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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. The model distinguishes among multiple channels affecting welfare. In particular, we decompose changes in welfare using the theoretical result developed by Holmes, Hsu and Lee (2014) (hereafter, HHL) in

[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).

which they consider three components: (1) Ricardian channel, (2) allocative efficiency, and (3) the markups terms of trade (ToT). In addition, we extend their framework to include a fourth component, which is related to the fraction of national income that accrues to the foreign owners of firms (the ratio of GDP and GNP).

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.

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.[2] The country saw large investments in road improvements during this period: for example, between 2010 and 2016, the number of kilometres of paved roads doubled. Our data allow us to measure the change in transportation costs resulting from road improvement. Therefore, we can use the calibrated model to 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 of about 16 percent.[3] We also find large gains in GNP of about 10 percent, which captures gains in income that accrue to Ethiopian nationals. These results imply that the gains from FDI in Ethiopian manufacturing are large, although a substantial

[2] Roads represent the main transport infrastructure in Ethiopia over the period covered in our analysis. The railway connecting Addis to Djibouti was re-established in 2017.

[3] These gains are large because foreign firms dominate the sectors they operate in, and consumers cannot substitute as easily to other sectors since the elasticity of substitution across sectors is much lower than within sectors.

fraction of these gains accrue to the foreign owners of these firms (approximately one-third of the gains accrue to GDP but not GNP).[4] Interestingly, the gains are spread out across the country, even in regions that did not receive large amounts of FDI. For example, Addis Ababa and Oromia, the main targets of FDI, gained over 11 percent on average, whereas the other regions gained slightly more than 5 percent on average. While the baseline model treats the number of firms in a sector and region as fixed, we show that these findings are qualitatively robust to allowing for endogenous entry and exit.

We next apply the HHL decomposition and obtain some important findings. First, we find that FDI increases real income by about 17 percent through the Ricardian channel. On the one hand, 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. On the other hand, the Ricardian channel substantially overestimates the gains from FDI primarily because it does not take into account the profits that accrue to the owners 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 almost 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, 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.[5]

Third, 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. On the one hand, we find that the Ricardian term is lower with higher transportation costs, implying that higher transportation costs lower the gains from FDI. On the other hand, the losses in allocative efficiency are lower with higher transportation costs because higher transportation costs do not allow foreign firms to exercise as much market power throughout the country.

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

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

[5] Our results are consistent with a recent literature that empirically studies FDI and markups. For example, 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).

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 alternate measures of markups and foreign presence. In this way, we ensure that our findings are robust to potential biases related to selection and 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 versus that on 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.

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 we can determine the size of the welfare effects and disentangle the various channels through which FDI affects welfare. 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.[6]

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 it is costly to transport goods between regions. Our work has a few unique aspects with 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.[7] This allows us to better understand the heterogeneous effects of FDI throughout the country. For example, locations with higher levels of FDI will gain more; in addition, our model enables us to measure the variation in welfare gains in connected locations throughout the country. Second, a spatial model provides a robust framework to probe how transportation costs affect gains from FDI. We find that the interaction between these two policies can be positive or negative (in other words, lower transporation costs can have positive or negative effects on 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 micro data 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

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

[7] 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.

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.[8] 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 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.[9] The policies of the GTP I and GTP II explicitly focused on attracting foreign investment for the purposes of promoting growth in the economy and encouraging technology transfer to domestic firms. The plan recognizes the need for domestic manufacturers to collaborate with foreign investors to boost the manufacturing sector's contribution to the Ethiopian economy. 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

[8] 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 (2021) study how the acquisitions by large multinationals of competing entities affect competition in the beer and spirits industry.

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

made to attract FDI from every direction particularly by focusing on capable, quality and reputable companies."

An important reform enacted under GTP I was that foreign firms were allowed to enter a wide range of manufacturing sectors.[10] 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. GTP II largely unfolded after the time period of our study and is thus not directly relevant to the analysis in this paper.

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).[11]

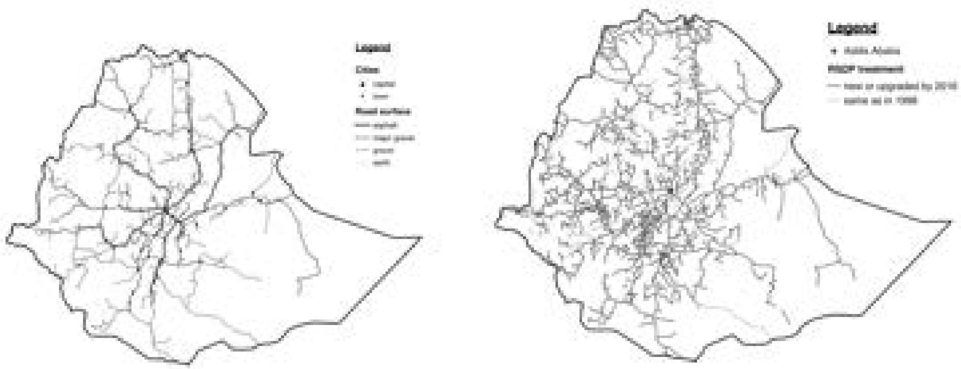
Table A.1 in Online Appendix A reports summary statistics of the quality and size of the Ethiopian road network as reported by the ERA between 1997 and 2016. The table divides the road network among the different road types. Major improvements have been made to the road network throughout time. We also 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 kilometres 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

[10] 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.

[11] 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 9 (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.

Figure 1: Ethiopian Road Network



(a) Road Network in 1996 (b) Road Network in 2006

between 1996 and 2016. Moreover, road development does not appear to be geographically concentrated, but spans different administrative areas across the country.

3 Model

In this section, we present our static general equilibrium model of internal trade based on Atkeson and Burstein (2008). This model has been used to study firm pricing and markups in the context of internal and international trade (e.g., Asturias, Garcia-Santana and Ramos 2018, Edmond, Midrigan and Xu 2015). More recently, it has been used to study rising markups within countries such as the United States (e.g., De Loecker, Eeckhout and Mongey 2021). Some of the exposition of the model in this section is borrowed from Asturias, Garcia-Santana and Ramos (2018), a paper that also used the Atkeson and Burstein (2008) model.

We consider N asymmetric regions trading with each other, and 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 [12].

[12] 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 70–80 percent of migration was within the same region.

3.1 Consumers

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

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

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

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

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

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

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

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

3.2 Firms

In each sector j in region o, there is a finite number of K_{oj} firms.[13] Firms draw their productivity from a distribution with CDF $G(a)$. A firm with productivity level a has a constant labor requirement of $1/a$ to produce one unit of good. Because firms do not pay a fixed cost to operate in a market, they sell to all N regions.

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

[13] We have opted to keep the model as simple as possible by letting K_{oj} be a parameter, which can easily be measured in the data. In Section 5.3, we discuss an extension of the model in which firms pay an entry cost and the number of firms can change after a policy reform.

(2), and (3) generate the demand

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

where

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

is the price index for sector j in region n and

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

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

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

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

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

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

where

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

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

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

The price that firms set in equation (8) is similar to the markup over marginal cost that is found in a setup with monopolistic competition. The difference is that 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.

The aggregate profits of firms in region n are characterized by

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

3.3 Balanced Trade and Labor-Clearing Condition

All regions n must have balanced trade:

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

The labor-clearing condition for region n is

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

3.4 Definition of Equilibrium

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

1. Given firm prices, sector prices, and aggregate variables, $\{c_{n'}^n(j,k)\}$ is given by (4), $C_n(j)$ by (2), and they solve the consumer's problem in (1) and (3).

2. Given aggregate variables, $p_{n'}^n(j,k)$ is given by (8), (9), and (10) and solves the problem of the firm in (7).

3. Aggregate profits satisfy (11), aggregate prices satisfy (6), and sector prices satisfy (5).

4. Trade flows satisfy (12).

5. Labor markets satisfy (13).

3.5 Defining Gross National Product

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

$$GNP_n = W_n L_n + \Pi_n^L, \tag{14}$$

where

$$\Pi_n^L = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \phi_o(j,k) \pi_d^n(j,k) \right) dj \tag{15}$$

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

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

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

We can apply 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. In particular, the framework allows us to distinguish between the effects of the Ricardian channel, allocative efficiency, and markups terms of trade from the entry of foreign firms. In addition, we extend the original decomposition to allow for changes in the ratio of GNP/GDP, which is important in the context of studying the effects of FDI.

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

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

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

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

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

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

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

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

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

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

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

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

The first component is the aggregate labor income. The second component is the productive efficiency component of welfare. This component is simply the inverse of the price index if all firms charged the marginal cost. The third component is the markups terms of trade.

This component compares the aggregate markups charged for the goods a region sells with those that it purchases. The fourth component is allocative efficiency. This term is related to the welfare loss that arises 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. The last term relates the fraction of GDP that accrues to GNP; a decline in this ratio corresponds to a decline in Ethiopian real income.

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

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

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.[14] This annual census covers all plants[15] with at least 10 persons engaged and that use electricity in their production process.[16] The census is representative of the formal manufacturing sector, which accounts for almost half of manufacturing employment and 90 percent

[14]Note that it is not possible to create a full panel of firms without having access to establishment names and other identifiers that are not available in the data. This is possible only for a subsample of firms for the period 1996–2010. For a detailed discussion on the issues related to the creation of a complete panel using the census, see the paper by Abebe, McMillan and Serafinelli (2022).

[15]We use the terms plant, establishment and firms interchangeably in the paper.

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

of the sector's production.[17]

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. The information also includes product-level value and quantity for the domestic and export markets. The product codes used in the census are a CSA product classification system, and the industry classification used is the four-digit ISIC revision 3.

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 from foreigners.[18] 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 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 2 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

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

[18] 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.

are not statistically significant.

Table 2: 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 2 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

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 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.[19]

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.3 in Online Appendix A.[20] The computed travel times are between all the districts in the country. We additionally aggregate wareda-level (district-level) travel times so that we have average travel times between regions. In this calculation, we weight woredas using night light intensity to emphasize the more economically important areas within a region.

[19] 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.

[20] The ERA speed matrix described in Table A.3 in Online Appendix A was also used by Jedwab and Storeygard (2022) and Fiorini, Sanfilippo and Sundaram (2021).

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 3.

Table 3: 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		
K_{oj}	Number of producers in sector j and region o	Varies by sector/region
$\phi_o(j,k)$	Fraction of local ownership of firm k in sector j and	1 for domestic firms 0.19 for foreign firms
(3) Parameters inferred using functional relationships		
τ_d^o	Iceberg transportation costs from region o to d	Varies across region pairs
(4) Parameters calibrated in equilibrium		
L_n	Labor endowment of region n	Varies across regions
α	Tail parameter of Pareto productivity distribution	1.15
λ	Multiplicative productivity increase (top 0.5% of firms in terms of value added)	7.12
ζ	Multiplicative productivity increase (foreign firms)	3.35

Notes: Table 3 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.

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, 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 (8)–(10). 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 (8)–(10). 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.[21]

Number of producers, K_{oj} For the number of producers in sector k and region o, k_{oj}, we find the number of producers at the product level that we observe in the manufacturing data. When we compute the number of producers, we use the disaggregated product-level information on output reported by firms. Note that accurately capturing the distribution of producers by sector across regions is important for our quantitative exercises. For example, having other producers from the same sector located in other regions will put competitive pressure on local firms, forcing them to lower their markups. Alternatively, having few competitors in other regions will allow local producers to raise their markups.

Fraction of local ownership of firms, $\phi_o(j,k)$ For firms that are foreign owned, we set $\phi_o(j,k) = 0.19$, which is the average paid-in capital by locals reported in the data for foreign firms, implying that 19 percent of the profit accrues to GNP for foreign owned firms.[22] For firms that are not foreign, we set $\phi_o(j,k) = 1$, meaning that all of the profit accrues to GNP. See Section 4.1 for more information about how we determine which firms are foreign owned.

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

[21] 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.

[22] To map a foreign firm from the data to the model, we first find the rank of all foreign firms within their sector and region by value added. We then assign firms in the model with the same rank in their sector and region as foreign owned. For example, if the third-largest firm in Oromia in a particular sector is foreign owned, we assign the third-largest firm in the corresponding sector in Oromia as foreign owned.

transporation costs and the optimal travel time between two locations:

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

where κ determines the level of transportation costs, $TravelTime_d^o$ is the optimal 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.[23] 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 (22) as follows:

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

which yields the following equation, which, we can estimate with our newly assembled dataset:

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

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.4 in Online Appendix A reports the results from the estimation of equation (24). The last column of the table reports the results when combining all of the data and 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,

[23]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 (SNNP), Jijiga (Somali), and Mekelle (Tigray).

and we find coefficients ranging from 0.44 to 0.76.[24]

We next pin down κ, which governs the level of iceberg transportation costs. We use 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 (22), 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.

Labor endowments, L_n The labor endowment, L_n, of one region is normalized to 1. For the other regions, we set the labor endowment so that the relative size of manufacturing value added across regions is the same in the data and model.

Firm productivity The correlation of firm productivity drawn across regions is important to determine the size of allocative efficiency gains because if firms across regions have similar productivity, then there is a high degree of head-to-head competition. This level of head-to-head competition plays an important role in determining the effects of policy changes on the allocative efficiency of the economy (e.g., the elimination of foreign firms).

We assume that firms across regions have perfectly correlated productivity draws. To implement this, we first find the maximum number of firms present in any region for each sector. We make this number of draws from a Pareto distribution. We then sort the productivities in descending order. If a region has one firm, we select the first productivity on the sorted list. If a region has 10 firms, we select the first 10 productivities on the sorted list. This setup ensures that the firms with the highest productivity face head-to-head competition. Note that this does not imply that the sectors are symmetric across regions since regions have a different number of operating firms. Furthermore, regions have different wages and transportation costs, which affect their marginal cost.

The Ethiopian manufacturing sector exhibits a high degree of concentration and we take steps to match this level of concentration in the model. First, we incorporate a parameter,

[24] 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 Adamopoulus (2020) to estimate transport costs in the context of rural Ethiopia.

λ, that multiplicatively increases the productivity of firms identified as being in the top 0.5 percent in terms of their value added.[25] We set λ such that in the model, the top 0.5 percent of firms account for 72 percent of value added, which is consistent with the data. We find that $\lambda = 7.12$, which indicates that we need a fairly high productivity premium among the very largest firms in order to rationalize the high levels of concentration. Second, we incorporate another parameter, ζ, that multiplicatively increases the productivity of foreign firms. We calibrate this parameter so that foreign firms account for 17 percent of value added, which is consistent with the data. Third, we set the tail parameter, α, such that the top 5 percent of firms account for 93 percent of value added.

It is important to determine whether the model generates reasonable levels of head-to-head competition given the assumption of perfectly correlated productivity draws. We create a "similarity" index that measures the similarity in size among the largest firms across regions. We focus on the largest firms since they are the ones that drive most of the dispersion in markups. To calculate the index, for each sector and region we identify the firm with the largest value added. Then, we regress the log of the value added of these firms on sector dummies. The R-squared of that regression, which we use as our index, indicates the extent to which large firms in each sector are of similar size. For example, an R-squared of 1 indicates that the largest firms across regions are exactly the same size.

We find an index of 0.66 in the data and 0.49 in the model, which indicates that the similarity index is higher in the data than in the model. It is also useful to compute the similarity index when restricting the sample to include only the two largest firms by sector across each region. Note that the sample is the same as in the previous calculation of the similarity index except that we restrict it to the two largest firms for each sector. This exercise is instructive if we want to focus on the level of head-to-head competition for the very largest sectoral producers across the country. In this case, we find a similarity index of 0.78 in the data and 0.48 in the model. The exercises indicate that the model generates levels of head-to-head competition that are similar to or potentially below what we observed in the data.

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.

We estimate firm-level markups from the manufacturing data dividing revenues by total

[25] We first identify firms in the data that are in the top 0.5 percent in terms of value added and identify the number of firms in each region and sector. We then apply the λ parameter to the productivity of those firms in the model. For example, if a particular sector and region has two firms that satisfy these criteria, we apply the λ parameter to the top two firms in this sector and region.

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.[26]

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

$$\mu_i = \frac{P_i Q_i}{p_i^l L_i + p_i^m M_i + r K_i}, \tag{25}$$

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 $r = 0.15$[27], which combines an estimated 5 percent for the cost of capital and a 10 percent depreciation rate.[28]

We compute the same statistics in the model (i.e., dividing the total value of production by the total cost of inputs). 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 4 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. For example, the weighted average markup in the model is 1.56, whereas the same statistic in the data is 1.60. We also find that in both cases, foreign firms have higher markups than domestic firms. For example, the weighted average markup of foreign firms in the model is 22 percent higher than domestic firms (1.84 vs. 1.51) and 27 percent higher in the data (1.93 vs. 1.52). 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 choosing conservative values for the elasticities, θ and γ, as described earlier in this section (see the beginning of Section 5.1).

[26]Compared to other methods commonly adopted in the literature (e.g., De Loecker and Warzynski, 2012), this approach has the advantage that no production function needs to be estimated to get output elasticities. On the other hand, since the approach imposes that first-order conditions must always be met, it can be inconsistent with different timing assumptions with regard to the choice of inputs (Ackerberg, Caves and Frazer, 2015). Thus, this approach may be more consistent with medium to long-term optimization than short-term optimization.

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

[28]As we expect some of the measurement to be imperfect, we follow standard practice in the literature (e.g. Lu and Yu, 2015; Brooks et al., 2021) and wisorize 2.5 percent in both side 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.5 in Online Appendix A) and sectorally (Table A.6); and (iii) the distribution of markups for foreign firms has a longer right tail (Figure A.1).

Table 4: Comparison of Markups in the Model and Empirical Estimates

	Model	Empirical estimates
Weighted average markup (all)	1.56	1.60
Weighted average markup (foreign)	1.84	1.93
Weighted average markup (domestic)	1.51	1.52
Average unweighted markup (all)	1.18	1.41
Median markup (all)	1.10	1.23

Notes: Table 4 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 statistic of markups in the calibrated model, and Column 3 reports the same statistics for the markups estimated in the data. 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 4 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:

$$\log Markup_i = \beta_0 + \beta_1 Foreign_i + FE_j + \epsilon_i, \tag{26}$$

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 as a weighted regression in which we use sales as the weight.[29]

Table 5 reports the results of the estimation of equation (26). The results indicate that foreign firms have markups that are 23 percent higher than non-foreign firms when we use the empirical estimates of markups, as reported in column 1. Similarly, foreign firms have markups that are also 23 percent higher when we use the model output, as reported in column 2. These results indicate that, within industries, foreign firms tend to have high markups relative to domestic firms and that this finding is consistent with the calibrated model. Besides, note that the differences in markups are quantitatively similar to those found in Table 4 (i.e., the weighted markups of foreign firms are 22 percent higher in the model and 21 percent percent higher when using the empirical estimates of markups).

[29]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.

Table 5: Markups in the Model and Empirical Estimates by Foreign Firm Status

Variables	(1) Log markup	(2) Log markup
Foreign firm dummy	0.230***	0.226***
	(0.0276)	(0.00537)
Constant	-0.163	0.463***
	(0.129)	(0.0825)
Observations	2,489	6,625
R-squared	0.422	0.570
Industry fixed effects	Yes	Yes
Empirical estimates/model	Estimates	Model

Notes: Table 5 reports the results of the estimation of equation (26). We use a weighted regression in which each observation is weighted by a firm's sales. Column 1 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. Column 2 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). For example, suppose that in the data 70 percent of the production of a product takes place in firms in industry A and 30 percent of production takes place in firms in industry B. Then we would assign the product to industry A.
*** p<0.01, ** p<0.05, * p<0.1

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. Improvements in roads would lower transportation costs and force local firms to lower their markups given the increased competition from other regions.

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 6 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 tables reports the results for the aggregate economy.

Table 6: Changes in Real Income after FDI Reform (%)

Region	GDP/P	GNP/P
Harari	4.63	4.63
Somali	6.05	6.05
Afar	5.08	5.08
Dire Dawa	22.77	9.52
Amhara	10.19	5.88
SNNP	4.48	4.16
Tigray	4.86	2.95
Oromia	25.61	13.23
Addis Ababa	14.30	9.90
Aggregate	15.88	9.69

Notes: Table 6 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 6 shows large aggregate gains, with real manufacturing GDP increasing by 15.9 percent and real GNP increasing by 9.7 percent. These results imply significant gains for the economy, 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 almost 40 percent 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, even though they tend to be higher in regions with many foreign firms, such as Oromia and Addis Ababa. For example, Addis Ababa and Oromia gained 11.56 percent on average whereas the other regions gained 5.47 percent on average. Thus, regions that did not receive significant amounts of FDI benefited significantly even though the FDI flows primarily targeted Oromia and Addis Ababa.

Table 7 reports the results of applying the HHL decomposition, as described in equation (21), to changes in real manufacturing 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 16.9 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. 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 similar 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}).

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 and the differences between GNP and GDP. 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 worsening of allocative efficiency (though modest). This result arises from the large market shares of some foreign firms, which allow them to charge high markups. In the aggregate, these losses equal 8 percent of the increase in real GNP; across the regions, these losses can be up to a quarter of the increase in real GNP, such as in the case of Tigray. Broadly, our results indicate that it is important to account for the markups and profits of foreign firms when determining the gains to the local economy.

Third, the results show that the markup ToT (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, the smallest regions such as Harari, Somali, and Afar, do not have any foreign firms and experience losses in the terms of trade. On the other hand, 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. The reason is that 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 7: Changes in Real Income after FDI Reform, Decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Residual
Harari	4.63	12.40	−6.66	−1.11	0.00	0.00
Somali	6.05	11.27	−4.09	−1.13	0.00	0.00
Afar	5.08	14.13	−8.05	−1.00	0.00	0.00
Dire Dawa	9.52	14.75	9.14	−1.12	−13.25	0.00
Amhara	5.88	12.18	−0.98	−1.01	−4.31	0.00
SNNP	4.16	8.66	−3.16	−1.01	−0.32	0.00
Tigray	2.95	7.67	−1.99	−0.82	−1.91	0.00
Oromia	13.23	23.75	2.90	−1.04	−12.38	0.00
Addis Ababa	9.90	16.25	−1.31	−0.63	−4.41	0.00
Aggregate	9.69	16.93	0.00	−0.81	−6.19	−0.24

Notes: Table 7 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 3–6 report the HHL decomposition of the changes in real GNP. Column 7 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.[30] 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 8 reports the results. We find a small increase in the gains in real income under the lower transportation costs, from 9.62 to 9.69. Note 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. In contrast, lower transportation costs result in a larger loss in allocative efficiency because they allow foreign firms to exercise their market power by making them more competitive across all the

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

regions of the country, which in this case worsens allocative efficiency.[31]

Table 8: Changes in Real Income after FDI Reform with High Transportation Costs, Decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Residual
Harari	4.54	12.30	−6.65	−1.10	0.00	0.00
Somali	6.01	11.25	−4.11	−1.14	0.00	0.00
Afar	4.95	14.08	−8.13	−0.99	0.00	0.00
Dire Dawa	9.47	14.70	9.17	−1.11	−13.29	0.00
Amhara	5.81	12.04	−0.92	−0.98	−4.34	0.00
SNNP	4.01	8.40	−3.13	−0.94	−0.32	0.00
Tigray	2.89	7.45	−1.89	−0.76	−1.91	0.00
Oromia	13.33	23.66	2.92	−0.89	−12.36	0.00
Addis Ababa	9.76	16.04	−1.37	−0.51	−4.40	0.00
Aggregate	9.62	16.76	0.00	−0.69	−6.19	−0.26

Notes: Table 8 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 3–6 report the HHL decomposition of the changes in real GNP. Column 5 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.

5.3 Extensions of the Model

Entry and exit We have opted to keep the model as simple as possible by letting K_{oj} be an exogenous parameter. When we take the model to the data in Section 5, this parameter can easily be measured as the number of firms in sector j located in region o. In Online Appendix B, we extend this baseline model to allow for the entry and exit of firms by introducing entry costs. We calibrate this model and conduct an FDI reform. We find that the quantitative results are broadly similar to the baseline model's results. For example, we find significant gains from the FDI reform (8.3 vs. 9.7 percent) and find that these gains are spread out across the country, even in regions that did not receive large amounts of FDI.

[31] In a separate exercise, the results of which are reported in Table A.7 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 8 also shows that there are consistently positive gains from allocative efficiency throughout the country, indicating that improved roads enhance the allocative efficiency of the economy.

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 C, 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.

5.4 Additional analysis of model output and comparison with data

As a next step, we proceed to an empirical analysis, whose goals are two fold. 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.[32]

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. Thus, although the presence of foreign firms is associated with lower markups of domestic firms, it is also associated with an increase in the dispersion of markups that worsens allocative efficiency.

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

[32] Damoah, Giovannetti and Sanfilippo (2021) similarly use the Theil index in the context of Ethiopia.

information from the manufacturing data.

5.4.1 Foreign firms and level of markups of domestic firms

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

$$y_{rjt} = \alpha_0 + \alpha_1 (FDIExposure)_{rjt} + \alpha_2 (Ln(TotalProduction))_{rt} + \gamma_{rj} + \theta_t + \epsilon_{rjt}, \quad (27)$$

where y_{rjt} is the variable of interest, which in this case is the weighted average markup of domestic firms in region r in industry j at time t (weighted by each firm's share of production); $(FDIExposure)_{rjt}$ 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 weighted average markup 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. Standard errors are clustered at the level of the treatment, which in this case is the level of region-industry.

The results of this estimation can be seen in column 2 of Table 9. We find that the entry of foreign firms is associated with a decline of 7 percent in the weighted average markup in the model. We similarly estimate equation (27) using firm data from census years, as described in Section 4. The markups are constructed using equation (25). The results of the regression are reported in column 4. In this case, we find that exposure to foreign firms is associated with a decline of 11 percent in the weighted average markup in the data.

5.4.2 Foreign firms and regional disperson of markups

We also study changes in the Theil index, which measures the dispersion of firms' markups within a region. 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:

$$Theil_{rjt} = \frac{1}{n_{rjt}} \sum_{i=1}^{n_{rjt}} \frac{\mu_{irjt}}{\overline{\mu}_{rj}} \log\left(\frac{\mu_{irjt}}{\overline{\mu}_{rjt}}\right), \quad (28)$$

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 average markup of firms in industry j in region r. The Theil index ranges

Table 9: Changes in Markups When Exposed to Foreign Firms

VARIABLES	(1) Theil	(2) Log markup	(3) Theil	(4) Log markup	(5) Theil	(6) Log markup
FDI dummy	0.00486***	-0.0725***	0.00666*	-0.107***	0.0176***	-0.106***
	(0.00155)	(0.0195)	(0.00353)	(0.0337)	(0.00355)	(0.0335)
Constant	-0.0294***	-0.1000	0.647***	-1.149***	0.638***	-1.540***
	(0.00934)	(0.144)	(0.0314)	(0.175)	(0.00890)	(0.124)
Observations	522	522	3,390	3,390	7,549	7,549
R-squared	0.892	0.960	0.457	0.457	0.374	0.455
Region*Industry FE	Y	Y	Y	Y		
District*Industry FE					Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Model/data	Model	Model	Data	Data	Data	Data

Notes: Theil and markups are calculated at the level of the relevant market (region-industry or district-industry). Columns 1–2 (model) and 3–4 (data) classify the market using the region and the industry, while columns 5–6 (data) use the district and the industry to define a market. 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. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

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.

Once we have computed the Theil index, we reestimate equation (27), except that we use a region's Theil index as the outcome variable, Y_{rjt}. The results of the estimation can be found in column 1 of Table 9. We find that the entry of a foreign firm is associated with an increase of 0.004 in the Theil index, implying increased dispersion in markups in the model with the entry of foreign firms. We similarly estimate equation (27) using the data from census years.[33] The results of this estimation can be found in column 3. In this case, we find that the entry of foreign firms is associated with an increase of 0.007 in the Theil index.

6 Reduced-Form Evidence

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

[33] Figure A.2 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.

define a local market in the country (e.g., Abebe, McMillan and Serafinelli, 2022; Moneke, 2020; Crescenzi and Limodio, 2021; Fiorini and Sanfilippo, 2022).

6.1 Empirical analysis

Our specifications are based on an unbalanced panel of markets (district-industry pairs) for which we estimate the effects of FDI exposure on both the levels and the distribution of markups. The baseline specification is

$$y_{rjt} = \beta_0 + \beta_1 (FDI)_{rjt} + \gamma_{rj} + \theta_t + \epsilon_{rjt}, \tag{29}$$

where r is the district, j is the sector, t is the year, and y_{rjt} is the outcomes 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 Measuring competition

We measure competition using the market (a district-industry pair) as our unit of analysis. We consider two measures capturing 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., as soon as a foreign firm begins production, a market remains treated for the rest of the time).[34]

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

[34] 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.

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:

$$\text{FDI Exposure}_{rjt} = \log\Big(\sum_{z\neq r} D_{rz,t}^{-\theta} L_{zjt}\Big), \tag{30}$$

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.[35] Bilateral distances in hours of travel are computed applying the Dijkstra algorithm on the network of Ethiopian districts (nodes) connected by federal and regional Ethiopian roads (links).[36] 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.3 in Online Appendix A). Changes in the bilateral travel time across districts account for the evolution of the road network, which 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.

Figure 2 provides an industry-specific example showing variation in exposure to FDI market access across districts for the years 1996 and 2016. The grain mills 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 map indicates that FDI market access increased substantially over this time period, which is represented by darker colors on the maps.

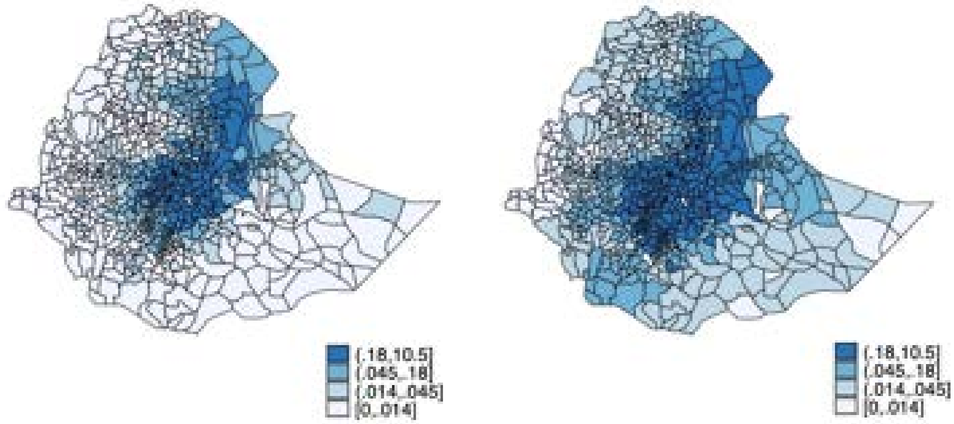
6.3 Markups and FDI

In Section 5.4, Table 9, 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 focus on results from the last two columns

[35] 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.

[36] 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 is a reasonable assumption, given the focus on regional and federal roads, which represent the majority of road infrastructure in the country.

Figure 2: FDI Market Access for Grain Mills Industry (ISIC 1531)



(a) FDI Market Access in 1996 (b) FDI Market Access in 2016

of Table 9 defining a market in the most granular setting and provide additional tests to to ensure robustness of the estimated relationships.

First, we check whether this first set of results is sensitive to different definitions of the treatment. Following the literature, 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. In Table A.8 of Online Appendix A, 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 percent, 20 percent, or 50 percent of a market's production or (ii) accounts for more than 10 percent of the market's total employment. We show that the results remain largely unaffected by the different definitions adopted.

Second, we tackle endogenous selection of locations by foreign investors. Specifically, comparing markets that receive FDI with all other market in the country may introduce a 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 in the time period of our analysis. To do this, we tag markets (or districts) that have received at least one FDI project over the 1996–2016 period, and drop those that were never targeted over the same time span [37].By replicating the analysis on this restricted sample, we exploit temporal variation in the distribution of FDI.[38] Results of this exercise, reported in Table A.9 of Online Appendix

[37]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).

[38]As pointed out by Abebe, McMillan and Serafinelli 2022, the timing of when land became available

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. In columns 3–4, we restrict to districts that were targeted by FDI at some point, but in any sector. In both cases, the direction and magnitude of the coefficients of interest remain similar to the baseline in Table 9.

Third, we follow a recent strand of 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 because in such settings, both *clean* (treated units against un-treated or not-yet-treated ones) and *forbidden* (treated units against other treated units) comparisons are computed, resulting in negative weights for some comparisons.[39] 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 (2022).[40] 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. The estimated average treatment effects (τ) based on this procedure are reported in Table 10 and are consistent with the baseline coefficients.[41].

Finally, 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

within regions for FDI projects was uncertain and driven by local idiosyncrasies.

[39] 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.

[40] We do this by using the user-written STATA command *did_imputation*, which is provided by the authors (Borusyak, Jaravel and Spiess, 2022).

[41] Other approaches have been proposed by the literature to address similar issues. Compared to these other approaches, however, the method proposed by Borusyak, Jaravel and Spiess (2022) 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 (2022) 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 provides some advantages compared to other methods that use only the first lag to create the control group (more discussion in the review by de Chaisemartin and D'Haultfoeuille, 2022).

Table 10: Average Treatment Effect Based on Borusyak, Jaravel and Spiess (2022)

Variables	(1) Theil	(2) Log markup
τ	0.0139***	-0.0599*
	(0.0032)	(0.0339)
Observations	7,218	7,218

Notes: The table reports the estimated average treatment effect (τ) resulting from estimating the relation between FDI and our outcomes of interest by means of the approach proposed by Borusyak, Jaravel and Spiess (2022). 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

pre-treatment. We do this graphically, plotting the FDI treatment coefficient in the three years before and after treatment. We conduct the event study using both a standard TWFE approach and the approach proposed by Borusyak, Jaravel and Spiess (2022). The outcomes for the Theil index and average markups as outcome variables are reported in Figures A.3 and A.4 of Online Appendix A, respectively. Neither figure shows large differences in estimated coefficients between treatment and control groups, neither in the TWFE approach nor in the approach accounting for negative weights. Most importantly, pre-trend coefficients are close to zero.[42]

6.4 Markups, FDI, and Roads

We next estimate the effects of FDI on markups accounting for changes in the road network that occurred under the RSDP. We do this by proxying for FDI exposure as defined in equation (30).

Table 11 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 replicates the previous estimation equation using the new measure of FDI exposure. Results confirm a pro-competitive effect of FDI from foreign firms in connected intranational markets that

[42] We formally test for joint significance of the pre-trends. We find a p-value of 0.2751 in the case of the Theil index and a p-value of 0.6709 for the specification using average markups as the dependent variable, suggesting that we cannot reject the null hypothesis of no pre-trends. Furthermore, we conduct an additional test to look for potential endogenous entry of FDI in markets with high markups. Table A.10 in Online Appendix A reports 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, both in an unconditional setting, and in a setting that accounts for market and year fixed effects.

leads to a reduction of markups charged by domestic firms. A foreign presence in other intranational markets exerts greater downward pressure on firm markups in a given market r the better connected it is.

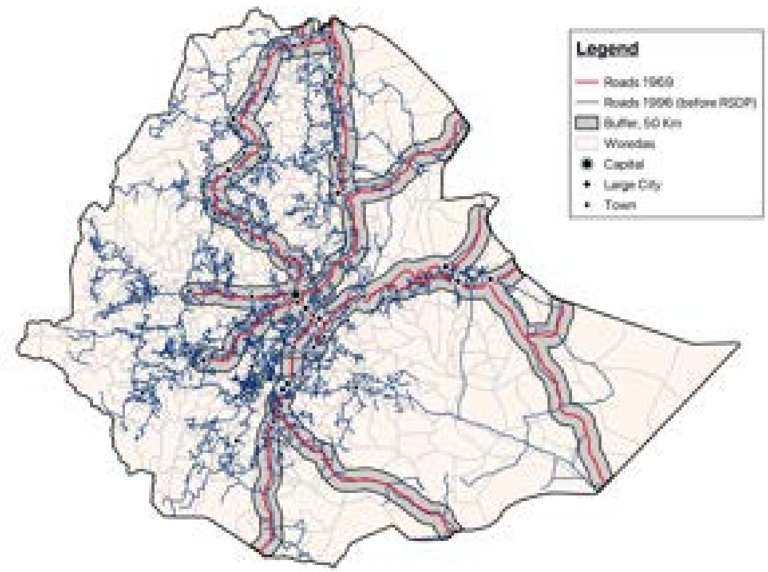
Table 11: FDI, Roads, and Markups

VARIABLES	(1) OLS	(2) OLS	(3) First Stage	(4) 2SLS
FDI Market Access	-0.0262***			-0.118***
	(0.00744)			(0.0277)
FDI Market Access (weight at t0)		-0.0328***		
		(0.0120)		
Instrument			0.342***	
			(0.0199)	
Constant	-1.436***	-1.471***	1.534***	
	(0.131)	(0.131)	(0.150)	
Observations	5,946	5,946	5,774	5,774
R-squared	0.434	0.433	0.965	0.078
District*Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
F-test				294.2

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 (30). In column 1, this variable is defined by varying both the $D_{rz,t}$ and the $L_{zj,t}$ varying over time. In column 2, $L_{zj,t}$ is fixed at the baseline, while $D_{rz,t}$ varies over time. Columns 3 and 4 report the 2SLS estimate. Column 3 reports the first-stage regression, while column 4 reports the second stage. Column 4 also reports the Kleibergen-Paap Wald F-statistic. 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

To address potential endogeneity, we first repeat our analysis by fixing the level of foreign production (L_{zjt} in equation 30) at pre-sample levels. The results are reported in column 2 of Table 11 and confirm the baseline. Next, we employ an instrumental variable approach. Our instrument replicates the construction of foreign exposure as in equation (30) but uses an alternative road network, resulting in a different definition of the D component. The alternative road network is based on a digitized map provided by the CIA for the year 1969. From this network, we identify a 50-kilometer buffer that delimits an exclusion zone. When constructing the synthetic road network, we follow the approach by Jedwab and Storeygard (2022) and *freeze* changes in the road network along the exclusion zone. Conversely, the road network outside the exclusion zones changes with RSDP improvements. Keeping roads in the areas inside the buffer at their pre-sample level allows us to exclude those improvements made under the RSDP that are more likely to be affected by endogeneity. The exclusion zones reflect historic transport lanes of the country, including major economic hubs. As shown in Figure 3, the 50-kilometer buffer includes all major cities that had a population larger than 50,000 people before the start of the RSDP. The instrument has a strong first stage (column 3), and its relevance is proven by the F-test reported at the bottom of column 4. As shown by the negative and statistically significant coefficient in column 4 of Table 11, our results hold qualitatively.

Figure 3: Buffer of 50 Kilometers around Roads from 1969



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 accruing 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 a market rj, we calculate market share as the share of production in the market in a given year. We then estimate the following specification:

$$y_{i(rj)t} = \beta_0 + \beta_1(FDI)_{rjt} + \beta_2(X)_{it} + \gamma_{rj} + \theta_t + \epsilon_{irjt}, \quad (31)$$

where $y_{i(rj)t}$ measures the market share of a domestic firm i in year t. The definition of treatment is the same as in the last two columns of Table 9. Market and year fixed effects are included in each specification. The term X includes firm-specific controls, such as firm age, size, and (labor) productivity. The results of this exercise are reported in Table 12. They reveal that, on average, domestic firms experience a drop in market share along the order of 7.2–7.8 percentage points once a foreign firm enters their market.

Table 12: 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 in columns 5–6 of Table 9. Column 2 reports a specification including the following controls: firms' 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 in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

6.6 Robustness

6.6.1 Alternative definitions of markups

We replicate our analysis using the production function approach to constructing firm markups which is an alternative to the one described in Section 5.1. We estimate markups using the approach adopted by De Loecker and Eeckhout (2018) as follows:

$$\mu_i = \alpha_i^v (\beta_i^v)^{-1}, \tag{32}$$

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 with an output elasticity that we obtain from Fiorini, Sanfilippo and Sundaram (2021), who estimate physical productivity (TFPQ) using a production function approach utilizing a fraction of the firm data that we use in this paper and for which panel data are available, covering the period 1996–2009.[43] We find that there is a high correlation (0.66)

[43]Table A.11 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)

with the definition of markup used earlier in the paper.[44] Results are reported in Table A.12 in Online Appendix A and are consistent with the results reported in previous sections.

6.6.2 Alternative specifications

Further, we check for the robustness of our results to different specifications. This includes adding a more granular set of fixed effects, controlling for both district-year and industry-year fixed effects, to remove most time-varying confounding factors underlying the relation examined. Specifically, this setting allows us to account for trade or industrial policy shocks specific to industry or location. Results of this exercise are reported in Table A.13 in Online Appendix A. Though the sample is reduced, results remain in line with the previous results, an exception being column 2, where the impact of interest is less precisely estimated.

6.6.3 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.14 in Online Appendix A reports the results. For the Conley method, we only report results based on a 150 kilometer cutoff, but standard errors are generally smaller when considering greater distances, and our results remain qualitatively stable.

7 Conclusions

Using a model of internal trade with variable markups, we study the effects of FDI and investments in road infrastructure on welfare in Ethiopia. We find large aggregate gains in real income to Ethiopians from FDI. We also find that FDI worsens allocative efficiency since foreign firms tend to be large and charge high markups relative to domestic firms. This

approach that uses the costs of raw material as a proxy for unobservable productivity shocks to correct for simultaneity bias and 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.

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

result is bolstered by the empirical analysis, where we show that greater foreign competition, both in a firm's own market and in connected intranational markets, is associated with lower markups. Finally, we find a small degree of complementarity between FDI and road improvement projects in determining welfare. We find complementarity through the Ricardian channel, although this effect is mitigated by the additional losses in allocative efficiency from the ability of foreign firms to exercise market power.

References

Abebe, Girum, Margaret McMillan, and Michel Serafinelli. 2022. "Foreign Direct Investment and Knowledge Diffusion in Poor Locations: Evidence from Ethiopia." *Journal of Development Economics*, 158.

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer. 2015. "Identification Properties of Recent Production Function Estimators." *Econometrica*, 83(6): 2411–2451.

Adamopoulus, Tasso. 2020. "Spatial Integration and Agricultural Productivity: Quantifying the Impact of New Roads." *Working Paper*.

Alfaro, Laura. 2017. "Gains from Foreign Direct Investment: Macro and Micro Approaches." *World Bank Economic Review*, 30(S1): S2–S15.

Alfaro-Ureña, Alonso, Isabela Manelici, and Jose P. Vasquez. 2022. "The Effects of Joining Multinational Supply Chains: New Evidence from Firm-to-Firm Linkages." *The Quarterly Journal of Economics*, 137(3): 1495–1552.

Alviarez, Vanessa, Keith Head, and Thierry Mayer. 2021. "Global Giants and Local Stars: How Changes in Brand Ownership Affect Competition." *Working Paper*.

Arkolakis, Costas, Natalia Ramondo, Andrés Rodríguez-Clare, and Stephen Yeaple. 2018. "Innovation and Production in the Global Economy." *American Economic Review*, 108(8): 2128–73.

Asturias, Jose, Manuel Garcia-Santana, and Roberto Ramos. 2018. "Competition and the Welfare Gains from Transportation Infrastructure: Evidence from the Golden Quadrilateral of India." *Journal of the European Economic Association*, 17(6): 1881–1940.

Asturias, Jose, Sewon Hur, Timothy J. Kehoe, and Kim J. Ruhl. 2016. "The Interaction and Sequencing of Policy Reforms." *Journal of Economic Dynamics and Control*, 72: 45–66.

Atkeson, Andrew, and Ariel Burstein. 2008. "Pricing-to-Market, Trade Costs, and International Relative Prices." *American Economic Review*, 98(5): 1998–2031.

Atkin, David, and Dave Donaldson. 2015. "Who's Getting Globalized? The Size and Implications of Intra-National Trade Costs." *NBER WP N. 21439*.

Atkin, David, Benjamin Faber, and Marco Gonzales-Navarro. 2018. "Retail Globalization and Household Welfare: Evidence from Mexico." *Journal of Political Economy*, 126(1): 1–73.

Bau, Natalia, and Adrien Matray. 2023. "Misallocation and Capital Market Integration: Evidence from India." *Econometrica*, 91(1): 67–106.

Bircan, Cagatay. 2019. "Ownership Structure and Productivity of Multinationals." *Journal of International Economics*, 116: 125–143.

Blalock, Garrick, and Paul J. Gertler. 2008. "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers." *Journal of International Economics*, 74(2): 402–421.

Borusyak, Kirill, Xavier Jaravel, and Jann Spiess. 2022. "Revisiting Event Study Designs: Robust and Efficient Estimation." *Working Paper.*

Brooks, Wyatt J., Joseph P. Kaboski, and Yao Amber Li. 2021. "Agglomeration, Misallocation, and (the Lack of) Competition." *American Economic Journal: Macroeconomics*, 13(4): 483–519.

Brooks, Wyatt J., Joseph P. Kaboski, Yao Amber Li, and Wei Qian. 2021. "Exploitation of labor? Classical monopsony power and labor's share." *Journal of Development Economics*, 150.

Buera, Francisco J., Joseph P. Kaboski, and Robert M. Townsend. 2023. "From Micro to Macro Development." *Journal of Economic Literature*, 61(2): 471–503.

Bundervoet, Tom. 2018. "Internal Migration in Ethiopia : Evidence from a Quantitative and Qualitative Research Study (English)." World Bank Group, Washington, D.C.

Burstein, Ariel T., and Alexander Monge-Naranjo. 2009. "Foreign Know-How, Firm Control, and the Income of Developing Countries*." *Quarterly Journal of Economics*, 124(1): 149–195.

Colella, Fabrizio, Rafael Lalive, Sayhun Orcan Sakalli, and Mathias Thoening. 2019. "Inference with Arbitrary Clustering." *IZA Discussion Paper n. 12584.*

Crescenzi, Riccardo, and Nicola Limodio. 2021. "The Impact of Chinese FDI in Africa: Evidence from Ethiopia." *Institute of Global Affairs, the London School of Economics and Political Science.*

Damoah, Kaku Attah, Giorgia Giovannetti, and Marco Sanfilippo. 2021. "Markup Dispersion and Firm Entry: Evidence from Ethiopia." *Oxford Bulletin of Economics and Statistics*, 83(2): 299–327.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review*, 110(9): 2964–96.

de Chaisemartin, Clément, and Xavier D'Haultfoeuille. 2022. "Two-Way Fixed Effects and Differences-in-Differences with Heterogeneous Treatment Effects: A Survey." *Econometrics Journal*.

De Loecker, Jan, and Jan Eeckhout. 2018. "Global Market Power." *NBER WP N. 24768*.

De Loecker, Jan, and Patrick Warzynski. 2012. "Markups and Firm-Level Export Status." *American Economic Review*, 102(2012): 2437–2471.

De Loecker, Jan, Jan Eeckhout, and Simon Mongey. 2021. "Quantifying Market Power And Business Dynamism In The Macroeconomy." *Working Paper*.

Diewert, W. Erwin, and Kevin J. Fox. 2008. "On the estimation of returns to scale, technical progress and monopolistic markups." *Journal of Econometrics*, 145(1-2): 174–193.

Donaldson, Dave. 2018. "Railroads of the Raj: Estimating the Impact of Transportation Infrastructure." *The American Economic Review*, 108(4-5): 899–934.

Donaldson, Dave, and Richard Hornbeck. 2016. "Railroads and American Economic Growth: A "Market Access" Approach." *The Quarterly Journal of Economics*, 131(2): 799–858.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu. 2015. "Competition, Markups, and the Gains from International Trade." *American Economic Review*, 105(10): 3183–3221.

Ethiopian Roads Authority. 2011. "Road Sector Development Program 13 Years Performance and Phase IV." *ERA*.

Ethiopian Roads Authority. 2015. "The Road Sector Development Program: Phase V." Ministry of Transport, The Federal Democratic Republic of Ethiopia.

Ethiopian Roads Authority. 2016. "The Road Sector Development Program: 19 Years Performance Assessment."

Fiorini, Matteo, and Marco Sanfilippo. 2022. "Roads and Jobs in Ethiopia." *The World Bank Economic Review*, 36(4): 999–1020.

Fiorini, Matteo, Marco Sanfilippo, and Asha Sundaram. 2021. "Trade liberalization, roads and firm productivity." *Journal of Development Economics*, 153: 102712.

Gabaix, Xavier, and Rustam Ibragimov. 2011. "Rank — 1/2: A Simple Way to Improve the OLS Estimation of Tail Exponents." *Journal of Business and Economic Statistics*, 29(1): 24–39.

Greenstone, Michael, Richard Hornbeck, and Enrico Moretti. 2010. "Identifying Agglomeration Spillovers: Evidence from Winners and Losers of Large Plant Openings." *Journal of Political Economy*, 118(3): 536–598.

Holmes, Thomas J., Wen-Tai Hsu, and Sanghoon Lee. 2014. "Allocative Efficiency, Mark-ups, and the Welfare Gains from Trade." *Journal of International Economics*, 94(2): 195–206.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *The Quarterly Journal of Economics*, 124(4): 1403–1448.

Hwang, Kyung In. 2022. "The Pro-competitive Effects of Foreign Firm Entry: Evidence from the Korean Retail Sector." *The World Economy*, 45(5): 1587–1613.

Irarrazabal, Alfonso, Andreas Moxnes, and Luca David Opromolla. 2013. "The Margins of Multinational Production and the Role of Intrafirm Trade." *Journal of Political Economy*, 121(1): 74–126.

Javorcik, Beata. 2019. "Eight Things Development Professionals Should Know about Foreign Direct Investment." *PEDL Synthesis Paper.*

Javorcik, Beata, and Steven Poelhekke. 2017. "Former Foreign Affiliates: Cast Out and Outperformed?" *Journal of the European Economic Association*, 15(3): 501–539.

Jedwab, Remi, and Adam Storeygard. 2022. "The Average and Heterogeneous Effects of Transportation Investments: Evidence from sub-Saharan Africa 1960-2010." *Journal of the European Economic Association*, 20(1): 1–38.

Keller, Wolfgang, and Stephen R. Yeaple. 2020. "Multinationals, Markets, and Markups." *Working Paper.*

Levinsohn, James, and Amil Petrin. 2003. "Estimating Production Functions Using Inputs to Control for Unobservables." *The Review of Economic Studies*, 70(2): 317–341.

Li, Yue, Ryan Kuo, Mauricio Pinzon-Latorre, and Mark Albertson. 2022. "FDI, Market Power, and Markups. Evidence from Vietnam." *World Bank Policy Research Working Paper 9998.*

Lu, Yi, and Linhui Yu. 2015. "Trade Liberalization and Markup Dispersion: Evidence from China's WTO Accession." *American Economic Journal: Applied Economics*, 7(4): 221–53.

McGrattan, Ellen R. 2012. "Transition to FDI openness: Reconciling theory and evidence." *Review of Economic Dynamics*, 15(4): 437–458.

Ministry of Finance and Economic Development. 2010. "Growth and Transformation Plan: 2010/11–2014/15." Federal Democratic Republic of Ethiopia.

Moneke, Niclas. 2020. "Can Big Push Infrastructure Unlock Development? Evidence from Ethiopia." *Working Paper.*

Nathan Associates, Inc. 2013. "Development of a National Logistics Strategy for Ethiopia."

National Planning Commission. 2016. "Growth and Transformation Plan II (GTP II): (2015/16–2019/20)." Federal Democratic Republic of Ethiopia.

Nishioka, Shuichiro, and Mari Tanaka. 2019. "Measuring Markups from Revenue and Total Cost: An Application to Japanese Plant-Product Matched Data." *RIETI Discussion Paper Series 19-E-018.*

Ramondo, Natalia, and Andrés Rodríguez-Clare. 2013. "Trade, Multinational Production, and the Gains from Openness." *Journal of Political Economy*, 121(2): 273–322.

Restuccia, Diego, and Richard Rogerson. 2013. "Misallocation and productivity." *Review of Economic Dynamics*, 16(1): 1–10. Special issue: Misallocation and Productivity.

Restuccia, Diego, and Richard Rogerson. 2017. "The Causes and Costs of Misallocation." *Journal of Economic Perspectives*, 31(3): 151–174.

Roberts, Mark, Uwe Deichmann, Bernard Fingleton, and Tuo Shi. 2012. "Evaluating China's Road to Prosperity: A New Economic Geography Approach." *Regional Science and Urban Economics*, 42(4): 580–594.

Stiebale, Joel, and Dev Vencappa. 2018. "Acquisitions, Markups, Efficiency, and Product Quality: Evidence from India." *Journal of International Economics*, 112(C): 70–87.

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: 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.3 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.4: 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.4 reports the results of the estimation of equation (24). 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.5: Average and Median Markups by Region

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

Source: Authors' summary of LMMS data from CSA.

Table A.6: Average and Median Markups by Sector

Industry	2-digit code	Mean Markup	Median Markup
Food and beverages	15	1.20	1.11
Tobacco	16	1.99	1.86
Textiles	17	1.25	1.17
Wearing	18	1.22	1.14
Leather	19	1.13	1.11
Wood and wood products	20	1.40	1.31
Paper and paper products	21	1.26	1.24
Publishing and printing	22	1.33	1.31
Coke, refined pretroleum products and nuclear fuel	23	1.53	1.46
Chemical and chemical products	24	1.25	1.24
Rubber and plastics products	25	1.21	1.19
Other non-metallic mineral products	26	1.41	1.31
Basic metals	27	1.28	1.21
Fabricated metal product	28	1.24	1.19
Machinery and equipment	29	1.25	1.16
Office, accounting and computing machinery	30	1.23	1.23
Electrical machinery and apparatus	31	1.16	1.12
Radio, television and communication equipment	32	1.29	1.33
Medical, precision and optical instruments	33	1.16	1.16
Motor vehicles	34	1.18	1.19
Furniture	36	1.31	1.24
Recycling	37	1.75	1.46

Source: Authors' summary of LMMS data from CSA.

Table A.7: Changes in Real Income with Lower Transportation Costs (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GDP/GNP	Residual
Harari	3.96	3.89	−0.02	0.09	0.00	0.00
Somali	5.55	5.53	0.00	0.03	0.00	0.00
Afar	2.78	2.56	0.13	0.09	0.00	0.00
Dire Dawa	3.96	3.94	−0.09	0.07	0.04	0.00
Amhara	3.40	3.36	−0.01	0.03	0.02	0.00
SNNP	5.70	5.54	0.11	0.05	0.00	0.00
Tigray	4.47	4.06	0.34	0.06	0.01	0.00
Oromia	1.94	2.40	−0.35	−0.09	−0.01	0.00
Addis Ababa	1.09	0.76	0.23	0.11	−0.01	0.00
Aggregate	2.03	1.93	0.00	0.04	0.00	0.06

Notes: Table A.7 decomposes the percentage changes in real GNP when we increase transportation costs in the calibrated model to be consistent with those from 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 3–6 report the HHL decomposition of the changes in real GNP. Column 5 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.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 (10% prod.)	0.0142***	-0.0809**						
	(0.00406)	(0.0345)						
FDI dummy (10% empl.)			0.0127***	-0.0820**				
			(0.00362)	(0.0333)				
FDI dummy (20% prod.)					0.0155***	-0.0757**		
					(0.00432)	(0.0355)		
FDI dummy (50% prod.)							0.0143**	-0.106**
							(0.00555)	(0.0466)
Constant	0.637***	-1.533***	0.637***	-1.535***	0.637***	-1.529***	0.637***	-1.536***
	(0.00891)	(0.124)	(0.00894)	(0.124)	(0.00895)	(0.124)	(0.00908)	(0.125)
Observations	7,549	7,549	7,549	7,549	7,549	7,549	7,549	7,549
R-squared	0.210	0.454	0.211	0.455	0.210	0.454	0.209	0.454
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%, 20%, and 50% refer to a definition of treatment based on FDI accounting for the share of production in a given market at one of these levels. EMP refers to using a 10 percent share of total employment, rather than production, in determining the threshold for the treatment. 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.9: Changes in Markups When Exposed to Foreign Firms–Sub-samples of markets and districts

VARIABLES	(1) Theil	(2) Log markup	(3) Theil	(4) Log markup
FDI dummy	0.0192***	-0.0825**	0.0175***	-0.0786**
	(0.00420)	(0.0358)	(0.00370)	(0.0347)
Constant	0.614***	-1.417***	0.627***	-1.487***
	(0.0191)	(0.190)	(0.0118)	(0.147)
Observations	1,768	1,768	4,319	4,319
R-squared	0.355	0.428	0.372	0.432
District*Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Notes: This analysis replicates results of the last two columns of Table 9. Columns 1 and 2 are based on a sample of markets (district-industry pairs) evert targeted by FDI, while columns 3 and 4 use a sample of districts 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.10: FDI Entry and Markups

Variables	(1) FDI Entry	(2) FDI Entry	(3) FDI Entry
Markups	-0.0473	-0.0637	-0.0801
	(0.0488)	(0.0524)	(0.0823)
Constant	-1.881***	-1.351***	-1.713***
	(0.0757)	(0.170)	(0.408)
Observations	6,465	5,966	2,467
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 1 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.11: 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.12: Robustness: Alternative Definition of Markups

Variables	(1) Theil	(2) Log markup	(3) Log markup
FDI dummy	0.0197***	-0.0577*	
	(0.00377)	(0.0316)	
FDI market access			-0.0280***
			(0.00766)
Constant	0.619***	-0.484***	-0.494***
	(0.00937)	(0.125)	(0.122)
Observations	7,172	7,172	5,781
R-squared	0.412	0.506	0.494
District*Industry FE	Y	Y	Y
Year FE	Y	Y	Y

Notes: Estimations are based on an alternative definition of markups, using the approach by De Loecker and Eeckhout (2018). Columns 1 and 2 replicate the specifications in columns 5–6 of Table 9, while column 3 replicates the specification in column 1 of Table 11, but for this alternative measure of markups. 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.13: Robustness: Including District-year and Industry-year Fixed Effects

Variables	(1) Theil	(2) Log markup	(3) Log markup
FDI dummy	0.0106***	-0.0610	
	(0.00400)	(0.0408)	
FDI market access			-0.0211***
			(0.00682)
Constant	0.609***	-1.623***	-1.525***
	(0.0130)	(0.135)	(0.144)
Observations	6,096	6,096	4,810
R-squared	0.596	0.655	0.641
District*Industry FE	Y	Y	Y
District*Year FE	Y	Y	Y
Industry*Year FE	Y	Y	Y

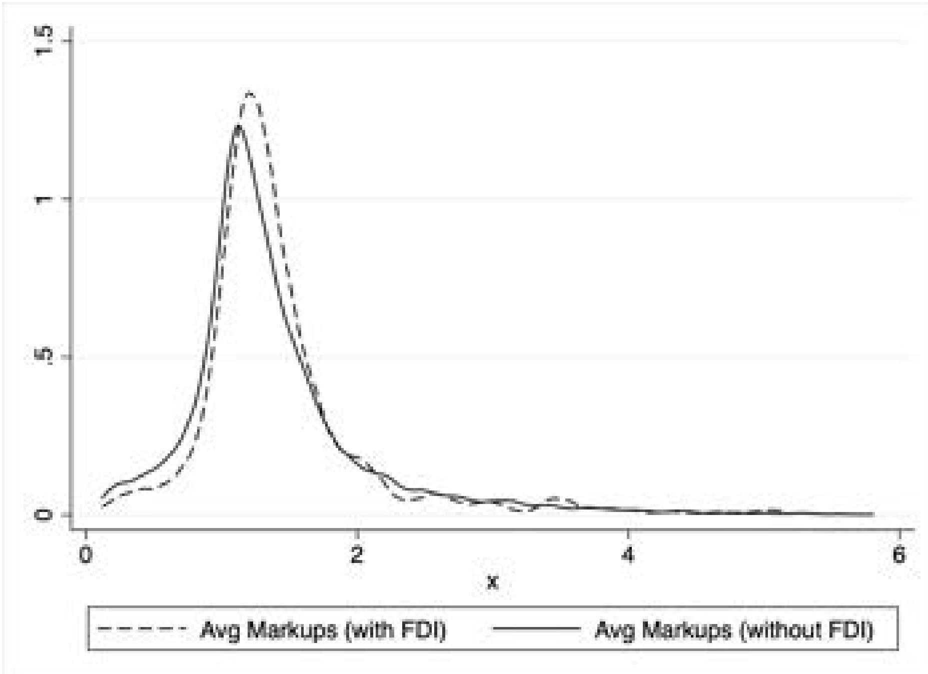
Notes: Columns 1 and 2 replicates the specifications in columns 5–6 of Table 9, while column 3 replicates the specification in column 1 of Table 11, but for the alternative measure of markups. All regressions control for the log of total production in each market. Standard errors clustered at the market level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A.14: Robustness: Accounting for Spatial Autocorrelation in the Residuals

Variables	(1) Theil	(2) Log markup	(3) Log markup	(4) Theil	(5) Log markup	(6) Log markup
FDI dummy	0.0176***	-0.106***		0.0170***	-0.111***	
	(0.00204)	(0.0335)		(0.00440)	(0.0256)	
FDI market access			-0.0262***			-0.0262***
			(0.00744)			(0.00932)
Constant	0.638***	-1.540***	-1.436***			
	(0.00759)	(0.124)	(0.131)			
Observations	7,549	7,549	5,946	7,418	7,418	6,293
R-squared	0.374	0.455	0.434	0.030	0.101	0.101
District*Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y

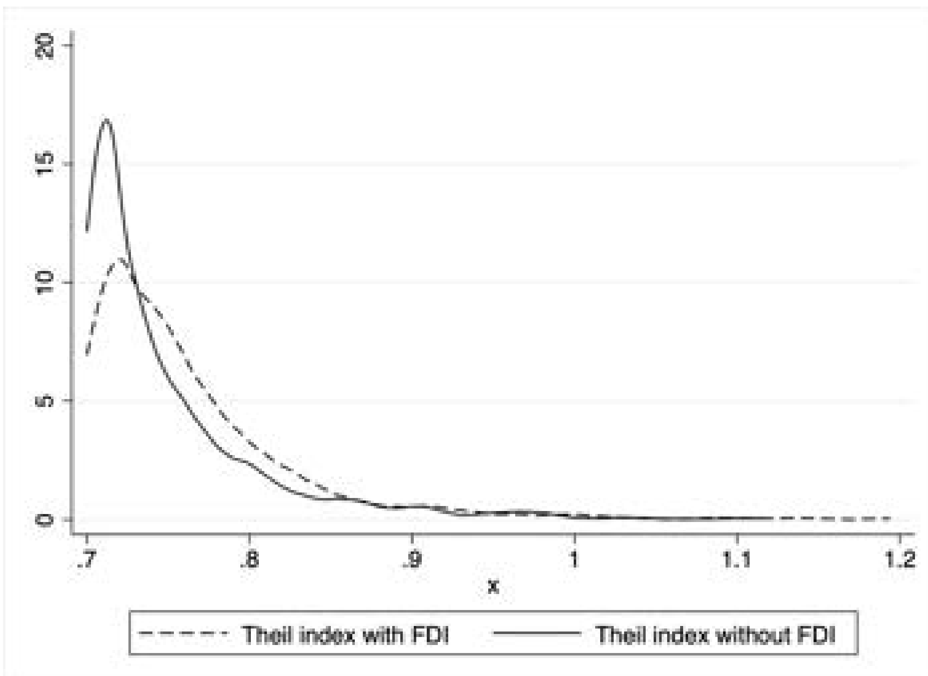
Notes: Columns 1–3 replicate the main results clustering the standard errors at the district level (rather than at the district-industry). Columns 4–6 replicate the main results correcting standard errors for spatial correlation using STATA command acreg, as introduced by Colella et al. (2019). All regressions 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



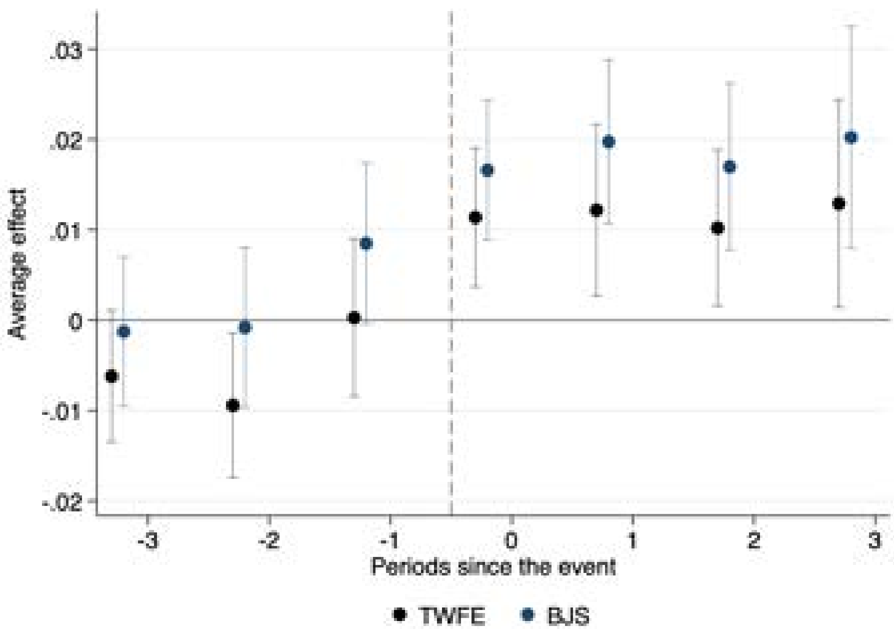
Notes: Figure A.1 reports kernel densities of markups, calculated for a sample of the market including only domestic firms and for a sample including both domestic and foreign firms.

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



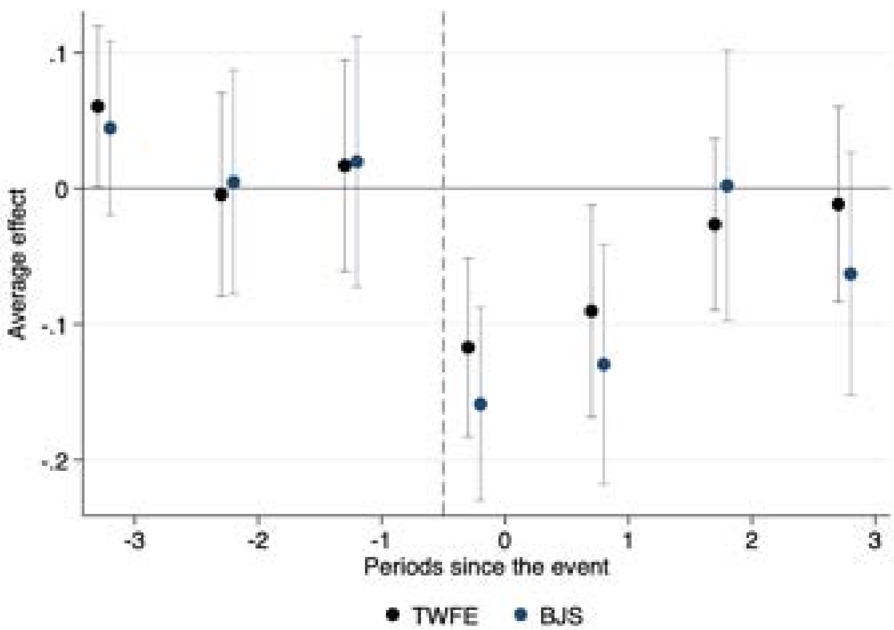
Notes: Figure A.2 reports kernel densities of the Theil index, calculated for a sample of the market including only domestic firms and for a sample including both domestic and foreign firms.

Figure A.3: Dynamic Specifications: Theil Index



Notes: Figure A.3 reports coefficients and their 90 percent confidence intervals based on estimators using a two-way fixed effect approach (TWFE) and the approach by Borusyak, Jaravel and Spiess (2022) (BJS). Estimates of the latter are based on the authors' STATA command did_imputation, while the graph has been produced using the command event_plot.

Figure A.4: Dynamic Specifications: Average Markups



Notes: Figure A.4 reports coefficients and their 90 percent confidence intervals based on estimators using a two-way fixed effect approach (TWFE) and the approach by Borusyak, Jaravel and Spiess (2022) (BJS). Estimates of the latter are based on the authors' STATA command did_imputation, while the graph has been produced using the command event_plot.

B Model with Entry and Exit

In this section, we extend the model in Section 3 so that the number of firms, K_{oj}, is endogenous. This extension allows us to study how our results are affected if we allow for the entry and exit of firms after the FDI reform.

B.1 Model

Firms play a two-stage entry game. In the second stage, a firm takes the number of other firms located in region o in sector j, K_{oj}, as given and solves the maximization problem described in equation (7) for every region. In the first stage, a large number of potential entrants can observe their productivity without paying any fixed cost but must pay a fixed cost, $F_o(j)$ in units of labor, if they choose to enter. Firm k will enter in the first stage if, taking the action of other firms in sector j and aggregate variables as given, the following condition is satisfied:

$$\sum_{d=1}^{N} \pi_d^o(j,k) \geq W_o F_o(j), \tag{33}$$

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

The aggregate profits of firms in region n, previously denoted by equation (11), becomes

$$\Pi_n = \int_0^1 \left[\sum_{k=1}^{K_{nj}} \left(\sum_{d=1}^{N} \pi_d^n(j,k) - W_o F_o(j) \right) \right] dj. \tag{34}$$

The labor clearing condition for region n, previously denoted by equation (13), becomes

$$\int_0^1 \left[\sum_{k=1}^{K_{nj}} \left(\sum_{d=1}^{N} \frac{c_d^n(j,k)}{a_n(j,k)} \tau_d^n + F_o(j) \right) \right] dj = L_n. \tag{35}$$

We must also update the HHL decomposition to allow for the inclusion of entry costs, as we do in Theorem 1.

Theorem 1. *In a model with entry costs, the HHL decomposition becomes*

$$\frac{GNP_n}{P_n} = \underbrace{W_n L_n}_{\text{Labor income}} * \underbrace{\frac{1}{P_n^{pc}}}_{\text{Prod. efficiency}} * \underbrace{\frac{\mu_n^{sell}}{\mu_n^{buy}}}_{\text{Markup ToT}} * \underbrace{\frac{P_n^{pc}}{P_n}\mu_n^{buy}}_{\text{Allocative efficiency}} * \underbrace{\frac{GNP_n}{GDP_n}}_{\text{Ratio GNP/GDP}} * \underbrace{\frac{L_n^V}{L_n}}_{\text{Entry cost}}, \tag{36}$$

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

$$L_n^V = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} \frac{c_d^n(j,k)}{a_n(j,k)} \tau_d^n \right) dj. \tag{37}$$

Proof. See Online Appendix D. □

Note that the expression in equation (36) is the same as before, as denoted in equation (21), except that it has 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.

B.2 Calibration

We aim to calibrate the new model so that it resembles the baseline model as much as possible. This approach will enable us to study the effects of allowing for the entry and exit of firms in our baseline results. For that reason, we will follow a calibration strategy so that the new model matches the number of firms in each region and sector in the baseline model. Note that the number of firms in the baseline model also matches that in the data.

We use the same demand elasticities, θ and γ, fraction of local ownership of firms, $\phi_o(j,k)$, and transportation costs, τ_d^o, as in the baseline calibration. In the following paragraphs, we describe the calibration of the entry costs and labor endowments as well as the selection of productivity draws for firms that are not present in the baseline calibration.

Productivity We use the same set of firm productivities as in the baseline model. However, we also need to select additional productivity draws, given that potentially a large number of new firms could enter. To do so, we use the following condition that has been commonly used to estimate the tail parameter of a Pareto distribution using data generated by that distribution:

$$\log \text{Rank} = \alpha_0 - \alpha_1 \log a, \tag{38}$$

where Rank is the rank of a productivity draw, a is the productivity draw, α_1 is an estimate of the tail parameter of the productivity distribution, and α_0 is a constant.[45]

[45] See, for example, Gabaix and Ibragimov (2011), which, discusses this estimation strategy and the necessary assumptions for identification.

We first determine α_0 implied by equation (38) for each region-sector pair. In particular, we solve for α_0 using the rank and productivity of the firm with the lowest productivity in the baseline model in a region-sector; in this process, we use $\alpha_1 = 1.15$, which is consistent with the tail parameter of the Pareto distribution in the baseline model. Having solved for the α_0 of a given region and sector, we generate the productivity of a large number of productivity draws using equation (38) along with the rank of the productivity draw.

Entry costs and labor endowments Given the large number of productivity draws, we take the following steps to calibrate the fixed entry cost for each region-sector pair and the labor endowment for each region:

1. Determine the entry cost, $F_o(j)$.
    - Using the output from the baseline model presented in Section 3, find $\pi_d^o(j,k)$ for each firm.
    - For each region o and sector j, find the firm with the lowest productivity, $\tilde{k}$.
    - Set $F_o(j) = \pi_d^o(j,\tilde{k})/W_o * \chi$. Note that if $\chi = 1$, then it would be similar to a case in which the smallest firm has zero profit and $0 < \chi < 1$ corresponds to the case in which the smallest firm has a positive profit.
2. Calibrate labor endowment, L_n.
    - Given $F_o(j)$ determined in the previous step and the K_{oj} from the baseline model, we calibrate the labor endowments of each region. Note that in this step, we take the number of firms as given.
3. Determine the number of firms, K_{oj}.
    - Using the K_{oj} from the baseline model as a starting point, we check to see whether it is profitable for additional firms to enter, which will be a function of the χ selected in the first step. For example, if $\chi = 0.80$, then some additional firms beyond those that we see in the data will find it profitable to enter. If $\chi = 0.85$, then the entry costs are high enough so that it is not profitable for additional firms to enter.
    - We check that it is profitable for all firms in equilibrium to enter after paying the entry cost.

We follow a guess and verify procedure. We first select a low χ and follow steps 1–3 as decribed above. If additional firms would like to enter in step 3 (relative to the number of firms in the baseline model), we raise χ by intervals of 0.05 and repeat steps 1–3. We continue to raise χ until we find that no additional firms would like to enter in step 3.

We find that $\chi = 0.85$ results in a calibration in which the new model has exactly the same number of firms as in the baseline model. Note that step 3 ensures that two key equilibrium conditions are satisfied: 1) all firms that entered are profitable after paying the entry cost and 2) no potential entrant finds it profitable to enter. It is also useful to note that, although multiple χ's in this calibration are consistent with the number of firms in the baseline model, the range of χ is relatively small (0.85 to 1).

B.3 FDI Reform

We conduct the FDI reform in the model in which there is entry and exit.[46] We find that, although there are significant changes in the number of firms in the economy, the aggregate welfare results are largely similar to the case with no entry or exit (i.e., we find large gains from the FDI reform and these gains are spread out throughout the country). However, we offer two general caveats. First, the aggregate gains are a little smaller than in the baseline case. Second, the model with entry and exit highlights subtleties in the channels through which FDI affects welfare.

We find a significant decline of 18 percent in the number of firms in the economy after the FDI reform. Thus, the model finds that there can be significant changes in the composition of firms in the local economy with the entry of foreign firms. Table B.1 reports the changes in real GDP and GNP after the FDI reform. We find that the gains are large although a little smaller than in the baseline case. For example, real GDP increases by 12.9 percent (vs. 15.9), and real GNP increases by 8.3 percent (vs. 9.7). We also find that, as in the baseline case, approximately one-third of the gains accrue to GDP but not GNP. As before, we find that the gains are spread out across the country, even in regions that did not receive large amounts of FDI. For example, Addis Ababa and Oromia, the main targets of FDI, gained

[46] To determine the number of firms in each region and sector when there are no foreign firms, we first remove foreign firms from the model and recalculate the aggregate variables (Y_n, P_n, and w_n). We then use the following procedure:

1. Given the aggregate variables, determine whether any firm is unprofitable. If so, drop that firm from the equilibrium.
2. Given the aggregate variables, determine whether the next firm in terms of productivity in each origin-destination finds it profitable to enter.
3. Recalculate all aggregate variables given the new firms that we eliminated in step 1 and the new firms that entered in step 2.

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

over 9.8 percent on average, whereas the other regions gained 4.5 percent on average.

Table B.1: Changes in Real Income after FDI Reform (%)

Region	GDP/P	GNP/P
Harari	−0.10	−0.10
Somali	9.14	9.14
Afar	3.60	3.60
Dire Dawa	8.67	7.89
Amhara	4.81	4.33
SNNP	4.17	4.15
Tigray	4.06	2.15
Oromia	20.47	11.07
Addis Ababa	12.16	8.55
Aggregate	12.91	8.26

Notes: Table B.1 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 B.2 reports the results of the HHL decomposition described in equation (36). We find that changes in allocative efficiency are negative, as in the baseline case, and of a very similar magnitude (–0.78 vs. –0.81). We also find that the entry cost channel contributes negatively and is –3.66 percent. Thus, the fraction of labor devoted to paying the entry cost increases with the presence of foreign firms. On the one hand, fewer firms are in the economy, which reduces the number of firms paying the entry cost. On the other hand, foreign firms tend to enter sectors with high entry costs, which increases the average entry cost of firms in the economy. We also find that the channel related to the ratio of GNP to GDP is –4.65 (vs. –6.19). Thus, the entry of foreign firms in sectors with high entry costs implies that the profitability of foreign firms is lower than in the baseline case, resulting a moderation in the decline in the ratio of GNP to GDP.

Table B.2: Changes in Real Income after FDI Reform, Decomposed (%)

Region	GNP/P	Ricardian	Markup ToT	AE	GNP/GDP	Entry cost	Residual
Harari	−0.10	12.65	−7.30	−1.07	0.00	−4.38	0.00
Somali	9.14	18.90	−3.44	−1.09	0.00	−5.22	0.00
Afar	3.60	12.46	−7.76	−0.95	0.00	−0.14	0.00
Dire Dawa	7.89	18.08	9.20	−1.08	−0.78	−17.53	0.00
Amhara	4.33	16.40	−1.30	−1.01	−0.48	−9.28	0.00
SNNP	4.15	13.70	−2.88	−1.06	−0.02	−5.60	0.00
Tigray	2.15	16.24	−3.78	−0.84	−1.91	−7.56	0.00
Oromia	11.07	23.01	3.05	−0.97	−9.40	−4.62	0.00
Addis Ababa	8.55	15.47	−1.20	−0.60	−3.61	−1.51	0.00
Aggregate	8.26	17.57	0.00	−0.78	−4.65	−3.66	−0.23

Notes: Table B.2 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.

C 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*

$$\hat{C}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \left[\xi(j,k)\hat{c}_n^o(j,k)\right]^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \tag{39}$$

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 can show that this model with quality is equivalent to our baseline model in which we rewrite the consumption of firm k*'s good as*

$$c_n^o(j,k) = \xi(j,k)\hat{c}_n^o(j,k), \tag{40}$$

firm k*'s productivity as*

$$a_o(j,k) = \xi(j,k)\hat{a}_o(j,k), \tag{41}$$

and firm k*'s price in location* d *as*

$$p_d^o(j,k) = \frac{\hat{p}_d^o(j,k)}{\xi(j,k)}. \tag{42}$$

Proof. See Online Appendix D.

□

D Proofs

Proof of Theorem 1

Proof. We define the following expressions:

$$L_n^F = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} F_o(j) \right) dj, \tag{43}$$

$$\Pi_n^V = \int_0^1 \left(\sum_{k=1}^{K_{nj}} \sum_{d=1}^{N} \pi_d^n(j,k) \right) dj, \tag{44}$$

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

Note that $L_n = L_n^V + L_n^F$ and $\Pi_n = \Pi_n^V + \Pi_n^F$.

We have that

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{W_n L_n^V + \Pi_n^V}{P_n} * \frac{W_n L_n + \Pi_n}{W_n L_n^V + \Pi_n^V}. \tag{46}$$

We now show that the last term is equal to 1

$$\frac{W_n L_n + \Pi_n}{W_n L_n^V + \Pi_n^V} = \frac{W_n L_n^V + W_n L_n^F + \Pi_n^V + \Pi_n^F}{W_n L_n^V + \Pi_n^V}, \tag{47}$$

where $W_n L_n^F = -\Pi_n^F$, which implies that the whole expression in equation (47) is equal to 1. We use this condition and substitute into equation (46):

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{W_n L_n^V + \Pi_n^V}{P_n}. \tag{48}$$

We can now apply the same process from the original HHL decomposition to find

$$\frac{W_n L_n + \Pi_n}{P_n} = \frac{\mu_n^{sell} W_n L_n^V}{P_n}. \tag{49}$$

We rearrange the equation to find

$$\frac{W_n L_n + \Pi_n}{P_n} = W_n L_n * \frac{1}{P_n^{pc}} * \frac{\mu_n^{sell}}{\mu_n^{buy}} * \frac{P_n^{pc}}{P_n} \mu_n^{buy} * \frac{L_n^V}{L_n}. \tag{50}$$

We substitute the expressions $GDP_n = W_n L_n + \Pi_n$ and $GNP_n = W_n L_n + \Pi_n^L$ and rearrange to find equation (36). □

Proof of Theorem 2

Proof. We can show that, in addition to equation (39), the model with heterogeneous quality is characterized by the following equations:

$$\hat{C}_n = \left(\int_0^1 \hat{C}_n(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \tag{51}$$

$$\int_0^1 \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \hat{p}_n^o(j,k) \hat{c}_n^o(j,k) \right) dj = \hat{W}_n L_n + \hat{\Pi}_n, \tag{52}$$

$$\hat{c}_n^o(j,k) = \left(\frac{\hat{P}_n}{\hat{P}_n(j)} \right)^{\theta} \left(\frac{\hat{P}_n(j)}{\hat{p}_n^o(j,k)} \right)^{\gamma} \xi(j,k)^{\gamma-1} \hat{C}_n, \tag{53}$$

$$\hat{P}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \xi(j,k)^{\gamma-1} \hat{p}_n^o(j,k)^{1-\gamma} \right)^{\frac{1}{1-\gamma}}, \tag{54}$$

$$\hat{P}_n = \left(\int_0^1 \hat{P}_n(j)^{1-\theta} dj \right)^{\frac{1}{1-\theta}}, \tag{55}$$

$$\hat{p}_d^o(j,k) = \frac{\hat{\epsilon}_d^o(j,k)}{\hat{\epsilon}_d^o(j,k) - 1} \frac{\hat{W}_o}{\hat{a}_o(j,k)} \tau_d^o, \tag{56}$$

$$\hat{\epsilon}_d^o(j,k) = \left(\hat{\omega}_d^o(j,k) \frac{1}{\theta} + (1 - \hat{\omega}_d^o(j,k)) \frac{1}{\gamma} \right)^{-1}, \tag{57}$$

$$\hat{\omega}_d^o(j,k) = \frac{\hat{p}_d^o(j,k) \hat{c}_d^o(j,k)}{\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} \hat{p}_d^o(j,k) \hat{c}_d^o(j,k)}, \tag{58}$$

$$\hat{\Pi}_n = \int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \hat{\pi}_d^n(j,k) \right) dj, \tag{59}$$

$$\int_0^1 \left(\sum_{o=1,\ o \neq n}^{N} \sum_{k=1}^{K_{oj}} \hat{p}_n^o(j,k) \hat{c}_n^o(j,k) \right) dj = \int_0^1 \left(\sum_{d=1,\ d \neq n}^{N} \sum_{k=1}^{K_{nj}} \hat{p}_d^n(j,k) \hat{c}_d^n(j,k) \right) dj, \tag{60}$$

$$\int_0^1 \left(\sum_{d=1}^{N} \sum_{k=1}^{K_{nj}} \frac{\hat{c}_d^n(j,k)}{\hat{a}_n(j,k)} \tau_d^n \right) dj = L_n. \tag{61}$$

We now want to show that if equations (40)–(42) hold, then the conditions in the baseline model are also satisfied. We will now show that the following relationships between the baseline model and the model with quality hold:

$$\hat{C}_n(j) = C_n(j), \tag{62}$$

$$\hat{C}_n = C_n, \tag{63}$$

$$\hat{P}_n(j) = P_n(j), \tag{64}$$

$$\hat{P}_n = P_n, \tag{65}$$

$$\hat{\epsilon}_d^o(j,k) = \epsilon_d^o(j,k), \tag{66}$$

$$\hat{\omega}_d^o(j,k) = \omega_d^o(j,k), \tag{67}$$

$$\hat{\Pi}_n = \Pi_n, \tag{68}$$

$$\hat{W}_n = W_n. \tag{69}$$

To derive equation (62), we combine equations (39) and (40):

$$\hat{C}_n(j) = \left(\sum_{o=1}^{N} \sum_{k=1}^{K_{oj}} c_n^o(j,k)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}. \tag{70}$$

We then substitute equation (2) to find equation (62). Furthermore, equation (62) implies equation (63). We can similarly arrive at equation (64) by combining equations (42) and (54). We similarly notice that equation (64) implies equation (65).

For equations (66) and (67), notice that the expenditure on all goods is the same in both models, meaning that $\tilde{p}_d^o(j,k)\tilde{c}_n^o(j,k) = p_d^o(j,k)c_n^o(j,k)$. 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 (68), we can also show that

$$\pi_d^o(j,k) = \frac{p_d^o(j,k)c_d^o(j,k)}{\epsilon_d^o(j,k)}. \tag{71}$$

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 (11).

For equation (69), because the expenditures on all goods remain the same, the balanced trade condition in equation (12) is satisifed. The labor demand to produce goods for region d, $\frac{\tilde{c}_d^n(j,k)}{\tilde{a}_n(j,k)}\tau_d^n$, remains the same as before after substituting the conditions in equations (40) and (41) into this expression. Thus, the labor clearing condition in equation (13) is satisfied. Given that the labor demand is the same in both formulations, it must be that wages also remain unchanged.

We can use the conditions in equations (40)–(42) and (62)–(69) to rewrite the equilibrium conditions in equations (39) and (51)–(61) 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.

□