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Essays on Economic Growth, Institutions and Technology Diffusion

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by

Diana María Van Patten Rivera

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ABSTRACT OF THE DISSERTATION

Essays on Economic Growth, Institutions and Technology Diffusion

by

Diana María Van Patten Rivera
Doctor of Philosophy in Economics
University of California, Los Angeles, 2020
Professor Lee Ohanian, Chair

In the first chapter of this dissertation (joint with Esteban Méndez-Chacón), we study the short- and long-run effects of large firms on economic development. To do so, we use evidence from one of the largest multinationals of the 20th Century: The United Fruit Company (UFCo). The firm was given a large land concession in Costa Rica — one of the so-called "Banana Republics"— from 1889 to 1984. Using administrative census data with census-block geo-references from 1973 to 2011, we implement a geographic regression discontinuity (RD) design that exploits a quasi-random assignment of land. We find that the firm had a positive and persistent effect on living standards. Regions within the UFCo were 26% less likely to be poor in 1973 than nearby counterfactual locations, with only 63% of the gap closing over the following 3 decades. Company documents explain that a key concern at the time was to attract and maintain a sizable workforce, which induced the firm to invest heavily in local amenities that likely account for our result.

We then build a dynamic spatial model in which a firm's labor market power *within* a region depends on how mobile workers are *across* locations and run counterfactual exercises. The model is consistent with observable spatial frictions and the RD estimates, and shows that the firm increases aggregate welfare by 2.9%. This effect is increasing in worker mobility: If workers were half as mobile,

the firm would have *decreased* aggregate welfare by 6%. The model also shows that a local monopsonist compensates workers mostly through local amenities keeping wages low, and leads to higher welfare levels than a counterfactual with perfectly competitive labor markets in all regions, if we assume amenities increase local productivity.

In the second chapter of this dissertation, I study an important question in the field of economic growth and development: How developing countries learn to adopt and use new technologies. In particular, the chapter studies how countries learn from each other through international trade. First, I build a panel of bilateral trade flows between industries in different countries. Matching this panel with data on industry-level productivity, I document how productivity grows systematically faster for countries that trade with partners with better technologies, but that this is reducing the gap between local and foreign productivity.

Second, I build a model in which knowledge transfers can occur through imported technology, leading to productivity growth. In my framework, agents have heterogeneous learning abilities: The probability of a producer adopting a technology slightly better than hers is larger than the probability of adopting a much more sophisticated one —the trade-off being that conditional on adoption, more sophisticated technologies lead to higher productivity. I document how the model matches the empirical dependence of productivity growth on productivity gaps across trading partners, and the firm size distribution. The model also highlights how ignoring differences in learning abilities can overestimate the impact of exposure to high-TFP trading partners, leading to suboptimal trade policies. I conclude that developing countries should direct relatively more trade to mid-productive countries —as opposed to very productive ones— to maximize technology transfers and increase growth.

The dissertation of Diana María Van Patten Rivera is approved.

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2020

To God, who has been my guide and companion through my journey,
and to my loving family, who always supports me and who I miss with all my heart every time we are apart.

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CHAPTER 1

Multinationals, Monopsony and Local Development: Evidence from the United Fruit Company

(with Esteban Méndez-Chacón)

1.1 Introduction

The top 1% of the largest firms in emerging economies account for more than one-half of local exports and are primarily foreign-owned (Freund and Pierola, 2015). Despite their central role in developing countries, the extent to which host economies benefit from these enterprises is widely debated. On the one hand, monopsony power and the extractive activities of these foreign companies may explain why some places remain persistently poorer than others (Borensztein et al., 1995; Aitken and Harrison, 1999; Xu, 2000; Alfaro et al., 2003; Alfaro and Charlton, 2007). On the other hand, new technologies and capital injections associated with these firms can positively affect long-run growth (Blomstrom, 1986; Blomstrom and Wolff, 1989; Lipsey, 2002; Smarzynska Javorcik, 2004; Harrison and Rodríguez-Clare, 2009). The empirical evidence, however, remains scarce. In fact, it is challenging to estimate the causal effects of these firms on local development and follow their evolution over time.

This paper studies the short- and long-run effects of large foreign investment projects on local economic development. We also explore the role of monopsony power and of the spatial structure of the labor market in determining the direction and persistence of these effects. To do so, we use evidence from one of the largest multinationals of the 20th Century: The United Fruit Company (UFCo), the infamous firm hosted by the so-called "Banana Republics". This American firm was given a large land concession in Costa Rica,[1] and was the only employer in this region—where it required workers to live—from 1889 to 1984. In this sense, the firm appeared to function as a *local* monopsonist.

The concession had a well-defined boundary, and we identify a segment of this boundary that was redrawn quasi-randomly.[2] This quasi-random variation, along with detailed census micro-data geo-referenced at the census-block level, allows us to use a geographic regression discontinuity design to identify the effect of being under the company's *direct* influence. Specifically, we compare units located within a close distance from, but on different sides of, the UFCo boundary. Our data spans over a decade before the company stops operating, and almost three decades after its closure (1973-2011), which allows us to document how the UFCo effect evolves over time.

We find that households living within the former UFCo regions have had better economic outcomes (housing, sanitation, education, and consumption capacity), and were 26% less likely to be poor than households living outside. This effect is persistent over time: Since the UFCo closed, the treated and untreated regions have converged slowly, with only 56% of the income gap closing over the following 3 decades.[3]

[1] This concession was equivalent to 4% of the national territory and of around 4500 acres. For reference, since 2006, more than 400 land acquisitions in Africa, Central and Southeast Asia, Eastern Europe and Latin America have been larger than the UFCo's concession in Costa Rica (Cotula and Vermeulen, 2009).

[2] This segment of the boundary was redrawn in 1904 and jointly shaped by a river and how this river intersected preexisting land plots, leading to a border with balanced geographic attributes and uncorrelated with ex-ante determinants of growth.

[3] Robustness checks include: A falsification test, in which we draw placebo borders and rerun our analysis; estimations using different bandwidths and considering different subsamples of the population, such as only non-migrants; and estimations using the entire boundary, among

Historical data collected from primary sources suggests that investments in local amenities carried out by the UFCo—hospitals, schools, roads—are the main drivers of our results. For instance, we document that investments per student and per patient in UFCo-operated schools and hospitals were significantly larger than in local schools and hospitals run by the government, and sometimes even twice as large. Access to these investments was restricted, for the most part, to UFCo workers who were required to live within the plantation. This might explain the sharp discontinuity in outcomes right at the boundary.We do not find evidence of other channels, such as selective migration or negative spillovers on the control group, being the main mechanisms behind our results.[4]

Why were these investments in local amenities higher than in the rest of the country? While the company might have invested in hospitals to have healthier workers, it is less clear why it would benefit from more schooling. Evidence from archival company annual reports suggests that these investments were induced by the need to attract and maintain a sizable workforce, given the initially high levels of worker turnover.[5] For instance, after describing annual turnovers of up to 100% per year, the 1922 report (p.74) states "These migratory habits do not permit them to remain in the plantation from one year to the next, and *as soon as they become physically efficient in our methods and acquire money they either return to their homes or migrate elsewhere and must be replaced.*" Later, the 1925 report (p.170) states "We recommend a greater investment in corporate welfare beyond medical measures. An endeavor should be made to stabilize the population...we must provide measures for taking care of families of married men, by furnishing them with *garden facilities, schools, and some forms of entertainment. In other*

others.

[4]Our analysis—using census micro-data dating as far back as 1927—actually suggests that migrants to the UFCo were *negatively* selected.

[5]High turnover was a result of the workers' main outside option: Coffee. Unlike bananas, coffee is a seasonal crop, and workers could earn relatively high wages during the coffee harvesting season.

words, we must take an interest in our people if we might hope to retain their services indefinitely."

Quantitative evidence is consistent with the qualitative evidence from the company reports. In fact, empirically, the intensity of UFCo's investments in a location is positively correlated with the degree of competition for labor faced by the company. Using suitability to grow coffee (the main outside option for agricultural workers at the time) to instrument for wages, we find that locations where workers had higher outside options in 1973 also had higher living standards in 2011, on average. For instance, an increase of 1 pp in the average outside option of an UFCo region in 1973 is associated with a .02 pp lower probability of being poor for households in this location in 2011.

Our mechanisms suggest that the relationship between labor mobility, monopsony power, and investments was crucial in determining the firm's effect. Motivated by this evidence and the growing literature on the effects of market power, and in order to account for spillover and run a counterfactual analysis, we build a dynamic model of economic geography. This framework allows us to have a better understanding of the company's aggregate effect after accounting for general equilibrium effects, and to run counterfactuals to shed light on how the firm's impact changes in scenarios with less worker mobility or with a more competitive labor market.

In our model, the company is a local monopsony in one location, while workers are mobile across locations. Thus, *the less mobile workers are, the more inelastic the labor supply that the firm faces is.* In other words, the degree of monopsony power of the firm *within* its region depends on how mobile workers are *across* locations. To incorporate the investment dynamics that we documented empirically, we assume that the local monopsonist can choose workers' compensation bundle: A combination of wages and local amenities. These local amenities are costly for the firm and depreciate over time, but increase workers' utility and make workers more productive. Understanding the conditions that determine the composition of this compensation is one of our goals. The model is consistent with local estimates from our empirical analysis and moments of the historical data, and captures observable spatial frictions. We also use the migration gravity equation along with an instrumental variables strategy that follows Allen and Donaldson (2018) to obtain an estimate of the migration elasticity.

We find that after accounting for general equilibrium effects, the company increased the country's welfare by 2.9%. A counterfactual exercise with perfect competition in the labor market in all regions, as opposed to monopsony within the company's region, shows a difference in the composition of the compensation bundles chosen by the firm. A monopsonist compensates workers mostly through local amenities while keeping wages low. Assuming the firm has no monopsony power, however, leads to a compensation consisting mostly of wages, with lower levels of investment. If we assume amenities (schools, hospitals) increase productivity, aggregate welfare is higher in the monopsonist's case compared with a case that features perfect competition in every region's labor market.

The company's welfare effect also depends crucially on worker mobility. For instance, the firm would have *decreased* aggregate welfare by 6% if workers were half as mobile. The intuition behind this result is that if workers are less mobile their outside option decreases, and the company can reduce their compensation. In the extreme case of immobile workers, the company could potentially not pay for the labor input, thereby negatively affecting worker's welfare.

The result of this counterfactual analysis—that the firm could have had a large negative impact on welfare if workers were relatively immobile—allows us to reconcile our results with findings from a growing body of literature that analyzes the long-run impact of colonial and historical institutions on economic development. Most prior literature has considered settings in which labor was coerced and relatively immobile, such as the slave trade (Nunn, 2008), the *mita* system in Peru (Dell, 2010), forced coffee cultivation in Puerto Rico (Bobonis and Morrow, 2013), forced rubber cultivation in what is today the Democratic

Republic of Congo (Lowes and Montero, 2016), or the Dutch Cultivation System (Dell and Olken, 2017). This literature consistently finds that companies tend to underprovide public goods within their concessions and that exposure to these regimes can lead to negative and persistent effects on development.[6] We thereby complement these studies by shedding light on the importance of workers' outside options in determining the direction of this effect.

Our works also contributes to three strands of the literature on the consequences of firms exercising market power. First, we explore theoretically and quantitatively how the degree of labor market power of a firm *within* a location depends on the mobility of workers *across* locations. This idea was explored by early literature describing the market for college professors, in which some employers are geographically isolated and pay low wages to professors with high moving costs (Black and Loewenstein, 1991; Ransom, 1993), and more recently by recent literature on labor economics that studies the effects of local labor market power and how this affects the spatial distribution of employment (Neumark et al., 2008; Holmes, 2011; Pope and Pope, 2015).[7] Second, we explore how this local monopsony power affects a firm's incentive to invest in local amenities, and consider a compensation that does not focus only on wages as in Gutiérrez and Philippon (2017) and Autor et al. (2017), who document an increase in market power associated with declines in the labor share across many industries. More recently, Berger et al. (2018) build a model to study labor market power and the declining labor share in the US. Third, we study long-run outcomes and how persistent these effects can be.

Finally, the paper is related to the literature on the effects and spillovers of

[6]An exception being Dell and Olken (2017), who find that villages forced to grow sugar cane have better long-run outcomes as a result of sugar factories and industrial structures promoting economic activity, with locations close to former factories in the mid-19th century being more industrialized today.

[7]Recent work by (Kahn and Tracy, 2019), which was developed in parallel with ours, also explores how local monopsony power affects the spatial distribution of wages and rents across cities.

foreign direct investment (FDI). Our paper contributes to this literature by providing novel micro-evidence of the benefits of large-scale FDI through a natural experiment. Empirical studies on the effects of FDI have produced mixed evidence. While some studies find evidence of FDI being beneficial using macro- and micro-data (e.g., Blomstrom 1986; Blomstrom and Wolff 1989; Smarzynska Javorcik 2004; Lipsey 2006; Harrison and Rodríguez-Clare 2009), others are not so optimistic about these benefits, especially for developing countries (e.g., Aitken and Harrison 1999; Borensztein et al. 1995; Xu 2000; Alfaro et al. 2003; Alfaro and Charlton 2007). We show how in a context with high labor mobility FDI had positive local and aggregate effects due to the need to compete for labor, while in cases with low labor mobility, both local and aggregate effects can be negative.

The rest of the paper is organized as follows. Section 1.2 provides an overview of the historical background. Section 1.3 includes details of the data used in our analysis. We describe our estimation framework in Section 1.4. Section 1.5 presents our results. We discuss evidence on the potential the mechanisms behind our findings in Section 1.6. Section 1.7 develops the model and presents the counterfactual exercises, and Section 1.8 concludes.

1.2 Historical Background

1.2.1 Historical Overview

The history of banana plantations in Costa Rica dates back to the construction of from the capital to the Caribbean Coast in 1884. In exchange of building this railroad, the government gave Minor C. Keith—an American contractor—a concession of 3,333 km^2 of undeveloped land equivalent to 4% of the country's territory (Casey, 1979). The area corresponding with this concession is shown in Figure 1.1. After completing the railroad's construction, Keith experimented with exporting the bananas he had planted along the railroad tracks to feed workers

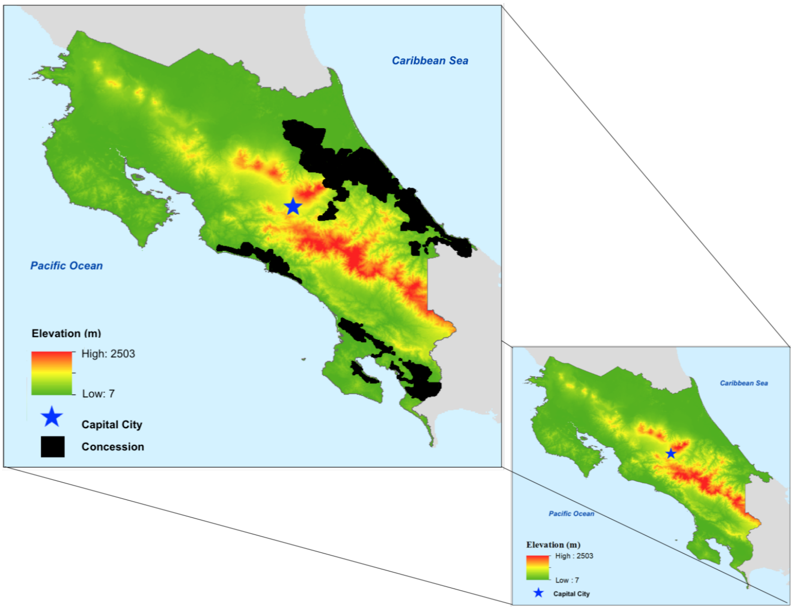
(Bucheli, 2005). The experiment was successful, and the UFCo was founded in 1899.

With its headquarters in Boston, the company eventually had operations in Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, and Panama (May and Lasso, 1958). According to the UFCo's Annual Reports to the Shareholders, by 1930, the company landholdings in Latin America reached 13,339.12 km^2.

The UFCo transformed the acquired lowlands into plantations and towns, where it provided healthcare, housing, schooling and sanitation to its workers and their families. The UFCo also invested in infrastructure, such as wireless communication systems to coordinate the whole process, and railroads to carry the bananas from the plantations to the ports where the bananas were shipped to the United States and Europe in company vessels. However, the firm was also infamous for its extractive practices in many of the "Banana Republics" where it operated. In Costa Rica, the UFCo significantly transformed the local economy. By 1950, it was responsible for 58% of the country's total exports. It employed approximately 7% of of the country's total labor force and 12% of its agricultural labor force.

In 1984 the UFCo went bankrupt and stopped production in the area of our study. The reasons for this closure include expropriations in other countries (like Cuba and Nicaragua), a sequence of hurricanes that destroyed some of the remaining plantations in the Caribbean (not in Costa Rica), and scandals of corruption that significantly affected the firm's stock price. After the firm's closure, land in the area of our study was auctioned and sold to the highest bidder. More historical details are discussed in A.1.

Figure 1.1: The UFCo's Boundary



Notes: The area of the UFCo's concession is shown in black. These contours surrounds the areas of land concession that was given to the UFCo. Elevation is shown in the background

1.2.2 Land Assignment

Understanding why some land was assigned to the company is key in identifying its long-run impact. It is documented that the firm took into consideration geographic characteristics when negotiating which areas were going to be part of their land concession (Casey, 1979; Cerdas Albertazzi, 1993). Thus, it is not surprising that geographical features change discretely along many segments of the UFCo boundary, as shown in Figure 1.1.

However, in the Caribbean Coast, we identified an area where land was assigned quasi-randomly. Initially, due to ambiguities in the concession's contract, the UFCo and the government had some discrepancies regarding the limits of the concession. In 1904, a legislative decree resolved these differences in criterion. The modification declared some land—that the UFCo considered as part of the original concessions—as state property. Officially, this area was called Astúa-Pirie Soley (1940), and the decree specified that the property rights over these lands could not be sold back to the company (Viales, 2012).

Because the Caribbean Coast was very scarcely populated, the boundaries of the Astúa-Pirie region were chosen using features of the landscape as reference so that they would be easy to enforce for the local authorities. The legislative decree declared that the southern boundary of the Astúa-Pirie region would "follow the Reventazón River, from La Junta to the Caribbean Sea."[8]; its eastern boundary adjoins the Atlantic Ocean; its northern boundary would "follow an imaginary line drawn from the intersection between Toro Amarillo River with the old railroad up to a point in the coast located five miles northeast from the mouth of Tortuguero River"[9]; finally, the western boundary would "follow the main railroad, from La Junta to the point where the railroad crosses Toro Amarillo River"(ANCR, 1904, p. 44).

In practice, the southern boundary—that defines the limit between the Astúa-Pirie region and the UFCo—follows the Reventazón River *closely but not exactly*. The reason is that expropriation was a very costly process, and preexisting plots of land that overlapped with the river were not broken apart. Instead, plots were allocated either as UFCo property or government property with the intent to follow the river as closely as possible. Figure A.6 shows an example of how the boundary follows this natural landmark (the river)—closely but not exactly—as it was jointly determined by the river and the preexisting plots. In 1904 the government also forbid, by law, to sell the plots within the Astúa-Pirie region to the company (or any foreigner), and therefore this boundary was kept constant during the company's tenure.

[8]La Junta was the point where the railroad from the capital intersected the railroad from Limón

[9]The "old railroad" was the name given to the railroad to Guápiles because it was the remains of an unsuccessful previous attempt to build a railroad to the central valley.

1.2.3 Commuting Between Regions

People who lived in regions near UFCo plantations, in general, did not commute and work for the company or used its services. Unlike other types of agricultural activities with a seasonal demand for labor, the UFCo needed a permanent labor supply of around 150 workers per 800-acre farm, and there were several incentives to keep people from commuting in and out of the plantation.

First, due to the extension of the plantations and to reduce transportation costs, the UFCo created camps within their farms for its workers (Cerdas Albertazzi, 1993). The typical farm consisted of 800 acres of land, with about 20 acres devoted to campsite and buildings, and 150 acres to pasture land (Jones and Morrison, 1952). Besides houses and administrative buildings, special facilities were also present, such as commissaries, schools, electric plants, sewage systems, and recreational facilities (Wiley, 2008). The wide range of services and facilities provided by the company converted plantations into communities that allowed people to live and work full time within them.[10] Second, given concerns about malaria spreading from outside the plantation, only workers were allowed to live within the UFCo and flows of people were discouraged. Finally, people living in areas around the UFCo had restricted access to services provided by the company. For example, as we describe in Section 1.5, data on patients at UFCo hospitals suggests that most of them were workers or part of a workers' family. For the few non-workers in the hospitals' records, we observe average spending per patient was lower relative to workers and their families, suggesting that commuters could not enjoy the amenities the company provided in the same way as locals. More details are discussed in Section 1.6.1.1.

[10] For people within the plantations, the company was omnipresent in their lives. Harpelle (2001) mention that typical residents "were likely born in the company hospital, educated in the company school, lived in company housing, obtained household supplies and clothing from the company commissaries, and, if they could afford it, looked forward to being carried to their final resting places in the Northern Railway's [a subsidiary of the UFCo] funeral car."

1.2.4 Other Historical Examples

Historically, it has been relatively common for one or a few large companies—often foreign ones—to dominate a local economy in a developing region. In colonial and quasi-colonial arrangements, labor was sometimes coerced into working for a major producer; examples like the mita mining system in Peru (Dell, 2010), coffee farms in Puerto Rico (Bobonis and Morrow, 2013), or rubber cultivation in what is today the Democratic Republic of Congo (Lowes and Montero, 2016) have been studied in detail. Another example is the Dutch East India Company, which used both coerced and paid labor while being a monopsony in many of the regions where it operated (Lucassen, 2004). Other case which involved coerced labor is the 1891 charters from the Portuguese to the Mozambique Company and the British Nyassa Company to administer the southern part of Mozambique for 50 years and the northern part of the country for 35 years, respectively (Vail, 1976). A more current example is the entrance of Firestone into Liberia in 1928, when rubber became crucial to the local economy. For instance, in 1972, Firestone produced 57% of the Liberian agricultural output and 6% of its GDP (McCoskey, 2011).

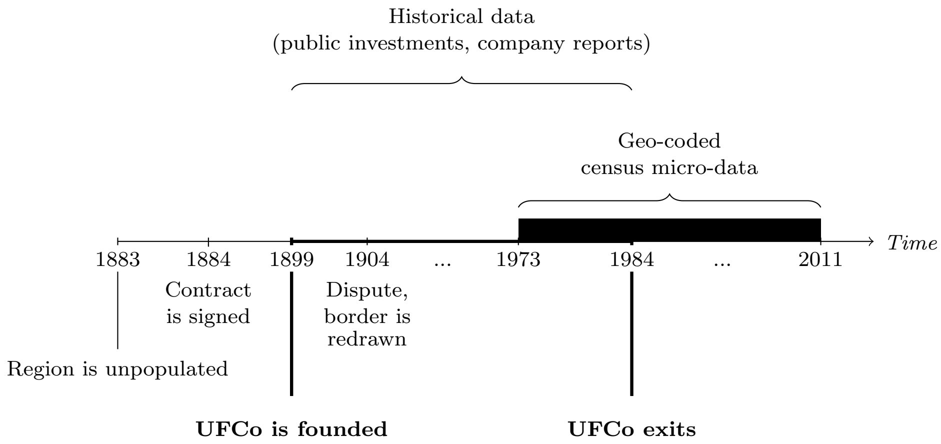
Finally, it is worth mentioning that these large investment projects are not only in the past. A recent wave of large-scale land acquisitions in developing countries—the so called "land grabs"—has been a subject of great debate. Driven mostly by a concern over food security and the biofuels boom, these projects consist of large leases (of up to 99 years) or purchases of farmland for agricultural investment in Africa, Central and Southeast Asia, Eastern Europe and Latin America; some of them involving hundreds of thousands of acres (Cotula et al., 2009; Cotula and Vermeulen, 2009). In fact, since 2006, over 64 million acres of land were assigned to foreigners to develop agricultural activities in developing countries, and more than 400 of these concessions were larger than the UFCo's concession in Costa Rica.

1.3 Data

1.3.1 Outcome Data

We examine the UFCo's long-run impact on economic development by testing whether it affects living standards today. To measure living standards, we obtained restricted-access microdata from Costa Rican Censuses collected by the National Institute of Statistics and Census (Instituto Nacional de Estadística y Censos) for years 1973, 1984, 2000, and 2011. As the UFCo stopped operations in 1984, the range covered by these censuses allows us to analyze the outcomes during and after the company's tenure. For ease of exposition, Figure 1.2 shows how the available data fits into a time line of main events.

Figure 1.2: Main Events and Data Availability



The data is recorded at the census-block level, the smallest territorial division of the country. Both the size and borders of a census-block change across censuses. For the 1973, 1984, and 2000 censuses, each census-block contains approximately 60 dwellings in urban areas and 40 dwellings in rural areas. They also tend to coincide with one or two city blocks in urban areas (Bonilla and Rosero, 2008). For the 2011 census, in most cases, the census-block coincides with a city-block (Fallas-Paniagua, 2013). For all years, the data include each census-block centroid's coordinates. The level of spatial disaggregation provided by the census-block data allows us to compare observations within close proximity of each other.

Except for the 1973 census, which includes information on wages, later censuses do not contain direct measures of income or consumption. Therefore, we follow the "Unsatisfied Basic Needs" (UBN) method to generate variables that measure economic outcomes. The UBN method was introduced by the Economic Commission for Latin America and the Caribbean (ECLAC), to identify households in poverty without relying on income data (Feres and Mancero, 2001). The method requires specifying a set of basic needs and a threshold to consider those needs as "satisfied" (Armendáriz and Larraín B., 2017).[11]

We construct variables that capture four dimensions: housing, sanitation, education, and consumption. While A.2 details the specific variables from the censuses that constitute each dimension, a general description of each is the following: (i) housing: refers to the quality of the household dwelling's material and household overcrowding; (ii) sanitation: refers to the method for disposal of human excreta that the household uses; (iii) education: refers to school attendance and academic achievement for household members from 7 to 17 years old; and (iv) consumption: refers to the relationship between the number of income recipients (employed, pensioned, or renter), their years of schooling, and the total number of household members. A household is considered poor if it has at least one unsatisfied need. We then estimate the severity of poverty through the total number of UBN: an index that ranges from 0 to 4, where each unsatisfied basic need adds one point to the index.

[11] As a robustness check, we also use a different unsatisfied basic needs for Costa Rica constructed by Méndez and Trejos (2004) using questions from the 2000 census. It is straightforward to apply their method to the 2011 census (Méndez and Bravo, 2014), while to extend it to the 1973 and 1984 censuses, we restrict the set of unsatisfied basic needs to those whose information is available in all the four censuses considered in our paper.

1.3.2 Historical Data

To understand which census-blocks were directly affected by the UFCo, we collected and digitized maps of the company's properties, which were published by the UFCo Engineering Department and are available in the Costa Rican National Archive.[12]

For a better understanding of living standards and investments during UFCo's tenure, we collected and digitized UFCo reports with data on wages, number of employees, production, and investments in areas such as education, housing, and health from collections held by Cornell University, University of Kansas, and the Center for Central American Historical Studies. We also use annual reports from the Medical Department of the UFCo describing the sanitation and health programs and spending per patient in company-run hospitals from 1912 to 1931. We also collected data from Costa Rican Statistic Yearbooks, which from 1907 to 1917 contain details on the number of patients and health expenses carried out by hospitals in Costa Rica, including the ones ran by the UFCo. Export data was also collected from these yearbooks, and from Export Bulletins. 19 agricultural censuses taken between 1900 and 1984 provide information on land use, and we use data from Costa Rican censuses between 1864-1963 to analyze aggregated population patterns, such as migration before and during the UFCo apogee, or the size and occupation of the country's labor force.

[12] Although the Virtual Map Library of the National University of Costa Rica (Mapoteca Virtual de la Universidad Nacional de Costa Rica) has digitized part of the collection, collecting all available maps required in-person visits to the archives, taking high-quality pictures of the original maps, and digitizing them. Figure A.5 in A.3 provides an example of a map showing the UFCo landholdings in the Costa Rican Pacific Coast.

1.4 Impact of the Company

1.4.1 Empirical Strategy

To estimate the causal effect of the UFCo, we use well-defined boundaries based on historical records and compare observations located just inside former UFCo plantations to observations located just outside them. Our estimation of the *average* UFCo effect uses the following RD specification:

$$y_{igt} = \gamma\, UFCo_g + f(\text{geographic location}_g) + \beta \mathbf{X}_{igt} + \Gamma \mathbf{X}_g + \alpha_t + \varepsilon_{igt},, \tag{1.1}$$

where y_{igt} is an outcome of individual or household i in census-block g and year t; and $UFCo_g$ is an indicator variable equal to one if the census-block g's centroid was inside a UFCo plantation, and equal to zero otherwise. $f(\text{geographic location}_g)$ is a RD polynomial, which is a smooth function on latitude and longitude that controls for the geographic location of census-block g. This multidimensional discontinuity in a longitude–latitude space allows us to compare units, not only on different sides of the boundary, but on a comparable position. Following Gelman and Imbens (2017), and in line with recent work whose estimation framework relies on a geographical regression discontinuity design (Dell et al., 2015; Lowes and Montero, 2016; Dell and Olken, 2017), we use a linear RD polynomial in longitude–latitude and test for robustness to a variety of specifications. $\mathbf{X}_{igt}$ is a vector of covariates (number of adults, children, infants per household) for individual or household i. $\mathbf{X}_g$ is a vector of geographic characteristics (slope, elevation, temperature) for census-block g, and α_t is a year fixed effect.

In order to study a *time-varying* UFCo effect, we allow for a different UFCo coefficient in every census, by estimating the following RD specification:

$$\begin{aligned} y_{igt} =& \gamma_{1973}\, UFCo_{g,1973} + \gamma_{1984}\, UFCo_{g,1984} + \gamma_{2000}\, UFCo_{g,2000} + \\ & \gamma_{2011}\, UFCo_{g,2011} + f(\text{location}_g) + \beta \mathbf{X}_{igt} + \Gamma \mathbf{X}_g + \alpha_t + \varepsilon_{igt}, \end{aligned} \tag{1.2}$$

where the indicator variable $UFCo_{g,t}$ is equal to one if at time t individual or household unit i is in census-block g, whose centroid was inside a UFCo plantation; and equal to zero otherwise.

1.4.2 Pre-Characteristic Balance

We begin by examining whether geographic characteristics are similar along the re-drawn boundary that was described in Section 1.2.2. Namely, we test a null hypothesis of no geographical differences on both sides of this segment of the UFCo boundary. We fail to reject this null in the segment shown in Figure 1.3. In this area, the border was redrawn arbitrarily and geographic characteristics are balanced. Table 1.1 shows that elevation, slope, and temperature do not change discretely across this segment of the UFCo boundary, thus fail to reject our null. [13] Following Conley (1999), we allow for spatial dependence of an unknown form (reported in brackets). For comparison, we also report robust standard errors (in parentheses). [14] This table also shows that as we move far away from this segment of the boundary the differences in elevation, slope, and temperature become significant.

Therefore, exploiting the level of disaggregation of our data—which includes close to 9000 households even within this subregion—and not to contaminate the analysis that might be very sensitive to changes in the landscape (most economic activity was related to agriculture), our main results will include only observations whose census-block's centroid is located within 5 km from this segment of

[13]The unit of analysis to examine the geographic characteristics is a 1x1 km grid cell. Results are statistically equal if we use 1x1 km grid cells or census-blocks as the unit of analysis. Elevation and temperature data were obtained from the Global Climate Database created by Hijmans et al. (2005). The spatial resolution is 30 arc-seconds. Elevation above sea level is in meters and was constructed using NASA's Shuttle Radar Topography Mission data. From the elevation information, we calculate the slope (in degrees). Hijmans et al. also compiled monthly averages of temperature measured by weather stations from 1960 to 1990. We measure temperature in Celsius and take an annual average.

[14]We compute Conley Standard errors at the cutoff distance of 2 km. However, the results are robust to alternative cutoffs.

the UFCo boundary where we know the border was arbitrary and observable geographic features are balanced.

Figure 1.3: Study boundary. Elevation is shown in the background.

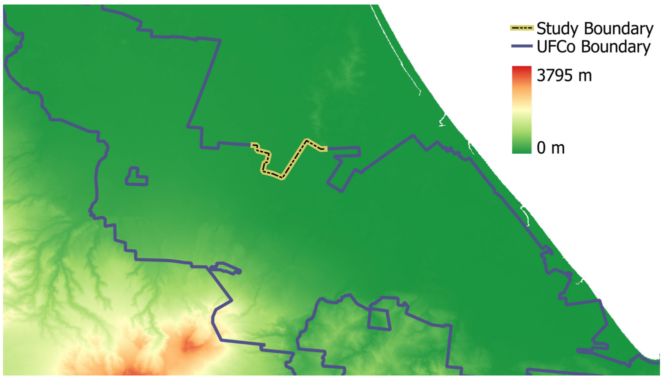


Table 1.1: Balance on Geographic Characteristics

	Sample falls within					
	<5 km of UFCo boundary			<10 km of UFCo boundary		
	Inside	Outside	s.e	Inside	Outside	s.e
Elevation	38.552	38.235	(1.330)	50.893	37.759	(2.273)***
			[3.530]			[6.514]**
Slope	0.256	0.312	(0.072)	0.493	0.328	(0.063)***
			[0.140]			[0.154]
Temperature	26.087	26.097	(0.006)	26.028	26.097	(0.011)***
			[0.014]			[0.031]**

Notes: The unit of observation is 1x1 km grid cells (with 181 and 309 cells in our sample when considering 5 and 10 km, respectively). Robust standard errors for the difference in means between UFCo and non-UFCo observations are in parentheses. Conley standard errors for the difference in means are in brackets. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In terms of pre-existing social and economic characteristics, the study area was close to being uninhabited before the UFCo's arrival, thus having no pre-trends on either side of the boundary. According to the 1864 Costa Rican Census, only 545 people lived in the entire Caribbean Coast, a 0.45% of the Costa Rican population at that time (Oficina Central de Estadística, 1868). Company officials wrote that when they first arrived "with the exception of the little village of Matina, which contained fifty or sixty inhabitants, not one individual was settled anywhere on the line. In fact, the route had not even been explored, and the rivers were first named when the engineers crossed them"(Keith, 1886).

1.5 Results

1.5.1 Average Effect Pooling Across Years

Table 1.2 explores whether households living in areas that were directly exposed to the UFCo are on average better-off than those living just across the border. The table includes the results of estimating Equation (1.1) using the probability of having an unsatisfied basic need (UBN) in each dimension (housing, sanitation, education, and consumption), the probability of being poor, and the total number of UBNs as dependent variables. All regressions include geographic controls, demographic controls for the number of household members aged 0-4 (infants), 5-14 (children), and 15 and older (adults), census fixed effects, and a linear polynomial in latitude and longitude. We report standard errors clustered at the census-block level and Conley standard errors.

Table 1.2: Average UFCo Effect

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.095	-0.016	-0.057	-0.059	-0.124	-0.228
	(0.026)***	(0.017)	(0.022)**	(0.025)**	(0.031)***	(0.057)***
	[0.029]***	[0.015]	[0.019]***	[0.025]**	[0.026]***	[0.051]***
Adj. R^2	0.102	0.173	0.241	0.015	0.115	0.200
N	8,786	8,786	8,786	8,786	8,786	8,786
Clusters	200	200	200	200	200	200
Mean	0.176	0.060	0.235	0.200	0.481	0.670
% Variation w.r.t. Mean	**-54.0**	**-26.7**	**-24.3**	**-30.0**	**-25.8**	**-34.0**

Notes: UBN=Unsatisfied Basic Need. The last row shows the percentage variation in each coefficient with respect to the sample's mean. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic (slope, elevation, temperature) and demographic (number of adults, children, infants per household) controls; census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimates suggest that the households located in the former UFCo region are in general better off. Column (1) to (4) of Table 1.2 shows that the households have higher living standards in every dimension considered. Note that, although some coefficients might seem somewhat small, the percentage variation of these probabilities with respect to the sample mean (last row) is sizable, and they are all statistically significant at the 1% or 5% level, except for sanitation. For instance, consider the coefficient -0,095 in Column (1): Households in former UFCo areas have 9.5 percentage points (pp) lower probability of having an unsatisfied housing need; a 54 percent decrease with respect to the sample's mean. These households also have 1.6pp and 5.7pp lower probability of having an unsatisfied need in sanitation and education, respectively.

Households in former UFCo areas also have a 12.4pp lower probability of being poor (Column 5); a 26 percent variation with respect to the sample's mean. Figure A.7 in Appendix A.4 summarizes the results in three dimensions, and shows the spatial distribution of households across space. In this figure, each dot corresponds to the centroid of a census-block; a monochromatic color scale represents the average outcome value for the households within the census-block, where lighter colors stand for better outcomes; and each dot's size represents the number of observations in the census-block. The background of the figure shows predicted values, for a finely spaced grid of longitude-latitude coordinates, from a regression of the outcome variable under consideration on the UFCo dummy and a linear polynomial in latitude and longitude. This figure shows a sharp discontinuity in households' living standards at the study boundary, with outcomes being better for households treated by the UFCo.

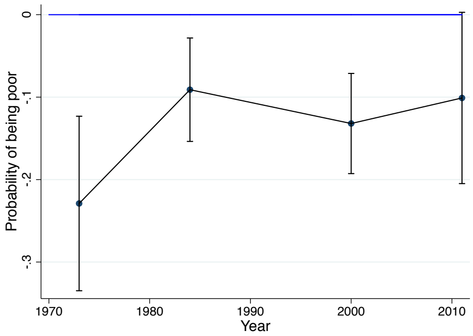
Column 6 (the number of UBN) is read differently than the rest of columns, as it takes values that range from 1 to 4. The severity of poverty is lower in the former UFCo areas, where the households have on average 0.228 fewer unsatisfied needs than the households in the non-UFCo region. For completeness, we also present results using the entire boundary—which are contaminated by unbalanced ex-ante geographic characteristics—in Appendix A.4. Results in the entire boundary are consistent with our results in the balanced subsample: in general, the former shows larger percentage variations with respect to the sample mean, but magnitudes in both estimations are overall close to each other.

1.5.2 Time-Varying Effect

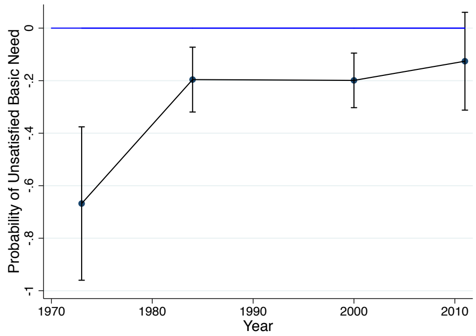
The company stopped operations in 1984, and we examine census data from 1973-2011. Therefore, we can disentangle the differentiated effects of the company's presence during its tenure, and also at different points in time after it stopped operating. Figure 1.4 shows how the UFCo effect changed over time. The table corresponding with these results is reported in Appendix A.4 (Table A.5). The probability of being poor and the total number of UBN are quite persistent over time, being significant during every year of our study. The probability of bad quality housing is also very persistent across years, for instance, in 2011, approximately 30 years after the UFCo left, households within UFCo former lands are 9.3 percentage points less likely of having a UBN in housing relative to households outside. The magnitude of the UFCo effect in this dimension is high given the mean probability for the entire region (0.124). The effect on sanitation rapidly vanishes and is insignificant after 1973. Finally, education and consumption are always worse outside the UFCo, but the significance of the coefficients disappears after 2000.

Figure 1.4 also shows how, since the UFCo closed, the treated and untreated regions have converged slowly, with only 63% of the poverty gap closing over the following 3 decades. More generally, the *severity* of poverty—measured by the number of UBN—has decreased over time. While a household in 1973 had 0.668 less UBN than a household outside, in 2011 the difference was reduced to 0.126, and the difference is statistically different from zero at 1% level.

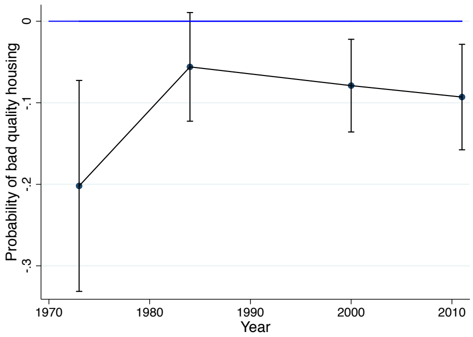
Figure 1.4: Time-Varying UFCo Effect (1973-2011)



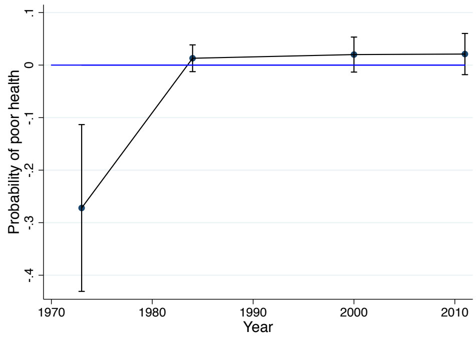
(a) Probability of Being Poor



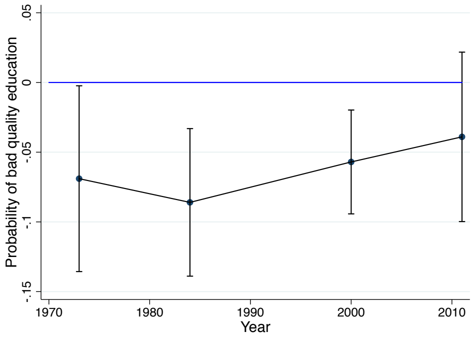
(b) Total Number of UBN



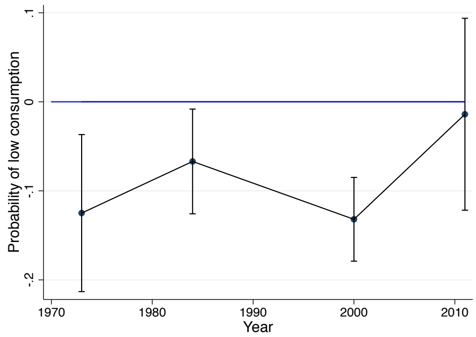
(c) Housing Dimension



(d) Sanitation Dimension



(e) Education Dimension



(f) Consumption Dimension

Notes: The figure shows the evolution of the UFCo effect across years for several outcome variables.The absolute effect is decreasing over time in all cases. Confidence intervals show Conley standard errors. Table A.5 shows further details regarding these regressions' output.

1.5.3 Robustness

Falsification Test: As a falsification test, we re-run the analysis using placebo borders. In particular, we draw placebo borders at a distance of 2 km both inwards and outwards of the actual UFCo border. For instance: We shift our border 2km outwards (inwards). and re-run our analysis within 2km of the "fake" border, so that all our observations lie above (below) the true boundary. Table A.10 in Appendix A.7 presents the results, showing that our placebo tests deliver insignificant results in every case, both economically and statistically. This is reassuring that what we are capturing is an effect that appears only precisely as we cross the boundary, and not spatial autocorrelation as warned by Kelly (2019).

Different Bandwidth and Polynomials As an additional robustness check, we eliminate observations close to the boundary in case there might have been some negative spillover from the company to the outside (note that when exploring the river's effect we did the opposite: limit the analysis to observations close to the boundary). Table A.23 in Appendix A.8.4 shows the results. Overall, the coefficients are very similar to the ones of our main regression, both qualitatively and quantitatively. Moreover, although in Tables 1.2 and A.5 we use a linear polynomial in latitude and longitude, our main message is robust to alternative specifications of the RD polynomial. A.8.1.1 documents that a quadratic polynomial leads to similar conclusions. A.8.1.2 shows that estimates are almost identical when we use a linear polynomial in latitude, longitude, and distance to the boundary.

Different Control Variables Besides the specification of the RD polynomial, we also analyze how the results change to varying the control variables. A.8.2.1 shows that results are robust to excluding demographic controls, A.8.2.2 to excluding geographic controls, and A.8.2.3 to excluding both demographic and geographic controls.

Effect of the River A possible concern is that the river, which is close to our boundary, is driving our result. To address this issue, we run our main specification restricting the sample to units "on the wrong side" of the river (1937 total units), that is, units that are above the river and belong to the UFCo, and units that are below the river and did not belong to the company. Appendix A.8.3 presents the results. In this limited sample, we are comparing only households located very close to each other (1km from the boundary, at most), and we still find results that are consistent with our main findings.

Income and Nighttime Lights Data We use nighttime lights data as a proxy of income to confirm our findings through an alternative measure of economic development. Figure A.8 in Appendix A.10 shows a satellite image in which areas inside the former UFCo landholdings display higher luminosity. Results in Table A.33 confirm this difference in luminosity is significant, both statistically and economically.[15]

Alternative Index of UBN Our Unsatisfied Basic Needs (UBN) are a modified version of the ones proposed by Méndez and Trejos (2004). Because Méndez and Trejos constructed the index using information from the 2000 and 2011 census, our modification consists of selecting the variables whose information is available in each of the 1973, 1984, 2000, and 2011 censuses. Therefore, as a robustness test, we re-run the estimation restricting the analysis to the 2000 and 2011 census and using the Unsatisfied Basic Needs (UBN) as proposed by Méndez and Trejos. A.31 shows that our main message is robust to this alternative definition of UBN.

[15] Assuming an elasticity between nighttime light intensity and GDP of 0.3 (consistent with the findings in Henderson et al. (2012) and Hodler and Raschky (2014)), the 21% difference in nighttime light intensity implies that the output in the former UFCo plantations is about 6.37% higher.

1.6 Suggestive Evidence on the Mechanism

To understand the channels that led to the difference between regions that we found with our empirical strategy, we collected and digitized data on different outcomes from 1907-1984. Using this data, Section 1.6.1 discusses evidence on investments in local amenities (such as schools, hospitals) being much larger within the UFCo than in nearby regions. Studying company reports, we show in Section 1.6.1.4 how it seems like these investments were at least partially motivated by the need to attract and maintain a sizable workforce. Finally, Section 1.6.2 considers other plausible mechanisms (selective migration, negative spillovers from the company to neighboring regions), finding no evidence in support of these being the main drivers behind our results given the available data.

1.6.1 Investments in Local Amenities

1.6.1.1 Investment in Healthcare and Sanitation

While constructing the railroad to the Caribbean Coast in Costa Rica, the company experienced the loss of around five thousand workers due to the unhealthy and dangerous conditions of the tropical forest (Bucheli, 2005). The experience, along with lessons from the Panama Canal's construction, taught managers about the importance of sanitation and health care to sustain a large workforce. As a consequence, the UFCo invested in sanitation infrastructure, launched health programs, and provided medical attention to its employees. Infrastructure investments included pipes, drinking water systems, sewage system, street lighting, macadamized roads, a dike (Sanou and Quesada, 1998), and by 1942 the company operated three hospitals in the country[16]

Employees and their dependents had access to medical and surgical treatment,

[16]The staff included doctors, sanitary inspectors, and nurses from the United States and other Central American countries (Morgan, 1993), and equipment was modern (Deeks, 1924).

including medicines in the case of employees, without any additional cost to the worker (UFCo, 1916).[17] Moreover, neighbors from non-UFCo regions could not commute and get access to the same quality of healthcare. As Figure 1.5b shows, between 1907 and 1917 workers or their families who attended a UFCo hospital (red line) received more than twice the spending per patient than people who attended UFCo hospitals but were *not* in the payroll or related to a worker (green line), and although a higher level of spending does not necessarily imply a higher quality of health care, UFCo's medical services were known of being among the best in the country (Casey, 1979). For reference, we also show expenditure per patient in the most modern *public* hospital at the time (San Juan de Dios); which suggests a non-worker would have been on average better-off attending this government-run hospital than commuting to the UFCo's hospital[18].

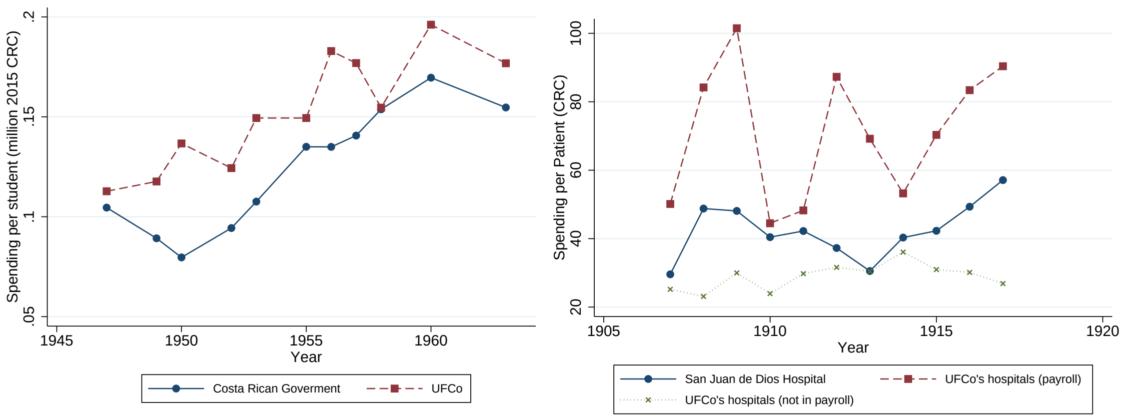
1.6.1.2 Investments in Housing Infrastructure

Given the remoteness the plantations and to reduce transportation costs, the UFCo provided the majority of its workers with free housing *within* the company's land. This was partially motivated by concerns with diseases like malaria and yellow fever, which spread easily if the population is constantly commuting from outside the plantation. Each of the UFCo's divisions consisted of farms, and each farm had a camp where workers lived.

Usually, the houses for plantation laborers were laid out around a soccer field. By 1958 the majority of laborers lived in barracks-type structures. Single families

[17]To cover healthcare for employees and their dependents, the UFCo deducted 2% from their salary, but there was no marginal cost for any treatment and it was mandatory to pay this fee.

[18]Despite the positive impact of the UFCo programs, its benefits were restricted to employees and their immediate families. The general manager of the Medical Department explained that given the size of the UFCo landholdings, it was impossible from a commercial standpoint to sanitate completely all areas and therefore their efforts were "mainly directed to protecting the larger communities and camps were our employees are located" UFCo (1921). In fact, to increase sanitary benefits, company doctors suggested preventing workers from traveling between plantations and surrounding villages, which were unscreened. Although non-employees could receive medical attention in the UFCo healthcare network, they had to pay higher fees.



(a) Spending per Student

(b) Spending per Patient

Notes: Panel (a) shows data on spending per student (in 2015 Costa Rican Colones) in UFCo schools vs local schools run by the government, between 1947-1963. Data results from authors' calculations based on company reports and Molina (2017). Panel (b) shows data on spending per patient (in Costa Rican Colones), between 1907-1917 in UFCo hospitals, and compares it with spending per patient in the San Juan de Dios Hospital; the largest Costa Rican hospital at the time, located in the capital. Data was calculated based on 1907- 1917 Costa Rican Statistic Yearbooks.

occupied the majority of barracks, and there were buildings for unmarried workers (May and Lasso, 1958). The barrack structures exceeded the standards of many surrounding communities (Wiley, 2008).

Related to the sanitary programs impulsed by the UFCo, a squad cleaned the grounds, collected trash, systematically sprayed with DDT to control for mosquitos and insects, and scrubbed out public toilets and bathing facilities. Moreover, the water supplied to the taps was safe for drinking. Besides housing, the UFCo provided basic services *for its employees* within each camp, such as schools, commissaries, dispensaries, and recreational facilities. May and Lasso (1958) claim that "the places of worship, recreational facilities, and athletic fields and equipment provided for United's workers are upon a scale matched by few, if any, locally owned agricultural enterprises."

1.6.1.3 Investments in Human Capital

One of the services that the company provided within its camps was primary education to the children of its employees. The curriculum in the schools included vocational training and before the 1940s, was taught mostly in English. The emphasis on primary education was significant, and child labor became uncommon in the banana regions (Viales, 1998). By 1955, the company had constructed 62 primary schools within its landholdings in Costa Rica (May and Lasso, 1958). As shown in Figure 1.5a,[19] spending per student in schools operated by the UFCo was consistently higher than public spending in primary education between 1947 and 1963.[20] On average, the company's yearly spending was 23% higher than the government's spending during this period.

By the time children completed primary education, they were old enough to work. The UFCo did not provide directly secondary education although offered some incentives. If the parents could afford the first two years of secondary education of their children in the United States, the UFCo paid for the last two years and provided free transportation to and from the United States. Moreover, if the parents organized secondary schools by themselves and paid a private tuition fee for the teachers, the UFCo provided a building and furniture (May and Lasso, 1958). Despite the incentives, secondary and tertiary education was costly and out of reach for most children. This is consistent with the company's effect on years of schooling being significant only for primary schooling, and not for secondary schooling, as documented in Table A.3. Appendix A.1.1.1 includes more details regarding this effect.

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[19]In Figure 1.5a the amounts were converted to constant 2015 Costa Rican Colones (CRC) by splicing four price indexes: (i) Cost of Living Index Base 1936 = 100 (*Índice de costo de la vida Base 1936 =100*); (ii) Consumer Price Index for Middle Income and Low-Income Citizens in the Metropolitan Area Base 1964 = 100 (*Índice de precios al consumidor de ingresos medios y bajos del Área Metropolitana Base 1964=100*); (iii) Consumer Price Index Base January 1995 = 100 (*Índice de precios al consumidor Base Enero 1995 = 100*); and (iv) Consumer Price Index Base June 2015 = 100 (*Índice de precios al consumidor Base Junio 2015 = 100*).

[20]Data is only available for this subset of years.

1.6.1.4 Why So Much Investment? Outside Option and Worker Turnover

While it is easier to imagine the motifs of the company to invest in hospitals and have healthy workers, it is less clear why would it benefit from more educated children. Annual Reports of the company, which were intended to inform shareholders of the situation in the plantations, suggest these investments were motivated by the need to attract and maintain a sizable workforce. High turnover was common, given the workers' outside option: coffee, which unlike bananas is a seasonal crop, and offered high wages during the coffee harvesting season.

Annual Reports to Shareholders up to 1924 consistently mention worker turnover as being an important problem to address. For instance, the report from 1922 (UFCo, 1929) mentions how there are problems with worker's "discipline", and refusal to comply with company medical policies as consequences of high turnover. In one division, there was 100% labor turnover within a year. An extract documenting this dynamic (UFCo, 1929, p. 74) appears below.

> "...stable communities tend to be more disciplined, and can be educated to take better care of themselves...this is impossible with fluctuating populations on our plantations...there is constant overturn of labor and we are periodically importing new laborers...these migratory habits do not permit them to remain in the plantation from one year to the next, and *as soon as they become physically efficient in our methods and acquire money they either return to their homes or migrate elsewhere and must be replaced.*"

In 1925, the company's president changed, and the new directives started mentioning new strategies in the company reports (UFCo, 1925, pp. 170-171). Namely, the report states:

> "We recommend a greater investment in corporate welfare beyond medical measures. An endeavor should be made to stabilize the pop-

> ulation...we must not only build and maintain attractive and comfortable camps, but we must also provide measures for taking care of families of married men, by furnishing them with *garden facilities, schools, and some forms of entertainment. In other words, we must take an interest in our people if we might hope to retain their services indefinitely.*"

Reports from 1927-1940 mention how strong investments started in 1927-1930, stopped during the depression, and continued in the late 1930s-early 1940s. ("we have *poured* resources into following the recommendations [to decrease turnover]"; 1928). Later reports (1937, 1940) document how "family housing served as an incentive for long service" and "schools formed the cornerstone of childrearing".

This sheds new light on a potential mechanism behind our positive results: Given the workers' outside options and initially high levels of turnover, there was a need to retain workers which led to an increase in investments in "welfare" (local amenities), which could explain the positive effect on development we previously documented.

We explore the mechanism described in these reports empirically. Namely, we test the existence of a positive relationship between better outcomes today due to UFCo's investments, and workers' outside options during UFCo times. To do so, we would like to consider

$$y_{j,2011} = \beta \sum_i \frac{1}{dist_{ji}} \frac{wage_{i,1973}}{price_{i,1973}} \Big/ \sum_n (dist_{jn})^{-1} + \varepsilon_{j,2011},$$

where $y_{j,2011}$ denotes the outcome in 2011 of household j. For each household j within the UFCo, we would like construct an outside option considering the wages in districts which are suitable to grow coffee (the main outside option for wages at the time). In particular, we proposed the sum of real wages in each district i weighted by the inverse of the distance between i and j as a proxy of the "outside option" of workers in region j. Through our mechanism, regions within the UFCo with a higher outside option in 1973 should have received higher UFCo investments, and should exhibit better outcomes (lower probability of being poor) in 2011.

However, using wages as regressors creates a potential endogeneity concern: UFCo investments might have increased wages in relatively close regions, for instance. Thus, we proceed in 2 stages. First, we construct an instrument for real wages: The suitability to grow coffee, which unlike banana is grown in highlands with relatively low humidity.

We measure the suitability to grow coffee by regressing the coffee intensity in region i—defined as the percentage of area where coffee was cultivated with respect to the total are of region i—during UFCo times on geographic characteristics (slope, temperature, elevation, latitude, longitude) in the same region, to obtain a proxy of each region's suitability to grow coffee based on geographic characteristics. Namely, we construct the following instrument

$$coffee_i^{1973} = \alpha_1 slope_i + \alpha_2 temperature_i + \alpha_3 elevation_i + \upsilon_i.$$

Second, we regress wages in 1973 in region i on a measure of suitability to grow coffee in nearby regions in the same year. We consider

$$y_{j2011} = \hat{\beta}\ outside\ option_i + \hat{\varepsilon}_{jt},$$

where $outside\ option_i = \sum_i \frac{1}{dist_{ji}} coffee_i^{1973} \big/ \sum_n (dist_{jn})^{-1}$ and $\hat{\beta}$ captures how outside options in 1973 affect outcomes in 2011. The idea being that regions more suitable to grow coffee—which grows in a different climate and altitude than banana—should offer higher wages for agricultural workers. Thus, the closest an UFCo region is to a place suitable to grow coffee, the higher outside option UFCo workers in this area will have, which in turn, would have led to more UFCo investments and better outcomes in 2011. The exclusion restriction to use this instrument is that land suitability for coffee during UFCo times in other regions affects current outcomes only through its effect on wages during UFCo times .

Data on wages outside the UFCo comes from the 1973 population census, while data on coffee production is obtained from the 1973 agricultural census. While the Minister of Finance reported price indexes for this year, the procedure to construct them is unclear, thus we will assume the price index is the same and normalized to 1 in all regions. Our first stage is shown in Table A.34, and shows that the suitability to grow coffee can predict wages well: A 1 percentage point increase in the suitability to grow coffee in a region is associated with 0.2% higher wages, with the effect being statistically significant at 1%.

The results of our second stage are shown in Table 1.3. We find that a higher outside option in 1973 is associated with better contemporary outcomes in all cases. For instance, the first coefficient can be interpreted as follows: An increase of 1 percentage point in the average outside option of an UFCo region in 1973 is associated with .025 percentage points lower probability of having bad quality housing in more recent years (2000 or 2011). Results are qualitatively similar for other outcomes.

Table 1.3: Second Stage: Outside Options in 1973 and Outcomes in 2000 and 2011

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
outside option$_i$	-.025	-.007	-.008	-.002	-.021	-.043
	(.0054)***	(.0021)***	(.0047)*	(.0052)	(.0102)**	(.0157)***

Notes: UBN = Unsatisfied Basic Need. N = 350152. The unit of observation is the household. Robust SE, clustering by district, in parentheses. The regression includes demographic (number of adults, children, infants per household) controls and year fixed-effects. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We consider this heroic calculation as suggestive evidence in support of our mechanism. Later on, we will asses the potential of this mechanism relating labor mobility to market power and investments to generate our results on economic outcomes through the lens of a model, and examine its implications.

Institutions and Labor Mobility Why didn't the UFCo take the approach of destroying workers' outside options? Work by Acemoglu and Wolitzky (2009) on labor coercion suggests an alternative approach to retain workers: preventing them from leaving or reducing their mobility. There were several reasons that prevented this from happening in our setting. First, throughout the 20th century, democratic institutions in Costa Rica were much stronger than in other developing countries,[21] which possibly played a role in protecting workers' rights. Second, the Costa Rican elite included many coffee producers who needed labor during the coffee harvesting season, which gave them an incentive to protect workers' mobility. Third, given political competition, there was an effort by particular political groups to enlarge their winning coalition by protecting UFCo workers (Bucheli and Kim, 2012). These circumstances were not present in other Latin American countries were the UFCo operated, like Santa Marta and Cienega in Colombia, where armed forced prevented workers from forming unions and leaving the plantations.[22] Today, these cities are among the poorest in the country, which does not contradict our findings: as our mechanism—labor market dynamics as an incentive for the company to invest—did not seem to be present in these other cases.

1.6.2 Ruling-Out Other Plausible Mechanisms as Main Drivers

Positively Selected Migration During UFCo's Tenure It might have been the case that outcomes are better within the UFCo because it attracted positively selected migrants. To consider if selective migration is generating the differences

[21]See Bucheli and Kim (2012) for a detailed comparison of political institutions between countries in Central America.

[22]See Bucheli (2005) for more details on this coercion and the "Banana Massacre". Bucheli refers to the Colombian authorities as a " business-friendly government". The Costa Rican army, on its part, was abolished on 1948.

in living standards between the two regions, we take three different approaches. In our first approach, we reestimate equations 1.1 and 1.2 using a restricted sample of the full dataset in which we drop all migrant households. We classify a household as migrant if any household member lived in a different place of residence five years before the census took place.[23] Appendix A.8.5.1 documents that the results are statistically equal to the estimates in Table 1.2 and Figure 1.4.

In our second approach, we look at observables of migrants to the UFCo sub-region where we ran our regressions, and compare them to observables of migrants to our control group in 1973 (while the UFCo is still operating). We find that, on average, migrants to the UFCo have 4.2 months less years of schooling than migrants to the control group. This suggests that, if anything, migrants to the UFCo were negatively selected.

While 1973 data is detailed and geo-referenced at the census-block level, it captures migrant patterns many years after the company started operations. To explore earlier waves of migration, we resort to earlier census data. Namely, we compare observable characteristics of migrants to UFCo regions with those of migrants to other Costa Rican regions in 1927; the earliest Census for which geo-referenced micro-data on migrants is available.[24] Consistent with the results from 1973, we find that migrants to the UFCo were negatively selected in terms of schooling, with 19% lower probability of completing primary school, 1% lower probability of completing secondary school and 25% higher probability of not having any education than migrants to other Costa Rican regions. Results from the 1927 Census also show that migrants to the UFCo had 30% lower probability of owning private properties (like houses and land plots) than the average Costa

[23]Our results remain unchanged if we instead classify a household as migrant if the head of household lived in a different place of residence five years before the census took place (see A.8.5.2)

[24]For 1927, the census micro-data is geo-referenced at the canton level.

Rican migrant. This negative selection aligns with more current findings like Lagakos et al. (2018), and holds whether we compare migrants to UFCo cantons with migrants to all other Costa Rican regions, with migrants to rural locations only, or with migrants to neighboring cantons around UFCo plantations. The results of our estimation are available in Table A.28.

Our third approach complements the second one by ruling-out that, maybe, migrants were not good students but were exceptional farmers. We compare the UFCo effect for households engaged in the agricultural sector versus other economic sectors. We consider a household as an agricultural household if any of its members work in agriculture.[25] If ability in agriculture production is highly heritable and selective migration is driving our results, then the UFCo effect should be stronger for the households engaged in the agricultural sector relative to other economic activities. Nevertheless, Appendix A.29 shows that this is not the case, and for each outcome we consider, we cannot reject at the 10% level that the estimates are the same across both groups (further, the coefficients themselves are very similar). In summary, the two approaches we take suggest that selective migration is unlikely be the main channel behind the differences between the regions we observe.

Positively Selected Migration at the Time of Each Census Differential rates of migration at the time of each census are relevant for our long-run analysis. Each census contains information about individuals' place of residence 5 years before the census took place. In census-blocks located in UFCo areas, 9.35% of individuals migrated from a former non-UFCo municipality, while in the non-UFCo areas 11.90% of individuals migrated from a UFCo municipality. Table 1.4 shows that the migration rates are decreasing over time and their difference is not statistically significant. As a robustness check, we examine the influence

[25] Our results remain unchanged if we instead consider a household as an agricultural household as migrant if its head works in agriculture (see A.30).

of migration in the estimates, with no change in our conclusions.

Table 1.4: Migration Rates in UFCo and Non-UFCo census-blocks (Percentage)

Census	UFCo (1)	Non-UFCo (2)	P-value of the difference (3)
1973	16.83	32.74	0.37
1984	14.62	13.48	0.79
2000	7.45	10.25	0.24
2011	6.20	6.73	0.69
All	9.35	11.90	0.30

Notes: The p-values in the third column are for the test of the hypothesis that the rates of migration in the UFCo and non-UFCo areas are equal. The p-values are clustered at the census-block level.

Negative Spillovers from the UFCo to Neighboring Regions Another possible concern, is that our results are driven by our "control group" having particularly bad outcomes, potentially because of negative spillovers from the firm to this adjacent region. First, we find migrants to the control group had statistically more years of schooling (2.52 months) than migrants to other nearby comparable rural locations in 1973 (while the company was still operating), as documented in Appendix A.6.2. Second, also in 1973, the average years of schooling of individuals in the control group is higher than that of individuals in other comparable rural regions, as shown in Appendix A.6.2. Third, 1973 outcomes (sanitation, consumption, housing, probability of being poor) are statistically equal to those in other comparable rural regions in the country on 1973, while the UFCo was still operating, as documented in Appendix A.6.1. Fourth, we find that the control region received the same amount of government spending per capita than other rural regions. This is discussed in A.5, where we compare spending per capita between municipalities adjacent to the UFCo and other rural municipalities during the UFCo's tenure. Thus, if anything, the "control region" seems like a relatively strong/mean location within the country. Finally, given Costa Rica was considered a poster child of good governance at the time, and income per capita was among the highest in the area, the control region is particularly strong within Latin America.

1.6.3 Discussion

In summary, levels of investment in local amenities such as hospitals and schools inside the UFCo were significantly higher than public investments undertaken by the government in comparable regions. Company reports suggest that these strong investments were at least partially driven by the need to attract and maintain a sizable workforce. The latter is supported by a positive correlation between the intensity of company investments and the levels of outside options for workers in regions near the UFCo. Our hypothesis is that these investments are likely to be the main drivers behind the income gap we found empirically. Moreover, as maximizing profits was the UFCo's main objective, it is likely that the level of their investments in physical and human capital would have been lower in the absence of competition for labor. It is worth mentioning that this mechanism would allow us to can reconcile our results with findings on the effects of colonial concessions, like Nunn (2008), Dell (2010), and Lowes and Montero (2016). In these cases, labor was coerced, highly immobile and with a very low outside option. Thus, potentially, the producer extracting resources had little or no incentive to invest in local amenities or "public goods" to retain workers; and this under-provision might be partially explaining the persistent negative effects found by these studies. We also find no evidence in support of selective migration or negative spillovers from the company to neighboring regions being the main channels behind the observed difference in outcomes.

These findings motivatee the general equilibrium model we develop in the next section: a dynamic spatial model in which the degree of local monopsony power of a firm *within* a location depends on how mobile workers are *across* locations, and where we allow firms to invest in local amenities.

1.7 Dynamic Model

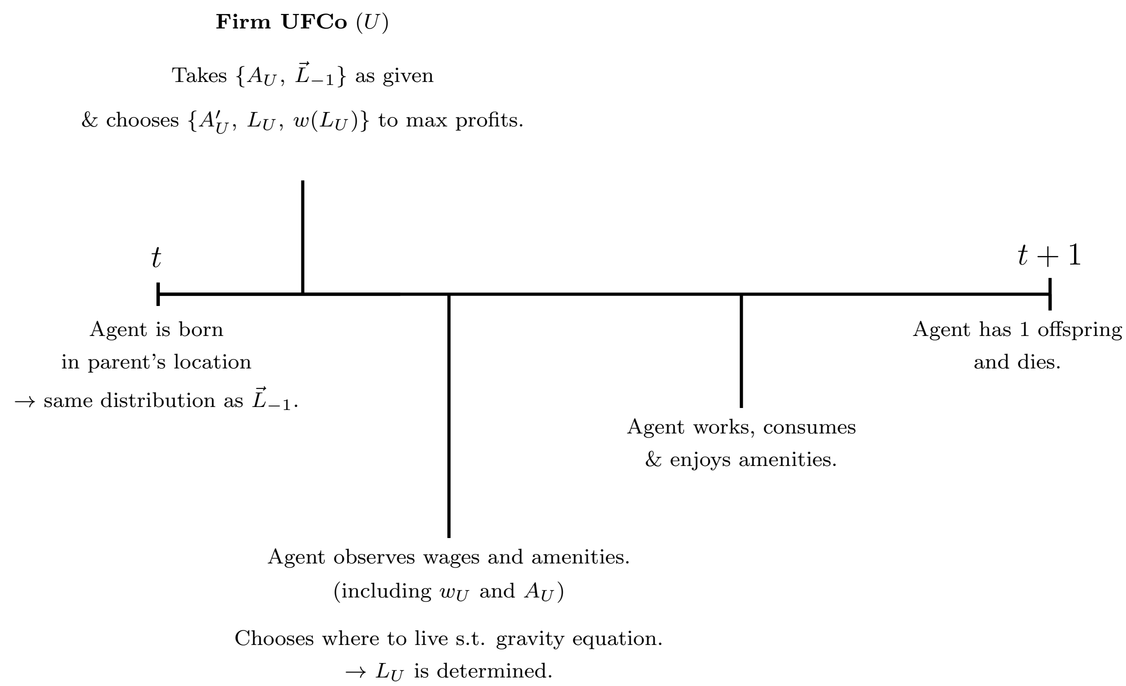
The evidence on the mechanism behind our results suggests a relationship between labor mobility, monopsony and investments that was crucial in determining the firm's effect. In light of this evidence, and given the large literature on monopsony power, we now lay out a dynamic general equilibrium framework that incorporates these new channels, and in which labor market power relates to worker mobility. The model captures observable spatial frictions, spillovers, and is consistent with local estimates from our empirical analysis. This framework allows us to quantify the difference between the firm's local and country-level effects, and run several counterfactual exercises to understand the relevance of labor mobility and of the local labor market structure.

In what follows, we outline the theoretical framework. Section 1.7.2 describes the model's calibration and Section 1.7.3 presents the results of our counterfactual exercises.

1.7.1 Theoretical Framework

There are $i \in \{1, ..., N\}$ locations and time is discrete. Throughout, we use a prime to denote next-period values. Each individual lives for one period. First, each agent is born in the location where her parent lives. Then, she chooses whether to live and work in this location, or move to a different location. Once the location is chose, the individual supplies a unit of labor inelastically to produce the differentiated variety in the location she lives, and she consumes. The period ends with the agent having one offspring. The total number of workers is normalized in each period and initial population is exogenous. To ease exposition, Figure 1.6 summarizes the timing of some events that we will describe in more detail below.

Figure 1.6: Model's Timing



1.7.1.1 Household Preferences and Consumption

Following their location choice, agents consume and derive utility. Workers living in region i have constant elasticity of substitution (CES) preference with elasticity σ across differentiated domestic (c) and foreign (m) goods. Additionally, they derive utility from the per capita local amenities of the region where they live.

The deterministic component of welfare—defined as welfare up to an idiosyncratic shock that we will introduce below—of a worker residing in location i is given by $\mathcal{U}(c_i, m_i, \tilde{a}_i) = \tilde{a}_i[\sum_{j=1}^{N} c_i^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}}]^{\frac{\alpha\sigma}{\sigma-1}}$, where $\tilde{a}_i = (A_i/L_i)^{\alpha_A}$ captures the utility derived from per capita local amenities.[26] Each worker supplies one unit of labor inelastically and earns a nominal wage (w_i). Letting P_i be the CES

[26]We assume there is perfect congestion in local amenities (i.e. $\tilde{a}_i = \bar{a}_i(A_i/L_i^{\rho})^{alpha_A}$ with $\rho = 1$). As will become clear in the next subsection, a model with imperfect congestion ($\rho < 1$), would lead to larger investments in local amenities from the UFCo (given the increasing returns to investment) and stronger welfare effects. However, to abstract from this additional agglomeration force and focus on mobility frictions and productivity spillovers, we set $\rho = 1$ and, in this sense, take the effects we find as a lower bound.

price index[27], the *equilibrium* deterministic utility of a worker in location i can be expressed as

$$W_i = \tilde{a}_i \left(\frac{w_i}{P_i} \right)^{\alpha}. \qquad (1.3)$$

1.7.1.2 Migration, Shocks and Location Choice

As previously stated, the utility of a worker in region i has a deterministic component given by W_i in equilibrium. Further, we allow for bilateral moving costs $\lambda_{ij} \geq 1$, where any value larger than one implies there are migration frictions. Thus, the deterministic utility of a worker who migrates from location i to location j is given by $\frac{W_j}{\lambda_{ij}}$.

Finally, the last component of the utility function is given by idiosyncratic taste differences, denoted by vector $\vec{\omega}$. Therefore, the ultimate utility of a worker living in location i who is *not moving* will depend on the idiosyncratic shock ω_j, and is given by $W_i\omega_i$, while the utility of a resident of location i *moving* to location j is denoted as

$$W_{ij}(\vec{\omega}) = \frac{W_i \omega_i}{\lambda_{ij}}. \qquad (1.4)$$

Thus, each period, a worker in location i chooses his location solving

$$\max_j \left\{ W_{ij}(\vec{\omega}) \right\} = \max_j \left\{ \frac{W_i \omega_i}{\lambda_{ij}} \right\}. \qquad (1.5)$$

We further assume that the idiosyncratic utility shifter, $\vec{\omega}$, follows a Frechet extreme value distribution with shape parameter θ. Let L_i denote the number of workers who live in location i at time t. It follows that the outflow of children in region i in a given period who will choose to work in region j the next period

[27] As is standard, the CES price index is given by $P_i = \left(\sum_{n=1}^{N} (\tau_{ni} p_n)^{1-\sigma} + p_w^{1-\sigma} \right)^{1/(1+\sigma)}$, where p_n denotes the price of the variety produced in region n, p_w is the exogenous price of the composite foreign good and τ_{ni} represents bilateral iceberg trade costs (as described below).

(L'_{ij}) can be described as

$$\frac{L'_{ij}}{L_i} = \frac{\left(\frac{W'_j}{\lambda'_{ij}}\right)^{\theta}}{\sum_{n=1}^{N}\left(\frac{W'_n}{\lambda'_{in}}\right)^{\theta}}. \tag{1.6}$$

Finally, we can derive a the gravity equation describing the bilateral migration flows from location i as a function of current population, expected utility in i and utility in other locations, as follows:

$$L'_{ij} = (\lambda'_{ij}\Omega'_i)^{-\theta}(W'_j)^{\theta}L_i, \tag{1.7}$$

where $\Omega_i = \left[\sum_{n=1}^{N}\left(\frac{W'_n}{\lambda'_{in}}\right)^{\theta}\right]^{\frac{1}{\theta}}$ denotes the expected utility of an individual in his childhood living in location i.

Trade Local bilateral trade flows from region i to region j incur an iceberg trade cost, $\tau_{ij} \geq 1$, where $\tau_{ij} = 1$ corresponds to frictionless trade. Thus, bilateral trade flows are governed by a standard gravity equation: $X_{ij} = \tau_{ij}^{1-\sigma}\left(\frac{w_i}{A_i^X}\right)^{1-\sigma}\frac{w_j L_j}{P_j^{1-\sigma}}$. We assume imported goods are purchased at an exogenous price p_w, that is calibrated to match observed terms of trade in the data.

1.7.1.3 Producers

The country is has N regions: one producing bananas where the UFCo operates (denoted 'U'), and other $N-1$ locations ($i \in \{1, 2, ..., N-1\}$) producing a domestic homogeneous good. We assume bananas are a pure export good, while domestic goods are consumed both locally and abroad. We proceed by describing these regions and their production schemes.

The UFCo Region (U) The banana producer is a profit maximizer, and the sole employer within its location. Besides wage, the firm may also provide local amenities as part of the worker's compensation bundle, and solves the following dynamic problem

$$V_t(A_U, \vec{L}_{-1}) = \max_{\{A'_U, L_U\}} \{P_U A_U^{\chi} L_U^{\phi} - w_U(L_U)L_U - P_A[A'_U - (1-\delta)A_U]\} + \beta V_{t+1}(A'_U, \vec{L})$$

such that

$$L'_U = L_U - \sum_{n=1}^{N-1} L_{Ui} + \sum_{n=1}^{N-1} L_{iU} \tag{1.8}$$

where L_{Ui} and L_{iU} satisfy Equation (1.7), and χ measures the strength with which the level of amenities (like hospitals or schools) increases productivity.[28]

This means that the firm will provide workers with enough utility as compared with their "outside option" to make next period's labor supply optimal, given bilateral migration flows. *In this sense, the firm is a local monopsonist, whose degree of monopsony power will depend on workers' mobility, which is governed by θ.* High values of θ imply higher worker mobility and less monopsony power for the firm, thus, attracting the same number of workers ($\text{Ł}'_U$) would be more costly: The firm will have to provide workers with a higher utility level, either through higher wages or more local amenities. Conversely, an extreme value of $\theta = 0$, which from Equation (1.7) implies no mobility ($L' = L$) would lead to a perfectly inelastic labor supply and a case of pure monopsony within this region.[29]

Firms in the Rest of the Country Each of the $N-1$ regions in the rest of the country produce a unique good. Producers in location $i \in \{1, ..., N-1\}$ maximize

[28] Costa Rican banana production represented, on average, less than 2 percent of the total world banana production from 1956-1984 (sample used in our calibration), which is why we are not considering p_U—the world banana price—as a function of q_U—bananas produced in Costa Rica. This also allows us to focus on monopsony forces that seemed to have been key, as explained in our empirical analysis.

[29] Also, note that the curvature of workers' utility function, which is concave in amenities and consumption will guarantee that the compensation bundle chosen by the company will be a combination of both amenities and wages.

profits in a competitive market and pay taxes to the government, solving

$$\max_{\{L_i\}} \Pi_i(L_i) = \max_{\{L_i\}} p_i A_i^{\chi} L_i^{\gamma} - w_i L_i - T_i.$$

Foreign Producers The foreign composite good (M) is produced abroad and imported at an exogenously determined price P_W. This good is consumed in both regions, and the value of these imports must equal the value of exported goods in equilibrium.

Local Amenities For simplicity, we assume that local amenities can be purchased at an exogenous price P_A in all regions.

1.7.1.4 Government

The government collects taxes T from firms in the "Rest of the Country", and provides local amenities to this region so that

$$P_A(A_i' - (1-\delta)A_i) = \frac{L_i}{\bar{L} - L_U} \sum_{i=1}^{N-1} T_i = \frac{L_i}{\bar{L} - L_U} \sum_{i=1}^{N-1} t P_i (A_i)^{\chi} L_i^{\phi},$$

where $\bar{L}$ is the total adult population in the country. As shown, we assume the government has no access to borrowing in foreign capital markets, and is therefore its provision of amenities is constrained at every point in time by $\sum_{i=1}^{N-1} T_i$, where each T_i is a fixed proportion t of the sales in region i. We also assume that revenue is spent on local amenities according to the labor share in each region. Appendix A.1.1.3 goes into the historical details behind these assumptions.

1.7.1.5 Dynamic Equilibrium

A recursive competitive equilibrium in this economy consists of prices $\{w_i, p_i\}_{i=1}^{N}$, and $\{P_A\}$; policy functions $\{A_U', L_U\}$; value function $\{V^U\}$; and labor supply

$\{L_i,\}_{i=1}^{N}$ such that: All firms and households optimize; trade is balanced; labor flows are consistent across regions $L'_i = \sum_j L'_{ji}$ and $L_i = \sum_j L'_{ij}$; and the labor, domestic good, foreign good, and UFCo fruit market clear. The solution of the system of equations implied by this equilibrium, and the proof of its uniqueness closely follows Allen and Donaldson (2018), who in turn use techniques derived from Allen et al. (2015).

1.7.2 Estimation

We calibrate the model to the historical reference equilibrium corresponding to the observed level of economic activity at the district-level. We preset the discount factor and depreciation parameters to standard values, and assume that trade costs have the form $\ln \tau_{ij} = \zeta \ln dist_{ij} + e_{ij}$, where $dist_{ij}$ is the great circle distance between districts. We the use Allen and Arkolakis (2014) estimate for ζ and set trade costs to $\tau_{ij} = dist_{ij}^{\zeta}$.

Our strategy to recover other parameters has several steps, which closely follow Allen and Donaldson (2018). Our first step assumes migration costs of the standard form $\ln(\lambda_{ij}) = \mu \ln(dist_{ij})$. We substitute these into Equation (1.6), and obtain

$$\ln (L_{ijt}) = -\theta\mu \ln(dist_{ij}) + \rho_{it} + \pi_{jt} + \varepsilon_{ijt,}$$

where $i \in R$, $j \in U$ and δ_{it}, π_{jt} are location fixed-effects. From these equations, we can estimate $\theta\mu$ jointly using data on migration of adults (20-65 years old) across districts and distances between districts for 1956-1984—years for which data is available. The second step relies on the following proposition[30] from Allen and Donaldson (2018): given observed data on $\{Y_{it}, L_{it}, L_{it-1}\}$ and identified values of $\{\lambda_{ij}^{-\theta}\} = \{dist_{ij}^{-\theta\mu}\}$, it is possible to recover unique values of $\{W_t^{\theta}, P_{it}^{\sigma-1}\}$.

[30] The application of this proposition, proven in Appendix A.3 of Allen and Donaldson (2018) to our case is straightforward.

Having identified $\{W_t^{\theta}, P_{it}^{\sigma-1}\}$, our third step consists of manipulating Equation (1.3) to obtain

$$ln(W_{it}^{\theta}) = \theta\alpha \ln w_{it} + (1-\sigma)^{-1}\alpha \ln(P_{it}^{1-\sigma}) + \theta\alpha_A ln\left(A_{it}/L_{it}\right) + \theta\bar{a}_i. \tag{1.9}$$

When estimating Equation (1.9) at hand, endogeneity is a concern. Therefore, we use model-based simulations to construct instrumental variables (IVs) for the endogenous regressors. The procedure we follow is: (i) construct proxies for get proxies for $\bar{a}_{it}$ from invariant geographic characteristics (temperature, precipitation, slope); (ii) make a guess of the elasticity parameters $\{\theta, \sigma, \alpha_A\}$ based on values in the literature; (iii) using this guess, use a simulated method of moments (SMM) to obtain estimates of other parameters in the model (including α); (iv) start the IV-generating model simulation at using the observed population shares in 1956 as the L_{i0}; (v) run the model forwards to generate simulations for $\{w_{it}, P_{it}^{1-\sigma}\}$; (vi) use these simulations to run the IV in Equation (1.9), controlling for geographical characteristics and initial population shares. Thus, the exclusion restriction is that the unobserved amenities are not correlated with the initial population shares of other locations, conditional on own attributes. Finally, with new estimated elasticities, iterate on (ii)-(vi) until there is convergence and SMM estimates do not change significantly.

We identify $\theta = 5.11$ as a parameter that governs the labor mobility elasticity, and $\sigma = 4.03$ as the elasticity of substitution. Our estimation also finds $\alpha_A = 0.09$. The results of our SMM[31] along with the sources, targets, and resulting values from the estimation are presented in Table 2.4.2. Other output from this estimation is reported in Appendix A.12.

The SMM is calibrated using standard targets, along with a particular one: The local RD estimate (last row). This estimate is a model-based version of the

[31]For the SMM, given in data availability restrictions, we restrict the data used to generate the targets to 1956-1973; the period for which we have data for all targets.

Table 1.5: Calibration Results

	Definition	Value	Target	Data	Model
Preset Parameters					
β	Discount Factor	0.96			
δ	Depreciation	0.07			
ϕ	UFCo share of L in factor payments	0.62	Company reports		
t	Share of taxes over GDP	0.13	National accounts		
Jointly Calibrated Values at SS (SMM)					
γ	RoC share of L in factor payments	0.38	Mean L_U/L_R	0.14	0.17
α	Consumption' share in utility	.97	% spent durables	.041	.059
p_W	Price of imports	0.83	Mean terms of trade	1.32	1.42
p_U	Price of banana exports	1.25	Share UFCo/total X	1.40	1.56
P_A	Price of local amenity	0.96	Share inv Gov/UFCo	0.30	0.25
χ	Amenity share of productivity	.058	Local RD estimate	0.26	0.24

Notes: GDP does not include UFCo's production. Data for all targets is available for years 1956-1973.

RD we conducted empirically, and is calculated by (i) estimating a projection of the probability of being poor on wages and investments from the data, while controlling for geographic and demographic characteristics of each location, such that $P(poor_{in}) = \beta_1 w_{in} + \beta_2 \frac{P_A A_n}{L_n} + \Gamma_{in} + \Gamma_n + \epsilon_{in}$; (ii) estimating $\widehat{P(poor_n)}$ for districts on both sides of the border where we ran our RD, both in the model and in the data; (iv) calculating $\gamma = P(\widehat{poor_{UFCo}}) - P(\widehat{poor_{NonUFCo}})$; and (v) choosing the value of χ that minimizes the difference between the empirical and model-based γ. For validation purposes, non-targeted moments are presented in Appendix A.12.

1.7.3 Counterfactuals

No UFCo and Perfectly Competitive Labor Markets in All Regions In our empirical analysis, we determined the UFCo's effect on several local economic outcomes. In this counterfactual, we do an analogous exercise within the model, where we assume there is no UFCo and quantify the impact on outcomes, both locally in the UFCo region and for the country as a whole; both for the case where there is a monopsony in the UFCo region, and for the case where there is a perfectly competitive labor market in both regions. Unlike our empirical estimates, these results account for general equilibrium effects.

First, the second column in Table 1.6 shows how the magnitude of the UFCo's local effect predicted by the model is in line with our empirical results, while out aggregate findings in Column 1—albeit smaller than the local ones—are sizable, accounting for a 2.88 (2.76) percent increase in welfare measured as change in utility (consumption equivalent variation).

Second, while the effects on welfare are similar under both scenarios (monopsony and perfect competition), there is a big difference in the company's strategy to compensate workers. This is evident observing the last two rows of Table 1.6. The monopsonist compensates workers mainly through amenities, while keeping wages low (thus, in a counterfactual without a monopsonist UFCo amenities are lower and wages are higher); while under perfect competition in the labor market the compensation is mostly through wages.

This leads to our third observation: Welfare is higher under the monopsony than under perfect competition. The reason are mainly the amenity-driven productivity increases paired with higher levels of amenities in the monopsony's case. Indeed, assuming amenities have no effect on productivity ($\chi = 0$) leads to lower welfare levels in the case with monopsony compared with the case of perfectly competitive labor markets in all regions.[32]

Table 1.6: Company's Effect under Different Labor Market Structures

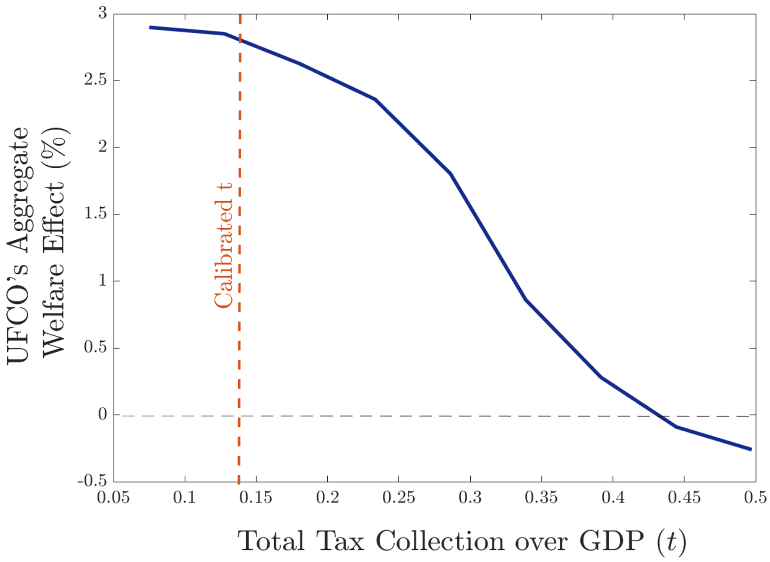
Outcome	%Δ w/Monopsony		%Δ w/Perfect Competition	
	Aggregate	UFCo Region	Aggregate	UFCo Region
Equiv. Δ (in C)	2.88	24.2	2.22	21.8
Welfare	2.76	22.9	2.01	19.1
Stock Amenities	5.59	38.1	1.62	11.2
Wages	-1.30	-7.8	1.88	14.9

Notes: The table shows the change in steady state outcomes. Equivalent Variation is the % increase/decrease in consumption in steady state necessary to get the new utility level.

[32] These results assuming $\chi = 0$ are shown in Table A.36, Appendix A.13.

Role of the Government's Budget Constraint The government's budget constraint is an important determinant of the UFCo's effect on welfare. As capacity to collect taxes increases, UFCo's aggregate effect on welfare becomes negative. The intuition is as follows: the UFCo is a monopsonist and is depressing wages, therefore, unless the government is somehow constrained and cannot provide the efficient level of local amenities on its own, the country would be better-off without the company. In developing countries, however, it has been historically difficult to raise taxes, with levels of tax revenue over GDP in the vicinity of 10 percent.

Figure 1.7: Changes in Aggregate Welfare and Public Tax Collection Capacity

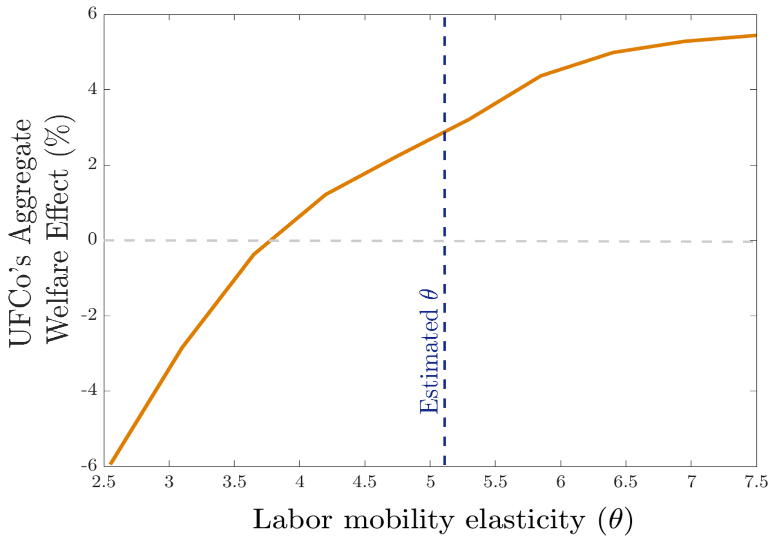


Notes: The figure shows the how the UFCo's effect on aggregate (country) welfare—measured by a consumption-equivalent % variation—changes as government's tax collection capacity (t) changes.

Labor Mobility as a Key Determinant of the UFCo's Effect on Welfare

In line with our mechanism, the UFCo's effect on welfare is decreasing on labor mobility, which in turn is directly related to workers' outside option. Of particular interest however, a counterfactual exercise where labor mobility decreases can flip the sign of the UFCo's effect. Further, as shown in Figure 1.8, the elasticity of the effect to the value of the labor mobility elasticity (θ) is significant. This highlights the importance of the local labor maker dynamics in determining the share of total profits that will stay and benefit the local economy, given large investment projects like this one.

Figure 1.8: Changes in Aggregate Welfare and Labor Mobility



Notes: The figure shows the how the UFCo's effect on aggregate (country) welfare—measured by a consumption-equivalent % variation—changes labor mobility changes.

1.8 Concluding Remarks

Understanding the implications of large-scale foreign investments is particularly relevant today. In the last 20 years, foreign private investors have acquired more than 64 million acres of land in over 80 countries of Africa, Central and Southeast Asia, Eastern Europe and Latin America via leases (of up to 99 years) or purchases of farmland for agricultural investment (Cotula et al., 2009; Cotula and Vermeulen, 2009). More than 400 of these concessions have been *larger* than the UFCo's concession in Costa Rica. This recent wave of large-scale land acquisitions by foreigners in developing countries —known as "land grabs"—is devoted to growing food crops and mainly driven by concerns about food security and by the biofuels boom, and makes understanding what is the effect of such projects a matter of first-order importance.

This paper studies the impact of large private investment projects on local economic development, while analyzing how these effects interact with conditions in the local economy using evidence from the United Fruit Company in Costa Rica. In particular, we use a regression discontinuity design and find a positive and persistent effect on economic outcomes in areas where the company operated. Households in the former UFCo areas have a better satisfaction of basic needs (housing, sanitation, education, and consumption capacity), are less likely of being poor, and have a lower number of unsatisfied basic needs.

Using data we have collected from primary sources, we test different potential mechanisms, and find evidence that investments in physical and human capital carried out by the UFCo were likely the drivers of the positive "UFCo effect". Studying company reports, we document that these high levels of investment were motivated by the need to attract and maintain a sizable workforce. An estimated general equilibrium model highlights how labor mobility is key in determining the sign and magnitude of the company's effect. Indeed, for relatively low elasticities, both the local and aggregate effects of the company become negative, which is in line with the negative effects found by the literature on coercive (and relatively immobile) labor. The company's effect is also decreasing in the ability of the local government to collect taxes and fund investment projects, stressing the role of domestic conditions in shaping the firm's effect.

In future research, we plan to explore the potential technological spillovers from the company to locals, and whether potential productivity differences are persistent when comparing firms who were differentially exposed to the UFCo using novel data on agricultural production, also with detailed geo-references.

CHAPTER 2

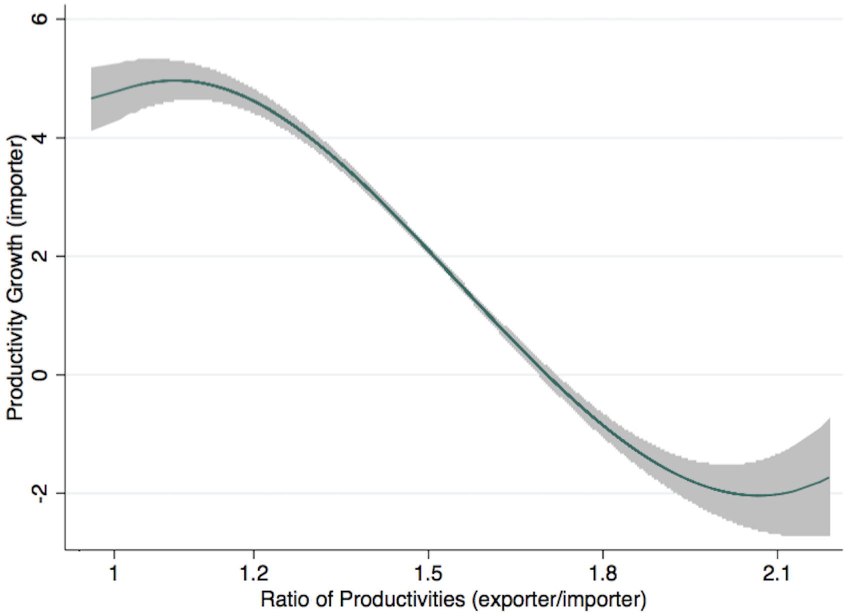
International Diffusion of Technology: Accounting for Differences in Learning Abilities

2.1 Introduction

There are well-known gains from trade for developing countries when trading with developed countries, such as lower prices and less competition with locally produced goods. However, these channels have proven to be insufficient in delivering sizable gains from trade. A recent body of literature has focused on dynamic gains from trade as a key element to understand how trade can be an engine of significant growth (Alvarez et al., 2013; Sampson, 2014; Perla et al., 2015; Buera and Oberfield, 2016). This paper proposes how, in terms of dynamic gains from trade, countries are better off trading with partners who have higher—but similar—levels of development.

In general, papers that study the mechanism through which international trade interacts with economic growth develop models with a wide range of learning processes through which diffusion takes place. However, little is known about this type of knowledge transfer across countries. A natural question is whether the model is a good representation of the true learning process behind knowledge transfers across countries, and this paper explores the question empirically. Who learns from whom? Is the magnitude of these technology transfers economically and statistically significant? Does this depend on the distance between the levels of knowledge of the parties involved? To answer these questions, I build a panel that spans over two decades, consisting of a network of industry-country pairs, the trade flows between each of them, and data on industry-country productivity per year.

Figure 2.1: Relationship between self-productivity growth and distance to trading partners' productivities.



Notes: Figure 2.1 shows a 5-degree polynomial obtained after running a panel non-parametric regression with fixed effects, with 95% confidence intervals shown in gray. The dependent variable is productivity growth of an importer from industry k in country i from period t to period $t+1$. The independent variable shown is the ratio between the productivity of each exporter (industry-country specific) to the productivity of importer from *the same industry* in country i in period t, from 1995-2011. The regression also includes the share of imports, the gap of productivities, and fixed effects, as described in detail in Section 2.2.3.

Using this data, I find, first, that the growth rate of productivity of importers is increasing in their trading partners' productivity, which is in line with the mechanism of Buera and Oberfield (2016). Second, there is a negative relationship between the importer's productivity growth rate and the ratio of productivities of the trading partners: If the ratio is very small, increasing it leads to more productivity growth. This is intuitive: If both parties know roughly the same, there are little gains from interacting. However, if the ratio is relatively large, increasing it leads to less productivity growth. The latter is also intuitive; if you do not know how to multiply, attending a quantum physics class might not be useful. This relationship is shown in Figure 2.1. Through the lens of the literature on diffusion of knowledge through trade, this is informative regarding the bounds to learning that intervene in this diffusion process. Third,the data suggest little congestion and no magnification effect in learning, as the knowledge transfer depends on the interaction between partners, but not on the share of goods being traded. I document how these effects are present over time, and both across and within industries. I also use the China shock, as well as an instrumental variable based on Autor et al. (2013) and revisit my regressions, finding little quantitative and no qualitative change in my results.

Guided by this evidence, I extend the benchmark model of Buera and Oberfield (2016) and develop a model in which producers can learn from their trading partners, and this learning is heterogeneous: Given a match, the probability of learning depends on the gap in knowledge of the parties that interact. This mechanism will allows for countries to learn easier from partners who are "close" to them, in terms of productivity. To validate the model, I rerun all my initial regressions using model-generated data, and find that learning heterogeneity allows the model to match the empirical coefficients, while shutting down this heterogeneity leads to largely counterfactual results.

Using the model, I find sizable differences in the predicted gains from trade when shutting down the heterogeneity in learning abilities, and in particular when comparing the contribution of trade to TFP dynamics for growth miracles. Moreover, in the extended model, when opening to trade, highly productive agents are learning the most. This is consistent with Steinwender (2015), who finds evidence that there are productivity increases after expanding export markets, but only for firms that were ex-ante the more productive ones. Learning heterogeneity is also crucial to match the firms size distribution and be consistent with Gibrat's law for firms.

Policy implications differ between models: For developing countries, the extended model implies inducing larger optimal trade shares with mid-developed countries, as opposed to trading more with very productive and developed ones. Moreover, this model allows—theoretically—for a divergence in welfare between low- and high-income countries.

The model and its calibration strategy rely on standard, but relatively strong, assumptions. However, they introduce heterogeneity in learning abilities in the general Buera-Oberfield benchmark model, without losing its tractability. This force could be introduced in a similar way in a wide range of models, including Alvarez et al. (2013), Perla et al. (2015), and Sampson (2014). As such, I view the structure imposed, based on the empirical results I obtained, as a natural way to study the general effects this important, but usually ignored, force can have. My empirical strategy using industry-country shares and productivities and my proposed model can be used to study a variety of phenomena that might affect learning across countries at an aggregate level, dynamically, and differently across sectors.

This paper belongs to a strand of literature studying the interaction between growth, trade and knowledge. This paper contributes to the literature on diffusion of ideas through trade, by providing a foundation as to why learning is heterogeneous depending on the relative level of development of the trading partners. The earliest models studying endogenous growth and the role of knowledge generally assumed knowledge was a public good, as in the learning-by-doing models of Arrow (1962), or Grossman and Helpman (1990) where searching for new technologies was rewarded with patents. Later on, Romer (1990) published a seminal paper on the role of ideas and knowledge in sustained growth.

In models of diffusion, producers improve their productivity by learning from others, but interpretations of the specific learning process have varied considerably. This paper proposes a new intuitive approach to modeling learning: Embed heterogeneous learning probabilities in the workhorse model of Buera and Oberfield (2016). In my model, conditional on learning, there are more gains from meeting better producers or running into better ideas, such as in Jovanovic and

Rob (1989), Kortum (2008), Eaton and Kortum (1999), Alvarez et al. (2013) and Buera and Oberfield (2016). However, in my model there is a trade-off: the probability of learning from a meeting is decreasing in the gap between a manager's current level of knowledge and the level of the manager she meets.

The paper also relates to the literature on diffusion and development, as it captures the limited extent to which technologies can spread across countries when there is a large gap between the levels of development of the trading partners. The former is crucial when analyzing the key aspects in which less developed countries should invest in order to increase their local productivity, in particular through learning from trading partners with more advanced technologies. In this sense, my work also relates to the literature on absorptive capacity. The notion of absorptive capacity dates back to Cohen and Levinthal (1989), who argue that a firm's innovative capabilities depend crucially on its ability to identify external information, assimilate it, and apply it to commercial ends.

Several other researchers have emphasized the difficulties in adapting advanced technologies, especially to the needs of less developed countries, such as Findlay (1978). Evenson and Westphal (1995) study how convergence between countries is slowed down as new technologies need a significant amount of "tacit knowledge", while Atkinson and Stiglitz (1969) and Stewart (1977) study the relevance of the "appropriateness" of technology. More recently, Acemoglu and Zilbotti (1999) considers the differences in relative supplies of skills across countries in a model in which technologies designed for skilled workers cannot be perfectly adopted by countries with mostly low-skilled labor.

The rest of the paper is organized as follows. Section 2.2 describes the data and the reduced-form evidence. Section 2.3 includes the theoretical model and an extended version of it that allows for international trade. A quantitative analysis using the model is presented in Section 2.4, which also includes my calibration strategy, the model's validation, an analysis of TFP dynamics, and a description of the main implications of the model. Section 2.5 concludes.

2.2 Reduced-Form Evidence

Guided by the theoretical model, this section aims to study the impact of trade interactions on productivity growth. My goal is to provide empirical evidence on the true learning process behind the diffusion of ideas through trade. Moreover, this will allow me to assess the relevance of productivity gaps in this process.

To do so, I begin by showing reduced-form evidence of the key mechanism in the model: learning being easier for trading partners who have similar TFP. I also find evidence of the learning in Buera and Oberfield (2016): productivity growth is significantly increasing in the productivity level of the trading partner. After establishing these correlations, I then turn to an instrumentation strategy for changes in exposure to trading partners, discuss the data used in the analysis, and present of my empirical findings.

I then use these reduced-form regressions to validate my model, and show how my mechanism is key to match both the sign and magnitude of the relations found empirically, by comparing it with the case of homogeneous learning.

2.2.1 Regression Framework

In this section, I use panel data on trade flows and productivity growth to investigate the relationship between trade-partner productivity and self-productivity growth. This will be informative about the true learning process behind the international diffusion of ideas, and about the relevance of productivity gaps in this process.

To do so, I begin in a reduced-form fashion relating the productivity growth of each industry-country pair to the productivity of its trading partners, and the ratio between self-productivity and each partner's productivity, as a measure of the "distance" between both technologies, using various flexible reduced-form specifications.

I am particularly interested in two questions: first, does productivity increase more when my trading partners have high productivity levels? Second, if so, how does this depend on the ratio between my productivity and his? Further, I present various robustness checks, with a particular focus on ruling out high non-linearities in this relationship that could flip the result, mean reversion, and a spurious relation not related to trade.

While none of the reduced-form specifications is tightly grounded in my theory, I nonetheless argue that the resulting picture is useful in understanding the true learning process behind learning from trade; a topic where the literature offers a menu of models with different mechanisms and implications, but little empirical grounds. Moreover, the regressions are useful as means of model validations in Section 2.4.3.

I begin with the following baseline specification:

$$\Delta\% z^v_{it+1} = \beta_1 + \beta_2 log\left(\frac{z^u_{jt}}{z^v_{it}}\right) + \beta_3 log\left(z^u_{jt}\right) + \beta_4 log\left(\frac{z^u_{jt}}{z^v_{it}} \times z^u_{jt}\right) + \beta_5 log\left(\pi^{uv}_{ij}\right) + \Psi + \epsilon_t, \tag{2.1}$$

where z^v_{it} is the log productivity of industry v in country i[1], and z^u_{jt} is the productivity a trading partner from industry u in country j. π^{uv}_{ij} denotes shares of imports (as producers learn from sellers) of each industry-country pair. Finally, Ψ captures industry, country, and year fixed effects.

Using productivity growth through Equation 2.3, provides a strategy for deriving a version of this reduced-form equation from the model. The details of this derivation can be found in Appendix B.3. However, to address issues suppressed in the theory but likely to matter in the estimation, I will not focus on structural regressions in the analytical model, but on reduced-form regressions that are motivated by the model but that do not identify structural parameters. Instead, in

[1]All productivities are demeaned using the country-industry mean across the sample (1995-2010), to make their magnitudes comparable across sectors

the quantitative analysis of Section 2.4.3, I will use these regressions for model validation, by running the same non-structural regressions in data generated by the extended model.

Equation 2.1 describes crucial relations from the model. It allows me to estimate whether the gap between the productivity of the learner (the importer) and the productivity of its trading partners (the exporters) induce on average an increase or a decrease in productivity growth, thereby allowing me to test if the mechanism behind my model is relevant empirically, and shed light on the true learning process behind learning from trade. A negative β_2 would support the idea of absorptive capacity constraints: the larger the ratio, the harder it is to learn given interactions take place.

The coefficient β_3 tests forces that should be present in this model as well as in the original Buera Oberfield model: that larger partners should lead to larger gains conditional on the productivity gap. I include the coefficient β_4 to allow the effect of the ratio to vary with the partner's productivity level. Finally, β_5 is included to allow for the share of imports to play a role. Note that, in the model, this share is irrelevant (and empirically it proves to be insignificant), however I include it as an effort to make the learning process more flexible in this empirical exploration.

2.2.2 Data

In my baseline analysis, I study changes in productivity between 1995 and 2010. In the sensitivity analysis, I use 2007 as an alternative end year to exclude the great recession. The data used to construct the import shares comes from the World Input-Output Database (WIOD)[2]. Data used to obtain the productivities per sector and per country comes from the GGDC database and world KLEMS

[2]The WIOD traces the flow of goods and services across 35 industries, 40 countries, and a constructed rest of the world (Timmer et al., 2015b).

data, which include data on real GDP per hours worked for a panel of 33 countries[3] dividing economic activity into 10 sectors[4]. Using the industry codes, I can map the sectors from the WIOD to these 10 aggregate sectors. this mapping is included in Appendix B.4.

For my dependent variable, I use the the log change in productivity for an industry within a country shown in 2.1; for a panel composed by each of the 10 industries in the 31 countries studied. For my independent variables, I measure the log of the ratio of the productivity of the synthetic trading partner, constructed as explained in Section **??**. As explained before, these productivities are demeaned using the average productivity of each industry within each country across the years of the study (1995-2010), to make them comparable across industries.

2.2.3 Empirical Results

The results from running 2.1 are shown in Table 2.1. In column (1), I exclude both the trading partner's productivity and the interaction term. This naive regression shows a correlation that is negative and large (-0.56) between the change in the productivity of a country and the gap between its productivity and that of its trading partners. Namely, a 1% increase in the ratio (trading partner's z/own z) leads to a decrease in productivity growth of -0.56 percentage points(pp); a sizable and significant effect.

Column (2) captures a force that is central in the work of Buera and Oberfield

[3]The countries included in this data-set are, from Africa: Botswana, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Nigeria, Senegal, South Africa, Tanzania, and Zambia; from Asia: China, Hong Kong, India, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand; from Latin America: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Venezuela.

[4]These sectors are: agriculture, hunting, forestry and fishing; mining and quarrying; manufacturing; electricity, gas and water supply; construction; wholesale and retail trade, hotels and restaurants; transport, storage, and communication; finance, insurance, real estate and business services; government services; community, social and personal services. Data is available from 1950 - 2010; details on the construction of these sectors can be found in citetggdc.

Table 2.1: Trade and Changes in Productivity: Industry-Country Pairs

Dependent variable: change in productivity of each country's industry $\left(\Delta z^k_{it+1}\right)$.

Log Variables	(1)	(2)	(3)	(4)
Ratio $\left(\frac{z^u_{jt}}{z^v_{it}}\right)$	-0.56^{***}	-1.46^{***}	-1.55^{***}	
	(0.014)	(0.037)	(0.038)	
Trading partner's productivity $\left(z^u_{jt}\right)$		0.94^{***}	0.83^{***}	
		(0.036)	(0.037)	
$\left(\frac{z^u_{jt}}{z^v_{it}}\right) \times z^u_{jt}$			-0.002^{***}	
			(0.000)	
Trade share $\left(\pi^{uv}_{ij}\right)$				
				(0.006)
FE	✓	✓	✓	✓
Adj R^2				

Notes: Table 2.1 reports the regression results when the dependent variable is change in productivity of each country's industry $\left(\Delta z^k_{it+1}\right)$. All productivities are demeaned using the mean of a country's industry during the period studied (1995-2010). Independent variables are in logs. In all cases, the number of observations equals 1,889. Constants not reported. Robust standard errors are in parentheses. Significance levels: $^{*}p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(2016): that more productive trading partners (sellers, in particular) lead to more productivity growth. The coefficients are sizable hand have the expected signs: (a) given a ratio, a more productive partner leads to better ideas, namely, a 1% increase in the trading partner's productivity leads to a 0.94 pp increase in productivity growth; and (b) a larger ratio limits learning with a 1% increase in the ratio leading to a -1.46 pp decrease in productivity growth. Moreover, it highlights the importance of the ratio: given the magnitudes of the log variables, Column (2) shows that the role of the ratio can be even larger than the one of the partner's productivity level.

In Column (3), I include the interaction term and allow the ratio to have differential effects on productive and improductive trading partners; while Column (4) incorporates the trade share. First, Column (4) shows that on average the effect of a large ratio is smaller for very productive trading partners, although the magnitude of this effect is small (-0.002). This result is consistent with the theoretical model: a large ratio implies a low probablility of adoption, however, if adoption occurs, the larger the productivity of the trading partner the more an agent would be able to learn.

These results highlight a new important element in the interaction of trade and productivity growth. The combination of a low productivity (e.g., manufacturing in Tanzania) and having a very large gap with your trading partners (e.g., machinery in Switzerland[5]) significantly decreases the dynamic gains from trade that come from ideas' diffusion. In Section 2.4, I will use my quantitative framework to show, in a generalized model, how this new channel can contribute to understanding the growth we see in countries like growth miracles through an examination of the TFP dynamics in these countries.

Within-Industry Results In line with the model presented in Section 2.3, the previous section ran Regression 2.1 pooling across industries. This allows

[5]Switzerland is Tanzania's main trading partner.

for producers to learn from importers from any industry, not only their own (for instance, they could learn about managerial practices that are applicable to a range of industries, or about how to apply technologies from other industries in their own). Although gains across fields are not hard to imagine, in this section I explore if the same gains are found within industries. That is, forcing $u = v$ for all u in Regression 2.1. This can be informative on the nature of the learning process behind gains from trade. The results are shown in Table **??**.

Non-linearities As the relationship between the ratio of productivities and the productivity growth of the importer might be non-linear in nature, I also perform a more flexible non-parametric regression, which which aims to capture any non-linear relationship with a polynomial of degree 5. The result when running the regression in Column (2) within industries is shown in Figure 2.1. A very similar result when pooling across industries is shown in Appendix .

As shown in the figure, there is a non-linear relationship between the importer's productivity growth rate the ratio of productivities of the trading partners, however productivity growth is consistently decreasing as the ratio increases. Through the lens of the literature on diffusion of knowledge through trade, this is informative of the bounds to learning that intervene in this diffusion process, especially when studying trade between countries or industries where the gap in productivities might be sizable (like it typically occurs in North-South trade). Note how this non-linearity is different in nature from what one would expect when learning from coworkers (Jarosh et al. (2018), Herkenhoff et al. (2018)), as the nature of learning is different when trying to acquire knowledge solely from trade: this transfer of technology and knowledge is occurring through imported technology and exposure to foreigners, not through face-to-face everyday interactions or direct teaching.

The China Shock and an Instrumental Variables Approach Although suggestive of significant learning from trading partners, these findings could in principle be contaminated by other events occurring in the world market, or be spurious in nature. To address this issue, I use the China shock and revisit all my regressions, constructing instruments for the trade shares in a fashion similar to Autor et al. (2013). Namely, I consider only imports coming from China, and calculate the change in variables from 1995 to 2007 for a subsample of countries for which it is possible to construct a strong Autor, Dorn Hanson instrument, so that:

$$\Delta\% z^{v}_{i2007} - \Delta\% z^{v}_{i1995} = \beta_2 (z^{u}_{j2007} - z^{u}_{j1995}) + \beta_3 (\pi^{vu}_{ij2007} - \pi^{vu}_{ij1995}) + \Psi + \epsilon. \quad (2.2)$$

Details of this instrument are available in Appendix **??**. The results for the within-industry are shown in in columns (1) and (2) of Table **??**, while the results while pooling across industries are shown in columns (1) and (2) Table **??** . As the tables, I find little no qualitative change in my results, and although the magnitudes are not directly comparable (as these new results are in log-changes), the effects of the ratios are still economically significant in size; even larger than previously found.

Robustness Even after checking the robustness of the results non-parametrically and through the China shock , the results embody an assumption about the relevant time period for the analysis, and about how long it takes for the learning mechanism to kick-in and for trade to have a causal effect on productivity.

Beginning with the latter, one concern about the specification may be that a year is not enough for effect to materialize, or at least not fully. Given how learning works in the model as derived in Section 2.2.1, the main specification only includes the first lag. To address this concern, Appendix B.5, includes results in which I inlcude further lags for the independent variables. This exercise allows me to assess if there is a "time-to-build" the stock of knowledge after a trade interaction, and whether or not it is empirically correct to include only the first lag. This exercise, discussed in more detail in Appendix B.5, reveals no evidence of lags of order higher than 1 having more importance than the first one, as they are not larger in magnitude nor significant for any ratio. Moreover, all the qualitative findings remain unchanged with little impact on the magnitudes of the coefficients.

Finally, I examine the sensitivity of my estimates to the time period studied. Namely, I rerun the regressions over the 1995-2007 period, excluding the great recession from the sample, also with little impact on the results as described in Appendix B.5.

2.3 Theoretical Framework

The model presented in this section combines the framework of global diffusion presented in Buera and Oberfield (2016) with the idea of absorption capacity (Cohen and Levinthal, 1989) and sectoral learning. This leads to a model that nests the original one, but has different key results (both qualitative and quantitative).

2.3.1 Learning Environment

There is a continuum of goods $s \in [0, 1]$, and for each good there are m producers, each of them with a knowledge q. The production function is given by $y(s) = q * l(s)$, where $l(s)$ is the labor input and $y(s)$ represents the output of good s. $M_t(q)$ is the fraction of producers with knowledge no greater than q, and the frontier of knowledge takes the form of $\tilde{F}_t(q) = M_t(q)^m$.

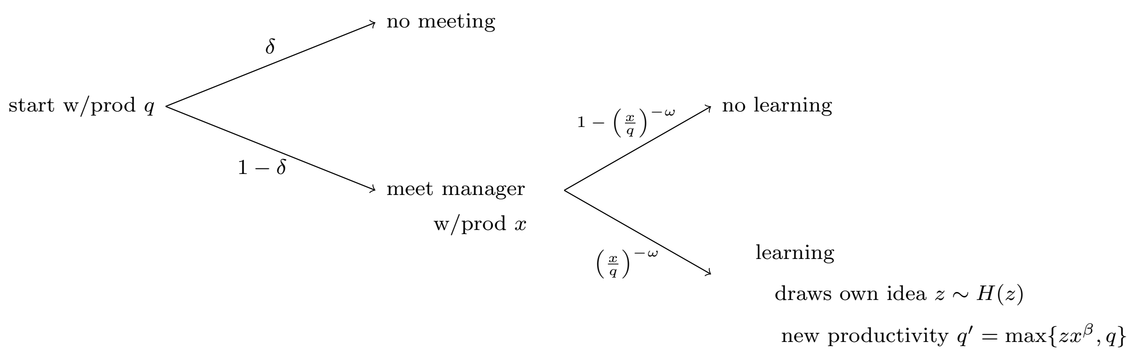
Each period t, a producer begins with a level of knowledge q, and with probability $1 - \delta_t$ is not matched with anyone, and thus keeps the same level q next period, i.e. $q_t = q$. With probability δ_t, the producer is matched with another producer with knowledge x drawn from a distribution with CDF $\tilde{G}(x)$.

An important point is that in the model, *not all matches lead to learning*, even if a manager matches with someone with higher productivity than her. In particular, given a match, a producer will be able to assimilate its counterpart's idea with probability $\left(\frac{x}{q}\right)^{\omega}$, which follows the spirit presented in Lucas and Moll (2011). More precisely, the learning probability would be

$$\max\left\{\left(\frac{x}{q_t}\right)^{-\omega},\ 1\right\},\quad \omega > 0$$

If this probability realizes, and the producer learns, then she draws a second idea (can be interpreted as her own idea) z from an exogenous distribution with CDF $H(z)$. Finally, the producer adopts the new hybrid idea if $q < zq'^{\beta}$. The timing of the learning process is summarized in Figure 2.2.

Figure 2.2: Timing of the Learning Process



Note that there is a trade-off: on one hand, a producer wants to match with someone with a productivity that is similar to hers, to make the probability of learning high. On the other hand, conditional on learning, she wants to match with someone with a productivity x that is as high as possible. The model is isomorphic to Buera and Oberfield (2016) if $\omega = 0$. In this $\omega = 0$ case, the gap in productivity levels plays no role in the probability of learning. Including $\omega > 0$ prevents someone from getting a very good draw of x and becomes a superstar producer overnight. For example, imagine importing books about quantum physics, while struggling with the basics of multiplication; even if there is a match, an insight about quantum physics might not transmitted, *and how hard the idea is to transmit will depend on the gap between both levels of knowledge.*

Dynamics of the Distribution of Knowledge Next, I provide conditions such that the frontier of knowledge converges to a Frechet distribution. Then, the state of knowledge can be summarized using this distribution's level, called the "stock of knowledge". The model is thus compatible with Eaton and Kortum (2002) machinery, and can be used to study trade flows in an environment with asymmetric countries, characterizing the stocks of knowledge only in terms of trade shares and parameters.

Given the distribution of knowledge at time t, $M_t(q)$, the source distribution $\tilde{G}(q)$, and the exogenous distribution of ideas $H(z)$, the distribution of knowledge at time $t + \Delta$ is given by[6]

$$M_{t+\Delta}(q) = M_t(q)[1 - \delta_t \Delta \int_0^\infty \left(\frac{x}{q}\right)^{-\omega} [1 - H(q/x^\beta)]\, d\tilde{G}(x)]$$

Rearranging and taking limits as $\Delta \to 0$ we obtain

$$\frac{d}{dt} lnM_t(q) = \lim_{\Delta \to 0} \frac{M_{t+\Delta}(q) - M_t(q)}{\Delta M_t(q)} = -\delta_t \int_0^\infty \left(\frac{x}{q}\right)^{-\omega} [1 - H(q/x^\beta)] d\tilde{G}_t(x) \tag{2.3}$$

With this limit, we can derive an equation describing the frontier of knowledge. Since $\tilde{F}_t(q) = M_t(q)^m$, the change in the frontier of knowledge evolves as

$$\frac{d}{dt} ln\tilde{F}_t(q) = -m\delta_t \int_0^\infty \left(\frac{x}{q}\right)^{-\omega} [1 - H(q/x^\beta)] d\tilde{G}_t(x)$$

[6]This is because $M_{t+\Delta}(q) = M_t(q)[1 - \alpha_t Prob(q < zq'^\beta)]$. This law of motion is easy to understand thinking $M_{t+\Delta}(q)$ will be equal to $M_t(q)$ unless: there is match (probability α_t), there is adoption given the match according to **??**, and the hybrid idea is better than the original one($q < zx^\beta \to \frac{q}{x^\beta} < z \to 1 - H(q/x^\beta)$).

The proof of convergence to a Frechet distribution requires the following assumptions:

i. The distribution of original ideas, $H(z)$, has Pareto tail with exponent θ, such that $\lim_{z\to\infty} \frac{1-H(z)}{z^{-\theta}} = 1$.

ii. $\beta \in [0,1]$, and $\omega < \beta\theta$.

iii. The distribution of ideas from other producers $G_t(q)$ has a thin tail. That is, for all t and $k > 0$, $\lim_{x\to\infty} x^{\beta\theta}[1 - \tilde{G}(x|x<k)] = 0$.

Define $F(q) = \tilde{F}(m^{\frac{1}{\theta-\theta\beta+\omega}} q)$ and $G(z) = \tilde{G}(m^{\frac{1}{\theta-\theta\beta+\omega}} z)$ to normalize these distributions by the number of producers. Then, as $m \to \infty$, the frontier of knowledge evolves as[7]

$$\frac{dlnF_t(q)}{dt} = -\delta_t q^{-\theta+\omega} \int_0^\infty x^{\beta\theta-\omega} dG_t(x).$$

Note that a higher q will have 2 different and opposite effects: it will reduce the speed at which the frontier of knowledge evolves ($q^{-\theta}$), but it will also speed up the evolution of this frontier through q^ω; an effect that is absent if $\omega = 0$.

Now, define $\lambda_t \equiv \int_{-\infty}^t \delta_s \int_0^\infty x^{\beta\theta-\omega} dG_s(x) ds$. Then, if $\lambda_t \to \infty$ as $t \to \infty$, the economy's frontier of knowledge can be described as a Frechet distribution, i.e.

$$F_t(\lambda_t^{\frac{1}{\theta-\omega}} q) \to e^{-q^{-\theta+\omega}};$$

the proof of this result is presented in Appendix B.1.2[8]. Further, the dynamics of the scale parameter λ — called the stock of knowledge — behaves according to

$$\dot{\lambda}_t = \delta_t \int_0^\infty x^{\beta\theta-\omega} dG(x). \tag{2.4}$$

[7]The proof is provided in Appendix B.1.1.

[8]Namely, it can be proved that the distribution of knowledge will be a Frechet either if the initial distribution F_0 is Frechet, or if we allow $t \to \infty$.

2.3.2 International Trade

In this section I will briefly present how to extend the simple model presented before to introduce many asymmetric countries and international trade, following Bernard et al. (2003). There are n countries in the economy. Each country i has a labor supply, Li, stock of knowledge, λ_i,and iceberg trade costs, κ_{ij}. Consumers in i have identical preferences over a continuum of goods;

$$C_i = [\int_0^1 c_i(s)^{\frac{\varepsilon-1}{\varepsilon}} ds]^{\frac{\varepsilon}{\varepsilon-1}},$$

where $c_i(s)$ denotes the consumption of a representative household in i of good s and utility is given by $u(Ci)$.

We assume production is linear in labor,therefore, for a manager in i, the unit cost of selling a good to country j is $\frac{w_i \kappa_{ji}}{q}$. Firms engage in Bertrand competition, therefore, in equilibrium the price index in country i is given by[9]

$$P_i^{-\theta+\omega} \propto \sum_j \lambda_j (w_j \kappa_{ij})^{\theta-\omega}.$$

The labor market clearing (with balanced trade) is $w_i L_i = \sum_j \pi_{ji} w_j L_j$, while trade shares are given by

$$\pi_{ij} = \frac{\lambda_j (w_j \kappa_{ij})^{\theta-\omega}}{\sum_k \lambda_k (w_k \kappa_{ik})^{\theta-\omega}}.$$

Diffusion Specification I will find the vector $\lambda = \lambda_1, ..., \lambda_n$ of stocks of knowledge under the assumption that insights are drawn uniformly from the distribution of producers *who sell* goods to the country. Empirical evidence of this being the relevant channel (as opposed to exporters learning) is provided in Appendix **??**. Denoting the set of goods s in country i such that the lowest cost seller is from country j as $S_{ij} \subset [0, 1]$, the source distribution can be written

[9]This follows from Bernard et al. (2003), and this proof, along with the one for the trade shares is completely analogous to the one in Appendix B in Buera and Oberfield (2016) using equation B.1.

as $G_i^*(q) = \sum_k \int_{s \in S_{ik} | q_j < q} ds$. As proved in Appendix B.1.3, if $\omega < \beta\theta$ then the general form of Equation 2.4 becomes

$$G_i^S(q) = \frac{\sum_j \int_{s \in S_{ij} | q_{j1}(s) < q} ds}{\sum_j \int_{s \in S_{ij}} ds}$$

Then, specializing the evolution of the stock of knowledge to this specific source distribution, it evolves according to

$$\dot{\lambda}_{it} = \Gamma\left(1 - \beta + \frac{\omega}{\theta}\right) \delta_{it} \sum_j \pi_{ijt} \left(\frac{\lambda_{jt}}{\pi_{ijt}}\right)^{\beta - \frac{\omega}{\theta}} \tag{2.5}$$

where $\Gamma(\,\cdot\,)$ denotes the Gamma distribution. Thus, opening to trade gives wider access to the most productive sellers in the world (exporters), improving the stock of knowledge.

Moreover, the less a country trades with another country, the better the insights it will receive, and the more the levels of productivity for which the probability of adoption will be very low, given a match. Finally, note that because of the learning externality, the condition that maximizes the stock of knowledge in each country i, $\frac{\pi_{ij}}{\pi_{ik}} = \frac{\lambda_j}{\lambda_k}$, which depends implicitly on ω and δ, is different from

$$\frac{\pi_{ij}}{\pi_{ik}} = \frac{\lambda_j (w_j \kappa_{ij})^{-\theta+\omega}}{\lambda_k (w_k \kappa_{ik})^{-\theta+\omega}},$$

which describes the relationship between the equilibrium expenditure shares, depending explicitly on ω.

2.4 Quantitative Exploration

I next present an extended quantitative model, in which I impose less restrictive assumptions than in Section 2.3. I then use model-generated data to validate the model using my reduced-form empirical estimates, and concluding that different learning probabilities are necessary to match the empirical relations I documented. I further compare the TFP dynamics predicted by the model with the data.

2.4.1 Quantitative Framework

Technology is CRS, such that output of country i with productivity q depends on an aggregate of intermediate inputs d_i and equipped labor l_i, where aggregate equipped labor results from combining aggregate units of capital and efficient units of labor using a Cobb Douglass technology[10]. Each good is denoted by m, and how much of it is used in the production of an intermediate input depends on the function $D_i(m)$. It follows that $\int d_i(m)dm = [\int D_i(m)^{\frac{\rho-1}{\rho}} dm]^{\frac{\rho}{\rho-1}}$, and a good m is produced according to $y_i(m) = q\frac{d_i(m)^{\eta} l_i(m)^{1-\eta}}{\eta^{\eta}(1-\eta)^{1-\eta}}$. Finally, the proportion of non-traded goods (goods with an infinite transportation cost) will be given by ψ. The results for the price index and evolution stock of knowledge for this case are derived in Appendix B.2.

2.4.2 Calibration

In the model derived in Section 2.3, on a balanced growth path the growth rate of productivity is

$$\frac{1}{(\theta-\omega)}\frac{\dot{\lambda}}{\lambda} = \frac{\gamma}{(\theta-\omega)(1-\beta+\frac{\omega}{\theta})}, \tag{2.6}$$

and the growth rate of the stock of knowledge is given by

$$\frac{\gamma}{(1-\beta+\frac{\omega}{\theta})}; \tag{2.7}$$

where γ represents the growth rate of the arrival of matches. First, I use the mean growth rate of population in the US from 1962 to 2007 to calibrate γ. This is done under the assumption that the US - a developed country - is a benchmark

[10]The paths of both the aggregate units of capital and the human capital will be taken from the data.

for a country on a balanced growth path. Second, the exponent of distribution of own-ideas H (Pareto) is calibrated to match the value of 4 in Simonovska and Waugh (2014), i.e. $\theta = 4$.

Then, calibrating the mean growth rate of the stock of knowledge to the mean growth rate of the stock of US patents from 1962 to 2007 (2.5%), I can identify $\beta - \frac{\omega}{\theta}$ from (2.7), It follows that, given θ, and assuming that the growth rate of TFP on the balanced growth path equals the mean groth rate for US (1962 and 2007; 0.8%), it is possible to identify ω from (2.6) and back-out β. Finally, the trade costs κ_{ij} will be chosen to match bilateral trade flows. The values for these and the rest of parameters are summarized in Table 2.2.

Table 2.2: Parameter values

Parameter	Value	Target
Share of non-traded goods (ψ)	0.34	Fraction of agr, min, man in gross output
Share of intermediate goods (η)	0.48	Intermediate share in gross production
Elasticity of substitution (ε)	1	Waugh (2014) - Robust
Exponent of $H(z)$ (θ)	4	Simonovska and Waugh (2014)
Concavity in learning (β)	0.819	
Absorption (ω)	0.875	

Arrival rates To assign values to the vector of arrival rates $\delta_t = (\delta_{1t}, ..., \delta_{nt})$ there are 2 steps. First, given the evolution of trade flows compute - in each year - the stocks of knowledge λ_{it} needed to match each country's own trade share. Where $\lambda_{it} \propto f(\kappa_{ijt}, \pi_{ijt})(\frac{w_{it}}{P_{it}})^{\eta(\theta-(\omega/\beta))}$. Second, given the evolution of trade flows and stocks of knowledge as well as values for β, ω, and the growth rate of the arrival of ideas γ, back out sequences of δ_t using the law of motion of λ_{it}.[11]. The bilateral data for these calibrations is taken from Feenstra et al. (2005) and on real GDP and the price index from the Penn World tables v.8.

[11]The explicit forms of these equations are summarized in Appendix B.1.2

2.4.3 Model Validation

In this section, I run the regressions presented in Section 2.2.3 on model-generated data. First, I show the results from the benchmark Regression 2.1, and compare the results of the model with heterogeneous learning with a model with homogeneous learning like Buera and Oberfield (2016). Then I run the same non-parametric regression on real data and model-generated data. Finally, I construct an Autor et al. (2013) instrument using model-generated data and compare it with the results obtained while using the China shock and the instrument on real data.

Benchmark Regression Looking at the results from Regression 2.1 shown in Table 2.3, we can see that the model replicates my empirical findings both qualitatively and quantitatively. Moreover, when running the model with homogeneous learning ($\omega = 0$, coinciding with the original forces in Buera and Oberfield (2016)), the relations between the variables are counterfactual.

Table 2.3: Technological Distance and Productivity Growth

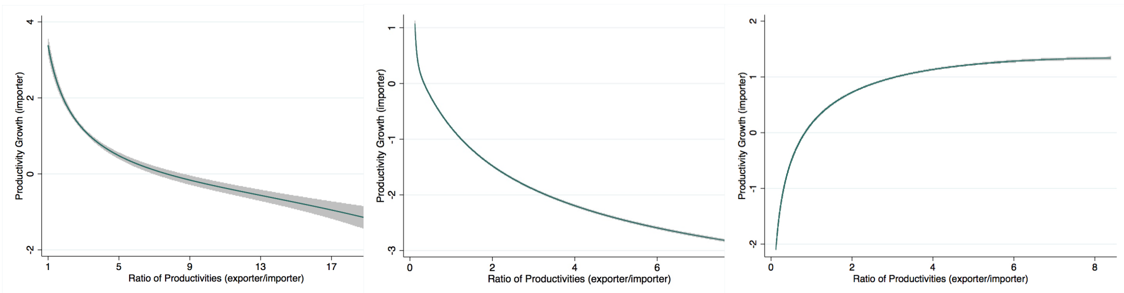
Dependent variable: percentage change in productivity

(Log) Variables	Data		Model		$\omega = 0$	
Ratio	-0.56^{***}	-1.46^{***}	-0.51^{***}	-1.01^{***}	0.50^{***}	1.00^{***}
	(0.014)	(0.037)	(0.038)	(0.003)	(0.003)	(0.002)
Trading partner's z^u_{jt}		0.94^{***}		0.99^{***}		1.09^{***}
		(0.038)		(0.003)		(0.004
FE/Robust SE	✓	✓	✓	✓	✓	✓

As shown, to answer the two main questions I am interested in: how does learning through trade depend on the trade partner's productivity level, and how does this learning depend on the productivity gap between the parties involved, it is essential to include heterogeneous learning into the model. Moreover, incorporating this heterogeneity through different learning probabilities

Non-Parametric Regression, China Shock and IV The model-generated data also captures the patterns found in the data through a non-parametric regression. Moreover, the non-parametric regression's results in panels (a)-(c) of Figure 2.3 also highlight how including differences in learning abilities in model is crucial, as results are counterfactual in the case in which $\omega = 0$ and learning is independent of one's current state of knowledge. Panels (d)-(f) show how using the China shock and constructing instruments in the same fashion as in Section 2.2.3 delivers qualitative results consistent with the my previous findings: the model can closely replicate the patterns found in the data, and the heterogeneous learning abilities are key in delivering this result; a model without this heterogeneity ($\omega = 0$) does not capture the relations in the data also when using using the instrument and China shock.

Figure 2.3: Productivity Growth vs Ratio of Productivities



(a)No Instrument (Data) (b)No Instrument(Model) (c)No Instrument($\omega = 0$)

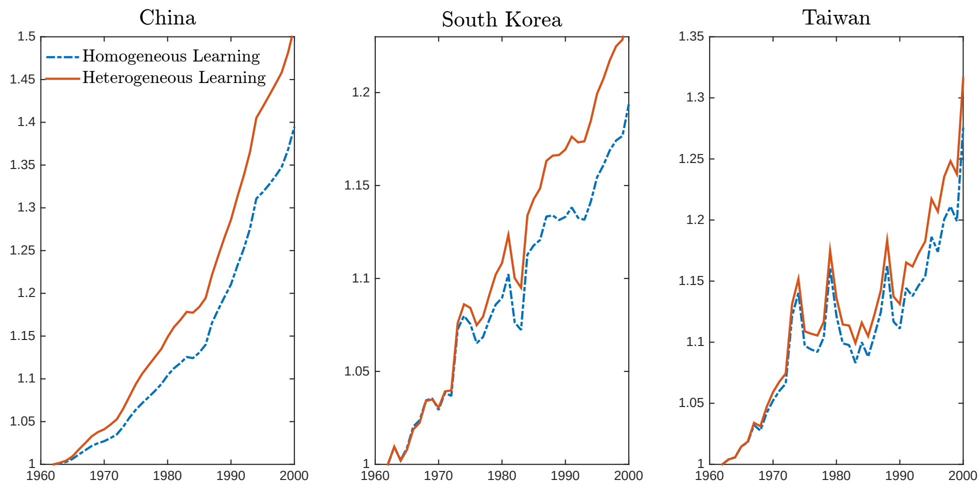
(d)Instrument(Data) (e)Instrument(Model) (f)Instrument($\omega = 0$)

2.4.4 Analysis of TFP Dynamics

One of the main motivations of this kind of models, is to understand the evolution of TFP across countries, in particular, how can the diffusion of knowledge help explain TFP dynamics and growth miracles. This section will explore the role of heterogeneous learning in explaining these dynamics, in comparison with models without absorptive capacity constraints. In particular, better understand the role of learning, I will quantify and decompose the contribution of learning, isolating the contribution of the (exogenous) arrival of ideas (δ_t).

Figure 2.4 shows the evolution of TFP both in the model with heterogeneous learning, and while turning-off learning heterogeneity ($\omega = 0$). Namely, it plots $\ln \frac{TFP_i(\delta_0, \kappa_t)}{TFP_i(\delta_0, \kappa_0)}$.

Figure 2.4: Evolution of TFP with Different Learning Abilities

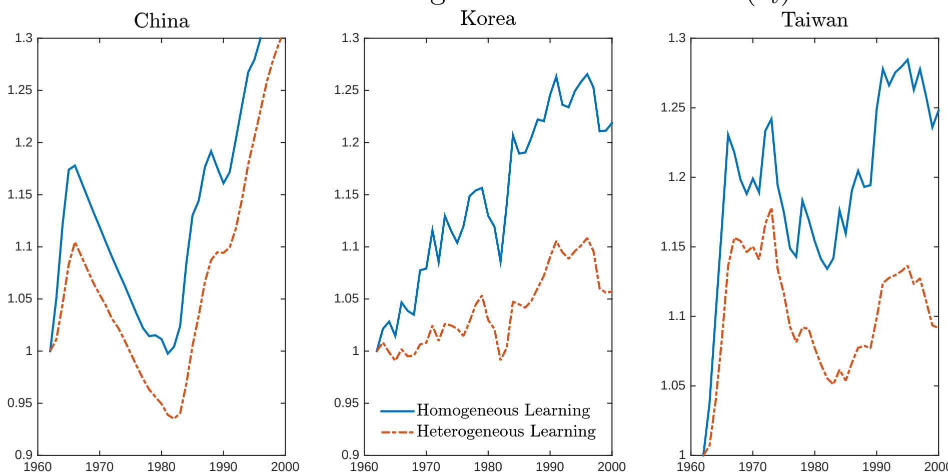


Notes: Figure 2.4 plots the changes in TFP generated for various growth miracles, detrending TFP by the average growth rate of TFP in the United States. All the values are calibrated as detailed in section 2.4.2.

This figure assumes that the three countries were on their balanced growth path in 1962. In all cases, the model with heterogeneous learning delivers a higher TFP, especially for the last decades when these countries grew the fastest. For China for instance, the TFP assuming different learning abilities is up to 20 percent larger than ignoring them.

To further understand the effect of learning constraints on TFP growth, I decompose the change in TFP to isolate the effect of changes in the exogenous arrival of ideas, δ_t. First, note that the contribution of an increase in the exogenous arrival of ideas is larger if we assume learning is independent of the current state of knowledge: if anyone can learn from a good producer, more arrivals of good producers will lead to more growth than in a case where only the a subset of productive people are likely to learn. This also means that the difference between how much each model explains from trade will be larger once we net-out the effect of exogenous arrivals of ideas. Figure 2.5 shows the contribution of changes in the exogenous arrival rate of ideas with and without different learning abilities, exhibiting the expected pattern. Finally, Figure 2.6 plots the contribution of trade to TFP with both modes of learning, and the evolution of TFP in the data; in all casses netting for the contribution of the exogenous arrival of ideas.[12]

Figure 2.5: Contribution of the exogenous arrival of ideas (δ_t) to Δ in TFP

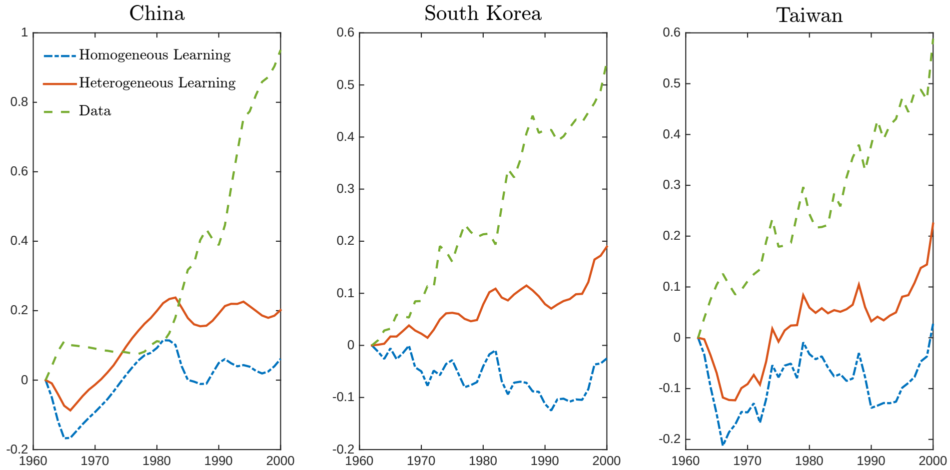


Notes: Figure 2.6 plots the changes in TFP attributed to increases in the exogenous arrival of ideas δ_t various growth miracles, detrending TFP by the average growth rate of TFP in the United States.

Figures 2.5 show how ignoring that learning ability depends on the current state of knowledge can overestimate the role of the exogenous arrival of ideas. Further, Figure 2.6 shows how it is possible to deliver a relatively high con-

[12]That is, subtracting $\frac{TFP_i(\delta_t,\kappa_0)}{TFP_i(\delta_0,\kappa_0)}$.

Figure 2.6: Evolution of TFP netted of exogenous changes in arrival rates



Notes: Figure 2.6 plots the changes in TFP generated for various growth miracles, de-trending TFP by the average growth rate of TFP in the United States *minus* changes in TFP due to changes in the exogenous arrival rate of ideas δ_t. All the values are calibrated as detailed in section 2.4.2.

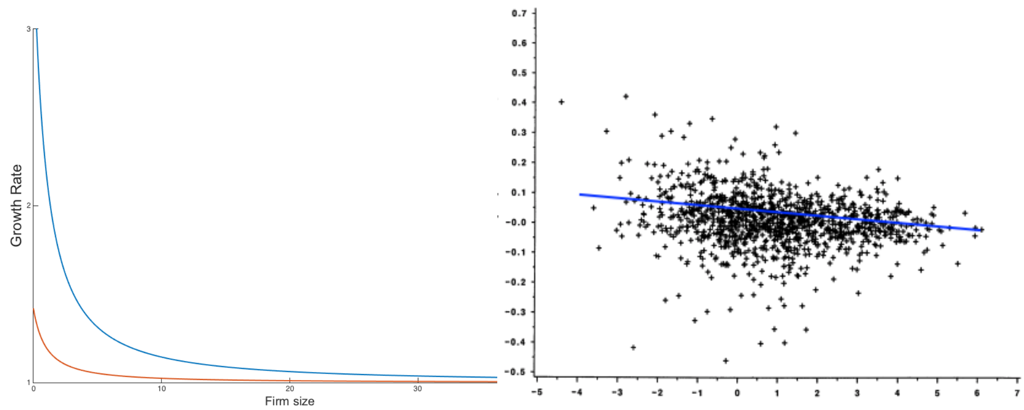
tribution of trade to TFP dynamics for growth miracles by introducing learning heterogeneity. With learning heterogeneity, no country can "buy a lottery ticket" and potentially increase the TFP of its producers overnight by importing from a very productive partner. In the model, this leads to optimal trade shares that "divert" trade towards countries with higher—but relatively close—TFP levels, from which it is more likely to learn given a meeting, resulting in a larger contribution of trade to TFP growth for growth miracles.

2.4.5 Further Implications

In Section 2.4.3, I discussed how learning heterogeneity allows the model to match an empirical dependence of productivity growth on productivity gaps across trading partners. In the previous Section, I showed how, for growth miracles, the contribution of trade to TFP can increase in around 20% due to the introduction of different learning abilities. In this section, I will discuss other implications of the model. Namely, (1) the model fits the firm size distribution, and follows Gibrat's law; (2) when opening to trade, the most productive sellers drive most of the productivity growth, as it happens empirically (Steinwender, 2015); and (3) policy recommendations drastically change: developing countries should direct more trade to mid-productive countries instead of to the most productive ones.

Consistency with Gibrat's Law for Firms According to Gibrat's Law for Firms, firm growth is independent of firm size. Adding heterogeneous learning allows the model to closely reproduce this fact. The unconstrained model where learning does not depend on the ratio of productivities delivers a relationship between a firm's growth rate and its size that is largely inconsistent with Gibrat's law, as shown in Figure **??**. That is because these firms always have the potential to grow overnight, and in expectation this growth is a lot larger that the one of an already productive firm (who expects most of its matches to be useless in terms of learning). The constrained model provides a much closer match to Gibrat's law. Moreover, in the data, Gibrat's law does not hold perfectly for small firms, something that is true in the model as well.

Figure 2.7: Growth rate vs firm size



Homogenous/Heterogenous learning   Data (Hall,1987)

Learning and the Distribution of Productivities Steinwender (2015) finds robust evidence that access to export markets leads to productivity increases within firms, but this only happens for firms that were already highly productive.

Since exporters tend to be more productive, introducing a notion of absorptive capacity (namely, preventing firms from learning other firms' ideas when there is a large gap in their productivities), ensures that only ex-ante more productive firms learn from foreigners. This is consistent with Steinwender (2015), who find evidence that there are productivity increases after expanding export markets, but only for firms that were ex-ante the more productive ones.

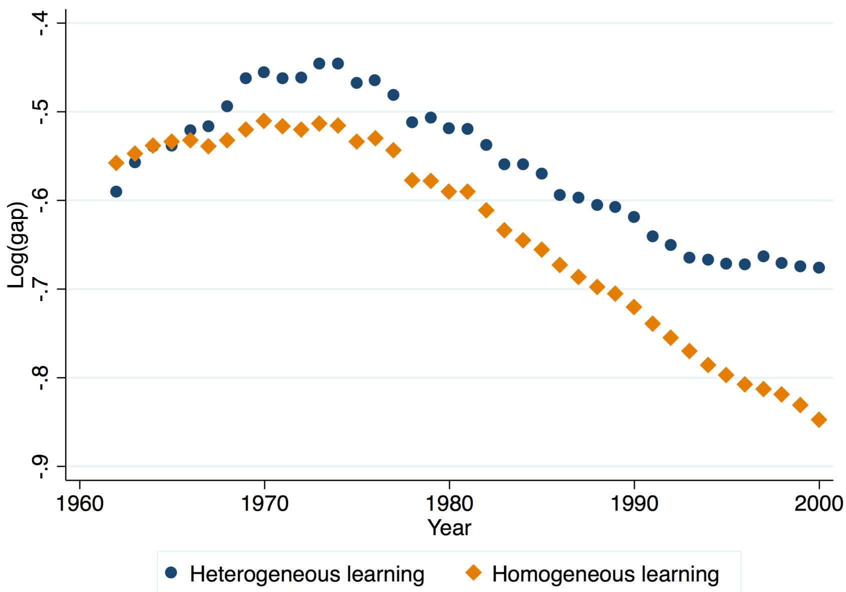
There is also considerable evidence that the time devoted to idea exchanges is greater when the agent has higher ability, as documented by Allen et al. (2010) who found that scientists who worked at more productive firms communicated with outsiders more. Current models imply the opposite: either (1) producers with low productivity benefit the most from diffusion[13](Alvarez et al. (2013), Buera and Oberfield (2016)), or (2) the entire distribution improves due to selection (Perla et al. (2015), and Sampson (2014)). This counterfactual result highlights why it is important to introduce a notion of absorptive capacity in the model. There must be some constraint on how much an agent can learn at once, otherwise the ones who proportionately gain the most will be the ex-ante low-ability agents. In the extended model, once an exporter (highly productive, given the Bertrand structure) enters a country, the most productive sellers are the ones that are more likely to learn, given the probability of learning is decreasing in the ratio of productivities.

Welfare Analysis In this subsection, I analyze the implications of the model on welfare. Figure 2.8 shows how the "welfare gap", which is computed as the difference in average welfare between the welfare of the top 25% and the bottom 25% of countries in the sample. I find that convergence, given the data in which the model was estimated, happens both with homogeneous and heterogeneous learning, but that heterogeneity in learning slows down this convergence by over

[13]This is because if a low-ability producer matches with a high-ability one, his gains can be very large, while if a high-ability producer matches his gains are moderate at best, given he is already productive.

20%.

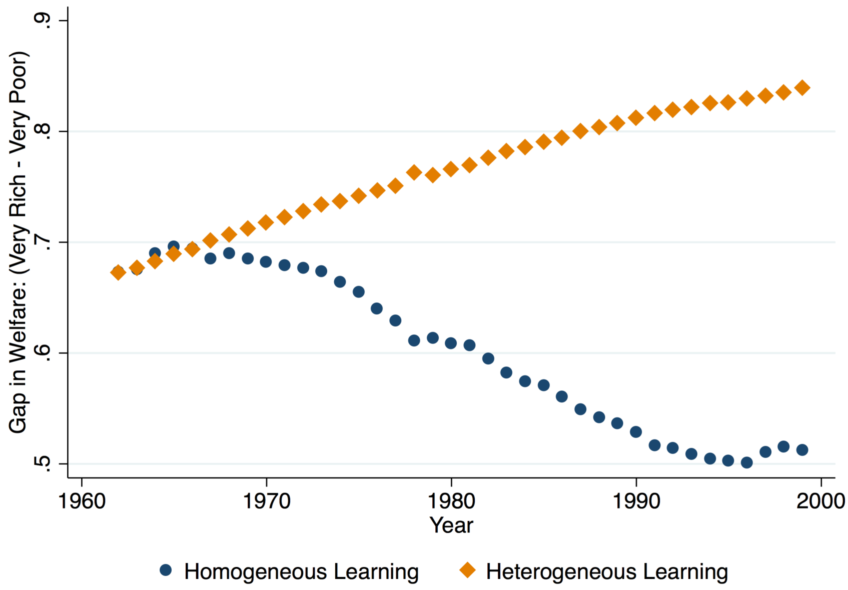
Figure 2.8: Welfare Gap Between Rich and Poor Countries



Also, I explore the theoretical possibility of divergence in welfare doing a counterfactual exercise, in which I only keep the top and bottom 15% of richest and poorest countries in 1962. This shows how the model with heterogeneous learning accommodates the possibility of divergence between developed and developing country. Turning down this heterogeneity would make it impossible to allow for this scenario.

Other Policy Implications As a result of the optimal trade shares exposed in Section 2.3, policy implications are different in both models: for developing countries, the model with heterogeneous learning implies inducing larger trade shares with countries with higher—but close—productivity, as opposed with trading more with very productive ones (as in a model where learning is independent of current knowledge). From the point of view of a developing country, this would mean trading more with mid-developed countries instead of very developed ones, in order to maximize the gains from trade coming from knowledge diffusion and

Figure 2.9: Welfare Gap Between Rich and Poor Countries



technological transfers.

2.5 Concluding Remarks

In this paper I developed a tractable theory of international diffusion of ideas. Crucially, I incorporated the idea of absorptive capacity, which allows the model to accommodate the fact that the productivity gap between two countries may be a barrier for an economy to have gains from the diffusion of ideas, even if trade is taking place and local firms match with foreign sellers. This idea is introduced in a way that is simple enough to be tractable, but that is able to capture well-documented empirical facts.

The model provides a theory to explain the fact that export markets lead to productivity increases within firms, but only for firms that were already highly productive. It also accounts for heterogeneous diffusion of technologies after conditioning on countries having the same trading partners[14].

[14] Remembering that in an Eaton-Kortum framework, it is the extensive margin the one that

The analysis shows how for underdeveloped countries, it is not always better to have very technologically-advanced trading partners in order to improve their state of knowledge. My model includes cases in which there are more gains from diffusion if trading partners have a relatively close state of development. This analysis suggests that previous models may be too enthusiastic when quantifying how much a low productivity economy may learn from foreign sellers with very high productivities once they start trading, leading to different potential policies to increase productivity.

Qualitatively, previous models were counterfactual: evidence shows high-ability managers and scientists have larger gains from exchanging ideas than low-ability ones. My model can account for this pattern. Aside from exploring this new mechanism theoretically, the quantitative exploration shows that including this feature has important implications. Namely, this framework can reproduce the dynamics of TFP up to 20 per cent more closely than previous models, and is particularly well-suited to examine North-South trade of ideas and the experience of growth miracles, where trading partners have very different levels of development.

As in other models in this literature, I abstract from FDI and purposeful imitation as sources of diffusion of ideas, and omit variation across sectors. A next step could be to focus on a particular industry or a specific country and analyze its learning process.

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is relevant when it comes to trading partners.

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APPENDIX A

A.1 Historical Details

A.1.1 The UFCo in Costa Rica

This subsection provides more details on the role and decay of the UFCo in Costa Rica and complements the historical background presented in Section 1.2.

Figure A.1 shows how, after 1880 banana production in Costa Rica increased in volume and importance. By 1905 bananas had reached the same place in Costa Rica's exporting value than coffee (Costa Rica's main export product at the time).

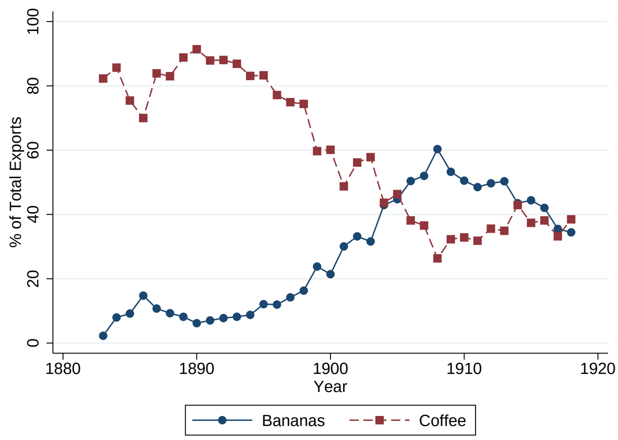


Figure A.1: Banana and Coffee as Percentage of Total Exports, 1883-1918

Source: Authors' calculations based on the "Statistical Summary, years 1883 to 1910: trade, agriculture, industry" and 1911 to 1918 Costa Rican Statistic Yearbooks.

The railroad construction and the banana activity stimulated population growth in Limón, the province where our paper restricts attention. Table A.1 shows the dynamics of population growth in Limón using census data from 1883 to 1963, while Table A.2 shows the role of foreigners in these population dynamics.

Table A.1: Population and Growth Rates

	Census									
	1883		1892		1927		1950		1963	
	Pop.	G.R	Pop.	G.R	Pop.	G.R	Pop.	G.R	Pop.	G.R
Limón Province	1,858	-	7,484	16.74	32,278	4.26	41,360	1.08	68,385	3.94
Rest of Costa Rica	180,215	-	235,721	3.03	439,246	1.79	759,515	2.41	1,267,889	4.02

Source: Authors' calculations based on 1883, 1892, 1927, 1950, and 1963 Costa Rican Census.
Notes: Pop= Population. G.R= Annual population growth rate (percentage).

Table A.2: Percentage of Foreigners in the Population

	Census				
	1883	1892	1927	1950	1963
Limón Province	68.51	14.04	68.75	26.84	7.53
Rest of Costa Rica	1.80	2.15	4.67	2.96	2.25

Source: Authors' calculations based on 1883, 1892, 1927, 1950, and 1963 Costa Rican Census.

Figure A.2 illustrates the evolution of UFCo employment in Costa Rica. On average, between 1912 and 1931 the UFCo employee around 7.96% of the total agricultural workers in the country and 4.82% of the entire labor force. Between 1946 and 1976, the numbers were 6.93% and 3.50% respectively.

The UFCo produced bananas in the Caribbean Coast until 1938, when the Panama disease forced the company to shift operations to the Pacific Coast. Figure A.3 shows how the ports located on the Pacific Coast took a predominant role in the banana exports, while the ports in the Atlantic Coast lost relevance. However, although the enclave structure and the banana production moved to the Pacific Coast, the UFCo kept landholdings in the Caribbean Coast and continued growing alternative products such as cacao and rubber (Viales, 1998). In 1976 the UFCo, now organized under the United Brands name, returned banana production to the Caribbean Coast. By then, new entrants in the banana market prevented the UFCo of having the protagonist role and monopoly power that it

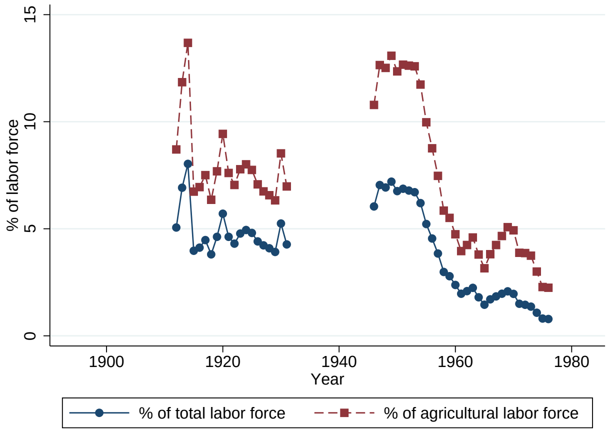


Figure A.2: UFCo Employees as Percentage of Costa Rican Labor Force, 1912-1976

Source: Authors' calculations based on United Fruit Company Medical Department Annual Report for 1912-1931, Ellis (1983) for 1946-1976, and 1892, 1927, 1950, 1963, 1973, and 1984 Costa Rican Census.

had at the beginning of the century (Viales and Montero, 2013). Finally, due to labor conflicts, soil exhaustion, increases in production costs, and a corporate strategy that divested in the production process to focus on marketing, the UFCo abandoned banana production in the Pacific Coast in 1984 (Royo, 2009, p. 37). The overall production pattern is evident in Figure A.4, which documents the total land destined to banana grow.

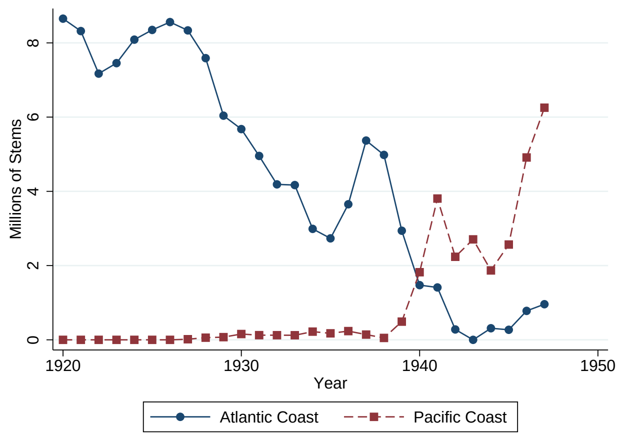


Figure A.3: Banana Exports by Coast of Origin, 1920-1947

Source: "Statistical Summary, years 1883 to 1910: trade, agriculture, industry", 1911 to 1926 Costa Rican Statistic Yearbooks, and "Export Bulletin 1941-1947".

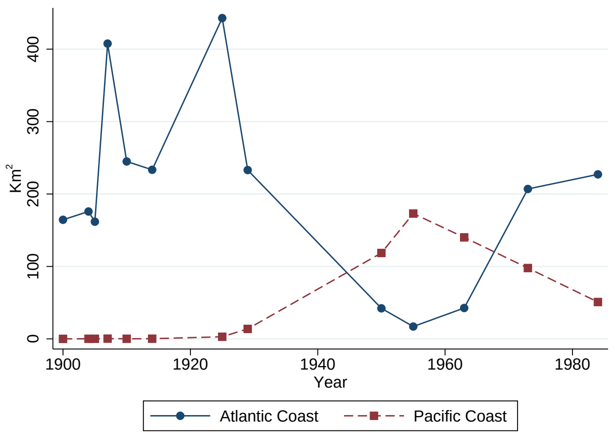


Figure A.4: Square Kilometers of Banana Plantations, 1900-1984

Source: 1900 to 1984 Costa Rican agricultural censuses.

A.1.1.1 The UFCo and its Differential Effect on Schooling

To assess the impact of the UFCo educational investments on current human capital accumulation, we estimate Equation (1.1) using educational attainment as the outcome variable. The results are presented in Table A.3, restricting the sample to non-migrants. Column (1) shows a positive UFCo effect on human capital accumulation. Consistent with the emphasis on primary education by the company, column (2) shows a positive UFCo effect on primary education attainment. Individuals in the former UFCo areas are 5.3 percentage points more likely of completing primary education. On the other hand, in column (3) the effect of the UFCo presence on secondary education attainment is zero, in line with the higher costs of completing higher education levels.

Table A.3: Human Capital Accumulation

	Years of schooling	Primary	Secondary
	(1)	(2)	(3)
UFCo	0.269	0.053	0.003
	(0.130)**	(0.018)***	(0.009)
	[0.143]*	[0.020]**	[0.007]
Adjusted R^2	0.240	0.204	0.042
N	24,587	24,587	24,587
Clusters	198	198	198
Mean	4.595	0.462	0.056

Notes: The unit of observation is the individual. The sample is restricted to non-migrants. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic (slope, elevation, and temperature), and individual (age, age squared, and gender) controls, census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.1.1.2 Monopsony Power vs Perfect Competition

Monopsony vs Perfect Competition Most of the agricultural production during the 20th Century in Costa Rica consisted of coffee farms, which were not only many, but owned by many different small producers (approximately 25 000 coffee farms owned by 21500 different producers, on average,from 1900-1925 according to the national Coffee Census with a Herfindahl Index of 39.03[1]). On its part, the banana company employed 14 percent of the total agricultural workforce, and was the only employer within its lands. These facts stand behind our assumptions of monopsony in the banana region, and perfect competition in the rest of the country.

[1]An industry is considered competitive if its Herfindahl Index is below 100.

We can measure the degree of monopsony of the UFCo using the variation in the company's employment (1912-1976), and the variation in world banana prices (as shocks to the UFCo's marginal productivity of labor in Costa Rica). Namely, we consider the following regression

$$ln(UFCo\ employment_t) = \alpha + \beta ln(P_{Bt}^W) + \varepsilon_t, \tag{A.1}$$

where P_B^W stands for the world banana price. Elasticity β would then measure the degree of monopsony. Assuming decreasing returns to scale, under perfect competition $\beta > 1$, while under monopsony it is possible to find elasticities below 1 (the extreme being a perfectly inelastic labor supply).[2]

Our estimation finds $\beta = 0.397$ with a robust standard error of 0.089 (thus the coefficient is significant at 1 percent). This suggests that the company indeed faced an upward sloping labor supply, which is consistent with the historical accounts on it being the sole employer within its concession.

A.1.1.3 Local Government Budget Constraints

The Costa Rican government during the first half of the 20th Century had very limited access to capital markets. In the 1870s, the government entered into \$15 million of external debt with an 18% interest rate (sovereign bonds sold in England and France). At the time, the service of this external debt represented between 50 and 20% of value of exports (Marichal, 1988). This burden proved to be too large, and on 1874 the first default on payments occurred. At this time, debt was restructured with a longer maturity and a higher interest rate. A similar story repeated itself on 1901 and 1933. By this time, the debt had

[2] The intuition behind this known result is the following: If the price of the product increases, the value of the marginal product of labor increases. If the firm cannot influence the wage, it adjusts by increasing employment, and with decreasing returns to scale, this change in employment must be more to proportional to the change in price. This result holds both if the firm has market power in the final product market and if it does not.

increased to \$21 millions of external debt, as new debt emitted to cover delayed interest payments. The country then entered a moratorium that lasted more than a decade (1935-1946) with payments being defaulted throughout the period. Therefore, the very high loan in the late 1800s and the local inability to serve the interest of this debt, incurred a penalty on the interest rates and borrowing ability. We therefore assume the local government had to finance local amenities using collected taxes and is intertemporally constrained.

A.2 Unsatisfied Basic Needs (UBN) Index Construction

To specify the set of basic needs that we consider in the paper and the threshold for attaining those needs, we follow the methodology proposed by Méndez and Trejos (2004) for Costa Rica. Méndez and Trejos constructed the index based on information from the 2000 Census. The method can be applied straightforwardly to the 2011 Census, given the similarity of the questions between the 2000 and 2011 censuses (Méndez and Bravo, 2014). To adapt the method to the 1973 and 1984 Census, we use only the subset of the components for which similar variables are available in all four censuses. . Table A.2 shows which census variables constitute each basic need, and describes the standards under which the need is considered unsatisfied. For instance, the basic housing need is considered unsatisfied if the household is living in a temporary shelter or slum, if it is living in a dwelling with bad conditions in roof, wall, and floor simultaneously, *or* if the dwelling's roof, wall, and floor as described as being in bad conditions simultaneously.

Appendix A.9 shows that if we use the index proposed by Méndez and Trejos only for the census where it can be directly applied (2000 and 2011 Census) and including all its original components (we used only the ones for which similar variables are available in all four censuses), the main results of the paper are preserved.

Table A.4: Definition and Classification of Basic Needs

Dimension	Component	Variable from Census
Housing	House Quality	Household living in a temporary shelter or slum Household living in a dwelling with waste material in wall, roof or dirt floor Household living in a dwelling with bad conditions in roof, wall, and floor simultaneously
	Overcrowding	Household with more than two persons per room
Sanitation		Urban household where the sanitary service is connected to ditch, trench, river, estuary, cesspit, or latrine, or without sanitary service

Continued on next page

Table A.4 – continued from previous page

Dimension	Component	Variable from Census
		Rural household where the sanitary service is connected to direct connection to ditch, trench, river, estuary, or without sanitary service
Education	School Attendance	Household with at least one member from 7 to 17 years old not attending school
	School Achievement	Household with at least one member from 7 to 17 years old attending school regularly, but with a school backwardness higher than 2 years
Consumption	Consumption Capacity	Household without regular income recipients (employed, pensioners or rentiers) and whose head is 50 years old or older and with: • 3.59 years of schooling or less for Census 1973. • 5 years of schooling or less for Census 1984. • 6 years of schooling or less for Census 2000. • 6.39 years of schooling or less for Census 2011. Urban household with three or more dependents and one income recipient with less than: • 3.59 years of schooling for Census 1973. • 5 years of schooling for Census 1984. • 6 years of schooling for Census 2000. • 6.39 years of schooling for Census 2011. Urban household with three or more dependents and two income recipients whose on average have less than: • 2.59 years of schooling for Census 1973. • 4 years of schooling for Census 1984. • 5 years of schooling for Census 2000. • 5.39 years of schooling for Census 2011.

Continued on next page

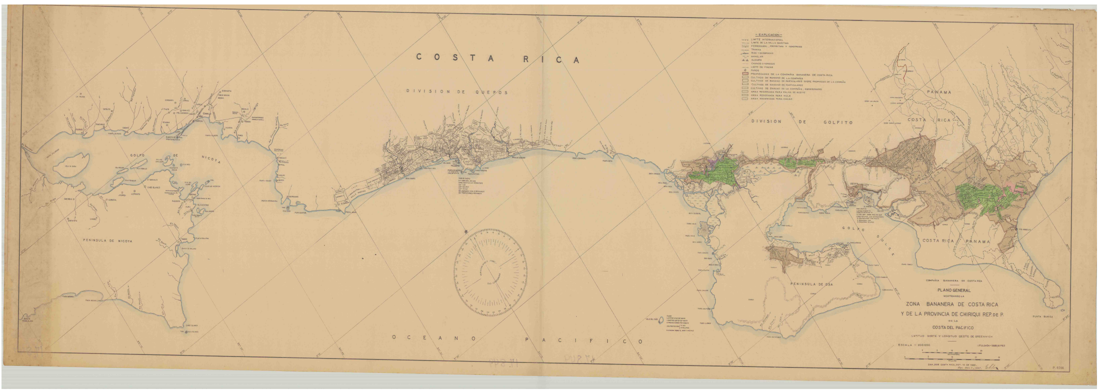
Table A.4 – continued from previous page

Dimension	Component	Variable from Census
		Urban household with three or more dependents and three or more income recipients whose on average have less than: • 1.59 years of schooling for Census 1973. • 3 years of schooling for Census 1984. • 4 years of schooling for Census 2000. • 4.39 years of schooling for Census 2011. Rural household with three or more dependents and one income recipient with less than: • 1.59 years of schooling for Census 1973. • 3 years of schooling for Census 1984. • 4 years of schooling for Census 2000. • 4.39 years of schooling for Census 2011. Rural household with three or more dependents and two income recipients whose on average have less than: • 0.59 years of schooling for Census 1973. • 2 years of schooling for Census 1984. • 3 years of schooling for Census 2000. • 3.39 years of schooling for Census 2011. Rural household with three or more dependents and three or more income recipients whose on average have: • 0 years of schooling for Census 1973. • Less than 1 years of schooling for Census 1984. • Less than 2 years of schooling for Census 2000. • Less than 2.39 years of schooling for Census 2011.

A.3 Additional Figures

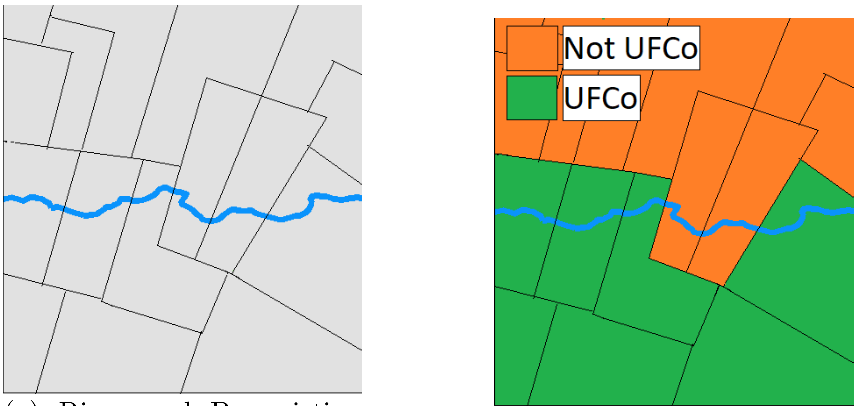
Figure A.5 provides an example of one of the original maps from the National Archives of Costa Rica that we collected, scanned, and digitized.

Figure A.5: One of the Original Maps from the National Archives of Costa Rica.



Notes: One of the maps collected form the national arcades. *Source*: National Archives of Costa Rica. Fondo: Mapa. Signatura: 17849.

Figure A.6: The UFCo Boundary Follows the River Closely but not Exactly



(a) River and Pre-existing Plots in 1904

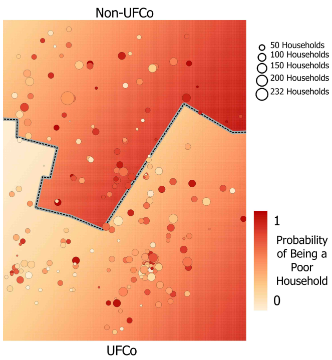
(b) Final Boundary

Notes: The Figure shows an example of how the boundary follows a natural landmark (the river) closely, but not exactly, as it was jointly determined by the river and preexisting plots. In 1904 the government forbid, by law, to sell the plots in orange back to the company (or any foreigner), therefore this boundary was kept constant during the company's tenure.

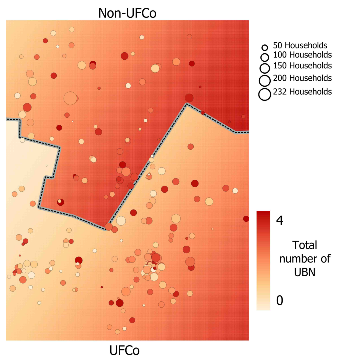
A.4 Additional Results

Figure A.7 shows the study boundary, with UFCo territories being South. Each dot represents a census-block's centroid. Dot-color indicates the average outcome value for households, and dot-size represents the number of households in each census-block. As shown, lighter colors stand for better economic outcomes. Panels A.7c, A.7d, A.7e, and A.7f presents the probability of having a UBN in housing, sanitation, education, and consumption respectively. Panel A.7a shows the probability of being classified as a poor household and Panel A.7b shows the total number of UBN.

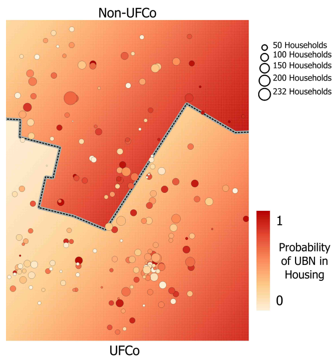
Figure A.7: Plots of the UFCo Effect on Contemporary Household Outcomes



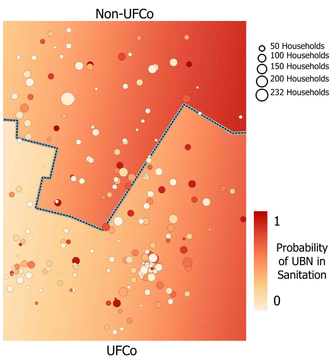
(a) Probability of Being Poor



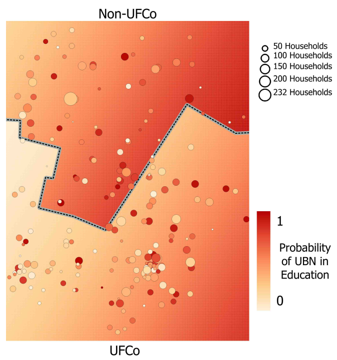
(b) Total Number of UBN



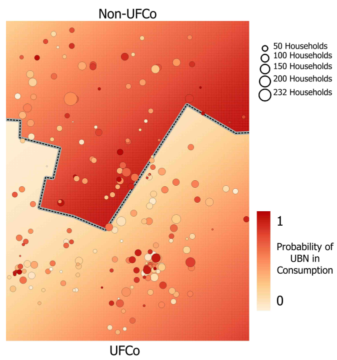
(c) Housing Dimension



(d) Sanitation Dimension



(e) Education Dimension



(f) Consumption Dimension

Notes: The figure shows the study boundary, with UFCo territories being South. Each dot represents a census-block's centroid. Dot-color indicates the average outcome value for households, and dot-size represents the number of households in each census-block. As shown, lighter colors stand for better economic outcomes.

Table A.5: Contemporary Household Outcomes: Dynamics Across Years

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.202	-0.272	-0.069	-0.125	-0.229	-0.668
	(0.064)***	(0.081)***	(0.043)	(0.048)***	(0.070)***	(0.164)***
	[0.066]***	[0.081]***	[0.034]**	[0.045]***	[0.054]***	[0.149]***
$UFCo_{1984}$	-0.056	0.013	-0.086	-0.067	-0.081	-0.196
	(0.048)	(0.028)	(0.028)***	(0.049)*	(0.046)**	(0.093)**
	[0.034]*	[0.013]	[0.027]***	[0.030]**	[0.032]**	[0.063]***
$UFCo_{2000}$	-0.079	0.020	-0.057	-0.132	-0.132	-0.199
	(0.032)**	(0.017)	(0.022)**	(0.036)***	(0.036)***	(0.059)***
	[0.029]***	[0.017]	[0.019]***	[0.024]***	[0.031]***	[0.053]***
$UFCo_{2011}$	-0.093	0.021	-0.039	-0.014	-0.101	-0.126
	(0.030)***	(0.016)	(0.030)	(0.037)	(0.038)***	(0.064)**
	[0.033]***	[0.020]	[0.031]	[0.055]	[0.053]*	[0.095]
Adjusted R^2	0.103	0.199	0.241	0.017	0.116	0.206
N	8,786	8,786	8,786	8,786	8,786	8,786
Clusters	200	200	200	200	200	200
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic (slope, elevation, temperature) and demographic (number of adults, children, infants per household) controls; census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As a robustness test, we also calculate the effects of the UFCo using the entire border, obtained by estimating Equation (1.1), using all four censuses' data. For this regression, we consider that a household is located in a former UFCo region following two criteria. First, an extensive margin of the UFCo presence is provided by a dummy variable equal to one if the UFCo had any landholding in the district where the household is located, and zero otherwise. Second, an extensive margin of the UFCo presence is provided by using the fraction of total district land that was part of UFCo landholdings.[3]

The results in Table A.6 suggest that in both cases, households located in a district where the UFCo operated, have better outcomes and living standards, with similar –sometimes statistically equal– results to the ones in our main regression. Although these results are in line with the conclusions draw from our analysis of the areas where the UFCo presence was exogenous, this naive approach only provides suggestive evidence of a positive UFCo effect, as they are contaminated by the ex-ante difference in land before the treatment.

[3]This analysis is done at the district-level as our confidential data with the census-block level reference pertains only the subset of households in our main specification.

Table A.6: Contemporary Household Outcomes: Average UFCo Effect in the Entire Border

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
Intensive Margin: Fraction of the district's area that belonged to the UFCo						
UFCo	-0.080	-0.026	-0.037	-0.047	-0.095	-0.190
	(0.017)***	(0.011)**	(0.016)**	(0.014)***	(0.023)***	(0.044)***
	[0.029]***	[0.015]	[0.019]***	[0.025]**	[0.026]***	[0.051]***
% Variation	**41.5**	**35.6**	**17.7**	**34.9**	**29.3**	**41.4**
Adjusted R^2	0.097	0.109	0.248	0.017	0.116	0.193
Extensive Margin: The UFCo had landholdings in the district						
UFCo	-0.023	-0.010	-0.021	-0.022	-0.048	-0.076
	(0.016)	(0.012)	(0.009)**	(0.010)**	(0.018)***	(0.039)*
	[0.029]***	[0.015]	[0.019]***	[0.025]**	[0.026]***	[0.051]***
% Variation	11.9	13.7	10.0	16.3	13.2	16.6
Adjusted R^2	0.096	0.109	0.247	0.016	0.114	0.191
N	672,102	672,102	672,102	672,102	672,102	672,102
Clusters	398	398	398	398	398	398
Mean	0.193	0.073	0.209	0.135	0.324	0.459

Notes: UBN= Unsatisfied Basic Need. Percentage variations with respect to the sample mean expressed as "% Variation". The unit of observation is the household. The sample is restricted to directly neighboring districts (districts sharing a border), with and without UFCo landholdings. Robust standard errors, adjusted for clustering by district-year, are in parentheses. Conley standard errors are in brackets. All regressions include geographic controls for slope, elevation, and temperature; demographic controls for the number of adults, children, and infants in the household; census fixed effects, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.5 Details on Government Expenditures

In this section, we discuss in more detail how government expenditures in regions around the UFCo were not low with respect to the rest of the country. To do so, we gathered data on government spending per canton from annual reports from the Comptroller General of the Republic of Costa Rica (*Contraloría General de la República de Costa Rica*) published between 1951 and 1984,[4]and estimate spend-

[4]Although the publication was annual, the records on government spending per canton appear for 15 years between 1951 (the first publication year) and 1984 (when the UFCo ended operations).

ing per capita. Table A.7 compares government spending per capita between municipalities around the UFCo and all other rural municipalities in the country. As shown, we do not find any significant differences between the treatment our "control region" received from the government in terms of spending and the one received by other rural regions in the country.

Table A.7: Comparison of Government Spending per Capita (Log)

UFCo	0.004	-0.006
	(0.084)	(0.086)
Adjusted R^2	-0.001	0.349
Year FE	No	Yes

Notes: Dependent variable is in logs. N=669 and # of clusters=50. The unit of observation is the municipality. Robust SE, clustering by municipality, in parentheses.

A.6 Comparison: Control Group vs Other Rural Regions

In this section, we compare the control group with nearby regions to grasp what is the direction of the spillovers from the company to this neighboring region, and to make sure that this region is not in the "left tail" of the distribution of districts in the country and this is not driving the gap we documented. Namely, we compare this control group with rural regions on a belt around it; regions that are relatively similar but are further away from the UFCo. The choice of this belt's bandwidth is constrained by data availability; as the Costa Rican Census Bureau (INEC) only gave us clearance for the census-block geo-reference of households that are approximately 22.5 kms from the UFCo border. Thus, we use all the households in the control group and compare them with non-UFCo households within 17.5 kms of our control group, therefore using a belt as wide as possible.

A.6.1 Main Outcomes

We run the following regression for a belt of non-UFCo regions around our control group for the year 1973, while the company was still operating:

$$y_{ig1973} = \gamma counterfactual_g + f(geographic\ location_g) + \mathbf{X}_{ig1973}\beta + \mathbf{X}_g\Gamma + \varepsilon_{ig1973},, \tag{A.2}$$

where $counterfactual_g$ is a dummy that is equal to 1 if region g lies within the counterfactual region (within 5km from the boundary shown in Figure 1.3) and zero otherwise. Other variables follow a similar notation as in Equation (1.1), namely, y_{ig1973} is an outcome of individual or household i in district g in 1973 (we use district-level data as our administrative census-block geo-referenced data only covers the subsample around the UFCo boundary); $f(\text{geographic location}_g)$ is a RD polynomial, which is a smooth function on latitude and longitude that controls for the geographic location of census-block g. $\mathbf{X}_{ig1973}$ is a vector of covariates (number of adults, children, infants per household) for individual or household i. $\mathbf{X}_g$ is a vector of geographic characteristics (slope, elevation, temperature) for district g.

The results of this equation are presented in Table A.8, showing that outcomes are better within the control group for all outcomes except education. However, Section A.6.2 "unpacks" the education index, and studies years of schooling (the index includes other less traditional aspects like school attendance and school backwardness), finding that individuals in the control group actually have more years of schooling than individuals in the control group (although, as shown by the index, regular attendance is lower).

A.6.2 Years of Schooling

Comparing Migrants We compare the years of schooling of migrants to our control group with the years of schooling of migrants to other nearby rural regions,

Table A.8: Counterfactual Region vs Other RuraL Regions

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.514	-0.612	- 0.124	-0.221	-0.420	-1.222
	(0.027)***	(0.028)***	(0.030)**	(0.029)***	(0.006)***	(0.058)***
	[0..025]***	[0.026]***	[0.028]**	[0.027]***	[0.006]***	[0.053]***
Adjusted R^2	0.098	0.198	0.415	0.072	0.076	0.166

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a quadratic polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

again, to grasp what is the direction of the spillovers from the company to this neighboring region: Is the control group attracting particularly “bad” migrants? Is this driving our result? The answer to both questions is no. If anything, the control group is attracting relatively skilled migrants with 2.52 months more years of schooling than migrants to other nearby regions.

Comparing Average Years of Schooling To see this, we run the following regression:

$$yrs\ schooling_{ig1973} = \gamma counterfactual_g + f(geographic\ location_g) + \beta \mathbf{X}_{ig1973} + \Gamma \mathbf{X}_g + \varepsilon_{ig1973} \tag{A.3}$$

where $counterfactual_g$ is a dummy that is equal to 1 if region g lies within the counterfactual region (within 5km from the boundary shown in Figure 1.3) and zero otherwise. Other variables follow a similar notation as in Equation (A.2). Results are shown in Table A.9, showing that years of schooling were 1.453 years higher in the control group during UFCo times than in other nearby rural areas.

Table A.9: Years of Schooling: Control Group vs Nearby Non-UFCo Rural Regions

	Years of Schooling
counterfactual	1.453
	(0.036)***
	[0.033]***
Adjusted R^2	0.083
Observations	2,067

Notes: he unit of observation is the individual. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a quadratic polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.7 Falsification Test

In this section we present the results of a falsification test, where we shift our study boundary 2km up, and rerun all our estimations within 2km of the placebo boundary (so that all observations lie above the true border), and then do the same shifting the boundary 2km down. All our estimated are not significant in this placebo test, providing additional evidence that the effect we are capturing is indeed driven by the UFCo.

Table A.10: Average UFCo Effect: Placebo Test

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Placebo at +2km			
UFCo	0.022	-0.009	0.027	-0.010	0.008	0.031
	(0.034)	(0.019)	(0.018)	(0.030)	(0.040)	(0.066)
	[0.039]	[0.017]	[0.021]	[0.020]	[0.031]	[0.067]
Adjusted R^2	0.098	0.173	0.240	0.014	0.111	0.195
			Panel B: Placebo at -2km			
UFCo	-0.030	0.008	-0.006	0.005	-0.008	-0.023
	(0.025)	(0.019)	(0.019)	(0.024)	(0.030)	(0.056)
	[0.031]	[0.019]	[0.019]	[0.027]	[0.029]	[0.054]
Adjusted R^2	0.098	0.173	0.239	0.014	0.111	0.195

Notes: N =8,786 and # of clusters=200 for both panels. UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.8 Additional Robustness Checks

Our additional robustness checks presented in this Section include: changing the specifications of the latitude-longitude polynomial, not including geographic and/or demographic controls, running our regressions at different distances from the boundary, using only subsamples of non-migrants and comparing the results of subsamples where individuals worked in agricultural versus non-agricultural activities.

A.8.1 Varying Specifications for the Latitude-Longitude Polynomial

In our original results, we used a linear polynomial in latitude and longitude. In this section we test the robustness of our results to different specifications for the polynomial in latitude and longitude. First, using a quadratic polynomial, we reestimate both the *average* UFCo effect, and the *yearly* UFCo effect. We then do the same using a linear polynomial in latitude, longitude *and* distance to the boundary.

A.8.1.1 Quadratic Latitude-Longitude Polynomial

Table A.11: Average UFCo Effect-Quadratic Latitude-Longitude Polynomial

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.097	-0.013	-0.058	-0.059	-0.122	-0.226
	(0.028)***	(0.019)	(0.022)**	(0.025)**	(0.032)***	(0.060)***
	[0.033]***	[0.015]	[0.012]***	[0.025]**	[0.027]***	[0.055]***
Adjusted R^2	0.102	0.173	0.241	0.015	0.115	0.200
N	8,786	8,786	8,786	8,786	8,786	8,786
Clusters	200	200	200	200	200	200
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a quadratic polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.12: Dynamics Across Years-Quadratic Latitude-Longitude Polynomial

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.204	-0.277	-0.064	-0.127	-0.225	-0.672
	(0.068)***	(0.080)***	(0.041)	(0.046)***	(0.070)***	(0.164)***
	[0.071]***	[0.078]***	[0.031]**	[0.050]**	[0.054]***	[0.148]***
$UFCo_{1984}$	-0.059	0.016	-0.087	-0.065	-0.079	-0.194
	(0.050)	(0.027)	(0.028)***	(0.036)*	(0.049)	(0.095)**
	[0.035]*	[0.010]*	[0.022]***	[0.030]**	[0.032]**	[0.060]***
$UFCo_{2000}$	-0.084	0.020	-0.062	-0.085	-0.136	-0.210
	(0.033)**	(0.019)	(0.022)***	(0.027)***	(0.038)***	(0.062)***
	[0.032]***	[0.019]	[0.012]***	[0.024]***	[0.032]***	[0.054]***
$UFCo_{2011}$	-0.095	0.021	-0.039	-0.013	-0.099	-0.126
	(0.031)***	(0.017)	(0.036)	(0.037)	(0.039)**	(0.064)*
	[0.034]***	[0.021]	[0.027]	[0.054]	[0.052]*	[0.093]
Adjusted R^2	0.103	0.199	0.241	0.017	0.116	0.207
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. N=8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a quadratic polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.1.2 Linear Polynomial in Latitude, Longitude and Distance to the Boundary

Table A.13: Contemporary Household Outcomes: Dynamics Across Years-Linear polynomial in latitude, longitude and distance to the boundary

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.200	-0.275	-0.064	-0.127	-0.227	-0.666
	(0.066)***	(0.080)***	(0.041)	(0.048)***	(0.071)***	(0.165)***
	[0.069]***	[0.081]***	[0.034]*	[0.045]***	[0.057]***	[0.153]***
$UFCo_{1984}$	-0.055	0.013	-0.084	-0.068	-0.080	-0.195
	(0.048)	(0.028)	(0.028)***	(0.036)*	(0.049)	(0.093)**
	[0.033]*	[0.014]	[0.026]***	[0.030]**	[0.032]**	[0.063]***
$UFCo_{2000}$	-0.079	0.020	-0.057	-0.082	-0.132	-0.199
	(0.032)**	(0.017)	(0.058)***	(0.026)***	(0.036)***	(0.062)***
	[0.029]***	[0.017]	[0.018]***	[0.024]***	[0.031]***	[0.053]***
$UFCo_{2011}$	-0.093	0.020	-0.038	-0.015	-0.101	-0.125
	(0.030)***	(0.016)	(0.030)	(0.037)	(0.038)**	(0.063)**
	[0.033]***	[0.020]	[0.031]	[0.056]	[0.053]*	[0.095]
Adjusted R^2	0.103	0.199	0.241	0.017	0.116	0.206
N	8,786	8,786	8,786	8,786	8,786	8,786
Clusters	200	200	200	200	200	200
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a linear polynomial in latitude, longitude and distance to the UFCo boundary.
We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.14: Contemporary Household Outcomes: Average UFCo Effect-Linear polynomial in latitude, longitude and distance to the boundary

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.095	-0.016	-0.055	-0.060	-0.123	-0.226
	(0.026)***	(0.017)	(0.022)**	(0.025)**	(0.030)***	(0.056)***
	[0.029]***	[0.014]	[0.018]***	[0.026]**	[0.026]***	[0.051]***
Adjusted R^2	0.102	0.173	0.241	0.015	0.115	0.200
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude and distance to the UFCo boundary.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.2 No Demographic and Geographic Controls

A.8.2.1 No Demographic Controls

Table A.15: Average UFCo Effect-No Demographic Controls

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.102	-0.014	-0.086	-0.062	-0.142	-0.264
	(0.027)***	(0.017)	(0.025)***	(0.025)**	(0.033)***	(0.063)***
	[0.032]***	[0.014]	[0.014]***	[0.023]***	[0.025]***	[0.055]***
Adjusted R^2	0.071	0.166	0.044	0.003	0.057	0.111
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude and distance to the UFCo boundary.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.16: Contemporary Household Outcomes: Dynamics Across Years-No Demographic Controls

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.209	-0.269	-0.098	-0.127	-0.247	-0.703
	(0.066)***	(0.081)***	(0.055)*	(0.052)**	(0.073)***	(0.175)***
	[0.067]***	[0.081]***	[0.052]*	[0.049]**	[0.058]***	[0.160]***
$UFCo_{1984}$	-0.056	0.013	-0.089	-0.068	-0.082	-0.200
	(0.051)	(0.027)	(0.034)***	(0.037)*	(0.057)	(0.109)*
	[0.040]	[0.014]	[0.027]***	[0.030]**	[0.035]**	[0.074]***
$UFCo_{2000}$	-0.089	0.023	-0.092	-0.085	-0.155	-0.244
	(0.031)***	(0.018)	(0.027)***	(0.026)***	(0.039)***	(0.062)***
	[0.032]***	[0.017]	[0.017]***	[0.022]***	[0.034]***	[0.059]***
$UFCo_{2011}$	-0.099	0.023	-0.075	-0.017	-0.123	-0.168
	(0.031)***	(0.016)	(0.030)**	(0.037)	(0.039)***	(0.064)***
	[0.035]***	[0.020]	[0.021]***	[0.053]	[0.047]***	[0.083]**
Adjusted R^2	0.072	0.192	0.044	0.005	0.059	0.117
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic controls for slope, elevation, and temperature; census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.2.2 No Geographic Controls

Table A.17: Contemporary Household Outcomes: Dynamics Across Years-No Geographic Controls

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.219	-0.288	-0.054	-0.132	-0.247	-0.693
	(0.062)***	(0.079)***	(0.045)	(0.047)***	(0.067)***	(0.158)***
	[0.066]***	[0.078]***	[0.035]	[0.048]***	[0.053]***	[0.146]***
$UFCo_{1984}$	-0.062	0.010	-0.083	-0.088	-0.082	-0.207
	(0.048)	(0.028)	(0.027)***	(0.035)**	(0.046)*	(0.092)**
	[0.035]*	[0.016]	[0.023]***	[0.031]**	[0.033]***	[0.068]***
$UFCo_{2000}$	-0.082	0.018	-0.055	-0.085	-0.136	-0.204
	(0.031)***	(0.018)	(0.023)**	(0.026)***	(0.036)***	(0.059)***
	[0.029]***	[0.017]	[0.018]***	[0.025]***	[0.030]***	[0.051]***
$UFCo_{2011}$	-0.101	0.017	-0.036	-0.020	-0.110	-0.140
	(0.030)***	(0.017)	(0.030)	(0.035)	(0.037)***	(0.062)**
	[0.032]***	[0.020]	[0.031]	[0.050]	[0.049]**	[0.087]
Adjusted R^2	0.103	0.198	0.240	0.017	0.116	0.206
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include demographic controls for the number of adults, children, and infants in the household; census FE, and a linear polynomial in latitude and longitude.
We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.18: Average UFCo Effect-No Geographic Control

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.103	-0.021	-0.052	-0.062	-0.131	-0.238
	(0.026)***	(0.017)	(0.023)**	(0.024)**	(0.030)***	(0.057)***
	[0.031]***	[0.017]	[0.018]***	[0.024]***	[0.025]***	[0.052]***
Adjusted R^2	0.101	0.168	0.240	0.015	0.115	0.199
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.2.3 No Demographic or Geographic Controls

Table A.19: Average UFCo Effect-No Demographic or Geographic Controls

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.108	-0.018	-0.080	-0.064	-0.148	-0.271
	(0.027)***	(0.017)	(0.025)***	(0.025)**	(0.033)***	(0.064)***
	[0.034]***	[0.016]	[0.012]***	[0.023]***	[0.025]***	[0.057]***
Adjusted R^2	0.070	0.161	0.044	0.003	0.057	0.110
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.20: Dynamics Across Years-No Demographic or Geographic Controls

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.225	-0.285	-0.080	-0.133	-0.263	-0.722
	(0.064)***	(0.079)***	(0.058)	(0.050)***	(0.071)***	(0.170)***
	[0.068]***	[0.078]***	[0.050]	[0.051]***	[0.059]***	[0.158]***
$UFCo_{1984}$	-0.062	0.010	-0.085	-0.072	-0.089	-0.209
	(0.051)	(0.028)	(0.035)**	(0.036)**	(0.055)	(0.108)*
	[0.042]	[0.017]	[0.026]***	[0.031]**	[0.037]**	[0.079]***
$UFCo_{2000}$	-0.092	0.022	-0.090	-0.088	-0.159	-0.248
	(0.031)***	(0.018)	(0.028)**	(0.026)***	(0.039)***	(0.062)***
	[0.032]***	[0.017]	[0.016]***	[0.023]***	[0.034]***	[0.057]***
$UFCo_{2011}$	-0.106	0.020	-0.071	-0.022	-0.131	-0.179
	(0.031)***	(0.017)	(0.030)**	(0.034)	(0.038)***	(0.062)***
	[0.034]***	[0.020]	[0.021]***	[0.048]	[0.043]***	[0.075]**
Adjusted R^2	0.072	0.191	0.043	0.005	0.058	0.117
$Mean_{1973}$	0.462	0.353	0.393	0.208	0.777	1.416
$Mean_{1984}$	0.209	0.060	0.362	0.201	0.579	0.832
$Mean_{2000}$	0.145	0.031	0.230	0.178	0.452	0.584
$Mean_{2011}$	0.124	0.018	0.156	0.215	0.402	0.512

Notes: UBN= Unsatisfied Basic Need. N= 8786 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.3 The River vs the Boundary

In this Subsection we present our average and yearly results restricting our observations to units on the "worng side" of the river that closely follows our boundary. Our results hold even within these narrower neighborhoods.

Table A.21: Dynamics of the UFCo-Effect Across Years-River Test: Restricted 1km

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.123	-0.226	-0.058	-0.089	-0.132	-0.496
	(0.066)*	(0.059)***	(0.053)	(0.033)***	(0.069)*	(0.103)***
	[0.047]***	[0.061]***	[0.048]	[0.029]***	[0.054]**	[0.084]***
$UFCo_{1984}$	0.027	0.025	-0.092	-0.103	-0.063	-0.142
	(0.082)	(0.038)	(0.061)	(0.042)**	(0.072)	(0.129)
	[0.080]	[0.025]	[0.065]	[0.038]***	[0.054]	[0.109]
$UFCo_{2000}$	-0.103	0.002	-0.085	-0.042	-0.121	-0.229
	(0.044)**	(0.030)	(0.029)***	(0.027)	(0.059)**	(0.089)**
	[0.030]***	[0.025]	[0.017]***	[0.034]	[0.043]***	[0.059]***
$UFCo_{2011}$	-0.104	-0.000	-0.089	-0.117	-0.181	-0.310
	(0.039)**	(0.028)	(0.042)**	(0.032)***	(0.054)***	(0.086)***
	[0.023]***	[0.013]	[0.042]**	[0.020]***	[0.052]***	[0.061]***
Adjusted R^2	0.146	0.238	0.273	0.030	0.157	0.270
$Mean_{1973}$	0.491	0.396	0.455	0.252	0.829	1.595
$Mean_{1984}$	0.265	0.053	0.357	0.186	0.563	0.861
$Mean_{2000}$	0.150	0.037	0.255	0.208	0.497	0.650
$Mean_{2011}$	0.134	0.018	0.164	0.197	0.405	0.513

Notes: UBN= Unsatisfied Basic Need. N= 1937 and # of clusters=44. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.22: Average UFCo Effect–River Test: Restricted 1km

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
UFCo	-0.100	-0.014	-0.085	-0.084	-0.149	-0.284
	(0.034)***	(0.030)	(0.030)***	(0.024)***	(0.046)***	(0.074)***
	[0.022]***	[0.010]	[0.018]***	[0.019]***	[0.024]***	[0.027]***
Adjusted R^2	0.144	0.224	0.274	0.031	0.157	0.269
Mean	0.176	0.060	0.235	0.200	0.481	0.670

Notes: UBN= Unsatisfied Basic Need. N= 1937 and # of clusters=44. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.

A.8.4 Different Bandwidth: Results Eliminating Units within 3 kms of the Boundary.

In this Subsection we present our average and yearly results restricting our observations to units 3km away from the boundary. That is, we eliminate all observations that are relatively close to the boundary and run our regressions in the remaining ones (units).

Table A.23: Average UFCo Effect– Eliminating observations close to the Boundary

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
UFCo	-0.095	-0.016	-0.056	-0.059	-0.124	-0.228
	(0.026)***	(0.017)	(0.022)**	(0.031)***	(0.056)***	(0.074)***
	[0.031]***	[0.020]	[0.023]***	[0.042]**	[0.030]***	[0.071]***
Adjusted R^2	0.103	0.174	0.241	0.017	0.116	0.201
Mean	0.150	0.066	0.178	0.159	0.250	0.698

Notes: UBN= Unsatisfied Basic Need. N= 2,438 and # of clusters=200. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.

A.8.5 Assessing the Impact of Migration

In this Subsection we run our regressions on subsamples of households where (i) nobody migrated, and (ii) the head of household did not migrate; both within 5 years of each census. Our results persist, indicating that migration is not driving our results.

A.8.5.1 No member migrated within 5 years of the census.

Table A.24: Average UFCo Effect-Any Migrant

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
UFCo	-0.104	-0.004	-0.062	-0.055	-0.135	-0.225
	(0.027)***	(0.015)	(0.025)**	(0.025)**	(0.030)***	(0.052)***
	[0.031]***	[0.015]	[0.023]***	[0.028]**	[0.027]***	[0.049]***
Adjusted R^2	0.077	0.145	0.226	0.012	0.102	0.165
Mean	0.158	0.050	0.220	0.205	0.466	0.632
P-value for difference	0.49	0.19	0.64	0.78	0.43	0.94

Notes: UBN= Unsatisfied Basic Need. N= 6451 and # of clusters=198. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. P-values in the last row test whether the UFCo coefficient is the same than the corresponding in Table 1.2. P-values are clustered at the census-block level.

Table A.25: Dynamics of the UFCo-Effect Across Years-Any Migrant

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.252	-0.301	-0.070	-0.144	-0.285	-0.767
	(0.067)***	(0.100)***	(0.042)*	(0.035)***	(0.093)***	(0.191)***
	[0.080]***	[0.102]***	[0.031]**	[0.040]***	[0.080]***	[0.183]***
$UFCo_{1984}$	-0.084	-0.000	-0.107	-0.084	-0.131	-0.275
	(0.048)*	(0.029)	(0.033)***	(0.043)*	(0.050)***	(0.094)***
	[0.044]**	[0.019]	[0.026]***	[0.036]**	[0.031]***	[0.062]***
$UFCo_{2000}$	-0.085	0.008	-0.052	-0.098	-0.144	-0.226
	(0.031)***	(0.017)	(0.026)**	(0.030)***	(0.036)***	(0.057)***
	[0.029]***	[0.017]	[0.026]**	[0.028]***	[0.031]***	[0.051]***
$UFCo_{2011}$	-0.110	0.019	-0.053	0.001	-0.113	-0.143
	(0.031)***	(0.016)	(0.033)	(0.035)	(0.037)***	(0.061)**
	[0.036]***	[0.016]	[0.033]	[0.051]	[0.044]**	[0.077]*
Adjusted R^2	0.079	0.168	0.227	0.016	0.102	0.171
N	6,451	6,451	6,451	6,451	6,451	6,451
Clusters	198	198	198	198	198	198
$Mean_{1973}$	0.434	0.360	0.342	0.204	0.758	1.339
$Mean_{1984}$	0.212	0.061	0.369	0.232	0.604	0.875
$Mean_{2000}$	0.135	0.033	0.224	0.179	0.446	0.571
$Mean_{2011}$	0.121	0.018	0.154	0.216	0.400	0.509

Notes: UBN= Unsatisfied Basic Need. N= 6451 and # of clusters=198. The sample is restricted to households whose any of its members is non-migrant. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.8.5.2 Head-of-household did not migrate within 5 years of the census

Table A.26: Dynamics of the UFCo-Effect Across Years-Head Migrant

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{1973}$	-0.250	-0.315	-0.076	-0.141	-0.308	-0.782
	(0.075)***	(0.102)***	(0.036)**	(0.041)***	(0.086)***	(0.180)***
	[0.087]***	[0.104]***	[0.026]***	[0.048]***	[0.075]***	[0.177]***
$UFCo_{1984}$	-0.087	-0.002	-0.106	-0.094	-0.133	-0.290
	(0.048)*	(0.027)	(0.033)***	(0.041)**	(0.047)***	(0.092)***
	[0.038]**	[0.018]	[0.024]***	[0.038]**	[0.031]***	[0.062]***
$UFCo_{2000}$	-0.089	0.010	-0.060	-0.104	-0.150	-0.242
	(0.030)***	(0.017)	(0.025)**	(0.028)***	(0.035)***	(0.055)***
	[0.028]***	[0.017]	[0.025]**	[0.027]***	[0.030]***	[0.052]***
$UFCo_{2011}$	-0.112	0.018	-0.055	-0.005	-0.118	-0.155
	(0.030)***	(0.015)	(0.033)*	(0.035)	(0.036)***	(0.061)**
	[0.032]***	[0.015]	[0.036]	[0.055]	[0.047]**	[0.082]*
Adjusted R^2	0.084	0.183	0.224	0.017	0.106	0.174
$Mean_{1973}$	0.440	0.360	0.351	0.185	0.770	1.336
$Mean_{1984}$	0.213	0.057	0.379	0.219	0.603	0.868
$Mean_{2000}$	0.141	0.031	0.231	0.176	0.451	0.579
$Mean_{2011}$	0.124	0.018	0.158	0.216	0.404	0.515

Notes: UBN= Unsatisfied Basic Need. N= 7102 and # of clusters=198.The sample is restricted to households whose head of household is non-migrant. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.27: Average UFCo Effect-Head Migrant

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.107	-0.006	-0.066	-0.062	-0.142	-0.241
	(0.026)***	(0.015)	(0.025)***	(0.025)**	(0.029)***	(0.050)***
	[0.028]***	[0.014]	[0.025]***	[0.031]**	[0.028]***	[0.051]***
Adjusted R^2	0.082	0.157	0.224	0.013	0.104	0.168
Mean	0.163	0.050	0.227	0.201	0.472	0.641
P-value for difference	0.25	0.22	0.37	0.86	0.18	0.69

Notes: UBN= Unsatisfied Basic Need. N= 7102 and # of clusters=198.The sample is restricted to households whose head of household is non-migrant. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic and demographic controls; census FE, and a linear polynomial in latitude, longitude.We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.28 also shows the results after analyzing migrants from early waves of migration, namely, 1927. These results suggest that migrants to the UFCo were negatively selected in several dimensions, including education and property ownership, as compared with migrants to other Costa Rican regions. To generate this table, we considered the following regression:

$$y_{igt} = \gamma UFCo_g + f(\text{geographic location}_g) + \mathbf{X}_{igt}\beta + \alpha_t + \varepsilon_{igt},$$

where variables are defined as in Equation 1.1, except that g stands for cantons instead of census blocks.[5] We consider the probability of owning private property, of having competed primary school, of having competed secondary school, and of having no education as outcome variables. The top panel of Table A.28 shows the difference in outcomes for migrants to UFCo cantons and migrants to other Costa Rican cantons; while the bottom panel compares outcomes of migrants to UFCo cantons with outcomes of migrants to cantons neighboring UFCo locations

[5]Cantons are the most detailed geographic unit available in the 1927 Census. For the purposes of this exercise and given cantons are relatively large, we calculate the "UFCo intensity" of each canton based on the percentage of land of the canton that was part of the UFCo's concession.

(meaning they share at least one boundary segment).

Table A.28: Negatively Selected Migrants to UFCo Regions: 1923 Population Census

	Probability of receiving migrants who			
	are property owners	completed primary school	completed secondary school	have no education
	(1)	(2)	(3)	(4)
Migrants to UFCo compared with migrants to any region				
UFCo	-.380	-0.192	-0.055	0.253
	(0.033)***	(.043)***	(0.020)***	(0.044)***
Adjusted R^2	0.30	0.02	0.02	0.08
N	18,851	18,851	18,851	18,851
Migrants to UFCo compared with migrants to neighboring regions				
UFCo	-.488	-0.260	-0.0002	0.251
	(0.032)***	(0.047)***	(.0222)	(0.048)***
Adjusted R^2	0.36	0.05	0.01	0.13
N	6,087	6,087	6,087	6,087

The unit of observation is the individual. Robust standard errors, adjusted for clustering by canton, are in parentheses. All regressions include demographic controls for the number of adults, children, and infants in the household and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.8.6 Results Not Driven by Persistence of Better Abilities in Agricultural Activities

A concern might be that the higher productivity and better infrastructure in the UFCo attracted people who were ex-ante better at growing crops; and that what we are capturing is the persistence of these abilities across generations. Therefore, in this subsection we compare the UFCo effect in households that worked in agricultural activities with the effect on households devoted to other non-agricultural enterprises, and find no significant difference in the UFCo effect.

Table A.29 compares our results for households where any member was employed in agricultural activities against all other households, and Table A.30 shows how households whose head works in agricultural activities deliver equivalent estimates to households where the head is employed in other activities.

Table A.29: Average UFCo Effect-Comparison of households where any member is engaged in the agricultural sector versus households employed in other economic sectors.

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
			Agricultural Sector			
UFCo	-0.097	-0.022	-0.052	-0.055	-0.123	-0.225
	(0.028)***	(0.018)	(0.024)**	(0.027)**	(0.033)***	(0.059)***
	[0.027]***	[0.014]	[0.023]**	[0.025]**	[0.024]***	[0.048]***
Adjusted R^2	0.122	0.192	0.248	0.045	0.152	0.247
N	6,190	6,190	6,190	6,190	6,190	6,190
Clusters	200	200	200	200	200	200
Mean	0.185	0.070	0.267	0.187	0.495	0.709
			Non-Agricultural Sector			
UFCo	-0.094	0.002	-0.076	-0.065	-0.122	-0.233
	(0.037)**	(0.024)	(0.031)**	(0.049)	(0.052)**	(0.091)**
	[0.044]**	[0.026]	[0.023]***	[0.018]***	[0.034]***	[0.072]***
Adjusted R^2	0.052	0.091	0.171	0.020	0.043	0.069
N	2,596	2,596	2,596	2,596	2,596	2,596
Clusters	193	193	193	193	193	193
Mean	0.153	0.037	0.159	0.229	0.449	0.578
P-value for difference	0.94	0.32	0.48	0.85	0.98	0.93

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, adjusted for clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic controls and demographic controls; census FE, and a linear polynomial in latitude, longitude. P-values in the last row are for the test of the hypothesis that the UFCo coefficient is the same between the two groups. P-values are clustered at the census-block level.

Table A.30: Comparison of of households where the **head** of household is engaged in the agriculture sector versus other heads employed in other economic sectors

	Probability of UBN in				Probability	Total #
	Housing	Sanitation	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
			Agricultural Sector			
UFCo	-0.083	-0.025	-0.043	-0.039	-0.103	-0.191
	(0.030)***	(0.021)	(0.027)	(0.030)	(0.036)***	(0.065)***
	[0.025]***	[0.015]*	[0.029]	[0.025]	[0.030]***	[0.061]***
Adjusted R^2	0.128	0.200	0.255	0.045	0.065	0.255
N	5,337	5,337	5,337	5,337	5,337	5,337
Clusters	200	200	200	200	200	200
Mean	0.182	0.073	0.258	0.194	0.490	0.708
			Agricultural Sector			
UFCo	-0.120	0.000	-0.086	-0.092	-0.161	-0.299
	(0.033)***	(0.017)	(0.029)***	(0.040)**	(0.039)***	(0.064)***
	[0.044]***	[0.020]	[0.021]***	[0.025]***	[0.019]***	[0.054]***
Adjusted R^2	0.066	0.091	0.209	0.013	0.066	0.104
N	3,449	3,449	3,449	3,449	3,449	3,449
Clusters	197	197	197	197	197	197
Mean	0.166	0.039	0.200	0.208	0.467	0.612
P-value for difference	0.31	0.21	0.24	0.27	0.23	0.15

Notes: UBN= Unsatisfied Basic Need. The unit of observation is the household. Robust SE, adjusted for clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic controls and demographic controls; census FE, and a linear polynomial in latitude, longitude. P-values in the last row are for the test of the hypothesis that the UFCo coefficient is the same between the two groups. P-values are clustered at the census-block level.

A.9 Méndez & Trejos Index

Table A.31: Average UFCo Effect-Méndez & Trejos Index

	Probability of UBN in				Probability	Total #
	Housing	Health	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
UFCo	-0.088	-0.031	-0.057	-0.020	-0.109	-0.197
	(0.030)***	(0.051)	(0.026)**	(0.019)	(0.043)**	(0.077)**
	[0.033]***	[0.034]	[0.028]**	[0.014]	[0.034]***	[0.069]***
Adjusted R^2	0.020	0.025	0.044	0.025	0.075	0.090
Mean	0.178	0.132	0.180	0.132	0.433	0.622

Notes: UBN= Unsatisfied Basic Need. N= 6623 and # of clusters=160. The unit of observation is the household. Robust SE, clustering by census-block, in parentheses. Conley SE in brackets. All regressions include geographic(slope, elevation, temperature) and demographic(number of adults, children, infants per household) controls; census FE, and a linear polynomial in latitude and longitude. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.32: Dynamics Across Years-Méndez & Trejos Index

	Probability of UBN in				Probability	Total #
	Housing	Health	Education	Consumption	of being poor	of UBN
	(1)	(2)	(3)	(4)	(5)	(6)
$UFCo_{2000}$	-0.081	-0.022	-0.069	-0.038	-0.110	-0.210
	(0.036)**	(0.067)	(0.025)***	(0.022)*	(0.052)**	(0.102)**
	[0.035]**	[0.053]	[0.025]***	[0.016]**	[0.044]**	[0.084]**
$UFCo_{2011}$	-0.094	-0.039	-0.047	-0.005	-0.109	-0.186
	(0.032)***	(0.052)	(0.033)	(0.022)	(0.045)**	(0.074)**
	[0.037]***	[0.035]	[0.035]	[0.020]	[0.039]***	[0.076]**
Adjusted R^2	0.020	0.025	0.146	0.025	0.075	0.090
$Mean_{2000}$	0.164	0.172	0.230	0.178	0.511	0.744
$Mean_{2011}$	0.128	0.101	0.156	0.099	0.365	0.484

Notes: All definitions ans specifications coincide with the ones in Table A.31.

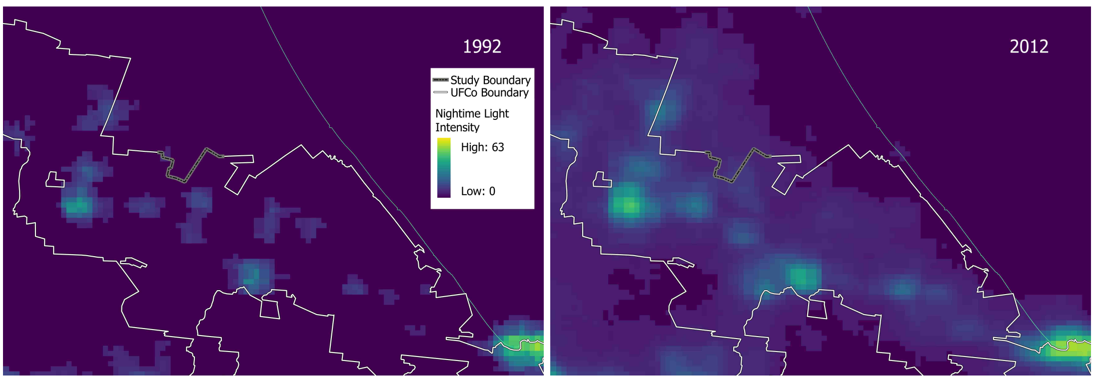
A.10 Luminosity Data

We use nighttime lights data[6] as a robustness check of our main results, treating satellite-recorded data on nighttime lights as a proxy for income and economic

[6]The data on nighttime light is collected by the US Air Force Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) and is processed by the National Oceanic and Atmospheric Agency's (NOAA) National Geophysical Data Center (NGDC). The data covers the years 1992 to 2013 at a spatial resolution of 30 arc-seconds.

activity. A series of papers that have shown a strong correlation between nighttime lights and economic activity (Chen and Nordhaus (2011); Henderson et al. (2012); Michalopoulos and Papaioannou (2014); Hodler and Raschky (2014)). For each grid cell, an integer between 0 (no light) and 63 represents its light intensity. The table and figures below present our results after we account for observations with a value of zero by adding 0.01 to the data on luminosity and luminosity per capita.[7] Column (1) in Table A.33 shows that nighttime light intensity is 21% (exp(0.193)-1=0.212) higher in the former UFCo plantations. To give a sense of the economic significance of this estimate, if we assume an elasticity between nighttime light intensity and GDP of 0.3 (consistent with the findings in Henderson et al. (2012) and Hodler and Raschky (2014)), the 21% difference in nighttime light intensity implies that the output in the former UFCo plantations is about 6.37% higher. Column (2) shows that luminosity per capita is 18% (exp(0.165)-1=0.18) higher in the former UFCo plantations. Column (3) shows that the annual growth rate of luminosity per capita is 2.064 percentage points higher in the former UFCo areas. All estimates are significant at least at the 5% significance level. In general, the nighttime lights results are consistent with the estimates from our main specification.

Figure A.8: Lights near the study boundary in 1992 and 2012



[7] A total of 9.2% observations in our luminosity data have a value equal to zero. The zero value can be due to a light that is too low for detection by the satellite, or because it corresponds to a sparsely populated area.

Table A.33: Luminosity Data

	Light	Light per Capita	Growth Rate Light per Capita	Log (.01 + Light)	Log (.01 + Light per Capita)
UFCo	0.193	0.165	2.064	0.342	0.215
	(0.006)***	(0.051)***	(0.781)***	(0.035)***	(0.046)***
	[0.017]***	[0.065]**	[0.953]**	[0.072]***	[0.059]***
Adjusted R^2	0.377	0.036	0.282	0.463	0.122
Observations	5,588	2,061	1,679	6,154	2,210

Notes: Light and light per capita are in logs, and growth rates are annual. The units of observation are 1x1 km grid cells located within 5 km of UFCo boundary. Robust SE in parentheses. Conley SE in brackets. All regressions include year FE. We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.11 Outside Options in 1973 and Current Outcomes

This section presents additional results for our discussion on how areas of the UFCo where workers had better outside options in 1973 showcase dis-proportionally better contemporary outcomes. Our design to arrive to proxy outside options with wages in enarby regions, and instrument for this wages using suitability to grow coffee (which was the main outside option for agricultural workers at the time, and grows in a very different environment than bananas–UFCo's main product).

Table A.34 shows our results of the first stage of this IV strategy:

Table A.34: First Stage: Suitability to Grow Coffee and Wages in 1973

The dependent variable is ln(wage)

$coffee_i^{1973}$	0.197
	(.071)***
N	86,538
R^2	0.11
Wald chi2	1112.31

Notes: UBN = Unsatisfied Basic Need. N = 678565. The unit of observation is the individual. Robust SE (clustered by district) in parentheses. The regression controls for demographic characteristics (age, gender and years of schooling). We denote: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.12 Model Calibration

In this section we present the output from the estimation of some of the model's parameters. In particular, Table A.35 shows the first and second stages of the estimation of Equation (1.8) using data on wages for 1973 for all districts in the country (484), and the equivalent cross-section generated by the model.

Table A.35: Estimating Elasticities

First stage	
	Wage
Model log wage	0.23^{***}
	(0.019)
Second stage	
Elasticity of substitution (σ)	6.46^{***}
	(1.562)
Labor mobility elasticity (θ)	4.63^{***}
	(0.899)

Notes: The table shows the change in steady state outcomes. Equivalent Variation is the % increase/decrease in consumption in steady state necessary to get the new utility level.

For validation purposes, we use measure the percentage of UFCo average investments in local amenities over its sales, both in the model, which are .041 and .062, respectively. We also calculate the correlation between UFCo investments and "outside options" proxied by wages in neighboring locations. We find that this correlation is .021 and .043 in the data and in the model, respectively.

A.13 Results Assuming Amenities Have no Effect on Productivity

Table A.36 shows the welfare effects of the company under different labor market structures — monopsony vs perfectly competitive labor markets in all regions — assuming amenities have no effect on productivity ($\chi = 0$).

Table A.36: Company's Effect under Different Labor Market Structures and Assuming Amenities Have no Effect on Productivity

Outcome	%Δ w/Monopsony		%Δ w/Perfect Competition	
	Aggregate	UFCo Region	Aggregate	UFCo Region
Equiv. Δ (in C)	2.19	22.1	4.22	30.9
Welfare	2.04	19.8	3.72	26.5
Stock Amenities	4.93	34.7	2.48	15.5
Wages	-2.02	-10.1	2.29	16.2

Notes: The table shows the change in steady state outcomes. Equivalent Variation is the % increase/decrease in consumption in steady state necessary to get the new utility level.

APPENDIX B

B.1 Proofs

B.1.1 Proof of Convergence of the Frontier of Knowledge

We derived previously how, since $\tilde{F}_t(q) = (M_t(q)^m)$, the change in the frontier of knowledge evolves as

$$\tfrac{d}{dt} ln\tilde{F}_t(q) = -m\delta_t \int_0^\infty \left(\tfrac{x}{q}\right)^{-\omega} \left[1 - H\left(\tfrac{q}{x^\beta}\right)\right] d\tilde{G}_t(x).$$

Define $F_t(q) = \tilde{F}(m^{\frac{1}{\theta-\beta\theta+\omega}} q)$ and evaluate the equation above in $m^{\frac{1}{\theta-\beta\theta+\omega}} q$. We obtain

$$\tfrac{d}{dt} ln\tilde{F}_t(m^{\frac{1}{\theta-\beta\theta+\omega}} q) = -m\delta_t \int_0^\infty \left(\frac{x}{m^{\frac{1}{\theta-\beta\theta+\omega}} q}\right)^{\omega} [1 - H(m^{\frac{1}{\theta-\beta\theta+\omega}} q/x^\beta)] d\tilde{G}_t(x)$$

Further, using the change of variables $w = m^{\frac{-1}{(\theta-\beta\theta+\omega)}} x$, and defining $G_t(x) = \tilde{G}_t(m^{\frac{1}{(\theta-\beta\theta+\omega}} x)$, we obtain

$$\tfrac{d}{dt} lnF_t(q) = -m\delta_t \int_0^\infty \left(\tfrac{x}{q}\right)^{-\omega} [1 - H(q/x)^\beta)] dG_t(x),$$

and we can rewrite the expression as

$$\begin{aligned}
\frac{d}{dt} lnF_t(q) &= -\delta_t q^{-\theta} \int_0^\infty \left(\frac{x}{q}\right)^{-\omega} \frac{[1 - H(m^{\frac{1}{\theta}} q/x^\beta)]}{(m^{\frac{1}{\theta}} q/x^\beta)^{-\theta}} x^{\beta\theta} dG_t(x) \\
&= -\delta_t q^{-\theta+\omega} \int_0^\infty \frac{[1 - H(m^{\frac{1}{\theta}} q/x^\beta)]}{(m^{\frac{1}{\theta}} q/x^\beta)^{-\theta}} x^{\beta\theta-\omega} dG_t(x)
\end{aligned}$$

From assumption (i), we can take the limit as $m \to \infty$ inside these integrals, and by (iii), the integrals $\int_0^\infty x^{\beta\theta} dG_t(x)$ and $\int_0^\infty x^{\beta\theta-\omega} dG_t(x)$ are finite. Therefore, we can take the limit as $m \to \infty$ inside the integral using the dominated convergence theorem to get

$$\frac{dlnF_t(q)}{dt} = \delta_t q^{-\theta+\omega} \int_0^\infty x^{\beta\theta-\omega} dG_t(x).$$

B.1.2 Proof of Frechet Limit

Solving

$$\frac{dlnF_t(q)}{dt} = \delta_t q^{-\theta+\omega} \int_0^\infty x^{\beta\theta-\omega} dG_t(x).$$

as a differential equation, we obtain $F_t(q) = F_0(q)e^{(-\lambda_t-\lambda_0)q^{-\theta+\omega}}$.

Evaluating this at $\lambda^{1/(\theta+\omega)}q$ gives us that

$$F\left(\lambda^{1/(\theta+\omega)}q\right) = F_0(\lambda^{1/(\theta+\omega)})e^{(-\lambda_t-\lambda_0)\lambda^{-1}q^{-\theta+\omega}}.$$

Asymptotically, this means that

$$\lim_{t\to\ \infty} F\left(\lambda^{1/(\theta+\omega)}q\right) = e^{-q^{-\theta+\omega}}.$$

B.1.3 Proof for Law of Motion of the Stock of Knowledge, λ_t

Assuming learning from sellers, and denoting the set of goods s in country i such that the lowest cost seller is from country j as $S_{ij} \subset [0,1]$, the source distribution can be written as $G_i^*(q) = \sum_k \int_{s\in S_{ik}|q_j<q} ds$, and the general form of Equation 2.4 becomes

$$\begin{aligned}\dot{\lambda}_{it} &= \delta_{it}\int_0^\infty x^{\beta\theta-\omega}dG_{it}^*(x) \\ &= \delta_{it}\Gamma\left(1-\beta+\frac{\omega}{\theta}\right)\sum_j \pi_{ij}\left(\frac{\lambda_{jt}}{\pi_{ij}}\right)^{\beta-\frac{\omega}{\theta}}\end{aligned}$$

where $\Gamma(\,\cdot\,)$ denotes the Gamma distribution.

Proof:

For τ_1 such that $0 \le \tau_1 < 1$, Buera and Oberfield (2016) show that

$$\int_{s\in S_{ij}} q_{j1}(s)^{\tau_1\theta} p_i^{-\tau_2\theta} = B(\tau_1,\tau_2)\left[\sum_k \lambda_k (w_i\kappa_{ik})^{-\theta}\right]^{\tau_2} \pi_{ij}\left(\frac{\lambda_j}{\pi_{ij}}\right)^{\tau_1} \tag{B.1}$$

where $B(\tau_1,\tau_2) = \left[1 - \frac{\tau_2}{1-\tau_1} + \frac{\tau_2}{1-\tau_1}\left(\frac{\epsilon}{1-\epsilon}\right)^{-\theta(1-\tau_1)}\right]\Gamma(1-\tau_1-\tau_2)$. Using this result, as $\omega < \beta\theta$, we obtain that

$$\begin{aligned}\int_0^\infty x^{\beta\theta-\omega} dG_i(x) &= B\left(\beta - \frac{\omega}{\theta}, 0\right)\sum_j \pi_{ij}\left(\frac{\lambda_j}{\pi_{ij}}\right)^{\beta-\frac{\omega}{\theta}} \\ &= \Gamma\left(1-\beta+\frac{\omega}{\theta}\right)\sum_j \pi_{ij}\left(\frac{\lambda_j}{\pi_{ij}}\right)^{\beta-\frac{\omega}{\theta}}.\end{aligned}$$

B.2 Extended Model for the Quantitative Analysis

This section derives the price index, expenditure shares, and the law of motion of λ_i for a version of the model that includes intermediate inputs, nontradables and human capital. First, with an elasticity of substitution given by ε, the expression for the price index is

$$p_i^{1-\varepsilon} = \left[\psi(\chi_i\lambda_i)^{\frac{\varepsilon-1}{\theta-\omega}} + (1-\psi)\left(\sum_{j=1}^n \frac{\chi_j\lambda_j}{\kappa_{ij}^{\theta-\omega}}\right)^{\frac{\varepsilon-1}{\theta-\omega}}\right] C,$$

where $\chi_i = \frac{1}{(p_i^{1-\psi} w_i^{\psi})^{\theta-\omega}}$ and C is a constant term; while country i's expendure in non-tradable and tradable goods, respectively, are

$$\pi_i^{NT} = \frac{\psi(\chi_i\lambda_i)^{\frac{\varepsilon-1}{\theta-\omega}}}{\psi(\chi_i\lambda_i)^{\frac{\varepsilon-1}{\theta-\omega}} + (1-\psi)\left(\sum_{j=1}^n \frac{\chi_j\lambda_j}{\kappa_{ij}^{\theta-\omega}}\right)^{\frac{\varepsilon-1}{\theta-\omega}}}, \text{ and}$$

$$\pi_i^T = \frac{(1-\psi)\left(\sum_{j=1}^n \frac{\chi_j\lambda_j}{\kappa_{ij}^{\theta-\omega}}\right)^{\frac{\varepsilon-1}{\theta-\omega}}}{\psi(\chi_i\lambda_i)^{\frac{\varepsilon-1}{\theta-\omega}} + (1-\psi)\left(\sum_{j=1}^n \frac{\chi_j\lambda_j}{\kappa_{ij}^{\theta-\omega}}\right)^{\frac{\varepsilon-1}{\theta-\omega}}}.$$

As producers learn from sellers, the dynamics of country i's stock of knowledge depend on two sources improvements: learning coming from locals who produce non-tradables, and learning coming from sellers of tradables (who may or may not be foreigners). These two forces are captured as the two components of the following sum:

$$\dot{\lambda}_i = \left[\psi\lambda_i^{\beta-\frac{\omega}{\theta-\omega}} + (1-\psi)\sum_j \pi_{ij}^T\left(\frac{\lambda_j}{\pi_{ij}^T}\right)^{\beta-\frac{\omega}{\theta-\omega}}\right]C',$$

where C' is a constant term, and $\pi_{ij}^T = \frac{\chi_j\lambda_j/\kappa_{ij}^{\theta-\omega}}{\sum_s \chi_s\lambda_s/\kappa_{is}^{\theta-\omega}}$ is i's expenditure share of *tradables* coming from j.

B.3 Model's Counterpart of Regression 2.1

Given the probability of learning in 2.3, an expectation taken using the source distribution $G_t(x)$, we can express average growth as

$$\frac{q_{t+1}-q_t}{q_t} = E_x\left[\delta\left(\frac{x}{q_t}\right)^{-\omega} z\left(\frac{x}{q_t}\right)x^{\beta-1}\mathbb{1}(zx^\beta > q_t) + \left(1-\delta\left(\frac{x}{q_t}\right)^{-\omega}\right)\right].$$

This can be rewritten as

$$\frac{q_{t+1}-q_t}{q_t} = E_x\left[\delta\left(\frac{x}{q_t}\right)^{-\omega}\left(H\left(1-\frac{q_t}{x}x^{1-\beta}\right)\left(\frac{x}{q_t}\right)x^{\beta-1}-1\right)+1\right].$$

$$\frac{q_{t+1} - q_t}{q_t} = \delta \rho_{\left(\frac{x}{q_t},t\right)} \rho_{\left(\frac{x}{q_t},x,t\right)}$$

where $\rho_{\left(\frac{x}{q_t},t\right)}$ and $\rho_{\left(\frac{x}{q_t},x,t\right)}$ capture, respectively, the effects of the ratio's importance and the interaction between the ratio and the partner's productivity. A certain equivalent of this equation would lead to a regression as in Equation (2.1), without including the trade shares(as explained, trade shares were included to explore their role in the learning process, but do not play a role in the model), which turned out to be insignificant empirically.

B.4 Mapping of Industries from the WIOD into 10 Aggregate Sectors

As explained in Section 2.2.2, two of the sources I use have different levels of aggregation. Namely, the WIOD traces the flow of goods and services across 35 industries, while the data used to obtain the productivities per sector and per country comes from the GGDC database and world KLEMS data, which divide economic activity into 10 sectors. These sectors are: agriculture, hunting, forestry and fishing; mining and quarrying; manufacturing; electricity, gas and water supply; construction; wholesale and retail trade, hotels and restaurants; transport, storage, and communication; finance, insurance, real estate and business services; government services; community, social and personal services. The mapping was designed according to the ISIC codes presented by Timmer et al. (2015a), to divide the categories in the WIOD into 10 sectors that corresponded with those in the GGCD as follows:

- **Sector 1:** Agriculture, Hunting, Forestry and Fishing
- **Sector 2:** Mining and Quarrying
- **Sector 3:** Food, Beverages and Tobacco, Textiles and Textile Products,

Leather, Leather and Footwear, Wood and Products of Wood and Cork, Pulp, Paper, Paper , Printing and Publishing, Coke, Refined Petroleum and Nuclear Fuel, Chemicals and Chemical Products, Rubber and Plastics, Other Non-Metallic Mineral, Basic Metals and Fabricated Metal, Machinery, Nec, Electrical and Optical Equipment, Transport Equipment, Manufacturing, Nec, Recycling

- **Sector 4:** Electricity, Gas and Water Supply
- **Sector 5:** Construction
- **Sector 6:** Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel, Wholesale Trade and Commission Trade, Except of Motor Vehicles, Retail Trade, Except of Motor Vehicles ; Repair of Household Goods, Hotels and Restaurants
- **Sector 7:** Inland Transport, Water Transport, Air Transport, Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies, Post and Telecommunications
- **Sector 8:** Financial Intermediation, Real Estate Activities, Renting of M&Eq and Other Business Activities
- **Sector 9:** Public Admin and Defence; Compulsory Social Security, Education, Health and Social Work
- **Sector 10:** Other Community, Social and Personal Services, Private Households with Employed Persons

I compare the aggregate GDP per country-sector that results from aggreagating sectors in this fashion across the WIOD, with production per section and per country reported in the GGDC to verify that this aggregation is correct.

B.5 Additional Tables and Figures

B.5.1 Robustness: Regressions Using Longer Lags

As explained in Section 2.2.3, one concern about the specification may be that a year is not enough for the effect to materialize, or at least not fully. This is because the mechanism requires for one party (the importer) to learn from the foreign seller. Given how learning works in the model as derived in Section 2.2.1, the main specification only includes the first lag. However to address this concern, Table B.1 includes results in which I inlcude further lags for the independent variables, namely, 3 lags for each of them. This exercise allows me to assess if there is a "time-to-build" the stock of knowledge after a trade interaction, and whether or not it is empirically correct to include only the first lag.

As shown, the exercise reveals no evidence of lags of order higher than 1 having more importance than the first one. First, none of the lags is larger in magnitude (iwhich seems to decrease on the lag's order). Second, these higher order lags in general are not significant. Column (1) shows how only the ratio for the first lag is significant (and at 1%); the second lag, while not significant, keeps the same sign as the first one with a lower magnitude; the third lag is the smallest in absolute value, and the most insignificant as well. Other independent variables show a similar pattern: the trading partner's productivity is significant and with the expected sign only for the first lag, while the interaction term's significance is also decreasing on the lag. Therefore, all the qualitative findings remain unchanged and consistent with the results presented in section 2.2.3, with little impact on the magnitudes of the coeficcients.

Table B.1: Trade and Changes in Productivity Using Longer Lags

Dependent variable: change in productivity of each country's industry $\left(\Delta z_{it+1}^{k}\right)$.

Log Variables	(1)	(2)	(3)
Ratio $(t-1)$,	-0.232	-0.239^{**}	$-0.362*$
	(0.209)	(0.085)	(0.198)
Ratio $(t-2)$,	0.068	0.076	0.331
	(0.041)	(0.085)	(0.187)
Trading partner's productivity (t)		0.717^{***}	0.824^{***}
		(0.153)	(0.166)
Trading partner's productivity $(t-1)$		-0.05	0.066
		(0.167)	(0.209)
Trading partner's productivity $(t-2)$		-0.04	-0.259
		(0.149)	(0.156)
$\left(\frac{\hat{z}_{it}^{k}}{z_{it}^{k}}\right) \times \hat{z}_{it}^{k}\ (t)$			0.032
			(0.048)
$\left(\frac{\hat{z}_{it}^{k}}{z_{it}^{k}}\right) \times \hat{z}_{it}^{k}(t-1)$			0.023
			(0.030)
$\left(\frac{\hat{z}_{it}^{k}}{z_{it}^{k}}\right) \times \hat{z}_{it}^{k}(t-2)$			-0.047
			(0.034)
FE	✓	✓	✓

Notes: Table B.1 reports the regression results when the dependent variable is the change in productivity of each country's industry $\left(\Delta z_{it+1}^{v}\right)$ with longer lags than Table 2.1. All productivities are demeaned using the mean of a country's industry. Independent variables are in logs. In all cases, the number of observations equals 1,635. Constants not reported. Robust SE are in parentheses. Significance levels: $^{*}p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

B.5.2 Regression Over a Sub-sample

Table B.2 presents the results of Table 2.1, but when dropping observations after year 2007. Namely, I run regression 2.1 over the period 1995-2007, to exclude the great recession and study the sensitivity of the results to the time period considered. As shown, qualitatively the results are preserved, while quantitatively the use of a subsample has little impact on the coeficcients.

Table B.2: Trade and Changes in Productivity in a Subsample

Dependent variable: change in productivity of each country's industry $\left(\Delta z_{it+1}^{k}\right)$.

	(1)	(2)	(3)
Ratio $\left(\frac{\hat{z}_{it}^{k}}{z_{it}^{k}}\right)$	-0.842^{***}	-0.523^{***}	-0.648^{***}
	(0.048)	(0.033)	(0.075)
Trading partner's productivity $\left(\hat{z}_{jt}^{k}\right)$		0.625^{***}	0.641^{***}
		(0.012)	(0.014)
$\left(\frac{\hat{z}_{it}^{k}}{z_{it}^{k}}\right) \times \hat{z}_{it}^{k}$			0.028^{**}
			(0.006)
FE	✓	✓	✓
Adj R^2	0.67	0.97	0.97

Notes: Table B.2 reports the regression results when the dependent variable is log change in productivity of each country's industry $\left(\Delta z_{it+1}^{k}\right)$. All productivities are demeaned using the mean of a country's industry during the period studied (1995-2010). Independent variables are also in logs. Average productivity of the trading partner of each industry-country is constructed based on industry-country pairs, according to **??**. In all cases, the number of observations equals 1,524. Constants not reported. Robust standard errors are in parentheses. Significance levels: $^{*}p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$