will enjoy a higher real income.

From the HHL decomposition, we have a few important findings. First, we find that FDI worsened allocative efficiency in Ethiopia. In the aggregate, this channel accounts for a loss of 0.86 percent of real income. Furthermore, we find that this channel consistently accounts for negative effects on real income across regions. The reason is that foreign firms tend to be large and have large market shares, which through the lens of the model correspond to having high markups. Second, there are important distributional effects that arise from the changing markup distribution through the ToT channel, in which regions with large foreign-owned firms gain and those without foreign firms lose.

In order to analyze whether FDI and road improvement projects are complementary policies, we conduct the same exercise, except that we use 1996 transportation costs to examine the interaction between these policies. We consider policies to be complements if once a country has enacted one reform, the percentage gain from enacting the other reform increases. Thus, if the benefit from having foreign firms is higher when transportation costs are lower, then the two policies are complements. We find a small decrease in the Ricaridan term with higher transportation costs, implying that there is a small degree of complementarity through this channel. However, higher transportation costs result in smaller losses in allocative effciency. The reason is that higher transportation costs do not allow foreign-owned firms to exercise as much market power throughout the country.

Finally, we look for empirical evidence of the impact of FDI and roads on firms' markups. We first estimate markups at the firm level using the cost approach, i.e. as revenues over costs. This approach provides a simple setting to compute markups, under the hypothesis that first-order conditions are met (Nishioka and Tanaka, 2019). Descriptives are in line with evidence on global markups provided by the alternative approach used in De Loecker, Eeckhout and Unger (2020). Our variable of interest is foreign exposure, or exposure to FDI, which we measure in two ways. First, by counting the number of foreign firms in a given market (a district-industry pair). Second, we construct a measure of foreign exposure coming from foreign firms based in all other districts in the country. We do this by constructing a modified version of market access (Donaldson and Hornbeck, 2016), in which total activity by foreign firms is weighted by the changes in distance (travel time) to the district where firms are based coming from road improvements. Changes in foreign exposure can thus come from two disparate sources: changes in foreign presence in locations across the country and improvements in the road network.

By including district-industry, district-year and industry-year fixed effects, our specification identifies changes in average markups within a given market over time, controlling for possible confounders at the local (e.g. policy changes and other time varying shocks) and the sectoral (e.g. changes in trade or industrial policies) levels. Our empirical set up enables us to fix one out of the two components of foreign exposure (foreign presence across locations and the road network) at its initial level, so that changes in foreign exposure only capture changes coming from the other. This exercise isolates the impact of one policy while keeping the other fixed, much in the spirit of the counterfactual exercises in our quantitative analysis.

We find that an increase in foreign exposure (both in the same market and in other intranational markets) is associated with lower average markups for firms. This is true for increases in foreign exposure coming from greater foreign presence across locations and an improved road network. Results are consistent with insights from the model, where foreign firms charge higher markups and domestic firms respond to foreign competition by charging lower markups, worsening allocative efficiency. Extensions of our baseline analysis that probe the distribution of markups (as opposed to average markups) and estimate the equation on product-level data for homogeneous goods (such as cement) yield qualitatively similar results.

Our paper contributes to several strands of literature. First, it analyzes the impact of FDI on markups, thereby contributing to the literature on the impacts of foreign investment on the domestic economy, which has so far largely focussed on productivity and productivity spillovers. Second, it studies the impact of FDI not only in the market in which a firm is located, but also in other intranational markets. This spatial dimension of competition from foreign firms is understudied in the literature.

Third, it speaks to the literature on firm markups and their evolution, both globally and in emerging economies (De Loecker and Eeckhout, 2018). De Loecker et al. (2016) examine the impact of trade liberalization on firm markups in India to find that lower import tariffs are associated with lower markups. However, the fall in input prices due to a decrease in input tariffs is attenuated for Indian firms. De Loecker, Eeckhout and Unger (2020) study the evolution of markups in the U.S. and find that firm markups have been on the rise since the 1980s, with implications for labour shares and labour market dynamism. Our study proposes FDI and transport infrastructure as drivers of markups and allocative efficiency in the context of developing countries.

Fourth, by focussing on FDI, road infrastructure and their impacts on allocative efficiency and welfare, our paper relates to the literature on the driving forces of measured misallocation of resources in developing countries and the potential gains from eliminating it (Hsieh and Klenow, 2009; Restuccia and Rogerson, 2017, 2013). Finally, by incorporating transport costs in determining the impacts of foreign competition on firms, it complements the recent literature on internal transport costs, improved infrastructure and their impacts on the economy (Coşar and Demir, 2016; Volpe Martincus and Blyde, 2013; Atkin and Donaldson, 2015; Donaldson, 2018; Asturias, Garcia-Santana and Ramos, 2018; Asher and Novosad, 2020).

The paper proceeds as follows. Section 2 summarizes the context, introducing Ethiopia's FDI policy and the RSDP, Section 3 presents the model and Section 4 the data, Section 5 discusses the quantitative exercise, Section 6 tackles the reduced-form empirical analysis and Section 7 concludes.

2 FDI and Road Policies

2.1 Foreign Investment in Manufacturing

The Ethiopian government implemented the Growth and Transformation Plan I (GTP I) during the fiscal years 2010–11 to 2014–15 as its overarching development strategy. The success of the development strategy led to a successor program, GTP II, starting in 2015/16 which largely follows the same path as before.[3] The policies of the GTP I and GTP II explicitly focused on attracting foreign investment for the purposes of promoting growth in the economy and encouraging technology transfer to local firms. For example, National Planning Commission (2016) states: "As domestic investors have limited capacity to meet all the required investment in the next few years, a significant part of the investment will be covered by foreign direct

[3]The government's development strategies include: Sustainable Development and Poverty Reduction Program (SDPRP) for the years 2002–03 to 2004–05; Plan for Accelerated and Sustained Development to End Poverty (PASDEP) for the years 2005–06 to 2009–10. See Ministry of Finance and Economic Development (2010) for more information.

investment (FDI). Thus, increasing FDI and attracting foreign investors will play a significant role during the plan period. In this regard, efforts will be made to attract FDI from every direction particularly by focusing on capable, quality and reputable companies."

As a result, foreign firms were encouraged to enter in a wide range of manufacturing sectors under GTP I[4]. For example, new investors were exempt from paying taxes for multiple years, with additional tax breaks given to firms that exported a large fraction of their output or to firms located in less prosperous regions. Foreign entrants also enjoyed the possibility to get land designated from the government (Abebe, McMillan and Serafinelli, 2019).[5] Another important policy is that the government established special economic zones in which firms could import raw materials and capital duty free with the condition that they export at least 80% of their production. Industrial parks, however, did not play a major role in the manufacturing sector until the enactment of GTP II as pointed out by National Planning Commission (2016).[6] Our data, presented in Section 4, also confirm that plants located in industrial parks accounted for a small fraction of output during the GTP I period.

2.2 Road Improvements under the Road Sector Development Program (RSDP)

Road Sector Development Program (RSDP) began in 1997 with the goal of improving the coverage and quality of the road network. It was implemented by the Ethiopian

[4]The incentives given to entrants can be found in Investment Regulation 270/2012 and the subsequent amendment in 2014. These incentives differs according to the specific industry and location.

[5]Manufacturing investments are entitled to get a cheap access to land from the Government. The Government can also decide to assign land to foreign investors. In this case, this normally involves regions more in need of investments. See the paper by Abebe, McMillan and Serafinelli (2019) for more discussion on this

[6]National Planning Commission (2016) states the following: "Although the significance of industrial parks was already highlighted in GTP I, the success in the development of industrial parks has been limited mainly for capacity and experience limitations. The construction of a total of 9 industrial parks was started by the government, private and/or jointly between government and the private sector. The parks have been enclosed and various development activities have been undertaken during the plan period. Of these, the construction of the first phase of 2 industrial parks has been started and partly completed, as a result buildings which are ready for use have been rented to private investors and these investors have already started production."

Roads Authority (ERA) through several rounds of the RSDP.[7]

Table 1 reports summary statistics of the Ethiopian road network, as reported by the ERA, between 1997 and 2016. The table divides the road network among the different road types. We find that there are major improvements in the road network throughout time. We also see that there is marked acceleration in the growth rate of paved roads after 2010, which was part of the GTP I program. There have also been very large increases in minor gravel and woreda roads, whose primary purpose is to link rural areas to major trunk roads. Woreda roads in particular were built as part of the Universal Rural Road Access Program (URRAP) beginning with RSDP IV (2010–2015), which aimed to provide all kebeles, the lowest administrative level in the country, year-round access to the major road networks.

Figure 1 presents the network of federal and regional roads in 1996 by type of surface. Figure 2 instead shows the same types of roads in 2016, distinguishing between segments which existed in 1996 and were not rehabilitated by 2016 (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 2016. Moreover, road development does not appear to be geographically concentrated, but spans over different administrative areas across the country.

3 Model

In this section, we present our static general equilibrium model of internal trade based on Atkeson and Burstein (2008). This model has been used to study firm pricing under strategic complementarities in international trade and also markups within countries like the United States (e.g., Asturias, Garcia-Santana and Ramos 2018, Edmond, Midrigan and Xu 2015, and De Loecker, Eeckhout and Mongey 2021). This model has CES demand while also generating variable markups by departing from monopolistic competition.

We consider N asymmetric regions trading with each other. In each region, there is a measure 1 of sectors. Within each sector, there is a finite number of firms that

[7] The phases of the RSDP program include: RSDP I (1997–2002), RSDP II (2002–2007), RSDP III (2007–2010), RSDP IV (2010–2015), and RSDP V (2015–2020). RSDP III corresponds to the road improvement program implemented as part of the Plan for Accelerated and Sustained Development to End Poverty (PASDEP), that ran from 2005/06 to 2009/10 (Ministry of Finance and Economic Development 2010). RSDP IV corresponds to the road improvement program implemented as part of GTP described in Section 2.1. See Ethiopian Roads Authority (2015), Ethiopian Roads Authority (2016), and Nathan Associates, Inc. (2013) for more information about the RSDP.

Table 1: Growth of the Ethiopian Road Network 1997–2016

	Paved		Major gravel		Minor gravel	
	Km	Growth (%)	Km	Growth (%)	Km	Growth (%)
1997	3,708		12,162		10,680	
1998	3,760	1.40	12,240	0.64	11,737	9.90
1999	3,812	1.38	12,250	0.08	12,600	7.35
2000	3,824	0.31	12,250	0.00	15,480	22.86
2001	3,924	2.62	12,467	1.77	16,480	6.46
2002	4,053	3.29	12,564	0.78	16,680	1.21
2003	4,362	7.62	12,340	−1.78	17,154	2.84
2004	4,635	6.26	13,905	12.68	17,956	4.68
2005	4,972	7.27	13,640	−1.91	18,406	2.51
2006	5,002	0.60	14,311	4.92	20,164	9.55
2007	5,452	9.00	14,628	2.22	22,349	10.84
2008	6,066	11.26	14,363	−1.81	23,930	7.07
2009	6,938	14.38	14,234	−0.90	25,640	7.15
2010	7,476	7.75	14,373	0.98	26,944	5.09
2011	8,295	10.96	14,136	−1.65	30,712	13.98
2012	9,875	19.05	14,675	3.81	31,550	2.73
2013	11,301	14.44	14,455	−1.50	32,582	3.27
2014	12,640	11.85	14,217	−1.65	33,609	3.15
2015	13,551	7.21	14,055	−1.14	30,641	−8.83
2016	14,632	7.98	13,400	−4.66	31,620	3.20

Notes: Table 1 describes the growth of the Ethiopian road network broken down into three types of roads: paved, major gravel, and minor gravel. The kilometers of each type of road came from table 19 of Ethiopian Roads Authority (2016). The growth rate was calculated as the percentage change in kilometers for a particular road type relative to the previous year.

Figure 1: RSDP road network in 1996 by surface type

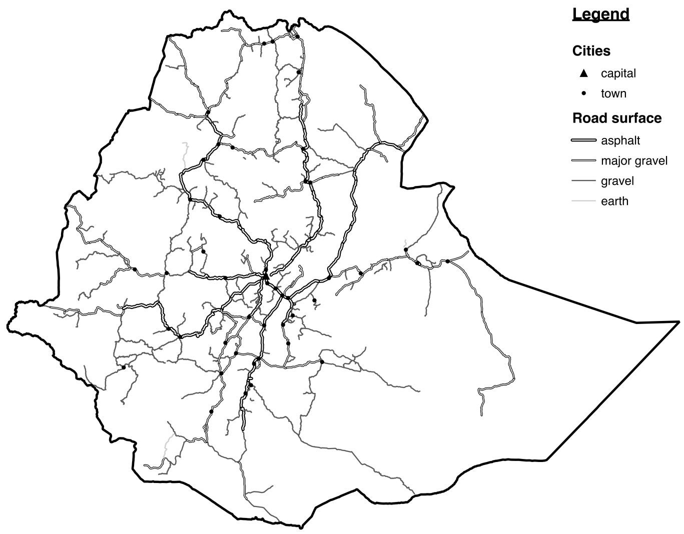
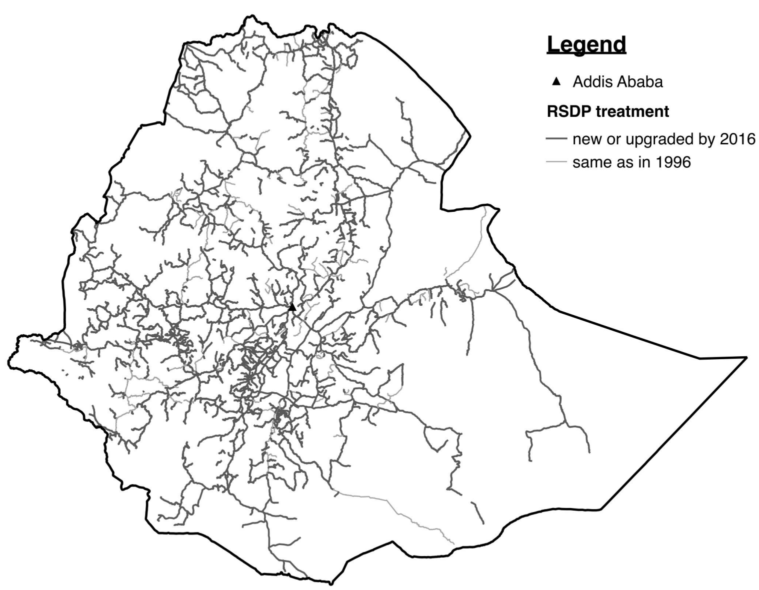


Figure 2: Upgraded and new roads from the 1996 RSDP road network



compete in an oligopolistic manner. Labor is immobile across regions.

3.1 Consumers

In each region n, there is a representative household with a utility function:

$$C_n = \left(\int_0^1 C_n(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{1}$$

where $C_n(j)$ is the composite good of sector j and $\theta > 1$ is the elasticity of substitution across composite goods of different sectors. The sector-level composite good is defined as:

$$C_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} c_n^o(j,k)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \tag{2}$$

where $c_n^o(j,k)$ is the good consumed by region n and provided by firm k in sector j shipped from region o, N is the number of regions, K_{oj} is the number of firms that operate in sector j in region o, and $\gamma > 1$ is the elasticity of substitution between goods produced by different firms in the same sector. We assume that $\gamma > \theta$, which means that goods are more substitutable within sectors than between sectors.

The budget constraint of the representative household in region n is given by:

$$\int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k) c_n^o(j,k) \right) dj = W_n L_n + \Pi_n, \tag{3}$$

where W_n is the equilibrium wage, L_n is the labor endowment, and Π_n is the income derived from the profits of firms located in n.

3.2 Firms

In each sector j in region o, there is a finite number of K_{oj} firms. Firms draw their productivity from a distribution with CDF $G(a)$. A firm with a productivity level a has a constant labor requirement of $1/a$ to produce one unit of good. Because firms do not pay a fixed cost to operate in a market, they sell to all N regions.

To determine the firm's pricing rule, we first find the demand it faces. Equations (1), (2), and (3) generate the demand:

$$c_n^o(j,k) = \left(\frac{P_n}{P_n(j)}\right)^{\theta} \left(\frac{P_n(j)}{p_n^o(j,k)}\right)^{\gamma} C_n, \tag{4}$$

where

$$P_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k)^{1-\gamma}\right)^{\frac{1}{1-\gamma}} \tag{5}$$

is the price index for sector j in region n and

$$P_n = \left(\int_0^1 P_n(j)^{1-\theta} dj\right)^{\frac{1}{1-\theta}} \tag{6}$$

is the aggregate price index in region n. Intuitively, the relative demand for a differentiated good within a sector depends on the price of the good relative to the price of the composite good of the sector, and also on the price of the composite good of the sector relative to the aggregate price index.

Firms within sectors compete à la Cournot. Firm k located in region o selling to region d takes the demand characterized by equation (4) and the quantity supplied by competitor firms in the sector as given and solves the following problem:

$$\pi_d^o(j,k) \; = \max_{c_d^o(j,k)} \; p_d^o(j,k) c_d^o(j,k) - \frac{W_o \tau_d^o}{a_o(j,k)} c_d^o(j,k), \tag{7}$$

where $a_o(j,k)$ is the productivity of firm k in sector j producing in region o, τ_d^o is the iceberg transportation cost to ship one unit of good from o to d. Note that, because of the constant returns to scale technology, the problem of a firm across all different destinations can be solved independently. The solution to this problem is:

$$p_d^o(j,k) = \frac{\epsilon_d^o(j,k)}{\epsilon_d^o(j,k) - 1} \frac{W_o}{a_o(j,k)} \tau_d^o, \tag{8}$$

where

$$\epsilon_d^o(j,k) = \left(\omega_d^o(j,k)\frac{1}{\theta} + (1 - \omega_d^o(j,k))\frac{1}{\gamma}\right)^{-1}, \tag{9}$$

and $\omega_d^o(k,j)$ is the market share of firm k producing in region o in sector j selling to region d:

$$\omega_d^o(j,k) = \frac{p_d^o(j,k)c_d^o(j,k)}{\sum_{o=1}^{N}\sum_{k=1}^{K_{oj}} p_d^o(j,k)c_d^o(j,k)}. \tag{10}$$

The price that firms set in equation (8) is similar to the markup over marginal cost that is found in a setup with monopolistic competition. The difference is that the markups are endogenous here, and depend on the market structure of the sector. For example, suppose that there is only one firm in a given sector, then that firm will compete only with firms operating in other sectors and its demand elasticity will be equal to θ. This means that the firm faces the sector-level elasticity of demand. At the other extreme, suppose that a firm's market share is close to zero, then the firm will compete only with firms in its own sector and its elasticity of demand will be equal to γ. Notice that a given firm will generally have different market shares and hence charge different markups across different destinations.

The aggregate profits of firms in region n are characterized by:

$$\Pi_n = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \pi_d^n(j,k) \right) dj. \tag{11}$$

3.3 Balanced Trade and Labor-Clearing Condition

All regions n must have balanced trade:

$$\int_0^1 \left(\sum_{o=1,\ o\neq n}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k)c_n^o(j,k) \right) dj = \int_0^1 \left(\sum_{d=1,\ d\neq n}^{N} \sum_{k=1}^{K_{nj}} p_d^n(j,k)c_d^n(j,k) \right) dj. \tag{12}$$

The labor-clearing condition for region n is:

$$\int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \frac{c_d^n(j,k)}{a_n(j,k)} \tau_d^n \right) dj = L_n. \tag{13}$$

3.4 Definition of Equilibrium

Equilibrium. For all regions n and n', sectors j, and firms k_{nj}, an equilibrium is a set of allocations of consumption goods $\{c_{n'}^n(j,k),\ C_n(j)\}$, firm prices $\{p_{n'}^n(j,k)\}$, sector prices $\{P_n(j)\}$, and aggregate variables $\{W_n,\ P_n,\ \Pi_n\}$ such that:

1. Given firm prices, sector prices, and aggregate variables, $\{c^n_{n'}(j,k)\}$ is given by (4), $C_n(j)$ by (2), and they solve the consumer's problem in (1), and (3).
2. Given aggregate variables, $p^n_{n'}(j,k)$ is given by (8), (9), and (10), and solves the problem of the firm in (7).
3. Aggregate profits satisfy (11), aggregate prices satisfy (6), and sector prices satisfy (5).
4. Trade flows satisfy (12).
5. Labor markets satisfy (13).

3.5 Defining GNP

The GDP of region n is $GDP_n = W_n L_n + \Pi_n$. Note that because of the ownership of foreign firms, some portion of the profits from foreign-owned firms will not accrue to GNP. For that reason, we define region n's GNP as

$$GNP_n = W_n L_n + \Pi^L_n \tag{14}$$

where

$$\Pi^L_n = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \phi_o(j,k) \pi^n_d(j,k) \right) dj \tag{15}$$

and $\phi_o(j,k)$ indicates the fraction of the firm owned by locals.

Our notion of welfare will be real GNP, $\left(W_n L_n + \Pi^L_n\right)/P_n$, to take into account the differences between GDP and GNP of the region in the presence of FDI. Note that real GNP is simply GNP divided by the model-consistent price index and is closely linked to welfare in our model. Our notion of real GNP does not correspond to the real GNP from the Ethiopian national accounts which is constructed using base year prices.

3.6 HHL

We can apply the framework developed by Holmes, Hsu and Lee (2014) (HHL) to decompose the changes in real income in our model in a way that highlights the various mechanisms at work. The framework allows us in particular to distinguish between Ricardian, allocative efficiency, and markups terms of trade effects from the entry of foreign firms or the lowering of transportation costs. Furthermore, we extend the original decomposition to allow for changes in the ratio of GNP/GDP, which is important in the context of studying the effects of FDI.

We now introduce some notation for the purpose of the decomposition. First, we define the aggregate markups on the goods sold. This reflects how much market power firms producing in a region have when selling to other regions. First, the revenue-weighted mean labor cost share for the products sold by region n is:

$$c_n^{sell} = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} c_{n,d}^{sell}(j,k) s_d^n(j,k) \right) dj, \tag{16}$$

where $c_{n,d}^{sell}(j,k)$ is the labor cost share of goods produced by firm k in sector j and sold in region d and $s_d^n(j,k)$ is the share of region n's revenue that comes from selling those goods. The aggregate markup on the goods sold can be expressed:

$$\mu_n^{sell} = \frac{R_n}{W_n L_n} = \frac{1}{c_n^{sell}}, \tag{17}$$

where $R_n = W_n L_n + \Pi_n$, which is the region's total revenue. Note that there is an analogous expression at the firm level which is that the firm's markup is equal to the reciprocal of the labor share.

We next define the aggregate markups on the goods purchased by region n, which reflect how much market power firms located in other regions have when selling to region n. The revenue-weighted mean labor cost for the products purchased by region n is:

$$c_n^{buy} = \int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} c_{o,n}^{buy}(j,k) b_n^o(j,k) \right) dj. \tag{18}$$

where $c_{o,n}^{buy}(j,k)$ is the labor cost share of goods produced by firm k in sector j located in region o and $b_n^o(j,k)$ is the share of expenditures in region n on those goods. The aggregate markups on the goods purchased are:

$$\mu_n^{buy} = \frac{1}{c_n^{buy}}. \tag{19}$$

Lastly, let P_n^{pc} be the aggregate price of region n if every firm engages in marginal cost pricing, which is the aggregate price index that would emerge in a context of perfect competition. This price index depends on the factors that determine the marginal cost of firms: the distribution of firm productivity, the wages paid by firms, and the transportation costs that these firms face.

Using this notation, the real income in region n can be rewritten into the following components:

$$\frac{GNP_n}{P_n} = \underbrace{W_n L_n}_{\text{Labor income}} * \underbrace{\frac{1}{P_n^{pc}}}_{\text{Prod. efficiency}} * \underbrace{\frac{\mu_n^{sell}}{\mu_n^{buy}}}_{\text{Markup ToT}} * \underbrace{\frac{P_n^{pc}}{P_n}\mu_n^{buy}}_{\text{Allocative efficiency}} * \underbrace{\frac{GNP_n}{GDP_n}}_{\text{Ratio GNP/GDP}} . \quad (20)$$

The first component is the aggregate labor income. The second component is the productive efficiency component of welfare. This component is simply the inverse of the price index if all firms charged the marginal cost. The third component is the markups terms of trade. This component compares the aggregate markups charged for the goods a region sells with those that it purchases. The fourth component is allocative efficiency. This term is related to the welfare loss that arises due to the dispersion in markups, which results in misallocation. In a situation in which there is no variations on markups, or when there is no misallocation, this index is equal to one. As misallocation increases, this index decreases.

Combining the first two terms leads to an expression that is equal to real income if firms charge their marginal cost, which we consider to be Ricardian effects. Taking the log difference of equation 20 we arrive at the following expression:

$$\underbrace{\Delta \ln \frac{GNP_n}{P_n}}_{\text{Real income}} = \underbrace{\Delta \ln \frac{W_n L_n}{P_n^{pc}}}_{\text{Ricardian}} + \underbrace{\Delta \ln \frac{\mu_n^{sell}}{\mu_n^{buy}}}_{\text{Markup ToT}} + \underbrace{\Delta \ln \frac{P_n^{pc}}{P_n}\mu_n^{buy}}_{\text{Allocative efficiency}} + \underbrace{\Delta \ln \frac{GNP_n}{GDP_n}}_{\text{Ratio GNP/GDP}} . \quad (21)$$

4 Data

4.1 Manufacturing Plant-level Data

We use pant level data from the annual census of Large and Medium Manufacturing Establishments, published by the Central Statistical Agency (CSA) of Ethiopia.[8]

[8] The census data includes information at the level of the single productive establishment. We will use the terms plant, establishment and firms interchangeably in the paper. In 2005, a representative survey of firms was conducted instead of a census. This does not represent a critical bias for our analysis, since we do not focus explicitly on entry and exit rates.

Data cover all firms with at least 10 persons engaged and that use electricity in their production process.[9] All firms need to comply with CSA requirements and the census is therefore representative of formal firms in the country. For purposes of context, formal firms represent almost half of the total manufacturing employment and about 90% of the total value added.[10]

The dataset provides detailed information on the characteristics of each establishment including output, employment, capital and inputs. Information on sales values and physical quantities is given for (up to eight) specific products produced by each firm. Products are recorded according to a CSA (Ethiopian Statistical Agency) classification and information available includes the value and quantity produced for the domestic and export markets for each product.[11] Firms belong to the manufacturing sector, and their industry is defined at the 4-digit level according to the ISIC revision 3 classification.

Overall, we have put together firm level information spanning the period 1996-2016[12]. We define a foreign firm through information on the share of initial capital. Namely, we classify a firm as foreign owned if more than 10& of the initial capital is in the hands of a foreign national. The census data does not allow to identify the nationality of such owners. Foreign firms included in our database are geographically concentrated, with most of them located in Addis (48.3%) and in Oromia (42.2%). Sectorally, they are more widespread. The majority (20%) is in the food industry, followed by the textiles-apparel and a few other more capital intensive industries (see Table 15). Table 2 reports the number of firms for some of the years covered by our sample, along with the shares of foreign owned firms on the total, and their relative weight in terms of employment and value of production.

Table 3 reports (unconditional) mean comparisons among foreign and domestic firms. Compared to their domestic counterparts, foreign firms employ more persons and are more capital intensive. A relatively large share of foreign firms is involved in export, which is an activity quite rare among domestic firms. Importing is also more

[9] The number of persons engaged refer to employees and working owners.

[10] These estimates are based on comparisons between formal and informal firms for the year 2010. Data on the formal firms is compared with the information coming from the Small Scale Industries survey, a representative survey covering manufacturing firms with less than 10 persons engaged. Most of these firms are informal as they do not keep books of accounts, or keep them incomplete.

[11] The product code necessary to identify products is missing in some cases.

[12] Information is not available for the year 1997 though. An important caveat of these data is that it is not possible to create a full panel of firms without having access to establishment names and other identifiers that are not available in the raw version of the data. For a detailed discussion on the issues related to the creation of a complete panel using the census see the recent papers by Diao et al. (2021) and Abebe, McMillan and Serafinelli (2019).

Table 2: Number of firms in census years

Year	Firms	Share firms	Share employ	Share production
1996	613	3.72 %	1.43 %	5.69%
2000	734	3.53 %	2.72 %	10.07%
2006	1,135	5.39 %	6.48 %	6.76%
2010	1,880	5.15 %	10.47 %	12.40%
2016	2,756	5.15 %	13.27 %	21.65%

Notes: Authors' summary of Ethiopian Census Data on firms.

frequent, even the difference here is more nuanced. Differences exist also in terms of (labour) productivity and wages, though they are not statistically significant.

Table 3: Mean comparisons among foreign and domestic firms

Variable	Domestic	Foreign	Difference
Number of employees	84.9778	168.9159	83.9381***
Wage per capita	29,642.05	42,960.02	13,3317
Labor productivity	237,157.3	402,478.6	165,321.3
Capital on labour	223,549.5	547,720.1	324,170.6***
Exporter	0.1036274	0.3177806	0.2141532***
Importer	0.7505922	0.8669468	0.1163546***

Notes: Authors' summary of Ethiopian Census Data on firms. The table reports results of t-tests comparing different variables for foreign and domestic firms. All variables are constructed at the firm level. The number of employees measure the number of employees; Wage per capita is the ratio of the total wage bill on the number of employees (in birr); labour productivity is the ratio of value added on employees (in birr); capital on labour is the capital labour ratio (in birr); exporter and importer are dummies taking 1 if the firm exports or imports. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.2 Geospatial and Road Quality Data

The information on surface and condition can be aggregated to compute the average travel speed for each road segment at each point in time. This is done following a standard speed matrix proposed by the ERA and reported in Table 4.[13]

[13] The same speed matrix has been used by Jedwab and Storeygard (2020).

Table 4: 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 kilometers per hour.

5 Quantifying the Impact of FDI and Road Improvements

In this section, we calibrate the model to Ethiopian manufacturing sector using data from Section 4 for the year 2016. At this point, the country had already attracted significant foreign investment while also embarking on an ambitious road improvement projects under the RSDP. We use the calibrated model to estimate the benefits from the presence of foreign-owned firms. We similarly use the model to estimate the benefit of lower transportation transportation costs relative to those of 1996. Finally, we study the complementarity between the presence of foreign-owned firms and lower transportation costs.

5.1 Calibration

We now discuss the calibration of the model, which is summarized in Table 5.

Elasticity of substitution across sectors, θ, and within sector, γ For the elasticities of the model, θ and γ, we draw on estimates from a recent literature that quantitatively applies the Atkeson and Burstein (2008) model to study questions relating to market power and markups. For θ, we use a value of 2, which is conservative relative to the parameter values previously estimated in the literature, ranging from 1.2 to 2.0. For γ, we use a value of 10, which again is conservative relative to the values estimated in the literature, ranging from 5.8 to 11.[14] Note that lower values of

[14] Asturias, Garcia-Santana and Ramos (2018), Edmond, Midrigan and Xu (2015), and De Loecker, Eeckhout and Mongey (2021) estimate a value of $\theta = 1.99$, 1.24, and 1.20 respectively; these same authors estimate a value of $\gamma = 10$, 10.5, and 5.75 respectively.

Table 5: Summary of calibration

Parameter	Description	Value
(1) Parameters from literature		
θ	Elasticity of substitution across sectors	2
γ	Elasticity of substitution within sector	10
(2) Parameters taken directly from data		
K_{oj}	Number of producers in sector j and region o	Varies by sector/region
$\phi_o(j,k)$	Fraction of local ownership of firm k in sector j and	1 for locally-owned firms 0.19 for foreign-owned firms
(3) Parameters inferred using functional relationships		
τ_d^o	Iceberg transportation costs from region o to d	Varies across region pairs
(4) Parameters calibrated in equilibrium		
L_n	Labor endowment of region n	Varies across regions
α	Tail parameter of Pareto productivity distribution	1.15
λ	Multiplicative productivity increase (top 0.5% of firms in terms of value added)	7.15
ζ	Multiplicative productivity increase (foreign-owned firms)	3.41

θ and γ imply that markups charged by firms are higher in the model all else equal.

Number of producers, K_{oj} For the number of producers in sector k and region o, k_{oj}, we use the number of local and foreign-owned producers that we observe in the manufacturing data. Note that accurately capturing the distribution of producers by sector across regions is important for our quantitative results. For example, suppose that there is a foreign firm in a sector in which there are no other competitors in the country. In that case, the presence of the foreign firm will not affect the markups of the other firms in the economy. Alternatively, there may be changes in markups if the foreign firm is in industries in which there are local firms present.

Fraction of local ownership of firms, $\phi_o(j,k)$ For the fraction of local ownership of firms, $\phi_o(j,k)$, we use information on the initial paid-in capital used to define whether a firm is foreign-owned. For firms that are not foreign-owned, we set $\phi_o(j,k) = 1$, meaning that all of the profit accrues to GNP. For firms defined to be foreign-owned, we set $\phi_o(j,k) = 0.19$, which is the average paid-in capital by locals reported in the data for foreign-owned firms, implying that 19% of profit accrues to GNP for foreign-owned firms.

Iceberg transportation costs, τ_d^o We follow Roberts et al. (2012) and use a formulation in which iceberg transportation costs increase less than proportionally with respect to optimal travel time (i.e., transportation costs exhibit economies of scale with respect to travel time). We use the following function form relating iceberg transporation costs and the optimal travel time between two locations

$$\tau_d^o = 1 + \kappa \left(TravelTime_d^o\right)^\rho, \tag{22}$$

where κ determines the level of transportation costs, $TravelTime_d^o$ is the optimal optimal travel time by road between regions o and d, and $0 < \rho < 1$ determines the rate at which iceberg transportation costs increase with optimal travel time.

As a first step, we collect data on the cost to transport a 20' container within Ethiopia in order to have an estimate ρ using microdata. We received quotes on the cost to transport a standardized 20' shipping container from Addis Ababa to the other regional capitals in Ethiopia from four different transportaton/logistics firms in October 2019.[15] We combine this data on transportation costs with Google map driving times between Addis Ababa and the destination cities in the price quote as our driving times do not extend to 2019.

With the data in hand, we rearrange equation 22 to be as follows

$$\log\left(\tau_d^o - 1\right) = \log\kappa + \rho\log\left(TravelTime_d^o\right), \tag{23}$$

which yields the following equation that we can estimate

$$\log TransportationCost_{d,i} = \alpha_0 + \alpha_1 \log TravelTime_d + FE_i + \epsilon_{d,i}, \tag{24}$$

where $TransportationCost_{d,i}$ is the transportation cost to ship a container from Addis Ababa to destination d using transportation firm i, $TravelTime_d$ is the travel time to destination d, FE_i is a fixed effect for transportation firm i, and $\epsilon_{d,i}$ is an error term. Thus, ρ is identified by comparing the changes in transportation costs with changes in travel times holding the transportation firm fixed.

Table 6 reports the results from the estimation of equation 24. The last column of the table reports the results when combining all of the data and we find a coefficient of 0.58. The other columns of the table report the results broken down by transportation firm and we find coefficients ranging from 0.44 to 0.76.[16]

[15] We received quotes to transport a 20' container from GREEN International Logistic Services (https://www.greenint.com/), Chenet Technologies, Honest Logistics (https://honestplc.com/), and the Freight Transport Owners Association. The destination cities and corresponding regions for which we collected are quotes include: Semera (Afar), Bahir Dar (Amhara), Assosa (Benishangul), Dire Dawa (Dire Dawa), Gambela (Gambela), Harar (Harari), Adama (Oromia), Awasa (SNNP),

Table 6: Estimation of ρ

	log Transportation cost				
	Firm 1	Firm 2	Firm 3	Firm 4	Combined data
log Travel time	0.581***	0.555***	0.440***	0.760***	0.584***
	(0.0941)	(0.0521)	(0.0646)	(0.0869)	(0.0413)
Firm FE	No	No	No	No	Yes
Observations	10	10	10	10	40
R-squared	0.826	0.934	0.853	0.905	0.870

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

We next pin down a value for κ which governs the level of iceberg transportation costs. We use information about transportation costs from Atkin and Donaldson (2015) who find that the "cost of remoteness," meaning the difference in ad-valorem transportation costs for nearby locations and those far away, is 1.20 in Ethiopia. We thus proceed with a guess and verify procedure. First, we guess a value of κ. Second, we calculate the implied iceberg transportation costs between all region. Third, for each region we find the difference between the highest and lowest iceberg transportation cost for all destination regions. Fourth, we update the guess of κ until the maximum difference between the highest and lowest destination is 1.20 for any region.

The travel times calculated in Section 4 are between waredas in the country. We aggregate the travel times between the waredas so that we have average travel times between regions, where we weight waredas using night light intensity as to give more importance to economically important areas within a region. After we have calculated average travel times between regions, we apply equation 22 along with our estimates of κ and γ, to arrive at the iceberg transportation costs between regions that we use in the model.

Labor endowments, L_n The labor endowment, L_n, of the region with the smallest value added is set to 1. For the other regions, we set the labor endowment so that the relative size of the regions in the model match the relative size of the value added of each region that in the data.

Jijiga (Somali), and Mekelle (Tigray).

[16]This estimate is also matches closely with Roberts et al. (2012) who estimate that, on average across the goods studied, $\rho = 0.60$ using 2007 Chinese data.

Productivity The correlation of firm productivity draws across regions is important to determine the size of allocative efficiency gains. The reason is that if firms across regions have a similar productivity, then there is a high degree of head-to-head competition. Thus, lowering transportation costs will have a larger impact on the distribution of markups.

We assume that firms across regions have perfectly correlated productivity draws. To implement this, we first find the maximum number of plants present in any region for each sector. We make this number of draws from a Pareto distribution. We then sort the productivities in descending order. If a region has one firm, we select the first productivity on the sorted list. If a region has ten firms, we select the first ten productivities on the sorted list. This setup ensures that the firms with the highest productivity face head-to-head competition. Note that this does not imply that the sectors are symmetric across regions. The reason is that regions have a different number of operating firms. Furthermore, regions have different wages and transportation costs, which affect their marginal cost.

Furthermore, in order to match the very high levels of concentration found in Ethiopian manufacturing we incorporate a productivity increase that enter multiplicatively, λ, for those firms identified as being in the top 0.5% in terms of their value added. We set λ such that the model matches the fact that the top 0.5% of firms in the data account for 72% of value added. Secondly, we similarly have a productivity increase that enters multiplicately, ζ, for foreign-owned firms. We calibrate this parameter so that we match the data in that foreign-owned plants account for 17% of value added. We find that $\lambda = 7.15$, which indicates that there is indeed high levels of concentration among the very largest firms in manufacturing. We also find that $\zeta = 3.41$ indicating that foreign firms tend to have higher productivities than their local counterparts.

It is important to determine whether the model generates reasonable levels of head-to-head competition given the assumption of perfectly correlated productivity draws. We create a "similarity" index that measures the similarity in size among the largest firms across regions. We focus on the largest firms since they are the ones that drive most of the dispersion in markups. To calculate the index, for each sector and region we identify the firm with the largest value added. Then, we regress the log of the value added of these firms on sector dummies. The R squared of that regression, which we use as our index, indicates the extent to which large firms in each sector are of similar size. For example, an R squared of one indicates that the largest firms across regions are exactly the same size.

We find an index of 0.66 in the data and 0.49 in the model, which indicates that the similarity index is higher in the data than in the model. It is also useful to compute the similarity index with a restricting the sample to include only the two largest plants by sector across the country (i.e., the sample is the same as in the previous calculation of the similarity index except that we restrict it to the two largest plants for each sector). This exercise is useful if we want to focus on the level of head-to-head competition for the very largest sectoral produers across the country. We find similar results where the similarity index is 0.78 in the data and 0.47 in the model. The exercises indicate that the model generates levels of head-to-head competition that are in line with the data.

5.2 Quantitative experiments

In this subsection, we use the calibrated model to conduct quantitative experiments to measure the benefits from policies that allowed the entry of foreign-owned firms into the manufacturing sector. We also analyze the ambitious road improvement project undertaken by the government since the 1990s and measure the degree of complementarity between the two policies.

5.2.1 Foreign-owned firms

As a first step, we measure the benefits from having foreign-owned firms in the manufacturing sector. To do so, we begin with the calibrated model and eliminate foreign-owned firms from the economy. Table 7 reports the changes in real GDP and GNP in the model (see Section 3.5 for more details). Note that the results are reported as the changes from the equilibrium with no firm-owned firms to the equilibrium with foreign-owned firms, resulting in positive increases in real income. The results are broken down by regions, where we list the regions in terms of the size of their total value added, where Harari is the smallest region and Addis Ababa is the largest. The last row of the tables hows the results for the aggregate economy. We calculate the weighted average changes across all regions, where we use the region's value added as the weight.

Table 7 shows that there are large aggregate gains, with real GDP increasing by 16.6 percent and real GNP increasing by 10.2 percent. Note that, because the model is static, these are gains that accrue every year to the country. Second, the differences in increases in real GDP and GNP imply that almost 40 percent of the gains in GDP do not accrue in GNP (10.20/16.62). These results indicate that, while there are large aggregate gains in Ethiopian real income, a large fraction of the gains from policies that allow foreign firms to enter the manufacturing sector accrue to the foreign investors. Third, the gains are spread out across the country, even though

Table 7: Changes in real income with foreign firms (%)

Region	GDP/P	GNP/P
Harari	4.40	4.40
Somali	6.34	6.34
Afar	6.67	6.67
Dire Dawa	26.09	10.78
Amhara	11.08	6.49
SNNP	5.33	5.00
Tigray	5.52	3.64
Oromia	25.77	13.20
Addis Ababa	13.94	9.93
Aggregate	16.62	10.20

they are more concentrated in regions that have large amount of foreign-owned firms like Oromia and Addis Ababa.

Table 8 reports the results of applying the HHL decomposition, as described in equation 21, to changes in real GNP. The second column shows the change in real GNP and columns 3-6 show the different channels in the HHL decomposition. We find that the largest component is the Ricardian term. The Ricardian term, which measures the real income gain if all firms charge their marginal cost, consistently overestimates the gains from foreign-owned firms because it does not take into account the negative effects from changes in allocative efficiency and the differences between GNP and GDP. We also find that there are negative and persistent acros regions, implying that, although there are large benefits from foreign-owned firms, these benefits are reduced by a worsening of allocative efficiency. These losses, are approximately equal to 8 percent of the increases in real GNP in the aggregate and can be equal to a quarter of the size of the increase in real GNP as in the case of Tigray. This result arises from the large market shares of some foreign-owned firms resulting in worsening allocative efficiency. The results also show that there are important distributional consequences through the markup ToT term. For example, the smallest regions such as Harari, Somali, and Afar, do not have any foreign-owned firms. At the same time, the regions such as Oromia, which has a high number of foreign-owned firms with large market shares, gain in terms of trade.

Table 8: Changes in real income with foreign-owned firms decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GDP/GNP
Harari	4.40	12.99	−7.43	−1.16	0.00
Somali	6.34	12.12	−4.57	−1.21	0.00
Afar	6.67	13.41	−5.64	−1.10	0.00
Dire Dawa	10.78	16.13	11.12	−1.16	−15.31
Amhara	6.49	13.40	−1.18	−1.14	−4.58
SNNP	5.00	10.07	−3.59	−1.15	−0.33
Tigray	3.64	8.62	−2.11	−0.99	−1.88
Oromia	13.20	23.79	3.05	−1.07	−12.57
Addis Ababa	9.93	16.25	−1.63	−0.68	−4.01
Aggregate	10.20	17.71	−0.22	−0.86	−6.42

5.2.2 Complementarity between foreign-owned firms and improvements in road infrastructure

We now use the model to measure whether the policies that promote foreign-owned firms in the economy is complementary to road infrastructure policy. We are motivated because Ethiopian policymakers widely saw the two policies as complementary and enacted them at the same time.

We define policies as complements if once a country has enacted one reform the percentage gain from enacting the other reform increases. This definition is similar to the one used by Asturias et al. (2016). We redo the exercise in Section 5.2.1 except that we do so with transportation costs consistent with those of 1996. Thus, foreign-owned firms are complementary to improved roads if the percentage increase in real income is higher without the improved road infrastructure (i.e., higher under 2016 transportation costs than those from 1996).

Table 9 reports the results. We find that there is a small increase in the gains in real income under the lower transportation costs, from 10.12 to 10.20. It is also interesting to study the interaction effects through the different channels, which move in opposing directions. For example, the Ricardian term exhibits complementarity. This result is due to lower transportation costs increasing the openess of the economies, which implies that the benefits are larger from the presence of foreign-owned firms in other regions. On the other hand, higher transportation costs lower the losses in allocative efficiency. The reason is that lower transportation costs allow foreign-owned firms to exercise their market power by making them more competitive across the regions of the country, which in this case worsens allocative efficiency.

Table 9: Changes in real income with foreign-owned firms decomposed without improved road infrastructure (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GDP/GNP
Harari	4.24	12.82	−7.43	−1.14	0.00
Somali	6.22	12.03	−4.60	−1.21	0.00
Afar	6.56	13.23	−5.62	−1.06	0.00
Dire Dawa	10.65	16.04	11.12	−1.14	−15.36
Amhara	6.34	13.19	−1.12	−1.10	−4.63
SNNP	4.73	9.78	−3.63	−1.08	−0.33
Tigray	3.45	8.32	−2.07	−0.90	−1.90
Oromia	13.37	23.65	3.09	−0.82	−12.55
Addis Ababa	9.74	15.94	−1.69	−0.51	−4.01
Aggregate	10.12	17.46	−0.23	−0.69	−6.41

5.2.3 Improvements in road infrastructure

We next estimate the gains from the ambitious road infrastructure projects undertaken by the Ethiopian government under the RSDP. We change transportation costs in the model to be consistent with those of 1996 and then compare with the economy in 2016. The results are reported in Table 10. We find that there are substantial gains of 2.42 percent per year in real GNP. Unlike the policies that encouraged foreign-owned firms, we do not find substantial changes in the ratio of GDP/GDP. Furthermore, we find that the regions farther away from the main industrial hubs of Oromia and Addis gain the most from the lower transportation costs. The table also show that there are consistently positive gains from allocative efficiency throughout the country indicating that improved roads improve the allocative effieicny of the economy.

5.3 Model and data comparison

As a next step, we apply commonly used reduced form methods to the output from the model (e.g., empirical work that measures FDI spillovers). This exercise will allow us to connect to this empirical literature and give us a better understanding of the model results.

We build two measures of FDI exposure, denoted as $(FDIExposure)_{rjt}$, for firms in region r and in sector j at time t. The first measure of exposure is a dummy that indicates whether there is a foreign-owned firm operating in the same sector and region. The second measure of exposure is the number of foreign-owned firm

Table 10: Changes in real income with lower transportation costs (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GDP/GNP
Harari	5.23	5.04	0.04	0.15	0.00
Somali	7.86	7.78	0.01	0.07	0.00
Afar	3.32	2.85	0.32	0.15	0.00
Dire Dawa	5.32	5.17	-0.03	0.13	0.05
Amhara	4.98	4.86	-0.01	0.08	0.04
SNNP	7.90	7.67	0.12	0.11	0.00
Tigray	6.64	6.06	0.43	0.13	0.02
Oromia	2.28	2.80	-0.38	-0.11	-0.02
Addis Ababa	1.36	0.87	0.29	0.20	0.00
Aggregate	2.42	2.27	0.07	0.09	-0.01

operating in the same sector and region. We do so using the output from the model from Section 5.2.1, in which we suppress foreign firms in the quantitative exercise, and estimate the following regression:

$$\log Markup_{irjt} = \alpha_0 + \alpha_1 (FDIExposure)_{rjt} + FE_{rj} + FE_t + \epsilon_{irjt} \qquad (25)$$

where $Markup_{irjt}$ indicates the markup of firm i in region r in sector j at time t, FE_{rj} is a region-sector fixed effect, FE_t is a time fixed effect, and ϵ_{irjt} is an error term. This specification measures changes in markups within region-sector pairs before and after being exposed to FDI.

The results of the estimation are reported in Table 11. Data in columns 1 and 3 are from the model, while those in columns 2 and 4 come from the firm census, as described in Section 4. More details on the construction of the variables of interest are provided in Section 6.1 and Section 6.2. The first two columns of the table reports the results from the FDI dummy treatment. We find that the coefficient is negative although it is not statistically significant. The second block of columns of the table reports the results using the number of foreign firms present in a region. As before, we find that the coefficient is negative although it is now statistically significant. Thus, we find that in the model firms exposed to foreign competition in their region see greater declines in markups.

Table 11: Changes in markups when exposed to foreign-owned firms

VARIABLES	(1) Log markup	(2) Log markup	(3) Log markup	(4) Log markup
FDI dummy	-0.0118		-0.0589**	
	(0.00732)		(0.0258)	
Number FDI		-0.0352**		-0.00133*
		(0.0146)		(0.000689)
Constant	0.153***	0.168***	0.175***	0.163***
	(0.00200)	(0.00739)	(0.00811)	(0.00340)
Observations	12,568	12,568	25,123	25,123
R-squared	0.722	0.723	0.102	0.102
Region*Industry FE	Y	Y	Y	Y
Model/data	Model	Model	Data	Data

Notes: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Reduced-Form Evidence on the Effects of FDI and Road Improvements

This Section presents the analysis, based on the data introduced in Section 4. We will first provide a description of the main measures concerning FDI exposure and road improvements, and then move to introducing the empirical specification and its main results. Different from the model, which uses the region as the geographic unit of interest, in what follows we will use the district (woreda), the third administrative unit of the country, to define a firm's own market (where a market is a district-industry pair). The district roughly corresponds to a county, and it has been used as well by other studies to define a local market in the country (Abebe, McMillan and Serafinelli, 2019; Damoah, Giovannetti and Sanfilippo, 2021; Crescenzi and Limodio, 2021).

6.1 Measuring competition

We measure competition using the market (a district-industry pair) as our unit of analysis. There are two main sources of competition that we will try to measure in this paper. The first is the (horizontal) effect that is due to the entry of a foreign firm. This effect is commonly measured using the size (in the number of firms or their production) of foreign direct investment in a given market.[17]

The second is more specific to the research setting of this work, and to the context under analysis. We look in fact at the complementarity among FDI and Roads, and have tried to come up with a measure that can match the provision of the theoretical part of this paper.

More specifically, we construct a measure of exposure to FDI that is dependent on the proximity to the foreign competitors. This is an alternative versions of the market access indicator that has been used by Donaldson and Hornbeck (2016) to measure the economic effects of infrastructural developments in the context of a formal structural gravity trade model. In our context, this measure captures the structure of road connections between a geographically defined area (a district) where a firm is located and all other markets in the country weighted by the intensity of production by foreign firms.

Formally, our modified version of market access is computed as follows:

$$\text{FDI Exposure}_{rjt} = \log\Big(\sum_{z \neq r} D_{rz,t}^{-\theta} L_{zjt}\Big) \tag{26}$$

where $D_{rz,t}$ is the minimum distance in hours of travel between district r and district z given the road network in place at t. L_{zjt} is the weight, which varies across locations and sector as it is calculated by using a destination district's z value of total production by foreign firms in each industry j. We use an elasticity (θ) equal to 3.6, which is the one estimated by Jedwab and Storeygard (2020) in their work on African urban areas[18]. This more general version of the market access accounts at the same time for both the improvements of the overall road network, as represented by changes in bilateral travel times across districts, and account for changes in the spatial distribution of foreign production with weights varying over time. Bilateral distances in travel hours are computed applying the Dijkstra algorithm on the network of Ethiopian districts (nodes) connected by federal and regional Ethiopian roads (links).[19] Each link is characterized by its average travel speed, which is a

[17] The two papers on Ethiopia both look –as we do– at the district level, and use either the number and size of foreign firms (Crescenzi and Limodio, 2021) or the entry of a big foreign project, comparing (Abebe, McMillan and Serafinelli, 2019).

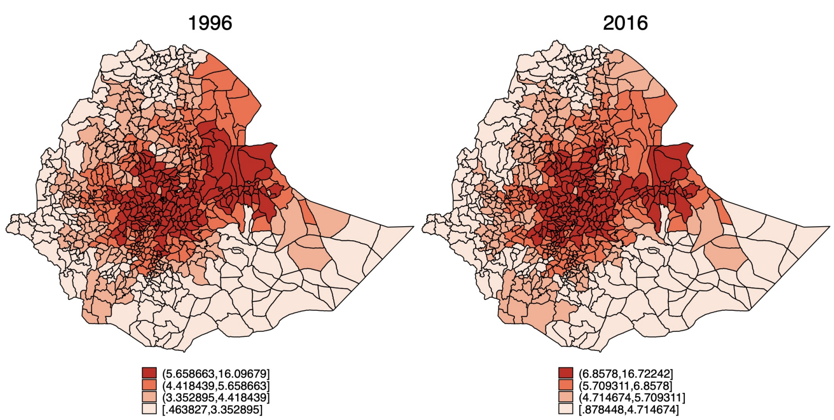
[18] This value is estimated based on the elasticity of trade to travel time found for the US multiplied by 3. The latter value is consistent with the work by Atkin and Donaldson (2015) who find that trade costs are three times higher in Nigeria and Ethiopia compared to the US. A value of 3.6 is as well in the middle of the estimated elasticities of trade to distance that are commonly found in the literature. We will show that the choice of this specific value of elasticity does not affect the substance of our findings, which remain robust to different definitions of (θ).

[19] Starting from the shapefiles with road segments, we create additional ancillary nodes to allow

function of the surface type and condition of the road segment(s) in the link (see Table 4).

Figures 3 and 4 provide a couple of industry specific examples showing variation in market access both across districts and over time in Ethiopia. The two industries selected, cement and grain mills, are among the most populated in terms of number of firms and have experienced a few entries by foreign owned firms in the sample period.

Figure 3: Market Access in the Cement industry (ISIC code 2695)



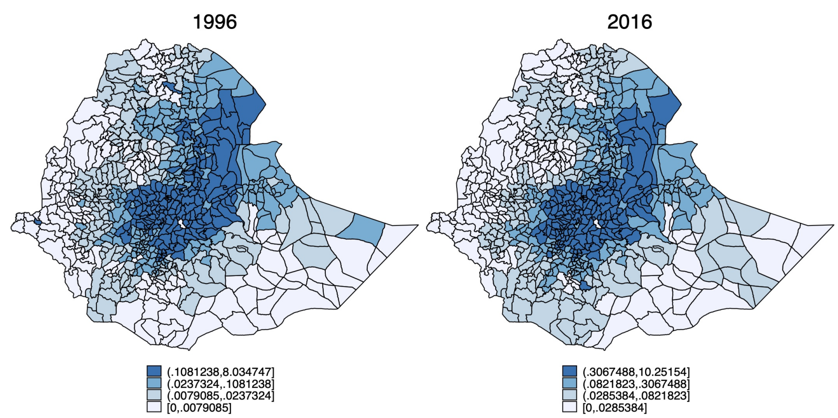
In order to better match results with theory we also construct two alternative indicators that–departing from equation (28)–try to isolate the contribution of roads and foreign production, as follows:

$$\text{Road market access}_{rjt} = \log\left(\sum_{z\neq r} D^{-1}_{rz,t} L_{zjt_0}\right) \tag{27}$$

$$\text{FDI market access}_{rjt} = \log\left(\sum_{z\neq r} D^{-1}_{rz,t_0} L_{zjt}\right) \tag{28}$$

for turns at every intersection between road segments. We have no information on the direction of travel allowed on each road segment. Hence, links are set so that they are not directed, reflecting the underlying assumption that each road segment can be travelled on in both directions. This is a reasonable assumption, given the focus on regional and federal roads which represent the majority of road infrastructure in the country.

Figure 4: Market Access in the Grain Mills industry (ISIC code 1531)



where "Road market access" is constructed by keeping roads free to vary over time with the weights fixed at their pre-sample level, while "FDI market access" keeps foreign production (the weight) free to vary over time while keeping roads at their pre-sample level. In both cases, we use 1996 data as pre-sample, which should not be a major issue for identification given that (a) the RSDP started in 1997; and (b) that the surge in FDI in the country has mostly taken place in the second part of the 2000s (see Table 2).

6.2 Markups

We estimate firm specific markups using the cost approach (Nishioka and Tanaka, 2019), as revenues divided by total costs. This is an intuitive metric, as it is equivalent to the ratio of output price to marginal cost when elasticities are equal to 1. Compared to other methods commonly adopted in the literature (De Loecker and Warzynski, 2012), the cost approach has the advantage that no production functions need to be estimated to get output elasticities. On the other hand, since the approach imposes first-order conditions to be always met can be inconsistent with assumptions on the different timing in the choice of inputs (Ackerberg, Caves and Frazer, 2015). This makes this approach more appropriate to as an indicator of medium-long term, rather than short-term, optimization.

We obtain markups from the following relation:

$$\mu_i = \frac{P_i Q_i}{p_i^l L_i + p_i^m M_i + rK_i} \tag{29}$$

where $P_i Q_i$ is the value of total production of firm i, $p_i^l L_i$ is the value of total wages paid and $p_i^m M_i$ the cost of intermediate inputs used in production. r is the cost of capital. We use a value of r=0.15, which combines an estimated 5% for the cost of capital and a 10% depreciation rate. Descriptive statistics show that (a) markups have been on the rise over the period considered (Figure 5), in line with global trends showed for instance by De Loecker, Eeckhout and Unger (2020); (b) values look similar both geographically (across regions, see Table 16) and sectorally (Table 17).

An alternative method that we use to corroborate our result is the one adopted by De Loecker and Eeckhout (2018)

$$\mu_i = \alpha_i^v (\beta_i^v)^{-1}, \tag{30}$$

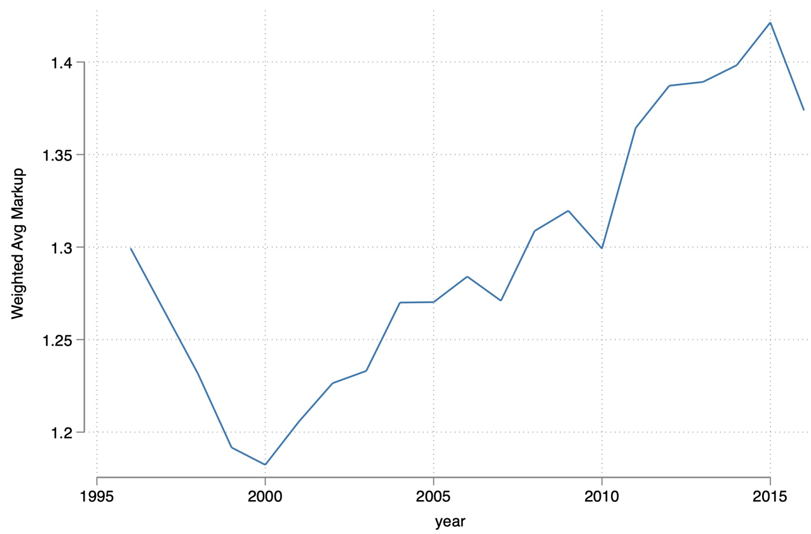
where $\alpha_i^v = \frac{\partial Q_{i(\cdot)}}{\partial V_i} \frac{V_i}{Q_i}$ is the output elasticity of variable inputs (labour and materials) and $\beta_{it}^v = \frac{p_{it}^v V_{it}}{P_{it} Q_{it}}$ is the share of expenditure in those inputs on total revenue. Each firm is assigned with an output elasticity that we obtain from Fiorini, Sanfilippo and Sundaram (2021), who estimated productivity using a fraction of the firm data that we use in this paper and for which panel data are available, covering the period 1996-2009[20].

6.3 Model data comparison

In this section, we run some empirical specification linking the model based findings to the data. In doing this, we exploit all the information available in our data covering 20 years of information on the Ethiopian manufacturing sector. We do this adopting three different specifications. The first, which is our preferred one, runs a model linking individual firms' markups to our different measures of FDI (and roads) exposure. The second aggregates information at the market (district-industry) level, and provides evidence on the nexus between FDI exposure and the dispersion of firms' markups. Finally, we move the analysis at the product level, trying to understand whether competition from foreign firms determines a reduction in firm prices for a bunch of homogeneous goods.

[20] ADD DETAILS

Figure 5: Average Markups over time



6.3.1 Firms' markups, FDI and Roads

The first specification mimics a standard one linking the presence of FDI in each firms' own market to the outcome of interest.

$$Markup_{irjt} = \beta_0 + \beta_1 (N\_FDI)_{rjt} + \beta_2 (FDIMarketAccess)_{rjt} + \beta_1 (RoadMarketAccess)_{rjt} + \gamma_{rj} + \theta_{rt} + \rho_{jt} \tag{31}$$

where i is the firm, r the district, j the sector and t the year. The inclusion of district-industry (γ_{rj}), district-year (θ_{rt}) and industry-year (ρ_{jt}) fixed effects should consistently account for most of the sources of omitted variable bias including local and sectoral policies and it reduces the identification to the effect on markups of an increasing exposure to FDI (and roads) for all firms based in a given market. Standard errors are clustered at the level of the treatment (district-industry).The coefficients of interests are the βs, measuring respectively the local competition of FDI and the competition coming increased market access due to improvements in internal roads and growth of FDI in other parts of the country. Note that all specifications exclude foreign firms.

Table 12 reports a full set of results based on equation 31. Coefficients of all the FDI variables are standardized in order to get a better comparison. Results point in a quite straightforward manner to a *negative* relation between competition and firms' markups. Specifically, in column 1 we confirm the result that we had already presented in Table 11, but with a now much granular definition of the market, i.e. one using the district instead of the region. We also show that this result remain unaffected when introducing the measures of competition based on market access. Column 2 adds that an increase in our constructed market access pushes firms to reduce their markups. Finally, in column 3 we disaggregate our measure of market access to make our results reflecting those discussed earlier in the quantitative exercise. We find that both measures of FDI and Road market access are in line with previous findings on a reduction of markups.

Table 12: FDI and markups

	FDI	FDI and market access	FDI and market access
N_FDI	-0.0208*	-0.0222**	-0.0206*
	(0.0107)	(0.0104)	(0.0107)
FDI Exposure		-0.0385*	
		(0.0213)	
Road Market Access			-0.0267***
			(0.00847)
FDI Market Access			-0.0710***
			(0.0215)
Constant	0.0827***	0.0835***	0.0828***
	(0.0203)	(0.0204)	(0.0203)
Observations	18,386	18,386	18,386
R-squared	0.238	0.238	0.238
District*Industry FE	Y	Y	Y
Industry*Year FE	Y	Y	Y
District*Year FE	Y	Y	Y

6.3.2 Distribution of markups

In this section, we move the analysis from the firm to the market level to try understanding if FDI (and roads) affects markup distribution, a potential source of misallocation. Previous research has found that an increase in competition, e.g. due to trade liberalization, has in fact contributed to reduce inequalities in the distribution of firms markups (e.g. Lu and Yu, 2015, for China). To do this, we construct a Theil index[21] based on the following formula:

[21] Among the different measures of dispersion, the Gini coefficient, which ranges from 0 (perfect equality) to 1 (perfect inequality), is one of the most widely used. Yet, and although the Gini index satisfies key inequality measure criteria (mean independence, population size independence, sym-

$$Theil_{rjt} = \frac{1}{n_{rjt}} \sum_{i=1}^{n_{rjt}} \frac{\mu_{irjt}}{\bar{\mu}_{rj}} \log\left(\frac{\mu_{irjt}}{\bar{\mu}_{rjt}}\right), \tag{32}$$

where μ_{irjt} is the markup of firm i in market rj at time t and $\bar{\mu}_{rjt} = \frac{1}{n_{rj}} \sum_{i=1}^{n} \mu_{irj}$ is the average markup of market rj at time t.

We then replicate the analysis of the previous section using the Theil index as the dependent variable and hence replacing the firm with the market (a district-industry pair) as the unit of analysis. The latter feature does not affect our identification strategy, which remains the same, given that set of fixed effects are all based on combination of district, industries and year pairs. To account for the the potential differences due across districts, we weight all regressions using the level of production. Standard errors are again clustered at the district-industry level. Results are reported in Table 13. They show that an increase in foreign competition tend to move together with a reduction in the dispersion of markups in targeted markets. Results show that this depends both by the entry of foreign firms in a firm's own market and by the exposure of FDI located elsewhere in the country (column 3). Conversely, there is no clear evidence concerning improvements in roads.

6.3.3 Firms' prices

We complete the set of results by digging deeper into the firm data. The census provides as well information on some (up to 8) products produced by firms. For each product, data are reported on the value (in birr) and quantity produced, sold and exported. Products are reported following a classification provided by the Central Statistical Agency of Ethiopia [22]. From the list of products included in our data, we select "cement blocks" [23], not only because it is the one ranking first in terms of

metry, and Pigou-Dalton Transfer sensitivity), it is not easily decomposable and suffers statistical testability. While statistical testability can be overcome by using bootstrap techniques to compute confidence intervals, the lack of decomposability is the most significant concern for our application. The Theil index is a special case of the generalised entropy index that satisfy both conditions, and it is one of the most used measures in the literature (see, for instance Lu and Yu, 2015; Damoah, Giovannetti and Sanfilippo, 2021)

[22] Note however that misreporting in product level data is frequent and relevant from the point of view of the size of missing information. For a description of some of the issues, see Fiorini, Sanfilippo and Sundaram (2021)

[23] While selecting this specific product we also make sure that the following two conditions apply: first, that the firms reporting the product belong to the same industry. This is the case for 96.8% of the observed instances, all reporting the isic code 2695. Second, that the unit of measure is the same. In this case, a part from a couple of clear mistakes, all the entries reprted the pieces as the main unit of measure for the product.

Table 13: FDI and Theil

	FDI	FDI and market access	FDI and market access
N_FDI	-0.00309*	-0.00309*	-0.00289*
	(0.00166)	(0.00160)	(0.00159)
FDI Exposure		0.000371	
		(0.0153)	
Road Market Access			0.00467
			(0.00854)
FDI Market Access			-0.0457**
			(0.0188)
Constant	0.509***	0.508***	0.517***
	(0.00250)	(0.00781)	(0.00485)
Observations	4,951	4,951	4,951
R-squared	0.854	0.854	0.855
District*Industry FE	Y	Y	Y
Industry*Year FE	Y	Y	Y
District*Year FE	Y	Y	Y

number of times it is reported by firms, but also because it is a homogeneous good Siba et al. (2020). Two recent papers have used cement exactly with the purposes of studying market power in the context of developing countries and in Africa in particular, finding in both cases that the entry of additional competitors can explain the drop in price differences (Beirne and Kirchberger, 2021; Leone, Machiavello and Reed, 2021).

Based on the information available In our sample, we have constructed a proxy for the price of cement by calculating its unit value (sales on quantity sold). The distribution of unit prices is reported in Figure 6. From the figure we can see how the mass of values lies below 20 birr per piece (about 0.43 USD).

Based on this information, we replicate our model using a similar specification but this time on a sample based on only firms reporting cement among their products (about 6,000 observations to start with). The specification includes district and year fixed effects, standard errors are clustered at the district level, and all regressions are weighted by the share of the product in a firm total value of production in that year[24]. Results are reported in Table 14. In addition to the estimate using unit value as a dependent variable, we also add two columns, replicating the preferred specification in which we regress our variables of interest against the value of sales and the quantity.

[24]On average, for firms reporting cement as one of their product, it represents about 36% of the total value of production.

Results show that there is no correlation between the entry of foreign firms and the price, whereas a negative coefficient appears for our measures of market access.

Table 14: FDI and firm prices

	Unit value	Value sold	Quantity sold
N_FDI	0.00411	0.0467**	0.0410
	(0.00884)	(0.0229)	(0.0246)
Road Market Access	-0.0196***	0.0168	0.0416**
	(0.00271)	(0.0180)	(0.0184)
FDI Market Access	-7.599***	0.595	23.32
	(2.518)	(8.354)	(14.75)
Constant	137.0***	2.246	-402.9
	(44.61)	(148.0)	(261.4)
Observations	4,421	4,412	4,421
R-squared	0.337	0.137	0.152
District FE	Y	Y	Y
Year FE	Y	Y	Y

7 Conclusions

Using a model of internal trade with variable markups, we study the effects of FDI and investments in road infrastructure on welfare in Ethiopia. We find large aggregate gains in real income to Ethiopians from FDI. We show that FDI worsened allocative efficiency, since foreign firms tend to be large and have large market shares, which corresponds to higher markups. This result is bolstered by the empirical analysis, where we show that greater foreign competition, both in a firm's own market and in connected intranational markets, is associated with lower markups. Additionally, there are important distributional effects that arise from the changing markup distribution, in which regions with large foreign-owned firms gain and those without foreign firms lose. Finally, we find a small degree of complementarity between FDI and road improvement projects in determining welfare and that higher transport costs mitigate the ability of foreign firms to exercise market power, attenuating the loss in allocative efficiency.

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A Data Appendix

Table 15: Sectoral distribution of foreign firms in the sample

Sector	Share on total foreign firms
Food and Beverages	20.17%
Textiles, Apparel and Footwear	18.32%
Fabricated Metals	11.78%
Rubber and plastic	10.93%
Chemicals	10.47%
Other industries	28.33%
Total	100%

Notes: Percentage values refer to the data collapsed over the whole sample period (1996-2016). Authors' summary of Ethiopian Census Data on firms.

Table 16: Average and median markups by region

Region	Mean Markup	Median Markup
Tigray	1.31	1.20
Afar	1.40	1.27
Amhara	1.33	1.22
Oromia	1.26	1.18
Somalie	1.35	1.24
Benshangul	1.48	1.44
S.N.N.P.R.	1.31	1.20
Gambela	1.17	0.84
Harari	1.33	1.27
Addis Ababa	1.25	1.20
Dire Dawa	1.29	1.22

Notes: Authors' summary of Ethiopian Census Data on firms.

Table 17: Average and median markups by sector

Sector	Mean Markup	Median Markup
15	1.20	1.11
16	1.99	1.86
17	1.25	1.17
18	1.22	1.14
19	1.13	1.11
20	1.40	1.31
21	1.26	1.24
22	1.33	1.31
23	1.53	1.46
24	1.25	1.24
25	1.21	1.19
26	1.41	1.31
27	1.28	1.21
28	1.24	1.19
29	1.25	1.16
30	1.23	1.23
31	1.16	1.12
32	1.29	1.33
33	1.16	1.16
34	1.18	1.19
36	1.31	1.24
37	1.75	1.46
39	1.28	1.28

Notes: Authors' summary of Ethiopian Census Data on firms.

Figure 6: Unit value of cement