Foreign Direct Investment, Geography, and Welfare*

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Abstract

We study the impact of FDI on domestic welfare using a model of internal trade with variable markups that incorporates intranational transport costs. The model allows us to disentangle the channels through which FDI affects welfare. We apply the model to the case of Ethiopian manufacturing, finding gains from the presence of foreign firms in the local market and other connected markets in the country. FDI resulted in a modest worsening of allocative efficiency because foreign firms have higher markups. We report consistent findings from our empirical analysis, using microdata on firms, FDI, and geospatial data on the road network.

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1 Introduction

A large literature examines the links between foreign direct investment (FDI) and economic development in developing countries.[1] Despite this, there has been little focus on measuring the welfare effects of FDI within a framework that incorporates the market power of firms. For example, the entry of foreign firms could force local firms to lower their markups, which could be beneficial to welfare. Measuring this effect is useful, as market power can result in an inefficient allocation of resources, providing a rationale for governments to implement industrial policies such as subsidizing the entry of foreign firms. Another area that has received little attention is analyzing the welfare effects of FDI in a model that incorporates a spatial dimension. This feature could be important if high domestic transportation costs dampen the effects of FDI across intranational markets.

In this paper, we contribute by studying the welfare effects of FDI using a model that incorporates variable markups and internal trade subject to transport costs. The variable markups feature of the model allows us to highlight how changes in markups account for the estimated welfare effects of FDI. Furthermore, the model of internal trade incorporates transportation costs between regions, which will affect the ability of foreign firms to serve the internal market. Our framework thus allows us to disentangle new channels through which FDI affects welfare.

We analyze the case of Ethiopian manufacturing over the period 1996–2016. Ethiopian manufacturing is a relevant case to examine because this sector received substantial amounts of FDI during the period that we study; by 2016, foreign firms accounted for 17 percent of manufacturing value added. During this time period, the Ethiopian government relaxed regulations for foreign firms, allowing them to more easily enter a wide range of manufacturing sectors. Our data indicate that these foreign firms primarily sold to the domestic market. The government also embarked on an ambitious road infrastructure development program that reduced transportation costs across regions within the country.

We explore the effects of FDI in the Ethiopian manufacturing sector using a quantitative trade model 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 region. We introduce entry and exit of firms into the model, which is an important channel underlying adjustments to

[1]For reviews of the literature, see Javorcik (2019) and Alfaro (2017). Most existing empirical studies on FDI focus on estimating productivity and technology spillovers that can arise when foreign firms invest in a country or establish supply chain linkages with local firms (e.g., Blalock and Gertler, 2008; Alfaro-Ureña, Manelici and Vasquez, 2022).

FDI.[2] The framework is well-suited to studying key mechanisms through which FDI could affect the economy. For instance, on the one hand, we expect that the entrance of foreign firms will force less productive domestic firms to exit, thus lowering the price index for local consumers. On the other hand, some profits will then accrue to foreign entrepreneurs, which will reduce the income of local consumers. Furthermore, it is important to account for changes in the distribution of markups as well as the entry costs that foreign firms must pay. Our quantitative model provides a way of jointly measuring these various forces.

In particular, we decompose changes in welfare using the theoretical result developed by Holmes, Hsu and Lee (2014) (hereafter, HHL) in which they consider three components: (1) Ricardian channel, (2) allocative efficiency, and (3) the markups terms of trade (ToT). The Ricardian component of the decomposition accounts for 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 under perfect competition. For example, if foreign firms are relatively productive and have a low marginal cost, then it will link to increases in the Ricardian component. The allocative efficiency component relates to the welfare loss arising from heterogeneous markups charged by firms. In the model, firms with high markups are inefficiently small relative to firms with low markups, and firms with high markups have a high marginal revenue product for their inputs. This dispersion in markups would be associated with a loss in allocative efficiency. The markups ToT component compares the average markup of the goods sold with the average markup of the goods purchased by a region. Regions with high markups on the goods they sell relative to the goods they buy will enjoy a higher real income.

Additionally, our extended framework includes two new components in the decomposition. The first is related to the fraction of national income that accrues to the foreign owners of firms (the ratio of GDP to GNP). The second captures changes in the proportion devoted to fixed entry costs relative to variable costs of production, driven by changes in the number of firms.

To identify the parameters of our model, we use two data sources. First, we use detailed microdata on manufacturing firms. Firm-level information comes from the annual census of large and medium establishments published by the Central Statistical Agency (CSA). Second, we use information on the quality of the Ethiopian road network to determine transportation costs between regions of the country. Ethiopia embarked on the Road Sector Development Program (RSDP), an extensive road improvement project, starting in 1997.[3]

[2]Crowley, Han and Prayer (2024) discuss the implications of the free entry of firms in models of imperfect competition. In this context, our study is one of the few to study the welfare impacts of FDI within a framework that allows for the free entry of firms.

[3]Roads represent the main transport infrastructure in Ethiopia over the period covered in our analysis.

The country saw large investments in road improvements during this period: between 2010 and 2016, the number of kilometers of paved roads doubled. Our data allow us to measure the change in transportation costs resulting from road improvement. Therefore, we can study how variation in transportation costs may affect the impact of FDI on welfare.

We use the calibrated model to conduct quantitative exercises. First, we calculate the benefit from the presence of FDI by removing foreign firms in the calibrated model. We find large increases in GDP (corresponding to manufacturing value added) of about 4.1 percent.[4] We also find large gains in GNP of about 2.2 percent, which captures the gains in income that accrue to Ethiopian nationals. These results imply that the gains from FDI in Ethiopian manufacturing are large, although a substantial fraction of these gains accrue to the foreign owners of these firms (approximately half of the gains accrue to GDP but not GNP).[5] Interestingly, the gains are spread out across the country, even in regions that did not receive large amounts of FDI.

We next apply the HHL decomposition and obtain some important findings. First, we find that FDI increases real income by about 8.1 percent through the Ricardian channel. Our analysis indicates that this is the dominant channel underlying aggregate welfare gains. These Ricardian gains are consistent with the idea that the entry of more productive foreign firms lowers marginal costs and raises real income. Conversely, the Ricardian channel overestimates the gains from FDI primarily because it does not take into account the profits that accrue to the owners of foreign firms or the higher entry costs associated with the entry of foreign firms. Second, we find that FDI resulted in a modest worsening in allocative efficiency in Ethiopia. In the aggregate, this channel accounts for a loss of 0.1 percent of real income. Additionally, we find that this channel consistently accounts for negative effects on real income across regions because foreign firms tend to have large market shares, which, as viewed through the lens of the model, correspond to having high markups. In fact, our empirical analysis of firm markups confirms this tendency of foreign firms to have high markups.[6] Third, the entry cost channel is associated with a negative effect on welfare. This

The railway connecting Addis to Djibouti was reestablished in 2017.

[4]Note that an increase in GDP refers to an increase in GDP in the manufacturing sector alone, and not in the entire economy. Manufacturing value added accounted for 5.7 percent of GDP in 2016 in Ethiopia (World Development Indicators, the World Bank). While not the largest sector, it holds strategic importance for the government because of its high potential for job creation and foreign exchange earnings. FDI is being actively pursued as a key policy to spur its development (Ministry of Industry, Government of Ethiopia, March 2025, accessed at this link).

[5]In the rest of this paper, we use the terms "GNP" and "real income" interchangeably.

[6]Our results are consistent with a recent literature that empirically studies FDI and markups. Studies find that local affiliates increase their markups after being acquired by a foreign firm (e.g., Stiebale and Vencappa, 2018; Bircan, 2019); besides, affiliates that underwent divestment tend to decrease their markups after the divestment (e.g., Javorcik and Poelhekke, 2017). Other empirical studies find that foreign affiliates tend to charge higher markups than local firms (Li et al., 2022).

is because foreign firms are in sectors with high entry costs. As a result, a larger fraction of costs is devoted to fixed entry costs rather than to variable costs of production, thereby lowering welfare.

Next, we focus on interactions between FDI and the level of transportation costs in the economy to examine the concern that high transportation costs could reduce the gains from FDI. Thus, we conduct the same exercise in which we remove foreign firms, except that we use 1996 transportation costs in the simulations. We find that the channels under consideration behave differently when we change the level of transportation costs. The Ricardian term is lower with higher transportation costs, implying that higher transportation costs lower the gains from FDI. Lower transportation costs, in addition, also result in a smaller loss in allocative efficiency because it encourages the entry of more firms when the country conducts the FDI reform, thus improving allocative efficiency. However, the entry of more firms when transportation costs are low makes the entry cost term more negative and reduces the gains from the FDI reform.

The quantitative findings described above are broadly aligned with the evidence from our empirical analysis. Specifically, using firm-level data, we construct an unbalanced panel of markets to estimate the effects of FDI and road improvements on two key variables: (1) the average markup and (2) the dispersion of markups, calculated using a Theil index. Our independent variable of interest is exposure to FDI.

We construct two measures of exposure to FDI. Consider a firm located in a given market. Our first measure is the entry of foreign firms into that market, thus capturing competition from local foreign firms. Second, we construct a measure of exposure to foreign firms based on *all other markets* within the country, using the market access approach (Donaldson and Hornbeck, 2016), which takes into account changes in road infrastructure and, thus, transport costs. We calculate an average of the total production of foreign firms in every market in the country, weighted by the travel time to that market given the road network. Changes in this second measure of foreign exposure can thus come from two separate sources: changes in the foreign presence in locations across the country and improvements in the road network.

By including district-industry and year fixed effects, our specification identifies changes in the two outcomes of interest within a given market over time. Since exposure to FDI is unlikely to be random across markets, our analysis employs multiple estimation strategies, including a two-way fixed effects estimator accounting for heterogeneous treatment in time, an event study, and an instrumental variable approach. Further, we check that our results hold when we employ alternative measures of markups and foreign presence. In this way, we ensure that our findings are robust to potential biases related to selection, omitted variables and measurement error.

We find that an increase in foreign exposure (in the same and other intranational markets) is associated with lower average markups. 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. Also, domestic firms lose market share, reflecting the reallocation between domestic and foreign capital, highlighted in the model by the differential welfare impact on GNP relative to GDP. Finally, greater foreign exposure is associated with an increase in the Theil index of markup dispersion, consistent with a worsening of allocative efficiency. Thus, findings from the reduced-form empirical analysis are closely in line with those from the model.

Related Literature Our findings complement the empirical literature that studies the effects of FDI on local competitors. For example, in the case of Ethiopia, Abebe, McMillan and Serafinelli (2022) survey manufacturing plants to study the linkages between local and foreign plants. They find that local firms' most commonly reported linkage was "competition from foreign plants in the output market." Crescenzi and Limodio (2021) show that the increase in Chinese FDI in Ethiopia had a negative effect on firms competing in the same market. Our findings are consistent with those of this literature (such as the result that increased competition from foreign firms results in a decline in the market share of local firms), and in addition, we study their implications for the estimated welfare effects of FDI. This analysis is insightful because few papers have attempted to determine the size of the welfare effects and disentangle the various channels through which FDI affects welfare.[7] One recent paper that follows an approach similar to ours is Atkin, Faber and Gonzales-Navarro (2018), which focuses on the retail sector in Mexico. They find positive effects on consumer welfare from the entry of foreign firms in the retail sector, including pro-competitive effects on markups.[8]

This paper also complements the recent literature that delves into the welfare effects of improved infrastructure in developing economies (Donaldson, 2018; Asturias, Garcia-Santana and Ramos, 2018; Jedwab and Storeygard, 2022). These papers use spatial models in which transporting goods between regions is costly. Our work has a few unique aspects with

[7] In addition to the channels studied in this paper, FDI can affect welfare through other channels, such as competitive pressures that compel domestic firms to upgrade, direct technological transfers, and productivity spillovers that operate through intersectoral linkages. These mechanisms have been the focus of a rich and extensive literature. The purpose of our paper, however, is to complement this literature by focusing on alternative, less-explored, channels through which FDI can affect welfare—specifically, through changes in allocative efficiency, entry costs, and profit repatriation. Our approach leverages the integration of these mechanisms within a framework that allows for variable markups and spatial frictions. These features are crucial for understanding the full picture of the impact of FDI on welfare.

[8] Hwang (2022) finds similar effects in the Korean retail sector.

respect to this literature. First, to our knowledge, we are the first to apply a spatial model of internal trade to study the welfare effects of FDI within a developing economy.[9] This approach allows us to better understand the heterogeneous welfare effects of FDI throughout the country, even in locations that do not have any FDI projects. Second, we adopt a unified framework that incorporates both variable markups and intranational trade with spatial frictions - two important features that, while studied separately in the literature, have not been jointly explored in the context of analyzing the impacts of FDI on welfare. Our spatial model provides a robust framework to probe how transportation costs affect gains from FDI, enabling us to evaluate the complementarity between FDI and road infrastructure investments, two policies commonly pursued in tandem by developing countries. We find that the interaction between these two policies can be positive or negative (in other words, lower transporation costs can attenuate or amplify gains from FDI) depending on the channel, a result that is novel to the literature.

Finally, our paper contributes to a growing literature combining macro theory with microdata to draw welfare implications (Buera, Kaboski and Townsend, 2023), particularly focusing on the role of competition and markups (Edmond, Midrigan and Xu, 2015; Asturias, Garcia-Santana and Ramos, 2018; Brooks, Kaboski and Li, 2021). Our findings also relate more generally to the literature on misallocation in developing economies (Restuccia and Rogerson, 2013; Hsieh and Klenow, 2009; Restuccia and Rogerson, 2017). This literature has found sizeable welfare gains from eliminating misallocation, although it has struggled to find particular policies that can account for the amount of measured misallocation. This paper focuses on FDI and how it affects misallocation within a developing economy, an area that has not been widely studied. One exception is Bau and Matray (2023), who find that the relaxation of the FDI policy in India helped reduce capital misallocation through the alleviation of financial constraints. In this paper, we study a unique channel through which FDI can affect misallocation, namely, the dispersion in markups.[10] We find that, although it generates large gains for the economy, FDI can increase misallocation through the dispersion channel. Though this channel is relatively small in our setting, this finding suggests that the

[9] A series of influential papers use quantitative trade models to measure gains from FDI (e.g., Burstein and Monge-Naranjo, 2009; Arkolakis et al., 2018; McGrattan, 2012; Ramondo and Rodríguez-Clare, 2013; Irarrazabal, Moxnes and Opromolla, 2013). We differ from these papers along two dimensions. First, in contrast to this literature, we use a model in which firms charge variable markups. Thus, FDI can affect welfare through changes in the allocative efficiency of the economy. Second, our paper focuses on the effect of FDI on a domestic market. For example, our model allows us to study the heterogeneous effects of FDI on the country's different regions that are connected through intranational trade.

[10] A recent literature has focused on the market power of multinationals. For example, Keller and Yeaple (2020) find that the market power of U.S. multinational manufacturing firms has risen substantially between 1999 and 2014. Alviarez, Head and Mayer (2025) study how the acquisitions by large multinationals of competing entities affect competition in the beer and spirits industry.

effects of FDI on misallocation depend on the channel studied.

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, and Section 5 discusses the quantitative exercise. Section 6 tackles the reduced-form empirical analysis, and Section 7 concludes.

2 FDI and Road Policies in Ethiopia

In this section, we describe the policies adopted by the Ethiopian government regarding FDI and the improvement of roads.

2.1 Foreign Investment in Manufacturing

The Ethiopian government implemented the Growth and Transformation Plan I (GTP I), a national five-year plan that defined the country's development policies, during the fiscal years 2010–11 to 2014–15. The government subsequently adopted GTP II, a plan that largely continued the same policies as GTP I, in 2015–16.[11] The policies of 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 domestic firms. The plans recognize the need for domestic manufacturers to collaborate with foreign investors to boost the manufacturing sector's contribution to the Ethiopian economy.[12]

An important reform enacted under GTP I was that foreign firms were allowed to enter a wide range of manufacturing sectors.[13] Another important policy that gained traction under GTP II is that the government established special economic zones (SEZs) or industrial parks in which firms could import raw materials and capital duty-free with the condition that they export at least 80 percent of their production.[14]

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

[12] For example, the 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 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."

[13] Regulation 720/2012, which was enacted in 2012, allowed for foreign firms to enter almost all manufacturing sectors without need for government approval. The following areas of activity within the manufacturing sector, however, continued to require government approval: 1) finishing of fabric and yarn, 2) tanning of hides and skins below finished level, 3) printing, 4) manufacture of cement, and 5) manufacture of clay and cement products.

[14] GTP II largely unfolded after the time period of our study and is thus not directly relevant to the

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

The Road Sector Development Program (RSDP) began in 1997 with the goal of improving the coverage and quality of the Ethiopian road network. The RSDP has been implemented in several rounds by the Ethiopian Roads Authority (ERA).[15]

Table A.1 in Online Appendix A reports summary statistics of the quality and size 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. Major improvements have been made to the road network throughout time. We also see a marked acceleration in the growth rate of paved roads after 2007, and the rapid pace of development continued after 2010 with the implementation of GTP I. For example, in 2007 the country had 5,452 kilometers of paved road, and by 2016 this number had increased to 14,632.

Figure 1a shows the network of federal and regional roads in 1996 by type of surface. Figure 1b shows the same types of roads in 2016, distinguishing between segments that 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, including in peripheral areas of the country.

3 Model

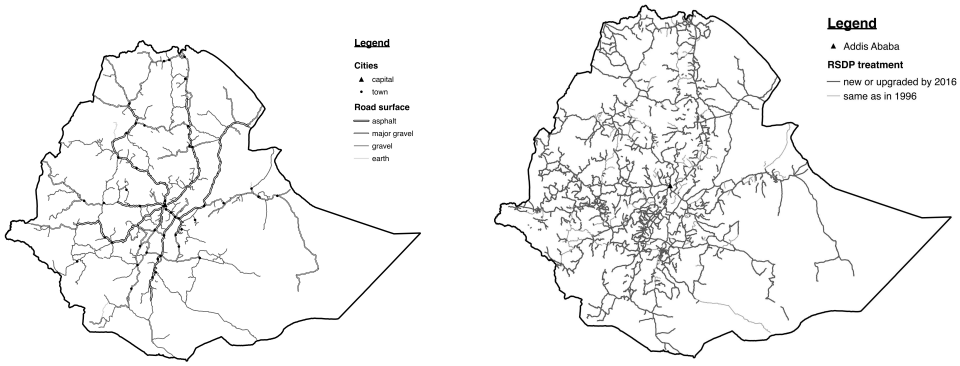
Consider a static model in which N asymmetric regions of Ethiopia trade with each other. In each region, there is a measure 1 of sectors. Within each sector, there is a finite number of firms that compete à la Cournot. Labor is immobile across regions.[16]

analysis in this paper.

[15]The phases of the RSDP program include RSDP I (1997–2002), RSDP II (2002–07), RSDP III (2007–10), RSDP IV (2010–15), and RSDP V (2015–20). RSDP III corresponds to the road improvement program implemented as part of the PASDEP development strategy that ran from 2005–06 to 2009–10, as described in footnote 11 (Ministry of Finance and Economic Development 2010). RSDP IV corresponds to the road improvement program implemented as part of GTP I, 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.

[16]This assumption is motivated by the limited migration between Ethiopian regions. For example, using data from the Ethiopian Labor Force Survey (LFS), Bundervoet (2018) documents that, in 2013, approximately 6 percent of the population had migrated internally in the previous five years. Furthermore, the majority of this internal migration was within the same region. Specifically, focusing on Oromia and Amhara, the two main origin regions for internal migrants, the study reveals that more than 70 percent to 80 percent of migration was within the same region.

Figure 1: Ethiopian Road Network



(a) Road Network in 1996 (b) Road Network in 2016

3.1 Ethiopian Household

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

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

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

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

where $c_n^o(j, k, L)$ is the good consumed by Ethiopian consumers in 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 Ethiopian household in region n is given by

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

where $p_n^o(j, k)$ is the price charged by firm k in sector j located in region o when selling to region n, W_n is the equilibrium wage, L_n is the labor endowment, and Π_n^L is the income

derived from the profits of firms located in n that accrue to the Ethiopian household.

3.2 Foreign Household

In each region n, there is a representative foreign household with a utility function with the same CES structure as the utility of the Ethiopian household described in equations (1) and (2):

$$C_n(F) = \left(\int_0^1 C_n(j,F)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{4}$$

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

where $C_n(F)$ is the utility of the foreign household, $C_n(j,F)$ is the composite good of sector j consumed by the foreign household in region n, and $c_n^o(j,k,F)$ is the good consumed by the foreign household in region n and provided by firm k in sector j shipped from region o. The budget constraint of the foreign household is

$$\int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k) c_n^o(j,k,F) \right) dj = \Pi_n^F, \tag{6}$$

where Π_n^F is the income derived from the profits of firms located in n that accrue to foreigners.

3.3 Firms

Firms play a two-stage entry game. In the first stage, a large number of local and foreign potential entrants observe their productivity without paying an entry cost and decide whether to enter. In the second stage, firms solve a profit maximization problem. Note that firms differ in their type according to their proportion of foreign ownership, which is fixed and exogenous in the model.

Second Stage We work backward through the entry game and begin by characterizing the second stage. Equations (1)–(3) generate the following demand for the local household:

$$c_n^o(j,k,L) = \left(\frac{P_n}{P_n(j)} \right)^{\theta} \left(\frac{P_n(j)}{p_n^o(j,k)} \right)^{\gamma} C_n(L), \tag{7}$$

where

$$P_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k)^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \tag{8}$$

is the price index for sector j in region n and

$$P_n = \left(\int_0^1 P_n(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}} \tag{9}$$

is the aggregate price index in region n. Similarly, equations (4)–(6) generate the following demand for the foreign household:

$$c_n^o(j,k,F) = \left(\frac{P_n}{P_n(j)} \right)^{\theta} \left(\frac{P_n(j)}{p_n^o(j,k)} \right)^{\gamma} C_n(F). \tag{10}$$

The total demand for a good is $c_n^o(j,k) = c_n^o(j,k,L) + c_n^o(j,k,F)$ and is characterized by

$$c_n^o(j,k) = \left(\frac{P_n}{P_n(j)} \right)^{\theta} \left(\frac{P_n(j)}{p_n^o(j,k)} \right)^{\gamma} \left[C_n(L) + C_n(F) \right]. \tag{11}$$

Firms within sectors compete à la Cournot. Firm k located in region o selling to region d takes the demand characterized by equation (11) and the quantity supplied by competitor firms in the sector as given and solves the following problem:

$$\pi_d^o(j,k) \ = \max_{c_d^o(j,k)} \ p_d^o(j,k) c_d^o(j,k) - \frac{W_o \tau_d^o}{a_o(j,k)} c_d^o(j,k), \tag{12}$$

where $a_o(j,k)$ is the productivity of firm k in sector j producing in region o, and τ_d^o is the iceberg transportation cost to ship one unit of good from region o to region 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

$$p_d^o(j,k) = \frac{\epsilon_d^o(j,k)}{\epsilon_d^o(j,k) - 1} \frac{W_o}{a_o(j,k)} \tau_d^o, \tag{13}$$

where

$$\epsilon_d^o(j,k) = \left(\omega_d^o(j,k) \frac{1}{\theta} + (1 - \omega_d^o(j,k)) \frac{1}{\gamma} \right)^{-1}, \tag{14}$$

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

$$\omega_d^o(j,k) = \frac{p_d^o(j,k) c_d^o(j,k)}{\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} p_d^o(j,k) c_d^o(j,k)}. \tag{15}$$

The price that firms set in equation (13) is similar to the markup over marginal cost that is found in a setup with monopolistic competition. The difference is that here the markups are endogenous and depend on the market structure of the sector. For example, suppose that there is only one firm in a given sector; that firm will then 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; the firm will then 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.

First Stage There are a large finite number of local potential entrants who can observe their productivity. Local potential entrants draw their productivity from a distribution with CDF $G_L(a)$. We similarly have a large finite number of foreign potential entrants who can observe their productivity and draw from a distribution with CDF $G_F(a)$. A firm with productivity level a has a constant labor requirement of $1/a$ to produce one additional unit of good. Note that, because once firms enter they do not pay any additional fixed costs to sell their goods to other regions, firms sell to all N regions.

Firm k will enter in the first stage if, taking the entry decision of other firms in sector j and aggregate variables as given, the following condition is satisfied:

$$\sum_{d=1}^{N} \pi_d^o(j,k) \geq W_o F_o(j), \tag{16}$$

where $\pi_d^o(j,k)$ is determined in the second stage and $F_o(j)$ is the fixed entry cost, denominated in units of labor, paid by firms in region o and sector j.

Let K_{nj}^L be the number of local firms that enter and K_{nj}^F be the number of foreign firms that enter in region o and sector k. Furthermore, let the total number of firms be $K_{nj} = K_{nj}^L + K_{nj}^F$.

3.4 Aggregate Profit

The aggregate profits of firms in region n are characterized by

$$\Pi_n = \int_0^1 \left[\sum_{k=1}^{K_{nj}} \left(\sum_{d=1}^{N} \pi_d^n(j,k) - W_o F_o(j) \right) \right] dj. \tag{17}$$

The income derived from profits of firms located in region n that accrue to locals is

$$\Pi_n^L = \int_0^1 \left[\sum_{k=1}^{K_{nj}} \phi_n(j,k) \left(\sum_{d=1}^{N} \pi_d^n(j,k) - W_o F_o(j) \right) \right] dj, \tag{18}$$

where $\phi_n(j,k)$ indicates the fraction of firm k in sector j located in region n owned by locals. We similarly characterize the profits of firms located in region n that accrue to foreigners as

$$\Pi_n^F = \int_0^1 \left[\sum_{k=1}^{K_{nj}} [1 - \phi_n(j,k)] \left(\sum_{d=1}^{N} \pi_d^n(j,k) - W_o F_o(j) \right) \right] dj. \tag{19}$$

3.5 Balanced Trade and Labor-Clearing Condition

All regions n must have balanced trade:

$$\int_0^1 \left(\sum_{o=1,\ o\neq n}^{N} \sum_{k=1}^{K_{oj}} p_n^o(j,k) c_n^o(j,k) \right) dj = \int_0^1 \left(\sum_{d=1,\ d\neq n}^{N} \sum_{k=1}^{K_{nj}} p_d^n(j,k) c_d^n(j,k) \right) dj. \tag{20}$$

The labor-clearing condition for region n is

$$\int_0^1 \left[\sum_{k=1}^{K_{nj}} \left(\sum_{d=1}^{N} \frac{c_d^n(j,k)}{a_n(j,k)} \tau_d^n + F_o(j) \right) \right] dj = L_n. \tag{21}$$

3.6 Defining Gross Domestic Product (GDP) and Gross National Product (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 firms will not accrue to GNP. For that reason, we define region n's GNP as

$$GNP_n = W_n L_n + \Pi_n^L. \tag{22}$$

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

3.7 Holmes, Hsu and Lee (2014) (HHL)

We extend the framework developed by Holmes, Hsu and Lee (2014) (hereafter, HHL) to decompose the changes in real income in our model in a way that highlights the various mechanisms at work.

We introduce some notation for the purpose of the decomposition. First, we define the aggregate markups on the goods sold. This measure 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

$$c_n^{sell} = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} c_{n,d}^{sell}(j,k) s_d^n(j,k) \right) dj, \tag{23}$$

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 as

$$\mu_n^{sell} = \frac{R_n}{W_n L_n} = \frac{1}{c_n^{sell}}, \tag{24}$$

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

$$c_n^{buy} = \int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} c_{o,n}^{buy}(j,k) b_n^o(j,k) \right) dj, \tag{25}$$

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

$$\mu_n^{buy} = \frac{1}{c_n^{buy}}. \tag{26}$$

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.

Theorem 1. *The expression for GNP_n/P_n can be rewritten as*

$$\frac{GNP_n}{P_n} = \underbrace{W_n L_n}_{\text{Labor income}} * \underbrace{\frac{1}{P_n^{pc}}}_{\text{Prod. efficiency}} * \underbrace{\frac{\mu_n^{sell}}{\mu_n^{buy}}}_{\text{Markup ToT}} * \underbrace{\frac{P_n^{pc}}{P_n}\mu_n^{buy}}_{\text{Allocative efficiency}} * \underbrace{\frac{GNP_n}{GDP_n}}_{\text{Ratio GNP/GDP}} * \underbrace{\frac{L_n^V}{L_n}}_{\text{Entry cost}}, \tag{27}$$

where L_n^V is the total labor used as a variable input (as opposed to paying the fixed entry cost) in region n and is defined as

$$L_n^V = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} \frac{c_d^n(j,k)}{a_n(j,k)} \tau_d^n \right) dj. \tag{28}$$

Proof. See Online Appendix C. □

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 from the dispersion in markups, which results in misallocation. In a situation in which there is no variation on markups, or when there is no misallocation, this index is equal to one. As misallocation increases, this index decreases.

Relative to the original HHL decomposition, our methodology adds the last two terms. One term relates the fraction of GDP that accrues to GNP; a decline in this ratio corresponds to a decline in Ethiopian real income. There is an additional term related to the fraction of labor used as a variable input (i.e., the fraction of labor that is not devoted to paying the entry cost). For example, if a large fraction of labor is devoted to paying entry costs, then the last term becomes smaller because fewer inputs are devoted to the direct production of goods.

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 (27), we arrive at the following expression:

$$\underbrace{\Delta \ln \frac{GNP_n}{P_n}}_{\text{Real income}} = \underbrace{\Delta \ln \frac{W_n L_n}{P_n^{pc}}}_{\text{Ricardian}} + \underbrace{\Delta \ln \frac{\mu_n^{sell}}{\mu_n^{buy}}}_{\text{Markup ToT}} + \underbrace{\Delta \ln \frac{P_n^{pc}}{P_n}\mu_n^{buy}}_{\text{Allocative efficiency}} + \underbrace{\Delta \ln \frac{GNP_n}{GDP_n}}_{\text{Ratio GNP/GDP}} + \underbrace{\Delta \ln \frac{L_n^V}{L_n}}_{\text{Entry cost}} \tag{29}$$

This expression provides a way to decompose the changes in real income into relevant channels of interest.

4 Data

4.1 Manufacturing Data

We use data from the Large and Medium Manufacturing Industries Survey (LMMS) published by the Central Statistical Agency (CSA) of Ethiopia for the years 1996 and 1998–2016. This annual census covers all plants[17] with at least 10 persons engaged and that use electricity in their production process.[18] The census is representative of the formal manufacturing sector, which accounts for almost half of manufacturing employment and 90 percent of the sector's production.[19]

The dataset provides detailed establishment-level information on output, employment, capital, and inputs. The establishment also supplies product-level information on sales values and physical quantities of its eight most important products.

Foreign firms We define a foreign firm using information on the share of initial capital. Namely, we classify a firm as foreign owned if more than 10 percent of the initial capital is

[17]We use the terms "plant," "establishment," and "firms" interchangeably in the paper. Given the constraints on identifying multi-establishment firms, our analysis does not consider potentially interesting topics, such as the optimal pricing for multi-establishment firms.

[18]The number of persons engaged refers to employees and working owners.

[19]These estimates are based on comparisons between formal and informal firms for the year 2010. Data on formal firms are compared with information coming from the Small Scale Industries Survey (SSIS), a representative survey covering the rest of the manufacturing firms, that is, those with less than 10 persons engaged. We do not include informal firms from the SSIS in our analysis, since the data are not available for all years. Given that formal firms covered by the LMMS cover more than 90 percent of the total production in manufacturing, the inclusion of informal firms is unlikely to qualitatively or quantitatively affect our results.

from foreigners.[20] Foreign firms included in our database are geographically concentrated, with most of them located in Addis (48 percent) and Oromia (42 percent). Sectorally, they are more widespread. The majority (20 percent) is in the food industry, followed by the textiles-apparel industry and a few other more capital-intensive industries (see Table A.2 in Online Appendix A). Table 1 reports the number of foreign firms and their share in the number of firms, employment, and the value of production for selected years in our sample.

We also find that foreign plants are domestically oriented in their sales. For example, exports account for only 4 percent of the total sales of foreign firms in 2015–16.

Table 1: Foreign Firms in Census Years

Year	Number of firms	Foreign firms share of total (%)		
		Number	Employment	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: Table 1 reports summary statistics for all firms in the sample. Foreign ownership is defined according to the initial share of capital owned by foreign nationals.
Source: Authors' elaboration on LMMS data from the CSA.

Table A.3 in Online Appendix A reports (unconditional) mean comparisons among foreign and domestic firms. Compared to their domestic counterparts, foreign firms employ more workers and are more capital intensive. Differences can also be found in labor productivity and wages, though they are not statistically significant.[21]

4.2 Road Data

The main source of information on Ethiopian road infrastructure is a proprietary geospatial database consisting of coded documents by the ERA and the Regional Roads Authorities' reporting on road construction sites that were part of the first three phases of the RSDP. The resulting database is a series of shapefiles of the Ethiopian road network, in which two main attributes are registered for each road segment: the type of road surface and the road's

[20]The census data include information about the fraction of initial capital that is foreign, but the data do not allow us to identify the nationality of such owners.

[21]Firms in LMMS report information on the products they produce. We find that, on average, foreign firms produce 4.2 products, while domestic firms produce 3.8. Regressions at the firm-product level with appropriate fixed effects for district, product, industry, and year show no statistically significant differences between foreign and domestic firms in the number of products produced and the product's share in total firm production (Table A.4 in Online Appendix A). As expected, there are significant differences in value and quantity produced, indicating that foreign firms are larger across all products.

condition. The data include four types of road surfaces: earth surface, minor gravel (regional rural roads made from a gravel surface), major gravel (federal gravel roads), and asphalt. As for road conditions, the database distinguishes between two categories: (i) not rehabilitated and (ii) new or rehabilitated.[22]

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 A.5 in Online Appendix A.[23] The computed travel times are between all the districts in the country. We additionally aggregate woreda-level (district-level) travel times so that we have average travel times between regions. In this calculation, we weigh woredas using night light intensity to emphasize the more economically important areas within a region.

5 Quantifying the Impact of FDI and Road Improvements

In this section, we calibrate the model to the Ethiopian manufacturing sector using the data described in Section 4 for the year 2016. At this point in time, the country had already attracted significant foreign investment while also embarking on the road improvement projects under the RSDP. We use the calibrated model to estimate the benefits from the presence of foreign firms; we additionally decompose these changes into the channels that affect welfare in the model. We similarly use the model to study the complementarity between the presence of foreign firms and lower transportation costs.

5.1 Calibration

We now discuss the calibration of the model in detail. A summary of the calibration of the model can be found in Table 2.

Elasticity of substitution across sectors, θ, and within sector, γ For the elasticities of the model, 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. First, the parameter θ governs the elasticity of the sectoral demand curve. Thus,

[22]Information on road surface and condition is recorded every two years from 1996 to 2016. The raw data were compiled by a local consultant. The consistency and accuracy of the original documents used for the coding exercise were checked by the authors during a field trip in 2017.

[23]The ERA speed matrix described in Table A.5 in Online Appendix A was also used by Jedwab and Storeygard (2022) and Fiorini, Sanfilippo and Sundaram (2021).

Table 2: Summary of Calibration

Parameter	Description	Value
(1) Parameters from literature		
θ	Elasticity of substitution across sectors	2
γ	Elasticity of substitution within sector	10.67
(2) Parameters taken directly from data		
$\phi_o(j,k)$	Fraction of local ownership of firm k in sector j in region o	Varies by firm
(3) Parameters inferred using functional relationships		
τ_d^o	Iceberg transportation costs from region o to region d	Varies across region pairs
(4) Parameters calibrated in equilibrium		
$a_o(j,k)$	Productivity of firm k in sector j in region o	Varies by firm
$F_o(j)$	Entry cost in sector j in region o	Varies by sector/region
(5) Normalizations		
L_n	Labor endowment of region n	Normalized to 1 for all regions

Notes: Table 2 summarizes the model calibration. Column 1 lists parameters of the model. Column 2 has a description of the parameter. Column 3 lists the parameter value used in the model.

lower values of θ imply that the sectoral demand curve is more inelastic and allows for firms with large market shares to charge higher markups. For example, a monopolist firm would have a markup of $\theta/(\theta-1)$, as indicated by equations (13)–(15). For θ, we use a value of 2, which is a conservative value relative to the parameter values previously estimated in the literature, which range from 1.2 to 2.0.

The parameter γ governs the level of differentiation of products within a sector and determines the markups of firms with very small market shares. For example, a firm with a market share approaching zero would have a markup approaching $\gamma/(\gamma-1)$, as indicated by equations (13)–(15). For γ, we use a value of 10.67, which is a conservative value relative to the values estimated in the literature, which range from 5.75 to 10.67.[24]

Fraction of local ownership of firms, $\phi_o(j,k)$ We set $\phi_o(j,k)$ to be consistent with the average paid-in capital by Ethiopian nationals as reported in the data for each firm.

Iceberg transportation costs, τ_d^o We follow Roberts et al. (2012) and use a formulation that allows for iceberg transportation costs to increase less than proportionally with respect to optimal travel time, which is consistent with transportation costs exhibiting economies of scale with respect to travel time. We use the following functional form relating iceberg transporation costs and the optimal travel time between two locations:

$$\tau_d^o = 1 + \kappa \left(TravelTime_d^o\right)^\rho, \tag{30}$$

[24]Asturias, Garcia-Santana and Ramos (2018), Edmond, Midrigan and Xu (2015), and De Loecker, Eeckhout and Mongey (2021) estimate a value for θ of 1.99, 1.24, and 1.20, respectively. These same authors estimate a value for γ of 10.67, 10.5, and 5.75, respectively.

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

To pin down the ρ parameter, we collect microdata on internal transportation costs within Ethiopia. In particular, we obtained quotes on the cost to transport a standardized 20-foot shipping container from Addis Ababa to the other regional capitals in Ethiopia from four different transportation/logistics firms in October 2019.[25] We combine these data with Google Maps driving times between Addis Ababa and the destination cities in the price quote.

With the data in hand, we rearrange equation (30) as follows:

$$\log\left(\tau_d^o - 1\right) = \log\kappa + \rho\log\left(TravelTime_d^o\right), \tag{31}$$

which yields the following equation, estimated with our newly assembled dataset:

$$\log TransportationCost_{di} = \alpha_0 + \alpha_1 \log TravelTime_d + FE_i + \epsilon_{di}, \tag{32}$$

where $TransportationCost_{di}$ 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 ϵ_{di} 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 A.6 in Online Appendix A reports the results from the estimation of equation (32). The last column of the table reports the results when combining all of the data and indicates a coefficient of 0.58. Note that this estimate is consistent with economies of scale in transportation since $\rho < 1$. The estimate in the last column also shows a high R-squared of 0.87, indicating that distance captures a large fraction of the variation in transportation costs. 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.[26]

We next pin down κ, which governs the level of iceberg transportation costs. We use

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

[26] This estimate is similar to that of Roberts et al. (2012), who estimate that on average, $\rho = 0.60$ across the goods studied using 2007 Chinese data. It is also similar to the value of 0.80 used by Adamopoulos (2025) to estimate transport costs in the context of rural Ethiopia.

information about transportation costs from Atkin and Donaldson (2015), who estimate that the "cost of remoteness," meaning the difference in ad valorem transportation costs for nearby locations and those far away, is 20 percent in ad valorem terms in Ethiopia. To find a value of κ, we use a guess and verify procedure. First, we guess a value of κ. Second, we calculate the implied iceberg transportation costs between all regions for 2016. To do so, we use equation (30), along with the estimate of ρ and the travel times between regions described in Section 4.2. 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 for κ until the maximum difference between the highest and lowest destination is 1.20 for any region.

Firm productivities, $a_o(j,k)$, and entry costs, $F_o(j)$ The distribution of the productivities of firms is important for our quantitative results because those productivities will determine the size and nature of the gains from having foreign firms in the economy. For example, if foreign firms tend to have productivities similar to local firms, then there will be more head-to-head competition and thus a more important role for changes in allocative efficiency through changes in markups.

For the firms that enter in the calibrated model (i.e., those firms in the calibrated model that have a corresponding data counterpart), we solve for the productivity of each firm so that it matches its national manufacturing value-added market share.

Next, we must generate productivity draws for potential entrants that chose not to enter (i.e., those potential entrants who did not find it worthwhile to pay the entry cost). To do so, we estimate a Pareto distribution using the calibrated productivities and then select productivities that are consistent with that estimated productivity distribution.

Finally, we set the entry costs, $F_o(j)$, such that the number of firms in the model is the same as in the data for that particular region and sector.

Note that the calibrated model matches the market shares and number of firms as observed in the data.[27] Given the complexity of this problem, we describe in detail the computational algorithm used to solve for entry costs and firm productivities in Online Appendix D.1.

It is possible for the model to have multiple equilibria in any given sector (i.e., it is possible to have different combinations of firms operating and be fully consistent with the definition of an equilibrium). Thus, for the purposes of the calibration, we are solving for an equilibrium that is consistent with the data.

[27]For the multi-product firms in the data, we divide a firm's value added into its various products based proportionally on each product's sales.

Labor endowments, L_n The labor endowment, L_n, of all regions is normalized to 1. Note that, given the calibration of the firm-level productivities to match each firm's national market share, the relative size of manufacturing value added across regions is the same in the data and model.

Comparison of markups in model and markups estimated in data We compare the markups in the calibrated model, which are moments that we did not target in our calibration and those that we empirically estimate using the manufacturing data. Solely for the purposes of this comparison, we estimate firm-level markups from the manufacturing data by dividing revenues by total costs (Diewert and Fox, 2008; Nishioka and Tanaka, 2019; Brooks et al., 2021). This intuitive metric is easy to map to the model output and is equivalent to the ratio of output price to marginal cost when scale elasticities are equal to 1.

We obtain markups for firm i in the data using the following equation:

$$\mu_i = \frac{P_i Q_i}{p_i^l L_i + p_i^m M_i + r K_i}, \tag{33}$$

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, and r is the cost of capital. We use a value of $r = 0.15$[28], which combines an estimated 5 percent for the cost of capital and a 10 percent depreciation rate.[29]

We compute the same statistics in the model (i.e., dividing the total value of production by the total cost of inputs without entry costs), considering only the sample of entrants. Note that in the model, firms charge a different markup in each region depending on the competition that they face. The firm-level markup that we calculate combines information about the markups that the firm charges across all destinations.

Table 3 shows summary statistics of the markups that we obtain using the data and the output from the model. We find that the levels of markups are similar in both cases. We also find that in both cases, foreign firms have higher markups than domestic firms. The weighted average markup of foreign firms in the model is 9 percent higher than domestic firms (1.55 vs.

[28]This value is similar to those values used in the literature. For instance, Brooks et al. (2021) use a value of 0.15 for China and 0.13 for India.

[29]As we expect some of the measurements to be imperfect, we follow standard practice in the literature (e.g., Lu and Yu, 2015; Brooks et al., 2021) and winsorize 2.5 percent in both sides of the tails. Descriptive statistics give relationships that are consistent with other studies about markups. For example, the statistics show that (i) markups have been on the rise over the period considered, in line with global trends shown, for instance, by De Loecker and Eeckhout (2018); (ii) values look similar both geographically (across regions, see Table A.8 in Online Appendix A) and sectorally (Table A.9); and (iii) the distribution of markups for foreign firms has a longer right tail (Figure A.1).

1.41) and 6 percent higher in the data (1.52 vs. 1.43). Note that the results from the table indicate that the model tends to predict lower markups relative to the empirical estimates, which is consistent with our choice for more conservative values for the elasticities, θ and γ, as described earlier in this section (see the beginning of Section 5.1).

Table 3: Comparison of Markups in the Model and Empirical Estimates

	Model	Empirical estimates
Weighted average markup (all)	1.42	1.45
Weighted average markup (foreign)	1.55	1.52
Weighted average markup (domestic)	1.41	1.43
Average unweighted markup (all)	1.18	1.41
Median markup (all)	1.11	1.22

Notes: Table 3 reports summary statistics of the markups in the calibrated model and markups derived from empirical estimates. Column 1 indicates the reported statistic. Column 2 reports the statistics of markups in the calibrated model, and Column 3 reports the same statistics for the markups estimated in the data. Both sources refer to the last year for which data are available. The construction of these markups is described in the subsection "Comparison of markups in model and markups estimated in data" found in Section 5.1.

Table 3 shows that the weighted average markups of foreign firms are higher than domestic firms, in both the model and the empirical estimates of markups. This comparison is useful as our focus is how foreign firms affect the allocative efficiency of the economy through the distribution of markups. We further examine whether this pattern holds within industries by estimating the following regression:

$$\log Markup_i = \beta_0 + \beta_1 Foreign_i + FE_j + \epsilon_i, \tag{34}$$

where $Markup_i$ is the markup of firm i, $Foreign_i$ is a dummy that indicates whether the firm is foreign owned, and FE_j is a dummy for firm i's sector. We estimate this regression using sales as the weight.[30]

Table A.7 in Online Appendix A reports the results of the estimation of equation (34). The results indicate that foreign firms have markups that are around 8 percent higher when we use the model output (column 1) and the estimates from the data (column 2). These results indicate that, within industries, foreign firms tend to have high markups relative to domestic firms, and this finding is consistent with the calibrated model. The differences in markups are quantitatively similar to those found in Table 3.

[30]In the data, each observation is a firm. In the model, each observation is a firm-product pair. The weighted regression makes these two measures comparable. For example, a weighted regression with one firm that has a markup of 1.5 and 100 in sales yields the same results as a regression with two firm-product pairs that have markups of 1.25 and 1.75, each with 50 in sales.

5.2 Quantitative experiments

In this section, we use the model calibrated in Section 5.1 to conduct quantitative experiments with the aim of measuring the benefits of policies that encourage FDI. We also evaluate the complementarity with another policy that affects competition across the country and the distribution of markups in the country: the roads improvements under the RSDP.

Online Appendix D.2 includes a description of the computational algorithm used to solve the model when we conduct the quantitative experiments.

5.2.1 FDI reform

As a first step, we measure the benefits from having foreign firms in the manufacturing sector. As discussed in Section 5.1, the model is calibrated to 2016, which is after the country received a significant inflow of FDI. In this quantitative exercise, we eliminate all foreign firms from the calibrated model. Table 4 reports the changes in real GDP and GNP from this simulation. Note that the results use the equilibrium with no foreign firms as the starting point, which gives positive increases in income. The results are broken down by regions. 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 table reports the results for the aggregate economy.

Table 4: Changes in Real Income after FDI Reform (%)

Region	GDP/P	GNP/P
Harari	−6.91	−6.91
Somali	3.62	3.62
Afar	5.87	5.87
Dire Dawa	0.25	−0.39
Amhara	11.33	9.33
SNNPR	1.38	1.36
Tigray	1.77	1.75
Oromia	8.27	2.90
Addis Ababa	1.94	1.42
Aggregate	4.10	2.21

Notes: Table 4 reports the percentage changes in real income after conducting the FDI reform in the model (i.e., the benefit from having foreign firms in the economy). Column 1 reports the region; the regions are sorted by the total manufacturing value added in ascending order. Column 2 reports the percentage change in real GDP for each region. Column 3 reports the percentage change in real GNP. The final row reports the aggregate percentage change, which is the weighted average of changes across all regions where the weights are based on a region's value added.

Table 4 shows large aggregate gains, with real manufacturing GDP increasing by 4.1

percent and real GNP increasing by 2.2 percent. These results imply significant gains for the manufacturing sector, and because the model is static, these gains accrue to the country every year.

Second, the differences in increases in real GDP and GNP imply that approximately half of the gains in GDP do not accrue in GNP. These results help us better understand the division of gains between locals and foreigners from these policies and show that a large fraction of the overall gains accrue to foreigners. Third, the gains are spread out across the country. Thus, regions that did not receive significant amounts of FDI benefited significantly even though the FDI flows primarily entered Oromia and Addis Ababa.

Table 5 reports the results of applying the HHL decomposition, as described in equation (29), to changes in real GNP. As mentioned before, the HHL decomposition allows us to quantify the various channels through which foreign firms affect Ethiopian welfare. First, the Ricardian term, which measures the real income gain if all firms charge their marginal cost, is 8.1 percent in the aggregate. These gains are driven by increases in productive efficiency from having foreign firms in the economy and increase in income accruing to factors—in this case, labor.[31]

Second, we find that the Ricardian term consistently overestimates the real income gains for Ethiopians because this term does not consider the negative effects from changes in allocative efficiency, the differences between GNP and GDP, and the large increase in entry costs. We find that the allocative efficiency channel is negative and persistent across regions, implying that, although there are large benefits from foreign firms, these benefits are reduced by a modest worsening of allocative efficiency. This result arises from the large market shares of some foreign firms, which allow them to charge high markups. We also find that the entry cost channel is negative, accounting for -4.1 percent in the aggregate, and the effect is persistent across regions. Reasons for these negative results are heterogeneous across regions. In the large regions, where FDI is primarily located, there is increased entry into high entry-cost sectors, although it is worth noting that there is a modest reduction in the number of firms. In the small regions, on the contrary, the increase in the entry cost can be accounted for by an increase in the number of firms. Thus, our results indicate that it is important to account for the markups, the profits of foreign firms, and the entry costs of foreign firms when determining the gains to the local economy.

[31]Note that the large gains in the Ricardian term are driven by the large market share of foreign firms in some of the most important sectors of the economy. For example, in the data, we find that in the 20 largest sectors by size nationally, foreign firms account for more than 80 percent of value added in 4 of these sectors. Moreover, the model shows the same patterns of concentration. These foreign firms are particularly valuable to consumers because the low θ implies that goods from other sectors are not highly substitutable (i.e., the loss of these foreign firms would have a large effect on P_n^{pc}).

Third, the results show that the markup ToT is a term that has important distributional consequences. As discussed, this term measures the changes in the aggregate markup of the goods sold relative to the aggregate markup of the goods purchased. Foreign firms charge relatively high markups, thereby improving the markups ToT for regions where foreign firms are concentrated and worsening this term in regions with few, if any, foreign firms. For example, regions such as Oromia, which has a high number of foreign firms, gain in terms of trade. Note that at the national level, the markup ToT is equal to zero, and the regional changes in the markup ToT reflects the shifting of income from one region to another. At the national level, the aggregate markup of the goods sold always equals the aggregate markup of the goods purchased. Thus, there is no change in this ratio since it is always equal to one at the national level.

Table 5: Changes in Real Income after FDI Reform, Decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Entry cost	Residual
Harari	−6.91	3.19	17.32	−0.13	0.00	−27.29	0.00
Somali	3.62	6.68	−2.06	−0.07	0.00	−0.93	0.00
Afar	5.87	10.51	−3.51	−0.07	0.00	−1.05	0.00
Dire Dawa	−0.39	4.66	−3.06	−0.16	−0.64	−1.19	0.00
Amhara	9.33	20.45	−2.97	−0.08	−2.00	−6.06	0.00
SNNPR	1.36	6.56	−2.91	0.04	−0.02	−2.31	0.00
Tigray	1.75	13.37	−1.88	−0.16	−0.02	−9.57	0.00
Oromia	2.90	15.44	2.00	−0.12	−5.37	−9.05	0.00
Addis Ababa	1.42	2.69	0.19	−0.11	−0.52	−0.83	0.00
Aggregate	2.21	8.10	0.00	−0.10	−1.89	−4.08	0.19

Notes: Table 5 decomposes the percentage changes in real GNP after conducting the FDI reform in the model (i.e., the benefit from having foreign firms in the economy). Column 1 reports the region; regions are sorted by the total manufacturing value added in ascending order. Column 2 reports the percentage change in real GNP for each region. Columns 3–7 report the HHL decomposition of the changes in real GNP. Column 8 reports the residual when the changes in real GNP do not equal the change in the HHL components. The final row reports the aggregate percentage change, which is the weighted average changes across all regions where the weights are based on a region's value added. Note that the change in the markup ToT in the aggregate must be equal to zero because the aggregate markup of the goods sold must equal the aggregate markup of the goods purchased at the national level. Thus, we assign the real income changes from the markup ToT to be zero in the aggregate; any differences between the change in real GNP and the channels of the HHL are reallocated to the residual term.

5.2.2 Complementarity between foreign firms and improvements in road infrastructure

We now use the model to study whether there is complementarity between the presence of foreign firms in the economy and the road improvement projects undertaken under the RSDP. Given that the government pursued both of these policies simultaneously, it is natural to wonder how these policies would interact with each other and whether these interactions depend on the particular channel of welfare being studied.

We define policies as complements if, once a country has enacted one reform, the percentage gain from enacting the other reform increases.[32] Thus, foreign firms are complementary to road improvements 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 6 reports the results. We find a decrease in the gains in real income under the lower transportation costs, from 2.3 to 2.2. Note, however, that the interaction effects vary across the different channels. For example, the Ricardian term exhibits complementarity. This result is from lower transportation costs increasing the openness of the regional economies, which implies that the benefits are larger from the presence of foreign firms. Similarly, lower transportation costs result in a smaller loss in allocative efficiency because these lower costs encourage the entry of more firms when the country conducts the FDI reform, thereby improving allocative efficiency. On the other hand, the entry of more firms when transportation costs are low makes the entry cost term more negative and reduces the gains from the FDI reform.[33]

5.3 Extensions of the Model

Quality The literature on FDI has found evidence that foreign firms tend to produce higher-quality goods (e.g., see Javorcik 2019 for a survey in which the topic of quality is discussed within the context of the literature on FDI). In Online Appendix B, we study the implications of including quality differences in our model. We find that a model in which firms have different levels of quality can be rewritten so that these differences are reflected in firm productivity. Thus, the productivities we calibrate in our quantitative exercises incorporate information about quality and a firm's productivity. Note that in the quantitative experiments, the model would not account for changes in quality that may occur in domestic firms after a policy change. For example, if we remove foreign firms from the calibrated model, then the quality of products produced by local firms may change, which implies FDI may affect welfare through additional channels.

[32] This definition is similar to the one used by Asturias et al. (2016).

[33] In a separate exercise, the results of which are reported in Table A.10 of Online Appendix A, we 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 them with the economy in 2016. We find gains of 2 percent per year in real manufacturing GNP. Unlike the policies that encouraged foreign firms, we do not find substantial changes in the ratio of GDP to GNP. Additionally, we find that the regions farther away from the main industrial hubs of Oromia and Addis gain the most from the lower transportation costs.

Table 6: Changes in Real Income after FDI Reform with High Transportation Costs, Decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Entry cost	Residual
Harari	−6.95	2.10	14.06	−0.16	0.00	−22.95	0.00
Somali	3.34	6.58	−2.29	−0.07	0.00	−0.88	0.00
Afar	5.91	10.75	−3.70	−0.09	0.00	−1.05	0.00
Dire Dawa	−0.57	4.78	−3.35	−0.20	−0.68	−1.11	0.00
Amhara	9.08	20.42	−3.22	−0.09	−1.97	−6.06	0.00
SNNPR	3.24	3.64	0.04	0.03	0.00	−0.46	0.00
Tigray	1.66	13.49	−2.08	−0.18	−0.03	−9.54	0.00
Oromia	2.98	15.93	1.54	−0.14	−5.32	−9.03	0.00
Addis Ababa	1.44	2.71	0.13	−0.11	−0.53	−0.75	0.00
Aggregate	2.32	8.05	0.00	−0.12	−1.88	−3.90	0.17

Notes: Table 6 decomposes the percentage changes in real GNP after conducting the FDI reform in the model (i.e., the benefit from having foreign firms in the economy) when transportation costs are equal to those of 1996. Column 1 reports the region; regions are sorted by the total manufacturing value added in ascending order. Column 2 reports the percentage change in real GNP for each region. Columns 3–7 report the HHL decomposition of the changes in real GNP. Column 8 reports the residual when the changes in real GNP do not equal the change in the HHL components. The final row reports the aggregate percentage change, which is the weighted average changes across all regions where the weights are based on a region's value added. Note that the change in the markup ToT in the aggregate must be equal to zero because the aggregate markup of the goods sold must equal the aggregate markup of the goods purchased at the national level. Thus, we assign the real income changes from the markup ToT to be zero in the aggregate; any differences between the change in real GNP and the channels of the HHL are reallocated to the residual term.

5.4 Additional analysis of model output and comparison with data

As a next step, we proceed to an empirical analysis with two main goals. First, we wish to ascertain whether and to what extent results from the model are borne out in the data. Second, we aim to delve deeper into the insights generated by the model and relate them to the existing empirical literature on the impacts of FDI. To do this, we adopt reduced-form methods that are employed in the FDI literature.

In particular, we examine whether the entry of foreign firms is associated with lower markups of domestic firms located in the same region. Furthermore, we study whether the entry of foreign firms increases the dispersion of markups in that region. To measure the dispersion of markups, we construct a Theil index at the region-industry level. The Theil index is a special case of the generalized entropy index and has previously been used in the literature. For example, Lu and Yu (2015) used the Theil index to find that increased competition after a trade liberalization in China reduced the dispersion of markups.[34]

[34]We calculate the Theil index using output from the model from the FDI reform described in Section 5.2.1. The Theil index for region r industry j at time t is defined as follows:

$$Theil_{rjt} = \frac{1}{n_{rjt}} \sum_{i=1}^{n_{rjt}} \frac{\mu_{irjt}}{\overline{\mu}_{rj}} \log\left(\frac{\mu_{irjt}}{\overline{\mu}_{rjt}}\right), \tag{35}$$

where n_{rjt} is the number of firms in industry j in region r, μ_{irjt} is the markup of firm i, and $\overline{\mu}_{rjt}$ is the

We estimate the following regression using output from the model from the FDI reform described in Section 5.2.1:

$$y_{rjt} = \alpha_0 + \beta(FDIExposure)_{rjt} + \gamma_{rj} + \theta_t + \epsilon_{rjt}, \tag{36}$$

where y_{rjt} is the variable of interest, which in this case is either the Theil index or the average markup of domestic firms (weighted by each firm's share of production). Both variables are aggregated at the market level (a region r-industry j pair) and year t level. The variable $(FDIExposure)_{rjt}$ is a dummy that indicates whether at least one foreign firm is operating in a given market at time t; γ_{rj} are region-industry fixed effects, θ_t is a time fixed effect; and ϵ_{rjt} is an error term.

This specification measures changes in the outcomes of interest within region-industry pairs before and after being exposed to FDI. Note that we include region-industry fixed effects, γ_{rj}, to account for region-industry specific sources of omitted variable bias. We also include year fixed effects, θ_t, to account for shocks common to all regions in the country. All regressions include the size of production as a control. Standard errors are clustered at the level of the treatment. Note that the analyses based on the model and data differ along one important dimension. The model analysis includes two periods only: one period with FDI and another period without FDI, as described in Section 5.2.1. The data analysis utilizes all of the annual information from the manufacturing data.

The results of this estimation can be seen in Table 7. We find that the entry of foreign firms is associated with an increase in the dispersion of markups and with a decline in the weighted average markup. We find substantial similarity in the results from the model and the data. In the model, the presence of foreign firms is associated with lower markups among domestic firms and an increase in dispersion captured by the Theil index. We find similar patterns in the data.

6 Reduced-Form Evidence

This section estimates a reduced-form relationship between foreign firms and markups. In contrast to Section 5, we use the district, which is a more disaggregated geographic unit

average markup of firms in industry j in region r. The Theil index ranges from zero to infinity, where zero implies that all markups are the same and higher measures imply an increased dispersion of markups. Note that we include all firms (i.e., foreign and domestic firms) when we calculate the Theil index since we are interested in measuring the total dispersion in markups. Figure A.2 in Online Appendix A reports the density distribution of the Theil index calculated at the market level. Markets in which foreign firms produce (i.e., those that we defined as being treated) have a distribution with a longer right tail, and in general they lie to the right compared to markets with solely domestic firms.

Table 7: Changes in Markups When Exposed to Foreign Firms

Variables	(1) Theil	(2) Log markup	(3) Theil	(4) Log markup
FDI dummy	0.00215***	-0.0307***	0.00666*	-0.107***
	(0.000751)	(0.00484)	(0.00353)	(0.0337)
Constant	-0.0171***	-0.0604	0.647***	-1.149***
	(0.00313)	(0.0480)	(0.0314)	(0.175)
Observations	2,424	2,424	3,390	3,390
R-squared	0.916	0.986	0.457	0.457
Region*Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Model/data	Model	Model	Data	Data

Notes: Theil index variables and markups are calculated at the level of the relevant market (region-industry). Note that the Theil index includes foreign firms, whereas the weighted average markup does not. All regressions control for the log of total production in each market. Columns 1 and 2 use model output. The calibration of the model is described in Section 5.1. In this specification, an observation is a firm-product pair as described in the subsection "Number of producers, K_{oj}." In order to construct industry dummies, each product is assigned to the four-digit industry code in which that product is most likely produced (i.e., the industry that claims the highest value of production for that good). Columns 3 and 4 use the census data. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

of analysis (the district is also referred to as a woreda). Districts roughly correspond to a county, and this unit has also been used by other studies (e.g., Abebe, McMillan and Serafinelli, 2022; Moneke, 2020; Crescenzi and Limodio, 2021) to define a local market in the country. Moreover, we employ the production function approach to constructing firm markups (De Loecker and Warzynski, 2012; De Loecker, Eeckhout and Unger, 2020) instead of the cost approach described in Section 5.1. We estimate markups as follows:

$$\mu_{it} = \alpha_i^v (\beta_{it}^v)^{-1}, \tag{37}$$

where $\alpha_i^v = \frac{\partial Q_{i(\cdot)}}{\partial V_i} \frac{V_i}{Q_i}$ is the output elasticity of variable inputs (labor and materials) and $\beta_{it}^v = \frac{p_{it}^v V_{it}}{P_{it} Q_{it}}$ is the share of expenditure on those inputs in total revenue. Each firm is assigned an output elasticity obtained from Fiorini, Sanfilippo and Sundaram (2021), who estimate physical productivity (TFPQ) using a production function approach. This approach utilizes a fraction of the firm data that we use in this paper and for which panel data are available.[35]

[35]Table A.13 in Online Appendix A reports the coefficients of the production function as estimated by Fiorini, Sanfilippo and Sundaram (2021). Productivity is estimated using the Levinsohn and Petrin (2003) approach that uses the costs of raw material as a proxy for unobservable productivity shocks to correct for simultaneity bias. It also corrects for simultaneity bias in the labor coefficient following Ackerberg et al. (2015). Importantly, the coefficients are based on physical productivity, given that output is deflated using a firm-specific price index constructed from product-level data reported by each firm. See Appendix D in Fiorini, Sanfilippo and Sundaram (2021) for more details on the construction of the price index.

We find a high correlation (0.66) with the definition of markup used earlier in the paper.[36]

6.1 Empirical analysis

We explore whether central insights from the quantitative analysis are reinforced in a reduced-form analysis that analyzes the relationship between FDI exposure on both the levels and the distribution of markups. A key contribution of this work is to introduce a novel approach to capturing the spatial effects of FDI through market-access exposure measures.

Our specifications are based on an unbalanced panel of markets (district-industry pairs). The baseline specification is

$$y_{rjt} = \beta_0 + \beta_1 (FDI)_{rjt} + \gamma_{rj} + \theta_t + \epsilon_{rjt}, \tag{38}$$

where r is the district, j is the sector, t is the year, and y_{rjt} is the outcome of interest. The outcomes of interest that we focus on are the district-level average markup charged by domestic firms and the Theil index. The coefficient of interest is β_1, which measures either local competition from FDI or competition from changes in FDI exposure resulting from improvements in internal roads and growth in the presence of foreign firms in markets across the country. Details on the construction of both measures are provided in the following section. All regressions control for (the log of) total production. We include district-industry (γ_{rj}) and year (θ_t) fixed effects to account for market-specific sources of omitted variable bias and time-contingent shocks that are common to all markets in the country. Standard errors are clustered at the level of the treatment (district-industry).

6.2 FDI penetration

We measure competition using the market (a district-industry pair) as our unit of analysis. We consider two measures that capture two sources of competition. The first measure is from FDI in the local market. We measure this direct effect with a dummy variable that takes a value of one if at least one foreign firm is operating in a given market rj at time t and beyond. We consider the treatment as an absorbing state (i.e., once a foreign firm begins production, a market remains treated for the rest of the time).[37]

[36] Brooks et al. (2021) also find a high correlation when comparing definitions of markups based on the production and cost approaches on firm data for India and China.

[37] Recent papers on FDI in Ethiopian districts use either the number or size of foreign firms (Crescenzi and Limodio 2021) or the entry of a foreign project (Abebe, McMillan and Serafinelli 2022) to define the treatment, which is FDI. We show in robustness checks that our results are not affected by the definition of the treatment.

The second measure leverages the specific context of our research that investigates the complementarity between FDI and road infrastructure. We construct a measure of exposure to FDI in all other markets in the country that changes as the road network improves, shaping the proximity of firms to their foreign competitors. The measure is based on the idea behind the market access indicator developed by Donaldson and Hornbeck (2016) to study the economic effects of infrastructure development in a formal structural gravity trade model.

Formally, our adapted measure of foreign exposure is constructed as follows:

$$\text{FDI Exposure}_{rjt} = \log\Big(\sum_{z \neq r} D_{rz,t}^{-\theta} L_{zjt}\Big), \tag{39}$$

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 time t. The term L_{zjt}, which varies across locations and industry, measures the destination district z's value of total production by foreign firms in each industry j. We use an elasticity (θ) of 3.8, which is equal to the one estimated by Jedwab and Storeygard (2022) in their work on African urban areas.[38] Bilateral distances in hours of travel are computed by applying the Dijkstra algorithm on the network of Ethiopian districts (nodes) connected by federal and regional Ethiopian roads (links).[39] Each link is characterized by its average travel speed, which is a function of the surface type and condition of the road segment(s) in the link (see Table A.5 in Online Appendix A). Changes in the bilateral travel time across districts account for the evolution of the road network. This evolution is combined with changes in foreign presence in all other markets in the country to get a sense of increased competition from FDI in connected intranational markets.[40]

[38]This value is estimated based on the elasticity of trade to travel time found for the United States 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 United States. A value of 3.8 lies in the middle of the estimated trade elasticities commonly found in the literature.

[39]Starting from the shapefiles with road segments, we create additional ancillary nodes to allow 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 travel on each road segment can go in both directions. This assumption is reasonable given the focus on regional and federal roads, which represent the majority of road infrastructure in the country.

[40]Figure A.3 in Online Appendix A provides an industry-specific example showing variation in exposure to FDI market access across districts for the years 1996 and 2016. The apparel industry is one of the largest in terms of the number of firms and has experienced entry by foreign firms in the sample period. The figure indicates that FDI market access, represented by darker colors on the 2016 maps, increased substantially over this time period.

6.3 Markups and FDI

In Section 5.4, Table 7, we provided evidence that direct exposure to FDI in a given local market is associated with a drop in the level of markups charged by domestic firms and an increase in markup dispersion. In this section, we depart from Table 7 and run empirical specifications in which we: (1) define a market in the most granular setting, (2) employ markups based on the production approach, and (3) provide additional tests to ensure the robustness of the estimated relationships.

The results are reported in Table 8. Columns 1 and 2 are related to the last two columns of Table 7 but use district-industry as the unit of analysis and the production function approach to measuring markups. Still, results are consistent. Markets exposed to FDI in their industry see a reduction in the average markups of domestic firms and an increase in the dispersion of markups, likely due to—as predicted by the model—the entry of larger foreign investors.

6.3.1 Robustness

Size of FDI In columns 3-8 of Table 8, we check whether this first set of results is sensitive to different definitions of the treatment. We evaluate the entry of big investors (as in Greenstone, Hornbeck and Moretti, 2010), where an investor is classified as big or small relative to total production or employment in each market. We report results based on the definition of the FDI dummy that considers a market to be treated when receiving FDI if it: (i) accounts for more than 10% or 50% of a market's production or (ii) accounts for more than 10% of the market's total employment. We show that the results remain largely unaffected by the different definitions adopted.

Endogeneity of FDI Second, we tackle the endogenous selection of locations by foreign investors. Specifically, comparing markets that receive FDI with all other markets in the country may introduce selection bias, since treated markets may differ systematically, attracting foreign investors. To check whether this concern affects our results, we restrict our sample to markets (or districts) that were targeted by foreign investors at some point within the time frame of our analysis. To do this, we tag markets (or districts) that received at least one FDI project over the 1996–2016 period and drop those that were never targeted.[41] By replicating the analysis on this restricted sample, we exploit the temporal variation in the

[41] The restricted sample includes an unbalanced panel of 167 unique markets (out of a total of 1,619) or 32 unique districts (out of 332).

distribution of FDI.[42] The results of this exercise, reported in Table A.11 of Online Appendix A, confirm the robustness of our findings. Columns 1–2, in particular, are based on a more restrictive comparison, including markets (a district-industry pair) that were targeted by FDI at some point in our time period. The changes in columns 3–4 are restricted to districts that were targeted by FDI at some point and in any sector. In both cases, the direction and magnitude of the coefficients of interest remain similar to the baseline in Table 8.

Event Study Third, we follow a recent strand of the econometric literature emphasizing the potential bias of the coefficient estimated in a setting such as ours—that is, a setting featuring a two-way fixed effect (TWFE) estimator with heterogeneous treatment (see the recent review by de Chaisemartin and D'Haultfoeuille, 2022). More specifically, the literature argues that when the timing of the treatment is not homogeneous, TWFE models may incorrectly estimate the weighted average of treatment effects across units. This occurs because in such settings, both *clean* (treated units against untreated or not-yet-treated ones) and *forbidden* (treated units against other treated units) comparisons are computed, resulting in negative weights for some comparisons.[43] We check that our results are not affected by the occurrence of such negative weights by applying the imputation procedure developed by Borusyak, Jaravel and Spiess (2024).[44] Compared to alternative approaches, the method proposed by Borusyak, Jaravel and Spiess (2024) is more efficient under the absence of serial correlation in the residuals. A more practical reason for us to choose this method is that Borusyak, Jaravel and Spiess (2024) select the control group using information for all the periods prior to t. Since our panel of markets is highly unbalanced, with several gaps, this method provides some advantages compared to other methods that use only the first lag to create the control group (for more discussion, see the review by de Chaisemartin and D'Haultfoeuille, 2022).

[42] As pointed out by Abebe, McMillan and Serafinelli (2022), the timing of when land became available within regions for FDI projects was uncertain and driven by local idiosyncrasies.

[43] We check whether the issue of negative weights affects our estimation sample by implementing the test proposed by de Chaisemartin and D'Haultfœuille (2020) using their user-written Stata command twowayfeweights. The test shows that beta estimates a weighted sum of 1,031 average treatment effects on the treated units (ATT); of these, 827 ATTs receive a positive weight and 204 receive a negative weight. The sum of the positive weights is equal to 1.05379672. The sum of the negative weights is equal to -.05379672.

[44] Under the assumptions of parallel trends in the outcome between treatment and control groups and the absence of anticipation, this estimator is constructed as follows. First, the unit and period fixed effects (γ_{rj} and θ_t in our case) are fitted by regressions on untreated observations only. Second, they are used to impute the untreated potential outcomes and, therefore, obtain an estimated treatment effect for each treated observation. Finally, a weighted average of these treatment effect estimates is calculated with weights corresponding to the estimation target.

Table 8: Changes in Markups When Exposed to Foreign Firms

Variables	(1) Theil	(2) Log markup	(3) Theil	(4) Log markup	(5) Theil	(6) Log markup	(7) Theil	(8) Log markup
FDI dummy	0.0189***	-0.0746**						
	(0.00322)	(0.0324)						
FDI dummy (10% prod.)			0.0218***	-0.0602*				
			(0.00373)	(0.0344)				
FDI dummy (10% empl.)					0.0190***	-0.0647*		
					(0.00341)	(0.0334)		
FDI dummy (50% prod.)							0.0147***	-0.113**
							(0.00466)	(0.0447)
Constant	0.613***	-0.844***	0.613***	-0.840***	0.613***	-0.842***	0.611***	-0.845***
	(0.00997)	(0.122)	(0.0101)	(0.122)	(0.0101)	(0.122)	(0.0101)	(0.121)
Observations	7,514	7,514	7,514	7,514	7,514	7,514	7,514	7,514
District*Industry FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y

Notes: The percentages (10% and 50%) refer to the thresholds used to define the treatment based on corresponding shares of foreign firms in production (prod.) or employment (empl.) in a given market. All regressions control for the log of total production in each market. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Moreover, the validity of our results rests on the identifying assumptions of parallel trends and no anticipation of treatment. We test whether key outcomes exhibit parallel trends pre-treatment. We do this graphically, plotting the FDI treatment coefficient in the three years before and after treatment. The outcomes for the Theil index and average markups as outcome variables are reported in Figures A.4 and A.5 of Online Appendix A, respectively. In both cases, pre-trend coefficients are close to zero.[45]

We find that overall, the trends align with our main findings. While the increase in the Theil index is persistent, the drop in domestic firms' markups is mitigated after a couple of years following the entry of foreign competitors. While the decline in markups is 10 percent in the period in which there is foreign entry in the same woreda and industry, this effect declines to about 4 percent three years after entry. The attenuation of the negative effect of FDI exposure on the average markup of domestic firms over time is in line with exit of smaller firms that charge lower markups following FDI exposure. In the model, markups decline by 3.1 percent (column 2 of Table 7). Despite differences in the method of estimating markups and the level of aggregation, model estimates thus most resemble the long term estimates from the event study, establishing consistency between the two.

6.4 Markups, FDI, and Roads

Next, we estimate the effects of FDI on markups that account for changes in the road network that occurred under the RSDP. We do this by proxying for FDI exposure as defined in equation (39). The measure we construct is prone to two potential sources of endogeneity, which we address using an instrumental variable (IV) approach.

Endogeneity of Roads The first source of endogeneity is related to the changes in travel time (term D in equation 39). We instrument for this variable by constructing a synthetic road network (as in Moneke, 2020). We digitize the historical road network during the Italian occupation and calculate the Euclidean distance to Italian roads (or arteries) for the centroid of each district. Next, we distribute the entire length of roads under the RSDP to districts, subject to the constraint of connecting them to the road network by the end of the sample period using an artificial regional budgeting algorithm. We sort district centroids on the basis of their proximity to the digitized Italian roads and gradually connect them until the annual

[45]Furthermore, we conduct an additional test to look for potential endogenous entry of FDI in markets with high markups. Table A.12 in Online Appendix A reports the results of a regression in which the level of markups in a market explains the entry of a foreign investment project. Reassuringly, we find no evidence of markups driving FDI entry, in both an unconditional setting and a setting that accounts for district, industry, and year fixed effects.

mileage per region of road construction has been achieved. The algorithm operates with a least-cost logic: districts closer to the road network at time t get connected at time $t+1$ first, until the annual regional budget is exhausted. For every subsequent year, we connect each district's centroid to its closest Italian artery or with the artificial roads constructed in the previous step, whichever is closer. In this way, districts far from the Italian arteries will be connected at later time periods in the synthetic network, as shown in Figure A.6 of Online Appendix A.[46]

Endogeneity of FDI To tackle the endogeneity of the foreign production weights (term L in equation 39), we adopt a shift-share approach. For each district z, we calculate its share in total FDI in Ethiopia in industry j in the pre-sample year of 1996. This share is intended to capture the district's FDI presence in the industry, which is arguably exogenous to subsequent shocks, including road infrastructure.[47] The shift is captured by the time-varying growth rate of global production in industry j, which is exogenous to Ethiopian economic conditions that may be correlated with FDI entry. Each foreign production weight, specific to district z and industry j at time t, is thus instrumented for by the product of the shift (which varies by time t) and the share that is fixed in the pre-sample period.[48] This shift-share instrument thus captures the propensity of a district to attract FDI in a given industry (determined by global production in that industry) based on its pre-sample share

[46]RSDP road improvements enter market access through changes in travel time. Hence, different from Moneke (2020), and along the lines of Perra, Sanfilippo and Sundaram (2024), we obtain the spatial and temporal variation in our artificial road network by allocating a speed increment (equal to 35 km/h) to each artificially added road segment. This measure corresponds to the average travel speed of major gravel roads before the upgrading of the RSDP. Therefore, for every subsequent year, each newly connected district is assigned a travel speed that it will maintain in future time periods. The temporal variation then comes from the change in travel time experienced by each road segment that is artificially added to the Italian artery. We thus generate a time-varying instrument that derives its exogenous variation from the straight-line distance to the digitized road map during Italy's occupation.

[47]We check if the initial (at year 1996) allocation of FDI correlates with successive improvements in roads. To do this, we run a simple regression in which the dependent variable is the yearly growth rate of total travel time (the sum of travel time to any other district in the country) at the district level and the control is the initial value of foreign firms' production in that district. We control for year fixed effects and cluster standard errors at the district level. We do not find a statistically significant difference in road improvements across locations based on their initial level of FDI (the coefficient on the FDI indicator is -.0000598 with a standard error of .0001245).

[48]We use data on global production rather than on global FDI flows since the latter are not available at a disaggregated industry level for the time period covered by our analysis (1996-2016). We conduct a similar exercise with industry FDI flows restricted to the period 2004-2016, for which such data are available, and find similar results. Data on global production are available at the two-digit level of the ISIC Rev. 3 classification system from UNIDO's Industrial Statistics. Note that since the data on global production (and global FDI) are available at the two-digit level, we apply that level of aggregation for both the fixed effects and the clustering. Results of the IV remain consistent when using four-digit-level fixed effects and clustering.

in Ethiopian FDI in that industry. It is thus likely to be correlated with FDI presence in each district and industry while being uncorrelated with other unobservable shocks specific to local Ethiopian economic conditions in subsequent time periods.

When we combine the two components, the resulting instrument for market access is, therefore, a revised version of the market access defined in equation (39) where D is replaced by the synthetic road network and L by the shift-share instrument. Table 9 reports the full set of results. We only report results based on the average level of markups as the dependent variable because the Theil index capturing markup dispersion with foreign firms in the local market is not relevant in this setting. Column 1 reports the OLS, with a negative coefficient for the FDI exposure variable that is not precisely estimated. Results of the first stage in column 2 confirm that the instrument is positive and strong, with an F-test of 281. The results in column 3 pertain to the second stage of the IV estimation and show a negative and statistically significant coefficient on market access. These results are consistent with a pro-competitive effect of FDI on domestic firms. Column 4 reports the second stage of a regression in which changes in global production are replaced by changes in global FDI flows, although these changes are limited to the period 2004-2016.[49]

6.5 FDI and Market Shares

A key result of our model is that foreign firms improve welfare, generating higher income in the Ethiopian manufacturing sector. Yet, gains attributed to the presence of foreign firms could be higher if they accrued to domestic factors of production. Instead, a proportion of these gains is lost as a result of the possibility that profits accrue to foreigners, as underscored in our quantitative analysis by the wedge between GDP and GNP gains. As the size of this loss is related to the size of market shares gained by foreign firms on entry, in what follows we estimate the loss in market share by domestic firms with foreign entry. For each firm i in our sample operating in market rj, we calculate market share as the share of production in the market in a given year. We then estimate the following specification:

$$y_{i(rj)t} = \beta_0 + \beta_1 (FDI)_{rjt} + \gamma_{rj} + \theta_t + \epsilon_{irjt}, \tag{40}$$

where $y_{i(rj)t}$ measures the market share of domestic firm i in year t. The definition of treatment is the same as in the baseline. Market and year fixed effects are included in each specification. The results of this exercise are reported in the first column of Table A.14 of Online Appendix A. They reveal that, on average, domestic firms experience a drop in market

[49]Data on global FDI flows are from UNCTAD's World Investment Report and cover only greenfield FDI.

Table 9: FDI, Roads, and Markups

Variables	(1) OLS	(2) First Stage	(3) Second Stage	(4) Global FDI
FDI Market Access	-0.00322		-0.0712***	-0.0811***
	(0.00297)		(0.00910)	(0.0106)
Instrument		0.200***		
		(0.119)		
Constant	-0.520***	-1.726***		
	(0.118)	(0.633)		
Observations	7,169	7,169	7,169	5,615
R-squared	0.342	0.489	-0.078	-0.140
District*Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
F-test			281.3	130.8

Notes: The dependent variable is the log average markup calculated at the level of each market rj. The variable of interest measures market access following equation (39). Column 1 reports the OLS coefficient. Columns 2 and 3 report the first and second stages of the 2SLS estimator, using an instrumented market access in which the $D_{rz,t}$ is based on a synthetic road network and the $L_{zj,t}$ on the changes in the industry's global production multiplied by the initial exposure to FDI (details on the construction of the instrument are discussed in Section 6.4). Column 4 is based on a similar strategy but uses global FDI flows to construct the instrument. Because of data limitations, the sample in column 4 is restricted to the period 2004-2016. Columns 3 and 4 report the Kleibergen-Paap Wald F-statistic. All regressions control for the log of total production in each market. The instrument is scaled in thousands. Industries are defined at the two-digit level of the ISIC classification. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

share along the order of 7.8 percentage points once a foreign firm enters their market.[50]

6.6 Robustness

6.6.1 Firm panel data

Our analysis is based on data at the firm level that has been aggregated to the market level. Because of a change in the attribution of firm identifiers, building a full panel for all the years covered in our sample is not possible. Nevertheless, an analysis at the firm level allows us to account for unobserved firm-specific shocks that are time invariant and may be correlated with the markup and FDI simultaneously. We rely on earlier work by Abebe, McMillan and Serafinelli (2022), who construct an algorithm linking firm identifiers from 1996 to 2013, and recent updates by the same authors who extend the panel for the years 2014-2017. Note that this is to an extent an incomplete exercise, as we are only able to cover 3,384 firms (50% of which are observed for a maximum of two consecutive years only), accounting on average for 47% of total production.[51] With these caveats in mind, Table A.15 of Online Appendix A replicates our analysis using a firm-level specification. We find that our key qualitative result endures: firms respond to FDI by lowering their markups.

6.6.2 Spatial correlation

Finally, results remain robust to clustering standard errors at various levels, including clustering at the level of the district and accounting for the possible presence of spatial correlation in the residuals. To do the latter, we estimate our model by introducing a spatial HAC correction of standard errors based on the Conley method, using the code proposed by Colella et al. (2019). We impose no constraints on the temporal decay of the weights and test the robustness of our specification to different lengths of the radius (respectively, from 100 to 500 kilometers) for the spatial kernel. Table A.16 in Online Appendix A reports the results. For the Conley method, we only report results based on a 150 km cutoff, but standard errors are generally smaller when considering greater distances, and our results remain qualitatively stable.

[50] Results remain unaffected, with the coefficient dropping to 7.2 (see column 2 of Table A.14) if we control for factors, such as size and (labor) productivity, that affect the relationship between FDI and market shares.

[51] Coverage varies by years, and it is higher for the period 2012-2016 and much lower for earlier years. In 2010 and 2011, the firms with the correct panel ID represent slightly less than 9% of total production in those years.

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. However, FDI worsens allocative efficiency since foreign firms tend to be large and charge high markups relative to domestic firms. We also find that foreign firms enter sectors with high fixed entry costs. Therefore, a larger fraction of costs is devoted to fixed rather than variable costs of production, thereby lowering welfare. Quantitative results are bolstered by the empirical analysis, where we show that greater foreign competition, in both a firm's own market and connected intranational markets, is associated with lower markups but a larger dispersion of markups. Finally, we explore the complementarity between FDI and road improvement projects. We show that the nature of complementarity depends on the channel under consideration. Low transport costs from better roads magnify the Ricardian gains and generate smaller losses in allocative efficiency by encouraging firm entry, thus amplifying gains from FDI reform. However, this increased firm entry exacerbates the loss from higher fixed costs of entry, reducing gains from the reform.

This paper focuses on underexplored channels through which FDI influences welfare—with a focus on changes in allocative efficiency, entry costs, and profit repatriation. While other well-documented mechanisms, such as spillover effects and intersectoral linkages, also shape welfare outcomes, they lie beyond the scope of this study because of data constraints and the need for tractability and analytical focus. We see scope for future research that extends this framework by leveraging firm-to-firm transaction data to incorporate these additional channels, particularly in contexts where such granular information is available.

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Online Appendix for "Foreign Direct Investment, Geography, and Welfare"

This document is an Online Appendix for "Foreign Direct Investment, Geography, and Welfare" by Jose Asturias, Marco Sanfilippo, and Asha Sundaram.

A Additional Tables and Figures

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

Table A.2: Sectoral Distribution of Foreign Firms

Sector	Share of 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	100.00

Notes: Percentage values refer to the data collapsed over the whole sample period (1996–2016).
Source: Authors' summary of LMMS data from CSA.

Table A.3: Mean Comparisons of Foreign and Domestic Firms

Variable	Domestic	Foreign	Difference
Number of employees	85	169	84***
Wage per capita	29,642	42,960	13,332
Labor productivity	237,157	402,478	165,321
Capital on labor	223,549	547,720	324,171***

Notes: Table A.3 reports summary statistics of the 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 measures the number of persons engaged; wage per capita is the ratio of the total wage bill on the number of employees (in birr); labor productivity is the ratio of value added on employees (in birr); capital on labor is the capital labour ratio (in birr). *** p<0.01, ** p<0.05, * p<0.1

Table A.4: Foreign vs. Domestic firms at the Product Level

Variables	(1) Number of products	(2) Product share	(3) Product sales	(4) Product quantity
Foreign firm	0.0863	-0.00443	0.726***	0.499***
	(0.0976)	(0.0130)	(0.163)	(0.182)
Constant	2.740***	0.326***	12.91***	8.635***
	(0.00469)	(0.000657)	(0.00814)	(0.00912)
Observations	10,823	29,911	29,684	29,377
R-squared	0.152	0.234	0.448	0.503
Product FE	N	Y	Y	Y
Industry FE	Y	N	N	N
District FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Notes: Table A.4 reports the results of a regression in which the outcomes of interest are regressed on a dummy variable, equal to one if firms are foreign owned and zero otherwise. Except for column 1, in which each ob- servation is a firm, observations are at the firm-product-year level and cover the whole period for which data are available (1996 to 2016). The number of products is the count of reported products (up to a max of eight) by each firm in a given year; Product share is the share of each individual product on firms' total sales; Product sales and Product quantity are the (log) values of sales and the quantity of products as reported by the firm. Standard errors clustered at the industry level in column 1 and at the product level in columns 2–4. *** p<0.01, ** p<0.05, * p<0.1

Table A.5: ERA Travel Speed Matrix (Kilometers per Hour)

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

Notes: Table A.5 reports average travel speed as a function of the surface and condition of the road segment. Speed is measured in kilometers per hour.
Source: Ethiopian Roads Authority (Ethiopian Roads Authority, 2011)

Table A.6: Estimation of ρ

	Log transportation cost				
Variables	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 are in parentheses. Table A.6 reports the results of the estimation of equation (32). The dependent variable is the logged cost to ship a 20-foot shipping container from Addis Ababa to a regional capital. The independent variable is the logged travel time between these two cities, where we use Google Maps to estimate the travel time. We include fixed effects for the transportation firm that provided the quote. Columns 2–5 report the results when we use data for quotes for each of the four individual transportation firms. Column 6 reports the results of the estimation when we pool the price quotes for all firms.
*** p<0.01, ** p<0.05, * p<0.1

Table A.7: Markups in the Model and Empirical Estimates by Foreign Firm Status

Variables	(1) Log markup	(2) Log markup
Foreign owned	0.0813***	0.0773
	(0.0196)	(0.0794)
Constant	0.237***	0.265***
	(0.00440)	(0.0232)
Observations	6,373	2,466
R-squared	0.382	0.337
Industry FE	Y	Y
Source	Model	Estimates

Notes: Table A.7 reports the results of the estimation of equation (34). We use a weighted regression in which each observation is weighted by a firm's share of the industry's total sales. Column 1 reports the results when we use output from the calibrated model. The calibration of the model is described in Section 5.1. In this specification, an observation is a firm-product pair as described in the subsection "Number of producers, K_{oj}." In order to construct industry dummies, each product is assigned to the four-digit industry code in which that product is most likely produced (i.e., the industry that claims the highest value of production for that good). Column 2 reports the results of the estimation when we use empirical estimates of markups. We discuss the construction of these empirical estimates in Section 5.1. Each observation is a firm and the industry is based on the four-digit Ethiopian industry classification system. Estimates refer to the last year for which the data are available, 2016. *** p<0.01, ** p<0.05, * p<0.1

Table A.8: Average and Median Markups by Region

Region	Mean markup	Median markup
Tigray	1.98	1.53
Afar	1.78	1.54
Amhara	1.85	1.49
Oromia	1.85	1.50
Somali	1.99	1.67
Benishangul	1.81	1.72
SNNPR	1.76	1.44
Gambela	1.73	1.46
Harari	1.83	1.49
Addis Ababa	1.81	1.51
Dire Dawa	1.92	1.63
Total	1.83	1.51

Source: Authors' elaboration on LMMS data from CSA. Markups are calculated at the firm level following equation (33). The table reports the simple mean and the median by region.

Table A.9: Average and Median Markups by Sector

Industry	Two-digit code	Mean markup	Median markup
Food and beverages	15	1.89	1.57
Tobacco	16	2.95	3.25
Textiles	17	1.58	1.11
Wearing	18	1.72	1.40
Leather	19	1.50	1.26
Wood and wood products	20	2.19	1.83
Paper and paper products	21	1.75	1.45
Publishing and printing	22	1.85	1.69
Coke, refined pretroleum products and nuclear fuel	23	1.62	1.54
Chemical and chemical products	24	1.58	1.30
Rubber and plastics products	25	2.01	1.73
Other non-metallic mineral products	26	2.17	1.64
Basic metals	27	1.62	1.36
Fabricated metal product	28	1.54	1.29
Machinery and equipment	29	1.59	1.36
Office, accounting and computing machinery	30	1.25	1.24
Electrical machinery and apparatus	31	1.42	1.27
Radio, television and communication equipment	32	2.09	1.56
Medical, precision and optical instruments	33	2.23	1.29
Motor vehicles	34	1.59	1.39
Furniture	36	1.60	1.39
Total		1.83	1.51

Source: Authors' elaboration on LMMS data from CSA. Markups are calculated at the firm level following equation (33). The table reports the simple mean and the median by sector.

Table A.10: Changes in Real Income with Lower Transportation Costs (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Entry cost	Residual
Harari	4.05	4.41	−0.25	0.00	0.00	−0.10	0.00
Somali	6.10	5.98	0.18	−0.01	0.00	−0.05	0.00
Afar	2.56	2.56	0.02	−0.01	0.00	−0.01	0.00
Dire Dawa	3.80	3.97	−0.14	0.00	0.05	−0.07	0.00
Amhara	3.36	3.50	−0.07	−0.03	−0.03	0.00	0.00
SNNPR	3.89	8.24	−2.61	0.04	−0.02	−1.76	0.00
Tigray	3.93	3.94	0.03	−0.01	0.00	−0.03	0.00
Oromia	2.29	2.09	0.26	0.01	−0.05	−0.02	0.00
Addis Ababa	1.15	0.92	0.26	−0.04	0.01	0.00	0.00
Aggregate	1.96	2.03	0.00	−0.02	−0.01	−0.11	0.06

Notes: Table A.10 decomposes the percentage changes in real GNP when we decrease transportation costs from those in 1996 to those in 2016. Column 1 reports the region; regions are sorted by the total manufacturing value added in ascending order. Column 2 reports the percentage change in real GNP for each region. Columns 3–7 report the HHL decomposition of the changes in real GNP. Column 8 reports the residual when the changes in real GNP do not equal the change in the HHL components. The final row reports the aggregate percentage change, which is the weighted average changes across all regions where the weights are based on a region's value added. Note that the change in the markup ToT in the aggregate must be equal to zero because the aggregate markup of the goods sold must equal the aggregate markup of the goods purchased at the national level. Thus, we assign the real income changes from the markup ToT to be zero in the aggregate; any differences between the change in real GNP and the channels of the HHL are reallocated to the residual term.

Table A.11: Changes in Markups When Exposed to Foreign Firms: Subsamples of Markets and Districts

Variables	(1) Theil	(2) Log markup	(3) Theil	(4) Log markup
FDI dummy	0.00935*	-0.109***	0.0166***	-0.0592*
	(0.00475)	(0.0361)	(0.00350)	(0.0330)
Constant	0.587***	-1.101***	0.599***	-0.878***
	(0.0206)	(0.196)	(0.0128)	(0.148)
Observations	1,753	1,753	4,547	4,547
R-squared	0.382	0.499	0.403	0.496
District*Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Notes: This analysis replicates the results of the first two columns of Table 8. Columns 1 and 2 are based on a sample of markets (district-industry pairs) that were ever targeted by FDI, while columns 3 and 4 use a sample of districts that were ever targeted by FDI. All regressions control for the log of total production in each market. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.12: FDI Entry and Markups

Variables	(1) FDI Entry	(2) FDI Entry	(3) FDI Entry
Markups	-0.0288	-0.0284	0.0256
	(0.0328)	(0.0335)	(0.0505)
Constant	-1.888***	-1.388***	-2.516***
	(0.0711)	(0.169)	(0.522)
Observations	6,453	5,953	2,699
District FE	N	N	Y
Industry FE	N	N	Y
Year FE	N	Y	Y

Notes: The dependent variable is a dummy that takes the value of one in the exact year in which an FDI project first entered a market and zero in all preceding years. All the regressions are estimated using a probit model. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.13: Production Function Coefficients

Sector	Labor coefficient	Capital coefficient	Materials coefficient
15	0.4126	0.0486	0.8142
17	0.0831	0.0317	0.6806
18	0.1221	-0.0289	0.9153
19	0.0679	0.0752	0.8332
20	0.4058	0.0115	0.7583
22	0.4919	-0.0105	0.5969
24	0.0809	0.1089	0.8244
25	0.4397	0.0269	0.7721
26	0.3447	0.0432	0.6823
28	0.1844	0.1293	0.7633
34	0.3016	0.0997	0.7081
36	0.1963	0.0382	0.8052

Notes: The table reports coefficients of the production function estimated for each two-digit ISIC Rev. 3 category. Coefficients were originally estimated by Fiorini, Sanfilippo and Sundaram (2021).

Table A.14: FDI and Market Shares of Domestic Firms

	(1)	(2)
FDI dummy	-0.0781***	-0.0722***
	(0.0257)	(0.0272)
Constant	0.334***	-0.349***
	(0.0123)	(0.0711)
Observations	27,885	22,653
R-squared	0.681	0.745
District*Industry FE	Y	Y
Year FE	Y	Y
Controls	N	Y

Notes: The dependent variable is the share of a firm's i production on the total of market rj in year t. The sample includes only domestically owned firms. The treatment is measured as a dummy taking the value of one if the market in which each firm is based has received an FDI. Column 2 reports a specification including the following controls: age; the (log of) total number of employees; and (the log of) labor productivity, measured as production per employee. Standard errors clustered at the market level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.15: Firm-level Analysis

	(1)	(2)
Variables	Log markup	Log markup
FDI dummy	-0.0663**	
	(0.0305)	
FDI market access		-0.166***
		(0.0502)
Constant	-0.280**	
	(0.127)	
Observations	10,828	10,227
R-squared	0.597	-0.988
Firm FE	Y	Y
Year FE	Y	Y
F-test		5.786

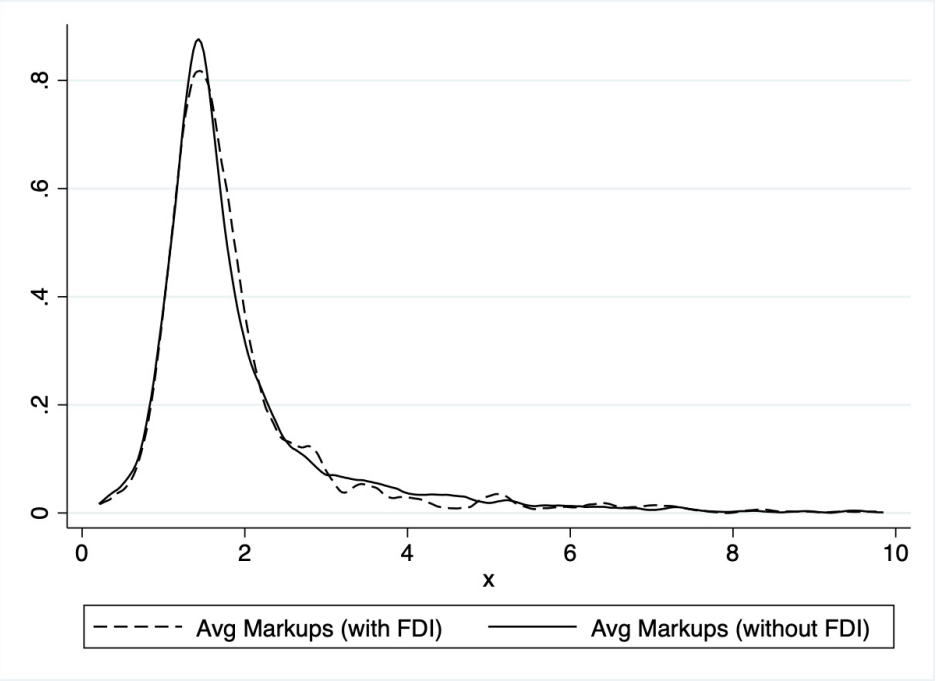
Notes: The dependent variable is log of a firm's markups. The sample includes only domestically owned firms and is limited to firms for which a panel identifier can be constructed based on Abebe, McMillan and Serafinelli (2022). The treatment is measured as a dummy taking the value of one if the market in which each firm is based has received FDI. All regressions control for the log of firms' production. Column 2 reports the IV specification based on the approach described in Section 6.4. It also reports the Kleibergen-Paap Wald F-statistic. Standard errors clustered at the district level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.16: Robustness: Accounting for Spatial Autocorrelation in the Residuals

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Theil	Log markup	Log markup	Theil	Log markup	Log markup
FDI dummy	0.0189***	-0.0746**		0.0181***	-0.0836**	
	(0.00244)	(0.0329)		(0.00492)	(0.0345)	
FDI market access			-0.0461***			-0.0461***
			(0.00900)			(0.0113)
Observations	7,514	7,514	6,932	6,932	6,932	6,932
R-squared	0.416	0.505	0.005	0.043	0.069	0.005
District*Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
F-test			363.6			1442

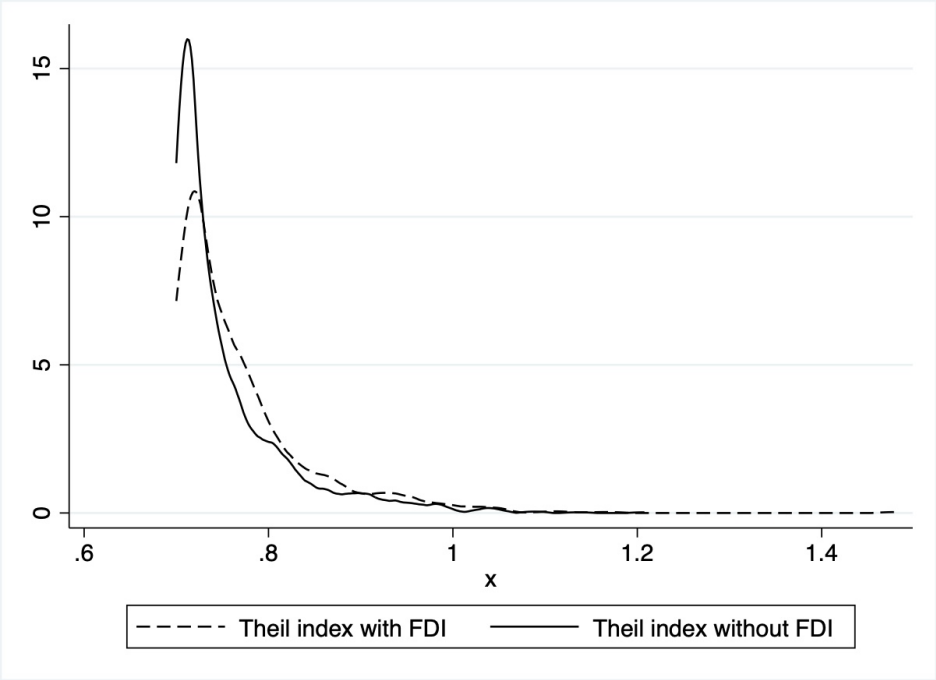
Notes: Columns 1–3 replicate the main results clustering the standard errors at the district level (rather than at the district-industry). Columns 4–6 replicate the main results correcting standard errors for spatial correlation using a distance cutoff of 150 km and a lag cutoff of 20. Estimations are run using the Stata command acreg, as introduced by Colella et al. (2019). All regressions control for the log of total production in each market.
*** p<0.01, ** p<0.05, * p<0.1

Figure A.1: Average Markups by Ownership



Notes: Figure A.1 reports kernel densities of markups, calculated for a sample of the market including only domestic firms and for a sample including both domestic and foreign firms.

Figure A.2: Theil Index in Markets with and without Foreign Firms



Notes: Figure A.2 reports kernel densities of the Theil index, calculated for a sample of the market including only domestic firms and for a sample including both domestic and foreign firms.

Figure A.3: Market Access in the Apparel Industry (ISIC code 1810)

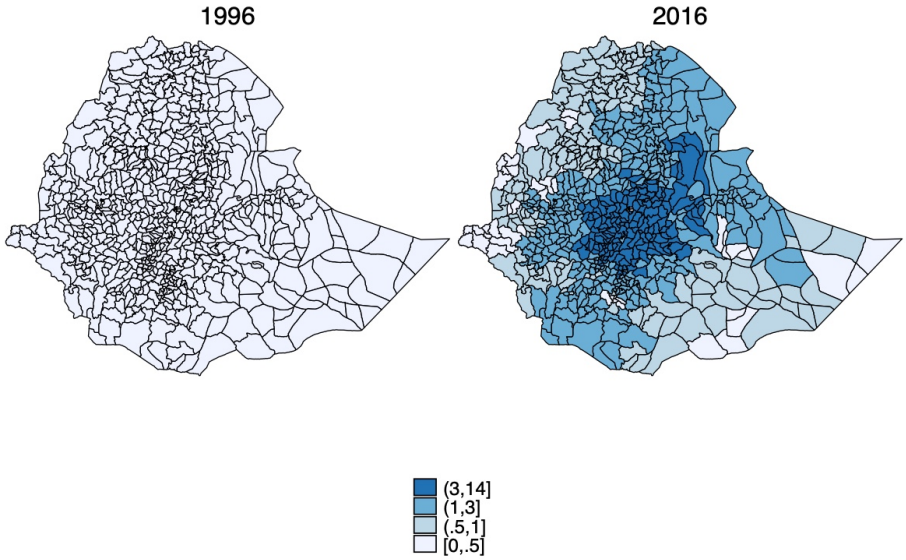
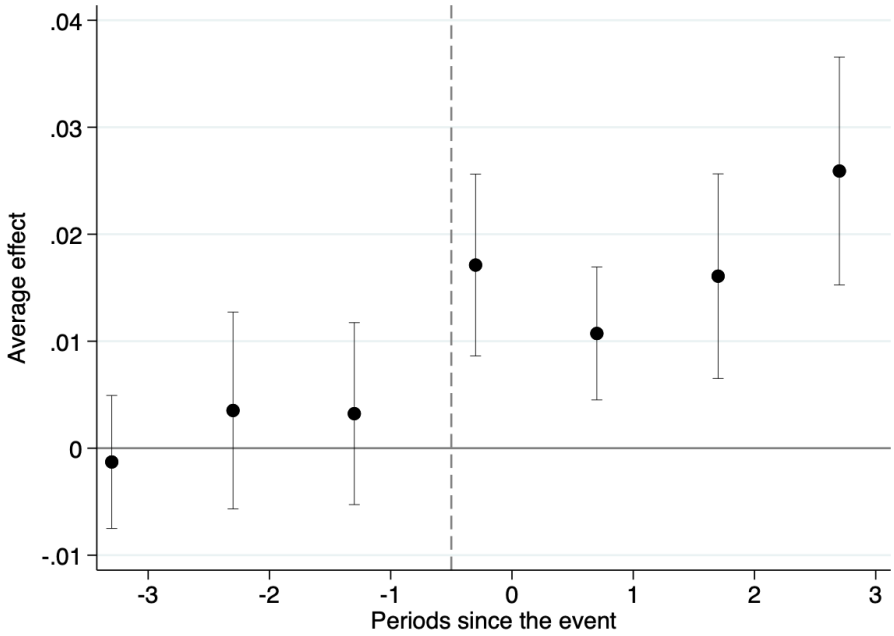
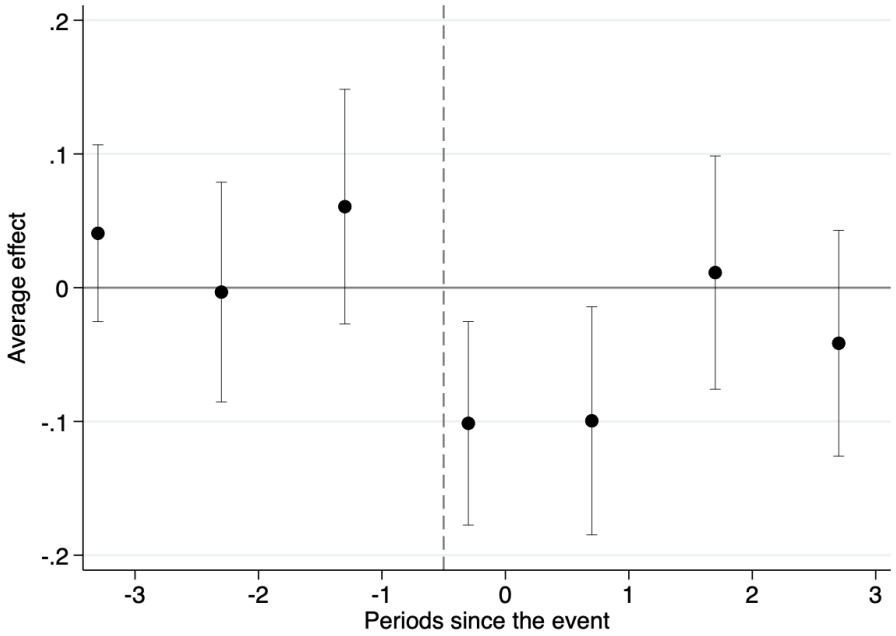


Figure A.4: Dynamic Specifications: Theil Index



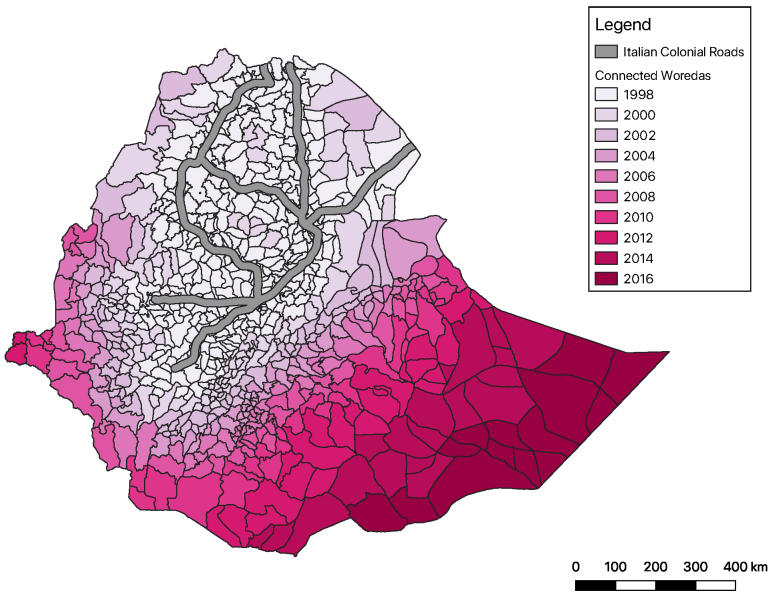
Notes: Figure A.4 reports coefficients and their 90% confidence intervals based on estimators using a two-way fixed effect (TWFE) approach and the approach by Borusyak, Jaravel and Spiess (2024) (BJS). Estimates of the latter are based on the authors' Stata command did_imputation, and the graph was produced using the command event_plot.

Figure A.5: Dynamic Specifications: Average Markups



Notes: Figure A.5 reports coefficients and their 90% confidence intervals based on estimators using a two-way fixed effect (TWFE) approach and the approach by Borusyak, Jaravel and Spiess (2024) (BJS). Estimates of the latter are based on the authors' Stata command did_imputation, and the graph was produced using the command event_plot.

Figure A.6: Colonial Roads and IV Design



Notes: Figure A.6 displays the synthetic road network constructed via the method discussed in Section 6.4. Original data on the colonial road network are from Gli Annali dell'Africa Italiana (1937-1943).

B Quality

In this section, we study a model in which firms produce goods of differing quality. We find that this model can be rewritten in a way that is consistent with our baseline model (i.e., all firms have the same level of quality and all differences in quality are assigned to the firm's productivity). Thus, the productivities that we calibrate in our baseline model reflect both quality and firm productivity.

Theorem 2. *Consider a model in which the sector-level composite good of region n is defined as*

$$\hat{C}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \left[\xi(j,k) \hat{c}_n^o(j,k) \right]^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \tag{41}$$

where $\xi(j,k) \geq 1$ is a quality shifter that increases the marginal utility of consuming the good of firm k in industry j for all n. A firm has productivity $\hat{a}_o(j,k)$ in producing $\hat{c}_n^o(j,k)$ and charges $\hat{p}_d^o(j,k)$ for one unit of $\hat{c}_n^o(j,k)$. We further suppose that the remaining parameters of the model with the quality shifter are the same as in the baseline model (i.e., those parameters listed in Table 2 except for firm productivity).

This model with quality is equivalent to our baseline model in which we rewrite the consumption of firm k's good as

$$c_n^o(j,k) = \xi(j,k) \hat{c}_n^o(j,k), \tag{42}$$

firm k's productivity as

$$a_o(j,k) = \xi(j,k) \hat{a}_o(j,k), \tag{43}$$

and firm k's price in location d as

$$p_d^o(j,k) = \frac{\hat{p}_d^o(j,k)}{\xi(j,k)}. \tag{44}$$

Proof. See Online Appendix C. □

C Proofs

Proof of Theorem 1

Proof. First, we define L_n^F as:

$$L_n^F = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} F_o(j) \right) dj. \tag{45}$$

The variable L_n^F characterizes the total amount of labor used to pay the entry cost. In contrast, L_n^V, which is characterized in (28), is the total labor used as an input in the production function of the firm. Thus, we have that

$$L_n = L_n^V + L_n^F. \tag{46}$$

We also define

$$\Pi_n^V = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} \pi_d^n(j,k) \right) dj, \tag{47}$$

$$\Pi_n^F = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} -W_o F_o(j) \right) dj, \tag{48}$$

where Π_n^V is the total profit of firms in region n before they pay the entry cost and Π_n^F is the total payments of the entry cost by those firms (note that $\Pi_n^F < 0$ since it denotes negative profits from paying the entry costs). Thus, we have that

$$\Pi_n = \Pi_n^V + \Pi_n^F. \tag{49}$$

We apply Lemma 1 (see below) to find

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{W_n L_n^V + \Pi_n^V}{P_n}. \tag{50}$$

We then apply a process similar to that in HHL to arrive at

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{\mu_n^{sell} W_n L_n^V}{P_n}. \tag{51}$$

We then rearrange the equation to find

$$\frac{W_n L_n + \Pi_n}{P_n} = W_n L_n * \frac{1}{P_n^{pc}} * \frac{\mu_n^{sell}}{\mu_n^{buy}} * \frac{P_n^{pc}}{P_n} \mu_n^{buy} * \frac{L_n^V}{L_n}, \tag{52}$$

$$\frac{W_n L_n + \Pi_n^L}{P_n} = W_n L_n * \frac{1}{P_n^{pc}} * \frac{\mu_n^{sell}}{\mu_n^{buy}} * \frac{P_n^{pc}}{P_n} \mu_n^{buy} * \frac{L_n^V}{L_n} * \frac{W_n L_n + \Pi_n^L}{W_n L_n + \Pi_n}. \tag{53}$$

We substitute the expressions $GDP_n = W_n L_n + \Pi_n$ and $GNP_n = W_n L_n + \Pi_n^L$ and rearrange them to find equation (27). □

Lemma 1. *The following relationship holds in the model:*

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{W_n L_n^V + \Pi_n^V}{P_n}. \tag{54}$$

Proof. We rearrange $(W_n L_n + \Pi_n)/P_n$ to find

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{W_n L_n^V + \Pi_n^V}{P_n} * \frac{W_n L_n + \Pi_n}{W_n L_n^V + \Pi_n^V}. \tag{55}$$

We now show that the last term is equal to 1, which would conclude the proof. To do so, we substitute (46) and (49) into this expression to find

$$\frac{W_n L_n + \Pi_n}{W_n L_n^V + \Pi_n^V} = \frac{W_n L_n^V + W_n L_n^F + \Pi_n^V + \Pi_n^F}{W_n L_n^V + \Pi_n^V}. \tag{56}$$

Note that multiplying both sides of equation (45) with W_o and using the condition in equation (48) to find

$$W_n L_n^F = -\Pi_n^F \tag{57}$$

implies that the right-hand side of equation (56) is equal to 1. □

Proof of Theorem 2

Proof. We can show that, in addition to equation (41), the model with heterogeneous quality is characterized by the following equations:

$$\hat{C}_n = \left(\int_0^1 \hat{C}_n(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{58}$$

$$\int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \hat{p}_n^o(j,k) \hat{c}_n^o(j,k) \right) dj = \hat{W}_n L_n + \hat{\Pi}_n, \tag{59}$$

$$\hat{c}_n^o(j,k) = \left(\frac{\hat{P}_n}{\hat{P}_n(j)}\right)^{\theta} \left(\frac{\hat{P}_n(j)}{\hat{p}_n^o(j,k)}\right)^{\gamma} \xi(j,k)^{\gamma-1} \hat{C}_n, \tag{60}$$

$$\hat{P}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \xi(j,k)^{\gamma-1} \hat{p}_n^o(j,k)^{1-\gamma}\right)^{\frac{1}{1-\gamma}}, \tag{61}$$

$$\hat{P}_n = \left(\int_0^1 \hat{P}_n(j)^{1-\theta} dj\right)^{\frac{1}{1-\theta}}, \tag{62}$$

$$\hat{p}_d^o(j,k) = \frac{\hat{\epsilon}_d^o(j,k)}{\hat{\epsilon}_d^o(j,k) - 1} \frac{\hat{W}_o}{\hat{a}_o(j,k)} \tau_d^o, \tag{63}$$

$$\hat{\epsilon}_d^o(j,k) = \left(\hat{\omega}_d^o(j,k)\frac{1}{\theta} + (1 - \hat{\omega}_d^o(j,k))\frac{1}{\gamma}\right)^{-1}, \tag{64}$$

$$\hat{\omega}_d^o(j,k) = \frac{\hat{p}_d^o(j,k)\hat{c}_d^o(j,k)}{\sum_{o=1}^{N}\sum_{k=1}^{K_{oj}} \hat{p}_d^o(j,k)\hat{c}_d^o(j,k)}, \tag{65}$$

$$\hat{\Pi}_n = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \hat{\pi}_d^n(j,k) - \hat{W}_o \hat{F}_o(j)\right) dj, \tag{66}$$

$$\int_0^1 \left(\sum_{o=1,\ o\neq n}^{N} \sum_{k=1}^{K_{oj}} \hat{p}_n^o(j,k)\hat{c}_n^o(j,k)\right) dj = \int_0^1 \left(\sum_{d=1,\ d\neq n}^{N} \sum_{k=1}^{K_{nj}} \hat{p}_d^n(j,k)\hat{c}_d^n(j,k)\right) dj, \tag{67}$$

$$\int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \frac{\hat{c}_d^n(j,k)}{\hat{a}_n(j,k)} \tau_d^n\right) dj = L_n. \tag{68}$$

The condition that a potential entrant will enter if it is profitable to do so is

$$\sum_{d=1}^{N} \hat{\pi}_d^o(j,k) \geq \hat{W}_o \hat{F}_o(j). \tag{69}$$

Note that in the above equations, we use the following characterizations:

$$\hat{c}_n^o(j,k) = \hat{c}_n^o(j,k,L) + \hat{c}_n^o(j,k,F), \tag{70}$$

$$\hat{C}_n(j) = \hat{C}_n(j,L) + \hat{C}_n(j,F), \tag{71}$$

$$\hat{C}_n = \hat{C}_n(L) + \hat{C}_n(F), \tag{72}$$

$$\hat{\Pi}_n = \hat{\Pi}_n^F + \hat{\Pi}_n^L. \tag{73}$$

We will first show that the following relationships between the baseline model and the model with quality hold:

$$\hat{C}_n(j) = C_n(j), \tag{74}$$

$$\hat{C}_n = C_n, \tag{75}$$

$$\hat{P}_n(j) = P_n(j), \tag{76}$$

$$\hat{P}_n = P_n, \tag{77}$$

$$\hat{\epsilon}_d^o(j,k) = \epsilon_d^o(j,k), \tag{78}$$

$$\hat{\omega}_d^o(j,k) = \omega_d^o(j,k), \tag{79}$$

$$\hat{\Pi}_n = \Pi_n, \tag{80}$$

$$\hat{W}_n = W_n. \tag{81}$$

To derive equation (74), we combine equations (41) and (42):

$$\hat{C}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} c_n^o(j,k)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}. \tag{82}$$

We then substitute equation (2) to find equation (74). Furthermore, equation (74) implies equation (75). We can similarly arrive at equation (76) by combining equations (44) and (61). We similarly notice that equation (76) implies equation (77).

For equations (78) and (79), notice that the expenditure on all goods is the same in both models, meaning that $\hat{p}_d^o(j,k)\hat{c}_n^o(j,k) = p_d^o(j,k)c_n^o(j,k)$. Thus, the market share of firms, $\omega_d^o(j,k)$, also remains the same in both formulations. Furthermore, the perceived price elasticity of firms, $\epsilon_d^o(j,k)$, also remains the same in both formulations because it is based on firm market shares.

For equation (80), we can also show that

$$\pi_d^o(j,k) = \frac{p_d^o(j,k)c_d^o(j,k)}{\epsilon_d^o(j,k)}. \tag{83}$$

We know that both the numerator and denominator of this fraction remain the same in both formulations of the model. Thus, the profits of all firms remain the same, as do the aggregate profits in equation (17). If profits remain the same for all firms, then all firms' entry decisions remain the same.

For equation (81), because the expenditures on all goods remain the same, the balanced trade condition in equation (20) is satisifed. The labor demand to produce goods for region d, $\frac{\hat{c}_d^n(j,k)}{\hat{a}_n(j,k)}\tau_d^n$, remains the same as before after substituting the conditions in equations (42) and (43) into this expression. Thus, the labor clearing condition in equation (21) is satisfied. Given the labor demand is the same in both formulations, it must be that wages also remain unchanged.

We use the conditions in equations (42)–(44) and (74)–(81) to rewrite the equilibrium conditions in equations (41) and (58)–(69) to be the same conditions that characterize the baseline model. We thus conclude that a model with differences in quality across goods can be rewritten as a model in which these differences in quality are mapped to productivity.

□

D Computational Algorithm for Calibrating the Model and Conducting Quantitative Experiments

In this section, we describe the computational algorithm used to calibrate the model and to later conduct quantitative experiments.

D.1 Calibrating the Model

The main parameters to pin down are: 1) the productivities of firms that choose to enter in the calibrated model (i.e., those firms that we observe in the data), 2) the productivity of potential entrants that choose not to enter, and 3) the entry cost for each region-sector. Given the complex problem nature of the problem, we devise a multi-step computational strategy to tackle this problem.

Step 1: Solving for the productivities of firms that enter and the entry costs for each region-industry In the first step, we use a model in which the number of firms is exogenous (i.e., a model with no endogenous entry). In particular, we solve a version of the model in which K_{oj} is exogenous and is equal to the number of firms that we observe in the data in region o and sector j.

In that model, we calibrate each firm's productivity to match the observed national market share in terms of its value added in the manufacturing sector.[52] To determine the entry costs, we set $F_o(j)$ such that

$$W_o F_o(j) = \pi_d^o(j, \tilde{k}_{jo}) * \chi, \tag{84}$$

where $\tilde{k}_{jo}$ is the firm with the lowest productivity in region o and sector j. Note that if $\chi = 1$, then the lowest productivity firm in each region-sector would have zero profit after paying its entry cost, and $0 < \chi < 1$ would correspond to the case in which the smallest firm has a positive profit. We select χ in a later step, and we will proceed given a value of χ.[53]

[52] We normalize the productivity of one firm and then set the productivities of all other firms so that the firms in the model match their national market share in manufacturing value added. For the multi-product firms in the data, we divide a firm's value added into its various products based proportionally on each product's sales.

[53] We use the following iterative procedure to jointly solve for the productivity of each firm and the entry costs:

1. Set an initial guess for firm productivities, entry costs for each sector and region, and aggregate variables Y_n and W_n for each region. Note that we define $Y_n = C_n(L) + C_n(F)$.
2. Solve for firm productivities and update the guess accordingly. In this step, we hold entry costs and aggregate variables Y_n and W_n fixed.

Step 2: Selecting productivities of potential entrants that do not enter As a next step, we select the productivities of potential entrants that choose not to enter in the calibrated model. To do so, we suppose that their productivity distribution follows a Pareto distribution. We estimate the tail parameter of the distribution using the productivities of firms that we solved for in step 1. We use the following condition that has been commonly used to estimate the tail parameter of the Pareto distribution:

$$\log \text{Rank} = \alpha_0 - \alpha_1 \log a, \tag{85}$$

where Rank is the rank of a productivity draw in a particular region and sector, a is the productivity draw, α_1 is an estimate of the tail parameter of the productivity distribution, and α_0 is a constant.[54] In our case, we estimate the following regression using the productivities from step 1:

$$\log \text{Rank}_{kjo} = FE_{jo} - \alpha_1 \log a_{kjo} + \zeta_{kjo}, \tag{86}$$

where Rank_{kjo} and a_{kjo} are the rank and productivity of firm k in sector j in region o, FE_{jo} is a sector-region fixed effect, and ζ_{kjo} is an error term. Note that the inclusion of the sector-region fixed effect, FE_{jo}, of this estimation procedure allows each sector and region to have differing productivity levels.[55] We find $\alpha_1 = 2.40$ when estimating equation (86). We include both foreign-owned and domestic firms in this estimation; note that excluding foreign firms when we estimate this equation results in a very similar estimate for the tail parameter (i.e., dropping foreign firms, reassigning the rank to domestic firms, and reestimating the equation).

Next, we determine α_0 implied by equation (85) for each region-sector pair so that this relationship holds exactly for firm $\tilde{k}_{jo}$; in this process, we use the α_1 estimated in (85). Having solved for the α_0 of each region and sector, we generate additional productivity draws using equation (85) along with the rank of the productivity draw. For example, if the firm ranked

3. Solve for entry costs such that equation (84) is satisfied, and update the guess accordingly. In this step, we hold firm productivities and aggregate variables Y_n and W_n fixed.

4. Solve for aggregate variables Y_n and W_n, and update the guess accordingly. In this step, we hold entry costs and firm productivities fixed.

5. Solve for entry costs such that equation (84) is satisfied, and update the guess accordingly. In this step, we hold firm productivities and aggregate variables Y_n and W_n fixed.

We repeat steps 2–5 of this procedure until it converges to a set of firm-level productivities and entry costs for each region and sector.

[54] See, for example, Rosen and Resnick (1980), which uses this type of "log-log rank-size" regression to estimate the tail parameter of a Pareto distribution for the size distribution of cities.

[55] Monte Carlo simulations conducted by the authors show that this methodology allows for recovery of the tail parameter of a Pareto distribution, even when the Pareto distributions have differing productivity levels (i.e., with the inclusion of the fixed effect to control for these differing levels).

20 is the one with the lowest productivity in a particular region and sector, we first find α_0 so that equation (85) holds exactly for that firm. We then generate the productivity of potential entrants with productivity rank of 21, 22,... in that region and sector.

Note that we assume that all new productivity draws are for domestically owned potential entrants. Also note that this procedure for selecting productivity draws only allows for potential entrants in region-sector pairs in which one firm was present in 2016.

Step 3: Check that no additional potential entrants want to enter in the calibrated model We follow a guess and verify procedure. We first select a low χ and follow steps 1–2 as decribed above. If additional firms would like to enter in step 3 in any region or sector relative to the number of firms in the data, we raise χ by intervals of 0.01 and repeat steps 1–2. We continue to raise χ until we find that no additional firms would like to enter in step 3.

We find that the selection of $\chi = 0.98$ results in the calibrated model having exactly the same number of firms in each region and sector as in the data. Note that this procedure ensures that two key equilibrium conditions are satisfied: 1) all firms that enter are profitable after paying the entry cost, and 2) no potential entrant finds it profitable to enter.

D.2 Conducting Quantitative Experiments

Consider the quantitative experiment in which we conduct the FDI reform (i.e., remove foreign-owned firms from the model). To determine the new number of firms in each region and sector, we use the following iterative procedure:

1. Determine whether any firm is unprofitable. If it is, we drop that firm from the equilibrium.

2. Determine whether the next firm (in terms of its productivity) in each region-sector finds it profitable to enter. Note that in this step, we hold the firms determined in step 1 to be fixed and individually test whether each additional firm wants to enter. At the end of this step, we allow all firms that were profitable to enter.

3. Re-solve the model given the new set of firms.

We continue this process until no potential entrants find it worthwhile to enter and all firms that enter are profitable after paying the entry cost.

Note that when we test firms to see if they would find it profitable to enter, we do not evaluate any firms in a region/industry pair that did not enter in the previous loop (i.e.,

in step 2 above). For this reason, we rerun steps 1–3 until no additional firms would like to enter in the first run of the loop. Also note that to reduce the computational burden, we allow for a maximum of five additional potential entrants. We found that increasing the number of potential entrants did not quantitatively affect our results because the additional firms are very small and the constraint was binding only in a few region-sector pairs.