

Industrial Place-Based Policies and Informality: Evidence from Colombia*

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Abstract

This paper studies the local economic impact of the Free Economic Zones (FEZs) program established in Colombia between 2005-2018. Based on a novel data set that combines georeferenced data on FEZs, municipalities, and household characteristics, I measure the spatial effects of the creation of these zones on labor market outcomes, focusing on informality. Results show that the FEZs establishment significantly increases informality, with positive spillovers to the nearby regions, decreasing with distance. This increase is mostly driven by workers shifting from the formal to the informal sector. I develop a spatial structural model with informality, internal trade, and labor mobility to rationalize these findings.

Keywords: Place-Based Policies, Local Labor Markets, Informality

JEL Classification: H25, J61, R11, R12

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1 Introduction

Governments have implemented place-based policies to promote the economic development of their most remote and lagged areas and mitigate regional disparities. Despite the high prevalence of developing economies implementing this policy tool, the existing literature on place-based policies has predominantly focused on examining their effects in developed economies (Mayer, Mayneris, and Py 2015; Boarnet and Bogart 1996; Ehrlich and Seidel 2018; Neumark and Kolko 2010 for a review). Nevertheless, the experience with place-based policies in developed countries can hardly be transferred to less-developed economies, for instance, because a substantial share of their labor force is employed informally (Gallé et al, 2022).

Special Economic Zones (SEZs) have become one of the most popular place-based policy instruments for developing countries. These share a similar setup: geographically delimited areas with eligibility for benefits based on physical location within the zone, intending to serve as mechanisms to promote economic development and growth, enhance industry competitiveness, attract foreign direct investment, and generate employment. In the last decades, zone development has increased substantially due to the emergence of new economic integration programs for the recent trade liberalization and the ongoing globalization (Facility for Investment Climate Advisory Services 2008; World Bank Group 2017). According to UNCTAD (2019), the total number of SEZs worldwide increased from 500 in 1995 to about 5400 in 2018. Consequently, a policy concern arises regarding the impact of SEZs on developing economies' labor market outcomes.

Labor market informality poses a significant challenge to low and middle-income countries, causing distortions that hamper economic growth, development, and aggregate efficiency. First, it generates hindrances to fiscal capacity and the provision of public goods due to tax evasion by informal firms. Second, it may distort firms' labor market decisions, such as the size of their labor force, due to considering the likelihood of detection in hiring practices. Third, it creates substantial misallocation of resources stemming from the presence of numerous small and unproductive informal economic agents competing with more productive (formal) firms coexisting even within narrowly defined industries (Ulyssea, 2018). More importantly, the informal sector hosts a substantial share of the total labor force; for instance, more than half of the employment in Latin America is informal (SEDLAC, 2020);¹ in India, it reaches about 90 percent of the total labor force. Therefore, understanding how the informal sector reacts to policies that affect the labor market is a central question.

The economic policy landscape in Colombia presents an intriguing case worth examining. Colombia is a developing economy that benefits from favorable demographic and external conditions that have helped contribute to its resilient economic growth. It is an OECD member with macroeconomic policies that have instilled confidence (OECD, 2019), positioning it as one of the countries with the best performance in the Latin American continent. Nevertheless, the economy's growth is not evenly spread across different regions. This results in a concentration of economic and social activity in certain areas, while development is slower and social opportunities are limited in

¹Informality ranges from 35 percent in Chile to around 80 percent in Peru.

others. As a solution, the government has intensified its efforts to reduce these disparities through public policy programs, such as the roll-out of Free Economic Zones ("Zonas Francas" in Spanish), which function as a specific type of SEZ regime. The Free Economic Zones are an industrial place-based policy instrument, offering incentives for firms to locate, invest, and engage in international trade. It aims to promote regional competitiveness, develop highly productive industrial processes and economies of scale, streamline trade procedures for goods and services, and ultimately, generate employment. (Cámara de Usuarios de Zonas Francas, ANDI 2019).

One salient characteristic of the Colombian labor market is the substantial size of its informal sector, accounting for nearly 50 percent of total employment and displaying regional variations ranging from 40 percent to 80 percent. This distinctive trait positions Colombia at the forefront among OECD members with the highest informality rate, surpassing Brazil and Turkey (OECD, 2018). In line with patterns observed in many developing economies, this prevalence of informality signifies that less than half of the Colombian population enjoys the stability of formal employment, leaving the majority to navigate the challenges of the informal sector. This pervasive informality encompasses a spectrum of heterogeneous economic activities, ranging from street vendors and workers engaged in illegal activities to individuals undertaking unpaid labor and those employed by informal firms that neglect to provide minimum labor conditions.

In this paper, I examine a large industrial place-based policy program, the Free Economic Zones (FEZs) regime, established in Colombia in 2005. Based on a novel data set that combines georeferenced data on FEZs, municipalities, and household characteristics, I measure the regional effects of the construction of these zones on labor market outcomes, focusing on the sector composition (informal and formal)². I consider the creation of these zones a source of variation to provide evidence of the causal mechanisms of changes in the Colombian labor market from 2005 to 2018. In particular, I first investigate to what extent the roll-out of this place-based policy influences the informal sector in Colombia; second, I estimate whether there is an effect on the spatial distribution of workers in the informal sector. To rationalize the effects of such a policy, I develop a spatial structural general equilibrium model with informality, labor mobility, and internal trade.

My findings suggest a positive and permanent effect of the roll-out of the FEZs on the informality rate. On average, the informality rate increases by 6.5 percentage points in Colombian municipalities hosting FEZs. I also find an insignificant effect on total employment. This implies a shift of workers from the formal to the informal sector. For wages, I observe a negative effect in the short run.

Additionally, I find evidence of spatial spillover effects. For instance, I show that informality increases in nearby municipalities but vanishes with distance. For employment and wages, I find a positive impact on total employment that increases with a distance of up to 25km. My results suggest that municipalities located 25 kilometers away experience an increase in formal employment, which is driving the overall increase in total employment. On the other hand, in municipalities located 10 kilometers away, the increasing employment and informality may indicate the emergence of informal firms in nearby markets, rather than a reallocation between formal and informal sectors.

²By sector, I refer to firms producing informally or formally.

For wages, the effect is insignificant.

Moreover, the results using the different proxies of economic development are consistent: they suggest that the FEZs regime did improve economic indicators in areas hosting the zones. Similarly, the state capacity indicators also show positive results. Since the benefits provided to the FEZs come from the national government rather than the regional government, municipalities experienced an increase in their tax revenues.

The theoretical model helps to explain these findings. I incorporate zones into my model through two channels. First, reducing the cost of formalization benefits firms entering these zones by streamlining access to tax authority procedures, such as company registration, obtaining licenses, and complying with tax regulations. Second, cheaper inputs are achieved by exempting consumers of zone-produced products from paying VAT, which I assume decreases the marginal cost. Consequently, it explains that changes in formalization and marginal costs impact firms' decisions to operate formally or informally, affecting their entry and exit. Similar to Melitz (2003) and Dix-Carneiro et al. (2024), these changes lead to higher-paying formal firms becoming more profitable, allowing them to raise wages and expand their workforce. However, this raises labor costs, causing low-productivity formal firms to exit due to unsustainable costs and increasing the productivity threshold for new formal firm entry, leading to more informality. These dynamics spread to nearby regions through lower price indices and a greater variety of products, boosting revenues.

Related literature. My paper contributes primarily to three strands of the economic literature.

First, my paper relates mainly to the sizable literature on the effects of place-based policies (PBPs). While existing studies have predominantly focused on developed economies, analyzing outcomes such as investment, productivity, employment, and firm creation (e.g., Neumark and Kolko 2010; Gobillon, Magnac, and Selod 2012; Freedman, Khanna, and Neumark 2023, Kline and Moretti 2013; Mayer, Mayneris, and Py 2015), little attention has been paid to the effect on less-developed countries. For example, some of the literature estimates the impact of PBPs on local economic growth through agglomeration economies and finds a positive effect of the Chinese SEZs program on capital investment, employment, output, productivity, and wages, and the entry of firms in designated areas (Alder, Shao, and Zilibotti 2016), with limited spillover effects to surrounding areas (Wang 2013; Lu, Wang, and Zhu 2019). However, these studies have largely focused on firms in the formal sector, while the effects of place-based policies on informal businesses remain largely unexplored.

The little evidence of informal activity is mixed. For instance, Gallé et al. (2022) identify the impact of SEZs on local employment in manufacturing and services, showing that smaller, informal entities respond strongly to SEZs establishment and contribute to the aggregate creation of non-agricultural jobs. They link SEZ establishment to sectoral shifts from agricultural to manufacturing through the increase in the informal sector. However, in an earlier work by Abeberese and Chaurey (2019), they find that place-based policies only affecting industrial firms lead to a decline in the number of firms in the targeted areas, resulting from a decrease in the number of informal firms.

I contribute to this literature. First, I estimate the effect of place-based policies on the informal sector in Colombia, accounting for spatial spillovers. To rationalize the empirical findings, I develop a spatial general equilibrium framework that includes both the formal and informal sectors.

The second strand is the development literature studying the main causes of informality. Part of the literature identifies potential determinants such as entry costs, labor and tax regulations, corruption, and institutional quality (see Ulyssea (2020) for an extensive review). Interventions targeting the reduction of formalization costs have shown significant impacts on formalization rates, particularly in lowering entry costs (Ulyssea 2018; De Soto 2002; Djankov et al. 2010). However, the empirical evidence supporting the effectiveness of such reforms remains limited (La Porta and Shleifer 2014). Similarly, the impact of reducing the tax burden on entrepreneurs' decisions to formalize or start new formal businesses lacks empirical support (Kaplan, Piedra, and Seira 2011). Yet, studies such as Rocha et al. (2018) demonstrate a transitory increase in formal firms resulting from large-scale formalization programs. Additionally, some literature emphasizes the role of the tax structure, particularly value-added tax (VAT), in transmitting informality, proposing mechanisms for informal transmission based on production chain informality (De Paula and Scheinkman 2010; Ulyssea 2020).

In this paper, I contribute to this literature by exploring the impact of the reduction of entry costs on the prevalence and spatial distribution of informal labor practices (Ulyssea, 2018). This goes in line with literature on the role of factor misallocation in lowering aggregate TFP (Banerjee & Duflo, 2005; Busso et al., 2012; Hsieh & Klenow, 2009). It particularly relates to Zarate (2022) who test whether infrastructure projects facilitating transit within a city improve allocative efficiency by reallocating workers from informal establishments to formal establishments in a spatial setting.

Finally, my study relates to a large literature in international economics that has estimated the effects of trade reforms on allocative efficiency in the presence of domestic distortions, especially on informality which could induce reallocation of firms and workers between sectors. For example, McCaig and Pavcnik (2018) study the impact of the free trade agreement between the US and Vietnam on informality and aggregate productivity; they find a substantial reallocation of workers from informal to formal sector firms. For Brazil, Dix-Carneiro et. al (2024) develop and estimate a trade model with firm dynamics and heterogeneity, formal and informal sectors, labor market frictions, and a rich institutional setting. Their results show that reductions in trade costs lead to a sizeable decrease in informality within manufacturing. However, the total effect on informality is small. While this literature focuses on trade reforms that affect labor demand, my paper examines the impact of place-based policies on aggregate productivity (informality).

The rest of the paper is organized as follows. Section 2 discusses the institutional context of the Free Economic Zones in Colombia. Section 3 presents and discusses the empirical analysis. Section 4 reports the results. Section 5 presents the robustness checks. Section 6 develops the theoretical framework and the mechanisms driving the empirical predictions. Section 6 concludes.

2 Institutional Context

In this section, I provide details on the institutional context of Free Economic Zones (FEZs) in Colombia, including their primary objectives, associated benefits, key characteristics, and overall economic significance for the country.

According to the Ministry of Industry and Commerce of Colombia, Free Economic Zones are *“geographical areas delimited within the national territory, where industrial activities of goods and services, and commercial activities have different regulations in tax, customs, and international trade matters”* (MINTIC, 2022). I consider this regime a place-based industrial policy, as defined.

The regime of Free Economic Zones in Colombia has a long history, with three remarkable stages. The first stage refers to the national public institutionalism era in the 1950s. In 1958, in the Department of Atlántico, the country inaugurated its first industrial and commercial zone, the first in Latin America (Ramírez-Vallejo, 2005). At that time, the government perceived it as a public mechanism for import substitution in a closed economy. Ten zones were declared and constructed under this goal.

The second era came with globalization, allowing the private sector to operate some already-built zones. At the same time, the government decided to wind up the public establishments due to a new principle set by the World Trade Organization (WTO) that ensures that Colombia’s free trade zones are on par with those existing in other parts of the world. The zones were undergoing a time of change in their structure and benefits, motivated by the policies and regulations of the WTO, where member countries committed themselves to dismantling prohibited subsidies tied to exports.

Finally, in 2005 through Act 1004, the current free trade regime was created, enabling the declaration of zones by private entities, changing the conditions and constitution of the already created zones, and establishing the purposes of the Free Economic Zone regime:

1. To be an instrument for promoting employment and attracting capital investments.
2. To be a development pole that promotes regional competitiveness, within and between.
3. To be a tool for developing highly productive and competitive industrial processes by facilitating the generation of economies of scale.
4. Simplify international trade procedures of goods and services.

To achieve these goals, the government offers different taxation and custom benefits to the firms aiming to locate within the zones (see Table 1). However, in exchange for the advantages, the hosted firms must respect the exclusivity principle, so they can only operate and produce in the declared area of the zone and must accomplish this with a certain amount of investment and employment as imposed by the legislation.

Several legislative changes have been introduced to enhance and modernize the economic efficiency of free zones. In 2007, the government established three different categories of free economic

Table 1: Tax and customs benefits in FEZ.

<i>Type of Benefit</i>	<i>Benefits</i>
Taxation	<ul style="list-style-type: none"> - Flat income tax rate of 20%. - VAT exemption for raw materials, supplies and final goods sold from the national customs territory to Free Zone or between them.
Customs	<ul style="list-style-type: none"> - Imported goods exempt from VAT and tariffs - Merchandise of foreign origin introduced into the free zone may remain in them indefinitely. - For licensed operations, there is no customs declaration.

Sources: Ministerio de Industria y Comercio, 2022

zones. The first category is "Permanent," which includes various industrial and commercial entities such as industrial parks and Permanent Offshore Free Zones. The second category is "Special," designed to accommodate a single user or firm. The third category is "Transitory," which is intended for hosting fairs, exhibitions, national and international conferences, and seminars, all of which fall under the special regime as per the enacted legislation. Each category aligns with the overarching objectives mandated by the law, contributing to the convergence of efforts toward common economic goals, albeit in different ways.

Since 2005, the number of FEZs in Colombia has increased dramatically. Panel (a) of Figure 1 illustrates this growth, highlighting the exponential increase in FEZs. The surge in FEZ activity after 2005 reflects the government's strategic efforts to attract investment and stimulate domestic production, thereby contributing to Colombia's overall economic growth. This phenomenon underscores the success of policy initiatives and the plausible importance of FEZs as dynamic catalysts for economic expansion in the region.

By 2023, there were 124 zones, 42 were "Permanent" and 82 were of the "Special" type. This makes it the South American country with the highest number of zones. These are distributed across various municipalities (Figure 1 panel (b)), but most are concentrated in the central and northern regions of the country. According to the Cámara de Usuarios de Zonas Francas (2019), the hosting municipalities contribute more than half of the national added value. Moreover, the government of Colombia has argued a positive correlation between the increase of firms and the increase of value-added in the regions with these zones, providing the importance of the flows of investment, employment created, and industrial process on the regional development.

The FEZs are characterized by a notable presence in industry, services, and agroindustry, comprising 60, 47, and 17 zones, respectively. This distribution reflects the multifaceted nature of these zones, catering to a range of economic activities. Regarding investment, a significant portion is derived domestically, with 77% from national sources. Foreign investment contributes 17%, proving the policy's appeal to international investors. Additionally, 5% of the investment is mixed, reflecting collaborative endeavors between domestic and foreign entities (Cámara de Usuarios de Zonas Francas, 2019).

Concerning employment, the zones have contributed significantly, generating approximately

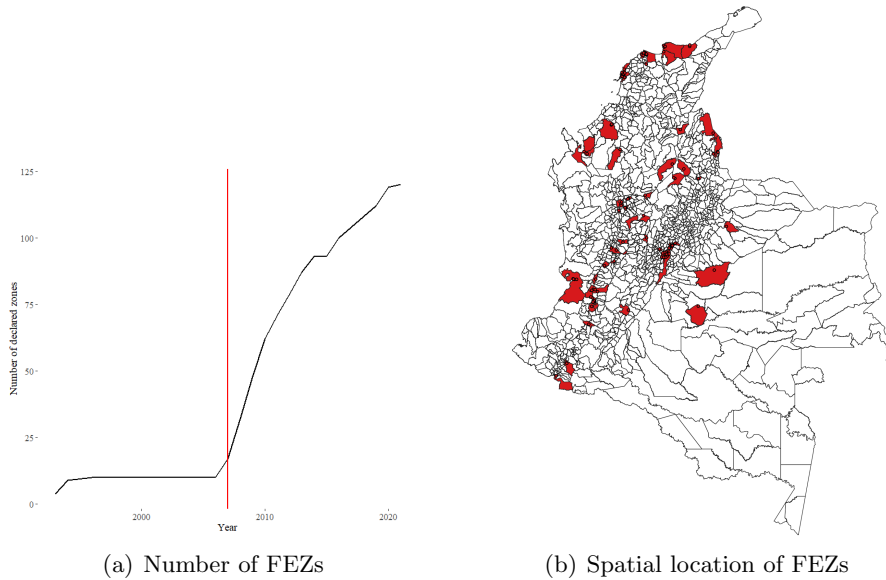


Figure 1: FEZs in Colombia

71,452 formal jobs from their inception until 2021. However, this number does not include indirect employment resulting from the productive linkages, particularly those created in the informal sector, given the coexistence of formal and informal activities within and around these zones. Moreover, 87% of the firms in these zones are small and medium-sized enterprises, highlighting the role of free economic zones in supporting smaller businesses, presumably informal before the policy.

The regime and its legislation have established the basic principles to promote and drive economic development. Nevertheless, there is an ongoing discussion on the impact of the zones on the region and national economy and its legislative accomplishment. This discussion has considered three main aspects: taxation inequality, the high fiscal cost, compatibility of the zone, and the competitive regime (Camara de Usuarios de Zonas Francas, 2019)). Therefore, the debate has forgotten one of the crucial issues: the effectiveness of the free economic zones in accomplishing the goals, especially the generation of employment and its impact on the labor market outcomes, not only considering the direct channels but also the production networks links and the agglomeration effects, leading to the spillover effects.

3 Empirical Analysis

In this section, I present the data, the variation from the FEZs construction, the main variables used in the empirical analysis, the descriptive statistics, and the empirical strategy.

3.1 Data and descriptive statistics

The basis of the empirical work of this paper is the geographical location of the Free Economic Zone, the administrative data from municipalities in Colombia, and its labor market information.

The analysis covers the period from 2000 to 2018, from the period before the change in the law to the period before the COVID-19 pandemic. My primary unit of observation for the baseline analysis is the municipality as it is the most disaggregated geographic unit in the data.³⁴

The data used in this paper come from multiple sources. The data on the characteristics of municipalities has been provided by the Center for Studies on Economic Development (CEDE by its acronym in Spanish), at the Universidad de los Andes. This dataset offers a comprehensive overview of a variety of variables at the municipality level from the 1990s to the present day. CEDE primarily collects data from government agencies. For the information on the FEZs, I use data on the declaration and operation of the zones by the Ministry of Industry and Commerce of Colombia. I georeference the exact location of the zones, identifying the municipalities hosting at least one of them. I restrict the sample of FEZs to operated areas, excluding offshore or transitory zones, as they do not account for spatial or lasting employment effects.

The data on labor market outcomes come from the Households National Surveys administered by the National Statistics Office of Colombia (DANE, by its acronym in Spanish). They cover approximately 240,000 households annually and are the national survey with the most detailed sample coverage. These cross-section surveys gather information about the employment condition of people (whether they work, whether they are part of the informal sector, what they do, how much they earn, whether they have social security for health care, or whether they are looking for a job), as well as about the general characteristics of the population, such as sex, age, marital status, educational level, sources of income and expenses.

To measure economic development, I use as a proxy nighttime light intensity from two sources (the Defense Meteorological Satellite Program (DMSP), and the Visible Infrared Imaging Radiometer Suite (VIIRS)) combined, cleaned, and harmonized to create a single panel dataset by Li et al. (2020). Additionally, I consider total tax revenues as a measure of state capacity that can reflect the taxation benefits from the FEZs. The data comes from the National Planning Department (DNP, by its acronym in Spanish). It includes property tax, industry and commerce tax, and gasoline tax, among others.

3.1.1 Definition of informality and key stylized facts

Informality can be an elusive concept, given the wide variety of definitions, measurements, and rationales. Following Busso et al. (2012) and Levy(2010), I use three measures: (i) the number of workers in a firm; (ii) contributions to social security, and (iii) employment contract (see Appendix A for a detailed description). The first two definitions are the most related to the legalistic definition, while the latter definition is more restrictive and refers to workers in the worst labor conditions. These definitions cover the two margins of informality: (a) Extensive, based on whether the firms register and pay entry fees to achieve the formal status related to the employment size, and (b)

³For clarification purposes, municipalities are second-level administration divisions, and each FEZ belongs to only one municipality.

⁴As part of the robustness checks, I consider the metropolitan areas when existing as they are a closer definition of Local Labor Markets.

Intensive: based on whether formal firms hire workers without a formal contract.

I construct the variable I_{it} that defines the informality rate in a municipality i at time t , defined by the ratio of the total number of informal workers to the total number of workers in municipality i for the year t (E_{it}).

There are some well-established facts in the literature about the informal sector in different countries (Brazil in Ulyssea 2018; La Porta and Shleifer 2014). These facts are also present in the Colombian data:

Fact (1). *The probability that a firm is informal declines sharply with its employment size.*

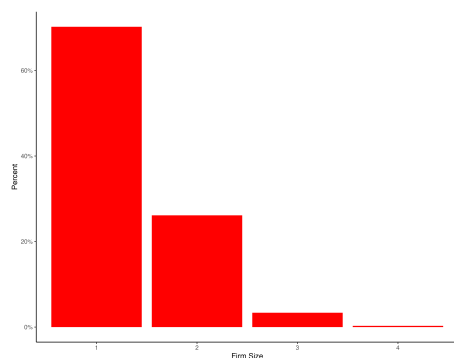


Figure 2: Informality and firm size

Note: category 1 refers to 1-2 workers, 2 refers to 3-5, 4 to 5-10, and 4 to more than 10.

Figure 2 shows the negative relationship between informality and firm size. Ulyssea 2018 argue that one possible rationale behind this fact is that larger firms are too visible to the government and thus more likely to be audited. This is important since it suggests that there is an employment threshold so that firms formalize.

Fact (2). *Informal firms are, on average, less productive than formal firms. Therefore, informal sector jobs are widely considered as low quality.*

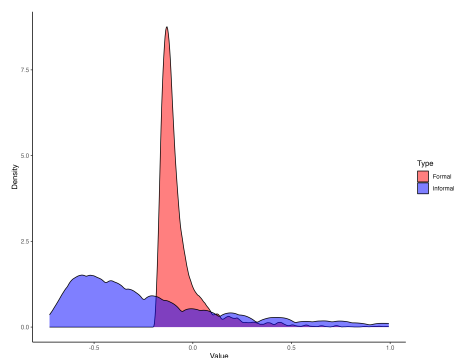


Figure 3: Productivity distribution by type

Using surveys for different countries, La Porta and Shleifer 2014 show that observing differences in employees, revenues, and profits between formal and informal firms reflect substantial differences

in average productivity. Using manufacturing census data (Encuesta Anual de Manufactura in Spanish) and microbusiness data (Encuesta de Microestablecimientos), I compute value-added per worker as a proxy for productivity for formal and informal firms, following Ulysea (2018). Figure 3 shows that the productivity distribution in the formal sector is substantially shifted to the right, suggesting that formal firms are on average more productive than informal.

Fact (3). *The average informal worker is paid lower wages than the average formal worker, even without benefits.*

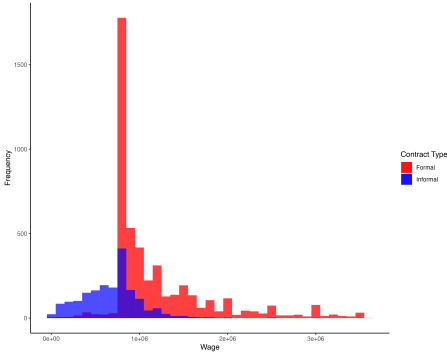


Figure 4: Wage distribution by type

Figure 4 shows the wage differences between formal and informal workers. It suggests that formal firms are subject to payroll and value-added taxes, firing costs, and minimum wage regulation.

3.1.2 Descriptive statistics

This subsection reports summary statistics for the main outcome variables.

In Colombia, nearly half of the total labor force is employed in the informal sector (48% by 2023). Since the early 2000s, the informality rate has steadily increased (see Figure 5). Although there was a 3% decrease in 2005, it subsequently rose more sharply. Furthermore, Figures 6 and 7 illustrate the trends over time for the logarithm of total employment and the average nominal wages, respectively. There was a decline in employment in the early 2000s, followed by an upturn after 2005. Over the past few years, employment has remained constant. In contrast, while nominal and real wages have been increasing over time, the increase in real wages has been of a lesser magnitude. This suggests that although wages are rising, the purchasing power of these wages is not growing as rapidly, likely due to inflation or rising living costs.

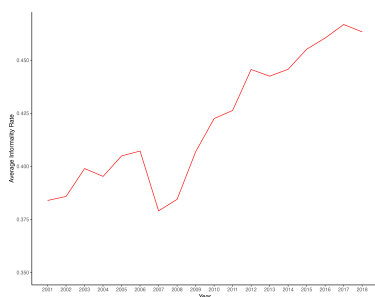


Figure 5: Informality rate



Figure 6: Employment

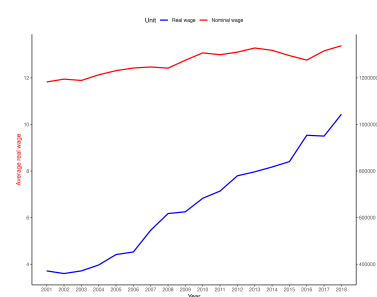


Figure 7: Wages

Table 2 shows descriptive statistics for municipalities with and without FEZs. In terms of observable characteristics, municipalities with FEZs have a higher informality rate, better labor market outcomes (employment and wages), better economic indicators (population density, rurality, and night-time light), and higher state capacity (tax revenues). On average, these municipalities are closer to the capital cities of their respective departments, and the capital of Colombia, Bogotá.⁵ In addition, municipalities with FEZs are smaller and less prone to natural disasters than non-FEZ municipalities.

3.2 Empirical strategy

To identify the causal effect of FEZs across space on municipalities, the primary analysis exploits a spatial difference-in-difference (DID) framework that compares changes in the economic outcomes in municipalities where FEZs were established with municipalities without zones. Similar to Gallé et al. (2022), I group municipalities in "i" km-distance rings around their closest FEZs up to 50km.⁶ Table 3 describes the different treatment groups.

⁵This can also be associated with a higher state capacity since political power and control are concentrated in these capitals.

⁶The selection of the reference category is arbitrary and serves as a basis for interpreting the coefficient estimates that reflect the influence of the FEZs on the economic development of municipalities within a radius of d relative to the reference municipalities.

Table 2: Descriptive Statistics

<i>Variable</i>	<i>Mean T=1</i>	<i>Mean T=0</i>
Informality rate	0.46	0.42
Total Employment	14.23	13.19
Wages	13.52	13.29
Population density	0.86	-0.97
Gov. tax revenue	11.02	9.10
Gov tax property revenue	8.36	5.27
Night-time light int.	19.98	4.54
Distance Capital	61.75	82.31
Distance Bogota	319.34	321.53
Rurality index	0.28	0.59
Size (km2)	898.74	1020.24
Public health coverage	0.87	0.92
Area exposed to risk	0.33	0.50
Average precipitation	78.22	78.22

Table 3: Different treatment groups

<i>Nomenclature</i>	<i>Description</i>
z	Municipality hosting a FEZ
z_b	The bordering municipalities
z_{10}	Municipalities at less than 10 km
z_{25}	Municipalities at less than 25 km
$z_{37.5}$	Municipalities at less than 35 km

I estimate the following event-study regression which allows me to measure the average treatment effects with elapsed treatment time and to investigate how the effect of participating in the treatment varies with the length of exposure to the treatment.⁷

$$Y_{it} = \sum_{j=-5}^{10} \beta_j D_{it}^j + \mu_i + \lambda_t + \epsilon_{it} \quad (1)$$

where Y_{it} are the outcomes of interest of municipality i at time t . The D_{it} terms are dummies for leads and lags of the treatment⁸ – e.g., D_{it}^{-4} is a dummy equal to 1 if the municipality i is treated 4 years later. The terms μ_i and λ_t are municipality and year-fixed effects, and ϵ_{it} is the error term. I thus exploit differences across municipalities (treated vs. non-treated) and differences across years t (before vs. after the construction).

Given the nature of the policy intervention, Free Economic Zones (FEZs) were phased in at different times, with varying effects across municipalities and years. Then, as highlighted by Sun and Abraham 2021, the fully dynamic version of the TWFE model estimated using OLS provides consistent estimates, but only under the strong assumption of treatment effect homogeneity. To allow for heterogeneity in treatment effects across time and treated units, I also present the event-

⁷I compare the results to the dynamic event study estimated by TWFE.

⁸I also consider a continuous treatment analysis. The reasoning behind this is that the scope of the treatment is unknown, but it decreases on distance. For instance, if a free economic zone can supply from a remote municipality, then the effect might be omitted when considering only the relatively close municipalities. In this continuous analysis, every municipality is exposed to FEZs with a different intensity at different points in time.

study figures generated by a set of recently proposed estimators that are robust to treatment effect heterogeneity (De Chaisemartin and D’Haultfoeuille 2020; Callaway and Sant’Anna 2021, and Sun and Abraham 2021) are also presented.

Complementary, to account for possible non-linearities in the treatment across space, I also regress the outcome variables (Y_{it}) on the dummies for whether a municipality belongs to a radius of 10, 25, 37.5 from the municipalities treated, the time, and individual fixed effects.

$$Y_{it} = \sum_r^{37.5km} \beta_r z_{rit} + \gamma_i + \delta_t + \epsilon_{it} \quad (2)$$

Threat to identification. The main empirical identification concern is that FEZs are not randomly allocated in space, but that their location systematically correlates with the economic trajectories before FEZ-establishment. I address this concern in two ways: First, I test for differential outcome pre-trends between FEZ-treated municipalities and reference municipalities in the years directly leading up to treatment.⁹

Second, as part of the robustness check, I use region-specific disaster risk as an instrumental variable to determine the placement of Free Economic Zones (FEZs). Multinational firms tend to invest in areas with lower disaster risk to safeguard their supply chains. Since FEZs aim to attract investment and promote economic development, they are typically constructed in less disaster-prone areas. Any disruptions in these zones could jeopardize the efficiency and profitability of businesses operating within them, affecting their investors.

4 Baseline results

In this section, I present estimation results from specification (1) and (2).

4.1 Main outcomes

Figure 10 provides the estimates from specification (1). The first finding is that pre-trends for informality are not statistically significant for all the estimation methods. More importantly, I find a positive and statistically significant effect of the roll-out of the zones on the informality rate. Figure 10 shows the staggered differences in differences are positive after the treatment was put in place, it also demonstrates that the longer the exposure, the more important the effect. The dots indicate the estimated parameters. The FEZs seem to have a positive and permanent effect on informality that lasts for years.

Figure 9 demonstrates that parallel trends for wages and employment are maintained before the treatment event, validating the difference-in-differences approach. Post-treatment, there is no

⁹The previous research on place-based policies has used identification strategies to compare locations that are targeted by a particular policy with locations that were considered but ultimately not selected for treatment. In this case, most FEZ applications are approved and finally constructed. Another strategy used in previous literature is to compare treated municipalities with municipalities treated in the future. I take the latter into account when estimating the staggered DiD.

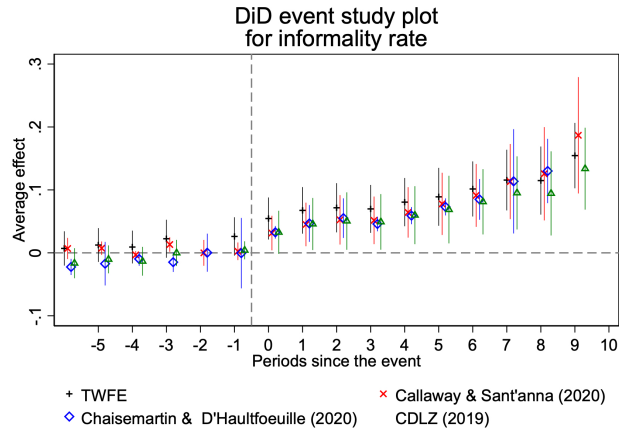
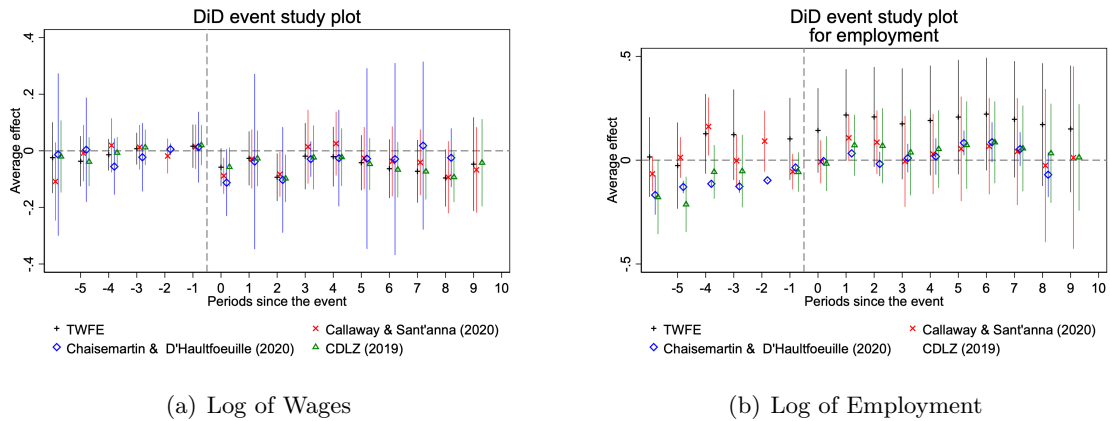


Figure 8: Informality rate

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities hosting a FEZ. The omitted category is the year before treatment.



(a) Log of Wages

(b) Log of Employment

Figure 9: Event-study results

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities hosting a FEZ. The omitted category is the year before treatment.

statistically significant effect on employment, suggesting overall employment levels remain stable in municipalities hosting an FEZ. However, the increase in informality indicates a shift of workers from the formal to the informal sector in the treated municipalities. For wages, there is a significant negative impact in the period immediately following the treatment, but this effect diminishes and becomes insignificant over time.

To recover the overall effect of the FEZs on the main outcomes, I use the aggregation method proposed by Callaway and Sant’Anna Callaway and Sant’Anna 2021 to aggregate group-time average treatment effects. The estimate is a weighted average of each $ATT(g, t)$ weighted by the group sizes. This combination rules out troubling issues due to negative weights, providing an unbiased estimate. Table 4 shows the results.

On average and in the aggregate, informality increases by 6.58 percentage points in municipalities hosting the free economic zones. Similar to the results highlighted with the event-study design, the effect on total employment is statistically insignificant. In contrast, for wages, the effect is negative and statistically significant at 10%. This indicates that hosting municipalities experience a decrease of 7% in wages.¹⁰

Table 4: Aggregated ATT for z

Outcome	Informality rate	Employment	Wages
Estimate	0.0658*** (0.02)	0.00454 (0.0761)	-0.0719* (0.0378)

Notes: This table explores the effect of the Free Economic Zones on informality rate, wages, and employment. Specifically, it presents aggregate estimates β from the aggregation procedure by Callaway and Sant’Anna 2021. I use as a control group the not-yet-treated units. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in parenthesis and are clustered at the department level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

To capture the spatial spillover effects of the policy, first, I run the same specification with a different treatment group: the bordering municipalities. Second, I run the specification 2 to capture the non-linearities in the treatment.

For the bordering municipalities, I observe positive but relatively lower effects on informality, compared to the hosting zones. This effect becomes noticeable in the mid-run, starting approximately three years after the treatment. This effect can be attributed to the fact that young businesses, like those located in the FEZs, in Colombia exhibit an "up or out" dynamic, that is, they face a high probability of exit but conditional on survival, they have higher net growth rates than their more mature counterparts by their fourth year of age (Eslava et. al 2022). By the third year, as these firms grow and the local labor market adjusts, employment opportunities may expand to the nearby municipalities. Nevertheless, the employment opportunities do not translate

¹⁰This result appears counterintuitive when examining Figure 9. However, the aggregate ATT is a weighted average that depends on the size of each treatment-year group. Since the weight is larger for the groups that have experienced a negative effect on wages, the aggregate effect reflects these negative impacts more prominently.

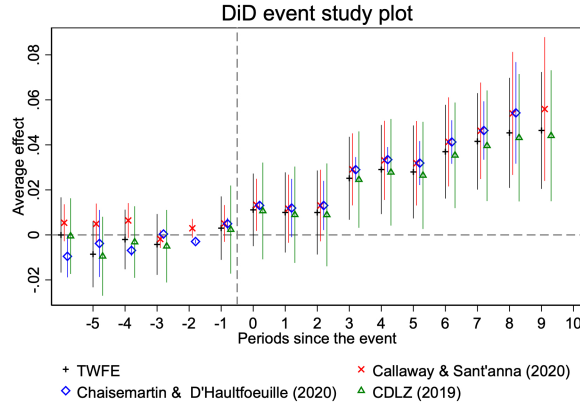
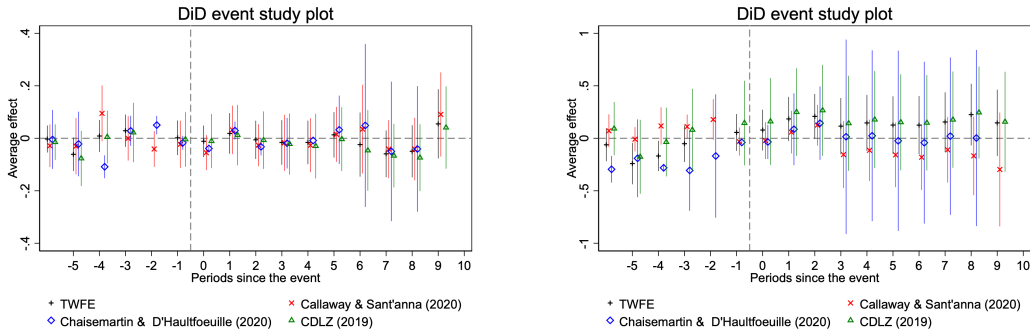


Figure 10: Informality rate in z_b

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities bordering a municipality with a FEZ. The omitted category is the year before treatment.



(a) Log of Wages

(b) Log of Employment

Figure 11: Event-study results for z_b

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities bordering a municipality with a FEZ. The omitted category is the year before treatment.

into increases in overall employment or changes in wages (see Figure (11)).

Table 5: Aggregated ATT for z_b

Outcome	Informality rate	Employment	Wages
Estimate	0.0332*** (0.00847)	-0.157 (0.177)	-0.0337 (0.0473)

Notes: This table explores the effect of the Free Economic Zones on informality rate, wages, and employment. Specifically, it presents aggregate estimates β from the aggregation procedure by Callaway and Sant’Anna 2021. I use as a control group the not-yet-treated units. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in parenthesis and are clustered at the department level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Table 5 reports the aggregate estimates for the main outcomes when considering z_b as the treatment. On average, informality increases by 3 percentage points in nearby areas. While for employment and wages, the effect is statistically insignificant.

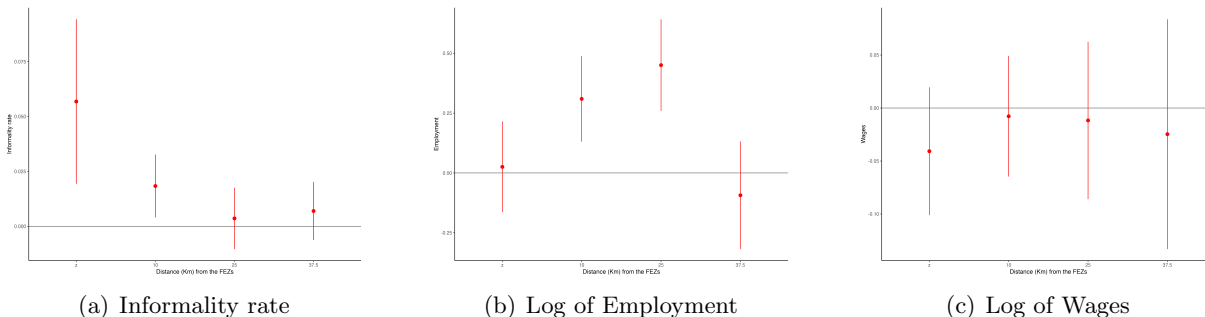


Figure 12: Non-linear effects of distance

Note: The dots indicate the estimated parameters $\hat{\beta}_r$. Each subscript d refers to a distance on the horizontal axis, e.g. the coefficient at 0km refers to z . The lines indicate 95% confidence intervals.

Figure 12 presents the results for the specification (2). The graph shows that the informality rate increases with distances until 25 kilometers, then the effect vanishes. It suggests that informality increases by 2 pp in municipalities less than 10km from a FEZ. For employment and wages, I find a positive impact on total employment that decreases with distance. Specifically, municipalities located 10 kilometers away from FEZs exhibit a 20% increase in employment, while those 25 kilometers away experience an increase of 40%. Furthermore, the findings indicate that municipalities located 25 kilometers away witness a surge in formal employment, which primarily propels the overall rise in total employment. Conversely, in municipalities positioned 10 kilometers away from FEZs, the simultaneous increase in employment and informality may suggest the emergence of informal enterprises in nearby markets, rather than a direct reallocation between formal and informal sectors. For wages, the effect remains statistically insignificant.

4.2 Other economic indicators

The results from the previous subsection suggest that the FEZs increased informality in the nearby municipalities to a zone and have persisted over time. In this subsection, I evaluate whether the creation of the FEZs translated into advances in different economic indicators. To do so, I use the same difference-in-difference strategy as in Section 4.1.

First, I use official estimates of population density by municipality from the National Statistical Office (DANE). Second, following the recent literature on new measures of economic activity (see for example, Donaldson and Storeygard 2016; Henderson, Storeygard, and Weil 2012; Henderson et al. 2017), I use nighttime light intensity as a proxy for economic development. For comparability, I standardize this measure for each year. Additionally, I consider total tax revenues, and total property tax revenue as a measure of state capacity that can reflect the taxation benefits from the FEZs, since more firms will be paying more taxes if they are located in these or nearby locations.

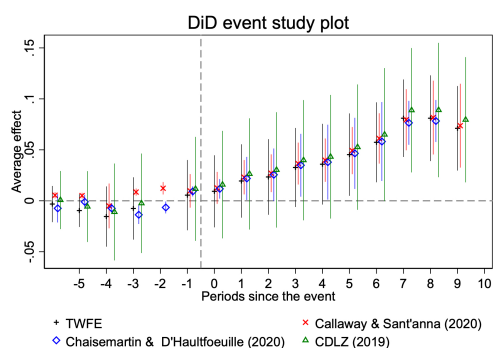


Figure 13: Population density

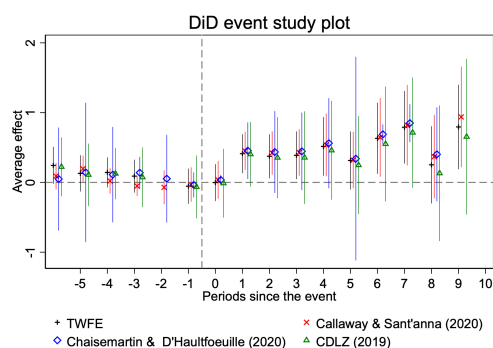


Figure 14: Night-time light

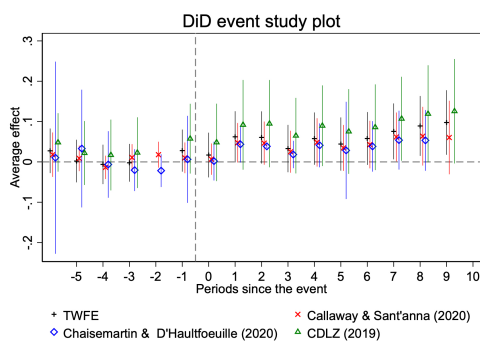


Figure 15: Total tax revenue

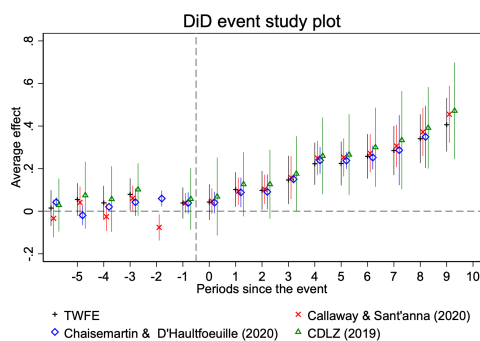


Figure 16: Total property tax revenue

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities bordering a municipality with an FEZ. The omitted category is the year before treatment.

Figure 13 - 16 show the estimates for the municipalities nearby FEZs.¹¹ Parallel trends holds for most of the outcomes except for population density. For the night-time light intensity, there is a positive effect in the first period after treatment, after it remains constant. Similarly, for total tax revenue, there is a positive effect in the first two periods, but this effect vanishes subsequently. In contrast, total property tax revenue shows an increasing effect over time, particularly after the third year following treatment. This increase could be attributed to a rise in the mass of economic agents in these municipalities, including both firms and individuals, leading to greater occupation of floor space.

Table 6: Aggregated ATT for z_b

Outcome	Population density	Night-light intensity	Total tax revenues	Total property tax
Estimate	0.0799***	0.988***	0.0946**	0.255***
Std. Error	(0.022)	(0.309)	(0.0375)	(0.049)

Notes: This table explores the effect of the Free Economic Zones on different measures of economic activity. Specifically, it presents aggregate estimates β from the aggregation procedure by Callaway and Sant’Anna 2021. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in brackets and are clustered at the department level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Additionally, in Table 6, I report the estimates of the aggregation method by Callaway and Sant’Anna 2021, to recover the overall effects of the FEZs. The results using the different proxies of economic development are consistent: they suggest that the FEZs regime improved economic indicators in nearby areas to the zones. For instance, based on the data for nighttime illumination intensity, there is a 0.98 standard deviation (SD) increase in light intensity. Similarly, the state capacity indicators also show positive results. For example, the findings reveal that total government revenues increased by 9% in the municipalities near FEZs, and total property tax revenues rose by 25%. This implies the existence of positive spatial spillover effects in the other economic activity measures. However, they do not materialize into improvements in the labor market.

4.3 Heterogenous effects

In this subsection, I shed light on heterogeneous treatment effects by zone characteristics. Zones in Colombia differ in two key dimensions: First, there is heterogeneity in their main industry domination, including manufacturing, agroindustrial, and services. Second, zones in Colombia are developed and run by either a single or multiple firms. I assess how these characteristics shape the impact of FEZs on local economic activity.

Single vs multiple user. As illustrated in Figure 17, over 60% of Colombia’s zones are operated by a single firm. One reason to suspect that the local employment effects of single and multi-user FEZs could diverge is the potential for industrial parks to have a more pronounced impact on local economies due to their typically larger size and higher employment capacity. In

¹¹The results for the hosting municipalities are reported in Appendix B.

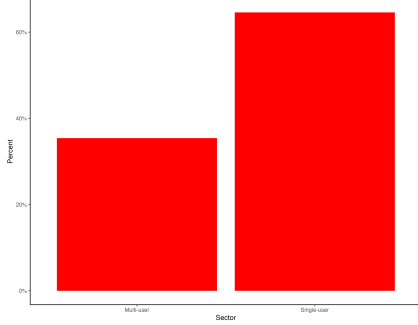


Figure 17: FEZs by type

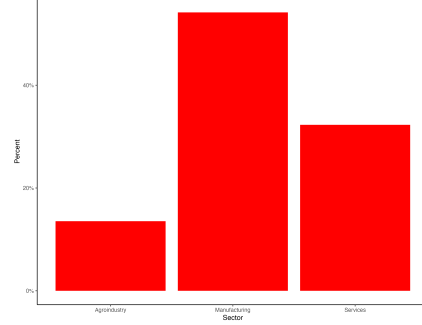


Figure 18: FEZs by sector

contrast, single-firm FEZs often prioritize profit maximization through tax exemptions, which may result in a different emphasis on employment generation compared to multi-user zones.

To test for the effect heterogeneity along these lines, I estimate the following model:

$$Y_{it} = \beta_h FEZ_{it} \times \text{type} + \gamma_i + \delta_t + \epsilon_{it} \quad (3)$$

where "type" is a dummy variable indicating whether the FEZ in municipality i is developed by a single firm or by different. I include municipality and time-fixed effects.

Table 7: Heterogeneous effects by type of zone

Dependent Variables:	Informality rate		Employment		Wages	
	Multi-user	Solo-user	Multi-user	Solo-user	Multi-user	Solo-user
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Estimate	0.0427 *	0.0769 ***	0.0236	-0.0619	-0.0645	-0.0724 *
Std. error	(0.0242)	(0.0268)	(0.0876)	(0.0876)	(0.044)	(0.0399)

Notes: This table explores the effect of the different types of Free Economic Zones on the main outcomes: Informality rate, employment, and wages. Specifically, it presents aggregate estimates β from the aggregation procedure by Callaway and Sant'Anna 2021. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in brackets and are clustered at the department level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

In Table 7, I present the impacts of FEZs on informality rate, employment, and wages for municipalities hosting single-firm and multi-firm zones separately. The findings indicate that the effect on informality varies depending on the zone type. In particular, in municipalities with a solo-user zone, informality rises significantly, by 7 percentage points. For employment, the results do not exhibit systematic differences between multi-user and single-user FEZs, in both cases, the effect is statistically insignificant. Conversely, regarding wages, municipalities hosting single-firm zones experience an average decrease of 7%.

Sector-specific effects. The influence of Free Economic Zones (FEZs) on local economic activity may also depend on the specific industries they accommodate. In this case, I characterize

three main macro-sectors: agroindustry, manufacturing, and services.¹² These sectors account for 17%, 48%, and 35% of the FEZs’ activities, respectively (Figure 18).

One potential reason to investigate heterogeneity by sector is that each sector may have distinct characteristics, which could lead to varying impacts on local economies. For instance, agroindustry zones, characterized by their seasonal labor demands and reliance on agricultural inputs, may exert unique effects on local labor markets compared to manufacturing or service-oriented zones. Additionally, manufacturing zones may play a pivotal role in enhancing local value-added production, while service-oriented zones may drive employment growth and foster skill development.

Table 8: Heterogeneous effects by type of sector

Dependent Variables:	Informality rate			Employment			Wages		
Model:	Industrial (1)	Agroindustrial (2)	Services (3)	Industrial (4)	Agroindustrial (5)	Services (6)	Industrial (7)	Agroindustrial (8)	Services (9)
<u>Variables</u>									
Estimate	0.0647**	0.1192***	0.0263***	0.0484	-0.5853**	0.2077***	-0.0438	0.0225	-0.0846**
Std. error	(0.0261)	(0.0549)	(0.00827)	(0.0809)	(0.1299)	(0.0725)	(0.0406)	(0.0544)	(0.0365)

Notes: This table explores the effect of the different sectors of Free Economic Zones on the main outcomes: Informality rate, employment, and wages. Specifically, it presents aggregate estimates β from the aggregation procedure by Callaway and Sant’Anna 2021. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in brackets and are clustered at the department level. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Table 8 presents the results from the heterogeneity analysis by sector, revealing notable variations in the impacts of FEZs by industrial, agroindustrial, and service sectors. Notably, municipalities hosting FEZs exhibit statistically significant effects on informality rates across all sectors. However, the effect is particularly pronounced in municipalities with agroindustrial zones, where informality increases by 11 percentage points. This substantial increase might be explained by the fact that agroindustry zones may experience a prevalence of informal labor arrangements, potentially attributed to seasonal fluctuations in labor demand.

Similarly for employment, while municipalities hosting industrial FEZs show non-significant effects, the results uncover significant variations in the impacts of the agroindustrial and services FEZs municipalities. For instance, municipalities hosting agroindustrial zones experience a decrease of 58% in their employment. This significant reduction in employment suggests that agro-industrial zones may have negative effects on local employment opportunities. Possible explanations for this finding include the mechanization of agricultural processes, leading to a decreased demand for manual labor. Together with the results for informality, these findings imply a reallocation of labor from the formal to the informal sector in these municipalities. In contrast, the employment effects on municipalities hosting services FEZs are positive. They translate into an increase of 20%. This suggests that services-focused FEZs may contribute to job creation and employment growth in the hosting municipalities. These results align with the “jobless industrialization” phenomenon highlighted by Alfaro et al. 2023. There is a divorce pattern between value-added and employment in late industrialized, which is accounted for by “jobless” large manufacturing firms, primarily

¹²The agroindustry includes all the activities that convert raw agricultural materials into value-added products, such as the food industry, etc.

formal, whose contribution to manufacturing value-added grows over their life cycle but not their contribution to employment.

Finally, while the impacts on wages are not statistically significant for the industrial and agroindustrial sectors, a significant negative effect is observed for the service sector. This suggests that, on average, wages decrease by 8% in municipalities hosting services FEZs. The decline in wages within service-oriented FEZs highlights potential challenges faced by workers in these areas, such as downward pressure on wages. This can occur due to an oversupply of (informal) labor relative to available job opportunities, allowing employers to offer lower wages to attract workers.

5 Robustness checks

In this section, I conduct a series of robustness checks to assess the reliability and robustness of my main findings regarding the impacts of Free Economic Zones (FEZs) on local economic outcomes. These checks aim to test the sensitivity of our results to different unit of analysis, such as municipality-level versus local labor markets, and to address potential endogeneity issues that may arise from reverse causality.

5.1 IV: Risk disaster

As discussed in Section 3.2, the main empirical identification concern is that FEZs are not randomly allocated in space, but that their location systematically correlates with the economic trajectories before FEZ-establishment. Therefore, I employ a Difference-in-Differences with Instrumental Variables (DiD-IV) approach for identification. This strategy utilizes an instrumental variable based on investment location decisions, specifically considering region-specific disaster risk. The rationale behind this is to mitigate potential endogeneity issues arising from the systematic correlation between FEZ locations and pre-existing economic conditions.

I construct a shift-share instrument, with the shares as the percentage of area at natural disaster risk and the shift as the average precipitation by municipality and year. I argue that the only way the index of risk disaster affects labor market conditions is through investment decisions, particularly of the free economic zones. The literature on global supply chains has shown that multinational firms consider the local costs and region-specific disaster risks when selecting locations for production, implying that investments tend to flow into less-disaster regions to avoid possible disruption risks (Friedt & Toner-Rodgers, 2022). Given the nature of the legislation, FEZs are investment decisions made by private investors. As FEZs aim to promote economic development and attract foreign direct investment, their success is contingent upon mitigating risks and ensuring the continuity of supply chains. Then, I argue that FEZs are constructed and less-prone disaster areas. Otherwise, any possible disruptions can hinder the efficiency and profitability of businesses operating within these zones, affecting their investors.

For this analysis, I consider the risk of hydro-meteorological disasters. According to the National Planning Department of Colombia (DNP, by its acronym in Spanish), 88% of occurred

catastrophes are of hydro-meteorological origin, comprising floods, landslides, and torrential flows. Unfortunately, the country is significantly prone to these types of natural hazards because it ranks first with the highest precipitation rate in the world (World Bank, 2020). I use the Municipality Index of Risk Disaster created by the which aggregates data on regions vulnerable to three types of hazards: slow-onset flood regions (valleys and flat areas with stream sources), mass movement areas (mountains), and torrential flows (natural stream channels on mountains or areas with high slope). This index helps identify the most threatened regions and computes the proportion of the municipality’s area at risk. Since this variable remains constant over time, I create a shift-share instrument, using the percentage of area at risk as the share component and the average precipitation per municipality per year as the shift component.

The main concern is the validity of the instrument. One can argue that this index affects labor market conditions and population density because people might live in safer places. However, because of the particular geography of Colombia, 61% of individuals at risk live in urban agglomerations, where the labor market characteristics might be better. Another argument, it’s that the people live there because the government might be taking away their risk by providing insurance. Nevertheless, it is not credible because the National Disaster Risk Management Plan is still under construction, so there are no clear rules on mitigating and attenuating the impact of a natural disaster. I argue that the index of disaster risk impacts labor market conditions primarily through investment decisions, particularly those concerning the establishment of free economic zones.

Table 9: IV results

<i>Dependent variable:</i>			
	Informality	Log Employment	z
	IV	IV	First Stage
z	0.065*** (0.005)	0.112*** (0.007)	
Shift-Share IV			-0.0002** (0.0001)
Observations	2,370	2,370	2,370
Municipality FE	X	X	
Year FE	X	X	
F Statistic	169.225***	241.578***	4.348**

Notes: This table explores the effect of the Free Economic Zones on the main outcomes accounting for the IV. Specifically, it presents estimates of coefficient β from the DiD-IV. Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in brackets and are clustered at the department level. *** $p < 0.01$.

Table 9 contains the results of the DiD-IV. I highlight the negative relationship between the index of risk disaster adjusted by rainfall and the treatment adoption, which implies that investors might tend to consider the risk when deciding where to invest (Friedt and Toner-Rodgers 2022).

Consistent with previous specifications, I also find a positive and statistically significant effect on the informality rate. Specifically, informality increases by 6 percentage points in municipalities hosting at least one FEZ. Moreover, the results for employment, for instance, show an increase of 11%, aligning with the estimates from previous analyses.

5.2 Local labor markets

One potential shortcoming of the analysis is the suitability of the comparison group.¹³ To address this, I transform the municipality variable into a more standard definition of local labor markets or commuting zones, using the methodology of Sanchez-Serra (2016). I build a smaller sample of functional urban areas (FUAs) in Colombia. This sample consists of the 53 biggest urban areas in the country defined from population grid data, municipal boundaries, and inter-municipal commuting flows.

To capture this, I estimate the following regression:

$$Y_{itl} = \beta_h FEZ_{itl} + \gamma_i + \delta_t + \varphi_l + \epsilon_{it} \quad (4)$$

where Y_{itl} corresponds to the outcome in municipality i at time t , belonging to the local labor market l . FEZ is a dummy indicating if the municipality has an active FEZ at time t . I control for the municipality, local labor market, and time-fixed effects. In this case, the control group is the municipalities in local labor markets that are not treated.

Table 10: Regression results: LLM

Dependent Variables:	Informality rate	Total Employment	Wages	Population density	Night-light intensity	Total gov. revenue	Property tax gov. revenue
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<u>Variables</u>							
z	0.0563** (0.0258)	0.7680* (0.3922)	0.0343 (0.0593)	0.8287*** (0.2994)	6.298 (4.020)	1.577*** (0.3721)	1.985*** (0.5189)
<u>Fixed-effects</u>							
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Local labor market	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<u>Fit statistics</u>							
Observations	1,092	1,092	1,092	2,322	2,322	2,297	2,293
R ²	0.43421	0.34651	0.71176	0.49107	0.53797	0.50483	0.52609

Notes: This table explores the effect of the Free Economic Zones on the main outcomes controlling for Local Labor Markets fixed effects. Specifically, it presents estimates of coefficient β . I estimate this equation by restricting the sample to all the municipalities being part of at least one of the 53 local labor markets (FUAs). Controls include specific-municipality trend fixed effects. The unit of analysis is at the municipality level for this table. Standard errors are reported in brackets and are clustered at the department level. *** $p < 0.01$.

The regression results in Table 10 shed light on the impact of Free Economic Zones (FEZs) within Local Labor Markets (LLMs) on various outcome variables. For informality, the effect is positive. It implies that informality increases by 5 percentage points. However, they significantly boost total employment by approximately 76.80% at a 10% significance level. Additionally, FEZs substantially increase population density by about 82.87%, suggesting they attract more residents. Furthermore, FEZs significantly enhance total government revenue and property tax revenue, highlighting their positive fiscal impact on the local labor markets.

¹³In the previous section, I compared treated with not-treated municipalities, comparing Bogotá, the Capital of Colombia, with other less economically important cities in Colombia.

6 A simple model

There are several channels through which the construction of free economic zones can impact informality, pushing the response to changes in the roll-out of the policy program in different directions. I consider the following two. The first mechanism linking this policy program and informality is the entry channel mechanism, which operates through the formalization of entrant firms to the zones because only formalized firms can benefit from the zone, which might decrease informality. Second, I consider the "demand-type" mechanism. The construction of an FEZ can be interpreted as a positive demand and income shock, encouraging the exit of the least productive formal firms. They are replaced by informal firms, which tends to increase informality.

In this section, I present a simple spatial structural equilibrium model with heterogeneous firms that choose to operate in the formal or the informal sector. The model highlights the key mechanism that can explain the empirical facts. It incorporates firm heterogeneity (Melitz, 2003; Ulyssea, 2018) driven by differences in the local productivity distribution into a Helpman (1998) framework with labor mobility (Bakker et. al, 2024). In the model, locations differ in their exogenous firm productivity distribution and amount of housing. Informal and formal market entry of firms and labor mobility across locations give rise to the equilibrium distribution of economic activity.

6.1 Setup

I consider an economy featuring N symmetric locations. Each location is endowed with an exogenous stock of local land T , and labor L is the sole production factor. Regions trade with each other at a symmetric iceberg trade cost ($d_{ni} > 1, d_{nn} = 1$), implying that d_{ni} must be shipped from region n for one unite to arrive in i . Workers are assumed to be perfectly mobile across locations.

For simplicity, I abstract from differences in amenities to focus on the role of differences in productivity distribution across locations. I also disregard labor market distortions, so I define informality as firms with a level of employment (and productivity) below a certain threshold.¹⁴ This goes in line with the Fact 1 (3.1.1).

Preferences. Workers are homogeneous; they decide where to locate and consume a bundle of goods and housing while earning the local wage w_i in location i . Worker preferences are given by:

$$U_i = c_i^\beta h_i^{1-\beta} \quad (5)$$

where h_i denotes (individual) housing consumption in location i , and c_i is a CES composite of the consumption of tradable varieties:

$$c_i = \left[\int c_i(x)^{\frac{\sigma-1}{\sigma}} dx \right]^{\frac{\sigma}{\sigma-1}} \quad (6)$$

¹⁴This definition highlights a well-documented fact that the share of informal firms declines as firms grow large. It reflects an opportunity cost of operating in the informal sector, such as accessing credit or issuing buyer tax receipts (Ulyssea, 2020).

which yields consumption of each variety by the representative consumer at each location n from location i

$$c_{ni} = p_{ni}^{-\sigma} P_i^{\sigma-1} w_i L_i \quad (7)$$

Since h is a non-tradeable and exogenously given local resource, we refer to it as “housing”, following Helpman (1998). In each location, housing is produced in perfect competition. The stock of housing in each region is constant. Therefore, given expenditure shares, the equilibrium price of h is given by:

$$p_i^h = \frac{(1 - \beta) w_i L_i}{\beta H_i} \quad (8)$$

Production. In each location, there is an unlimited supply of potential entrants. Each firm produces a differentiated tradable variety using local labor. Once they’ve paid the entry cost F_e in units of local labor, firms draw their productivity ψ from the location-specific productivity distribution $g_i(\psi)$. In each location, productivity is distributed Pareto with a common scale parameter set to value 1 and a location-specific shape parameter α_i .¹⁵ The production technology is given by:

$$l(q, \psi) = c_i \frac{q}{\psi} \quad (9)$$

where $l(q, \psi)$ denotes the local labor input required to produce a quantity of output q for a firm of productivity ψ . Depending on their productivity and employment level, firms choose to exit immediately, serve the market informally paying fixed cost F_u (in units of local labor), or serve the market formally (paying an additional fixed cost F_f to formalize). Additionally, I consider an additional marginal cost, denoted by $c_i = \frac{1}{c}$ ¹⁶ In equilibrium, there are three types of firms:

1. Unbounded informal firms. All firms entering the market with lower productivity and a level of employment lower than the regulation threshold \bar{l} .

$$l_u = F_u + c_i \frac{q}{\psi}$$

The entry of these firms depends upon an entry cutoff (ψ_u^*), implying that initially, all firms entering the market need productivity above the threshold. This definition reflects two main views of informality in the literature. The first suggests that informal firms are a reservoir of potentially productive entrepreneurs unable to enter the formal sector due to high entry costs (De Soto 2002). The second implies that some firms view informality as a survival strategy

¹⁵As in Bakker et al. (2024), I allow the shape parameter to vary across locations to account for locations with more productive firms featuring stronger labor demand for a given wage hence stronger selection effects.

¹⁶In line with Melitz (2003), I impose the parametric restriction that $F_f > F_u$, which ensures that formal firms are on average more productive than informal firms (Fact 3.1.1)

for low-skill individuals who are too unproductive to become formal. ¹⁷

2. Bounded informal firms. Informal firms with binding employment so that they exhaust their labor but gain from higher productivity ψ_b^* . Even though these firms do not consider productivity in their cost function, they consider a higher level of productivity in their revenues. Therefore, the entry to this type of firm is given by the "bounded informal" cutoff, ψ_b^c .

$$l_b = \bar{l}$$

This definition refers to the view that sees informal firms as parasite firms, which are productive enough to survive in the formal sector but choose to remain informal to earn higher profits from the cost advantages of not complying with taxes and regulations (Levy 2010; Ulyssea 2020; La Porta and Shleifer 2014).

3. Formal firms. Firms that produce with levels of employment and productivity above the thresholds, \bar{l} and ψ_f^* , respectively.

$$l_f = F_f + c \frac{q}{\psi}$$

I adopt the standard simplifying assumption that all firms can trade, paying a symmetric iceberg trade cost d_{ni} .

Firms engage in monopolistic competition. Given CES demand, this implies that prices are set at a constant markup over marginal cost:

$$p_{ni}(\psi) = \frac{\sigma}{\sigma - 1} d_{ni} c \frac{w_i}{\psi} \quad (10)$$

Operational profits derived from serving each sector are given by:

$$\pi_i^u(\psi^u) = \frac{r_i^u(\psi^u)}{\sigma} - w_i F_u \quad (11)$$

$$\pi_i^b(\psi^b) = \frac{r_i^b(\psi^b)}{\sigma} - w_i \bar{l} \quad (12)$$

$$\pi_i^f(\psi^f) = \frac{r_i^f(\psi^f)}{\sigma} - w_i F_f \quad (13)$$

where π_i^u , π_i^b , and π_i^f denote profits from the unbounded informal, bounded, and formal firms, respectively. While $r_i^u(\psi)$, $r_i^b(\psi)$, and $r_i^f(\psi)$ denote the revenue from serving the market informally and formally, respectively. Total firm revenue and profit (across destinations) are $r_i^j(\psi) = \sum_n r_{ni}^j(\psi)$ and $\pi_i^j(\psi) = \sum_n \pi_{ni}^j(\psi)$, j represents the type of firm.

As in Melitz (2003), the industry equilibrium (in this case, for each location) can be characterized using the zero-profit cutoff conditions (14) that yield expressions for the minimum productivity

¹⁷For the former, reducing the fixed cost associated with registration could have a significant impact on formalization. In the latter case, reducing the cost of formality might not be effective enough.

threshold for successful entry into the informal segment of the market (as a unbounded ψ_i^{u*} or bounded informal ψ_i^{b*} firm) and for successful entry into the formal segment (ψ_i^{f*}), as well as a free entry condition (15). The latter states that the expected operational profits of market entry $\bar{\pi}_i$ are equal to the fixed cost of market entry (in terms of local labor).¹⁸

$$\pi_i^d(\psi_i^{d*}) = 0, \quad \pi_i^d(\psi_i^{t*}) = \pi_i^t(\psi_i^{t*}), \quad \text{and} \quad \pi_i^t(\psi_i^{f*}) = \pi_i^f(\psi_i^{f*}) \quad (14)$$

$$\bar{\pi}_i = \int_{\psi_i^{d*}}^{\psi_i^{t*}} \pi_i^d(\psi) g_i(\psi) d\psi + \int_{\psi_i^{t*}}^{\psi_i^{f*}} \pi_i^t(\psi) g_i(\psi) d\psi + \int_{\psi_i^{f*}}^{\infty} \pi_i^f(\psi) g_i(\psi) d\psi = \frac{\delta w_i F_e}{1 - G_i(\psi_i^*)} \quad (15)$$

where $1 - G_i(\psi_i^*)$ denotes the probability of entering the market. Firms face an exogenous constant exit probability denoted by δ . Similarly to Melitz (2003) and Ulyssea (2020), there is endogenous entry but exogenous exit, as there are no actual dynamics after entry occurs.

Using the free entry condition at each location allows us to solve for the measure of entrants (M_i^e) in each city:

$$M_i^e = \frac{R_i}{\bar{r}_i} \quad (16)$$

where \bar{r}_i is the average revenue of a firm that enters at location i and is given by equation (A.10), and R_i denotes the aggregate revenues of the tradable sector in each location.

From the total mass of producing firms, I get each type of firm's mass in equilibrium by multiplying M by their conditional probability to exist. Then,

$$M_i = \underbrace{\chi_i^u M_i^e}_{\text{Mass of informal}} + \underbrace{\chi_b^t M_i^e}_{\text{Mass of bounded informal}} + \underbrace{\chi_i^f M_i^e}_{\text{Mass of formal}} \quad (17)$$

where $\chi_i^u = \frac{G_i(\psi_i^{b*}) - G_i(\psi_i^{u*})}{1 - G_i(\psi_i^{u*})}$, $\chi_b^t = \frac{G_i(\psi_i^{f*}) - G_i(\psi_i^{b*})}{1 - G_i(\psi_i^{u*})}$ and $\chi_i^f = \frac{1 - G_i(\psi_i^{f*})}{1 - G_i(\psi_i^{u*})}$ represent the conditional probability of being unbounded informal, bounded and formal, respectively.

Residential choice in spatial equilibrium. In spatial equilibrium, utility is equal across all locations and given by:

$$U_i = \frac{v_i}{(P_i)^{1-\beta} (p_i^h)^\beta} = \bar{U} \quad \forall i \quad (18)$$

where v_i denotes total income per worker, p_i^h is the price of housing at location i , and P_i is the price index of the tradable good. Total income in location i is given by labor income plus expenditure on housing:

$$v_i L_i = w_i L_i + (1 - \beta) v_i L_i = \frac{w_i L_i}{\beta} \quad (19)$$

¹⁸Before entry, firms are identical. To enter, firms must first make an initial investment, modeled as a fixed entry cost $f_e > 0$ (measured in labor units), which is after that sunk. The expectation of positive profits is the only reason firms consider sinking the investment costs required for entry.

General equilibrium. The general equilibrium of the model is represented by a measure of workers L_i , a set of entry thresholds for producing informally and formally (ψ_i^{u*} , ψ_i^{b*} and ψ_i^{f*} , respectively), a set of firm entrants M_i^e , wages w_i and price indices P_i for each location, as well as the level of utility in the economy \bar{U} , that satisfy the following system of equations:

1. The industry equilibrium consisting of the zero profit cut-off conditions and the free entry condition (equations 14 and 15)
2. Labor markets clear at each location i

$$M_i^e = \frac{R_i}{\bar{r}_i} = \frac{w_i L_i}{\bar{r}_i} \quad (20)$$

3. The price index at each location

$$P_i^{1-\sigma} = \underbrace{\sum_{k \in N} \chi_k^u M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{u\sigma-1}}_{\text{Unbounded Informal}} + \underbrace{\sum_{k \in N} \chi_k^b M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{b\sigma-1}}_{\text{Bounded formal}} \quad (21)$$

$$+ \underbrace{\sum_{k \in N} \chi_k^f M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{f\sigma-1}}_{\text{Formal}} \quad (22)$$

where χ_k^u , χ_k^b and χ_k^f correspond to the probability that a firm in location $k \in N$ enters the informal and the formal sector, respectively. I define $\rho \equiv \frac{\sigma-1}{\sigma}$.¹⁹

4. Good markets clear at each location i

In equilibrium, total expenditure equals the value of domestic production (total labor payments) in each location i by type of firm:

$$w_i L_i = \sum_{n \in N} \pi_{ni} W_n L_n \quad (23)$$

where π_{ni} denotes the expenditure share of goods sourced from i in the overall expenditure of location n . These expenditure shares comprise a combination of domestic and external, and formal and informal consumption.

5. Spatial equilibrium for workers among all locations

$$U_i = \bar{U} \quad \forall i \quad (20)$$

¹⁹The aggregate productivities for location i and sector j are denoted by $\tilde{\psi}_i^j$, these are detailed in equations A.13, A.14, A.15. Detailed derivation in equation (A.18).

6. National labor markets clear

$$\sum_i L_i = L \tag{21}$$

6.2 Comparative statics

I study the quantitative implications of my model for the relationship between the creation of free economic zones and informality across space. I embed the zones into my model by assuming two channels. First, a reduction in the cost of formalization as firms entering the zones may benefit from streamlined access to tax authority procedures.²⁰ Second, cheaper inputs, which rationales the fact that consumers of products from the zones are exempt from paying VAT. As this simple model does not consider the intermediates for production, I assume the latter effect through a decrease in the marginal cost ($c_i = \frac{1}{c}$, with $c \in (0, 1]$).

I consider three comparative statics involving only three regions to show the spatial spillover effects of the policy: one region hosting a municipality, another closer region, and a further one.

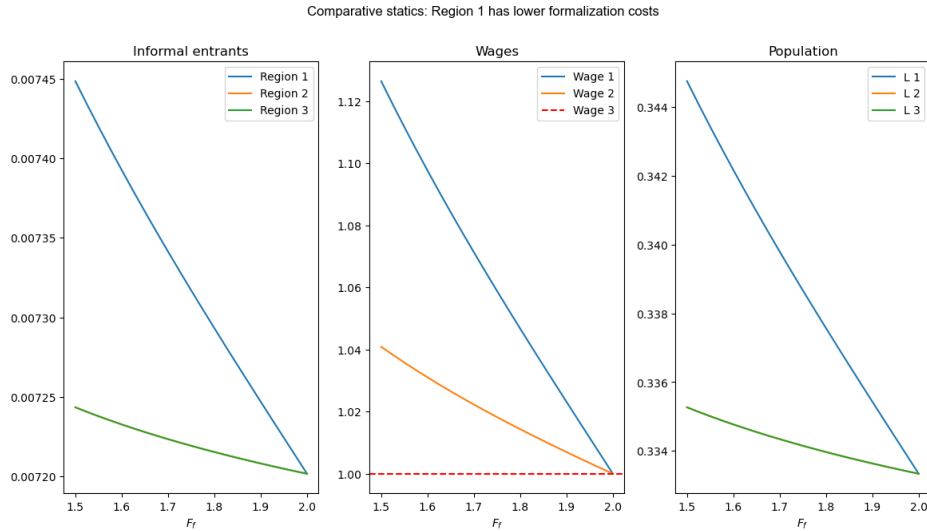


Figure 19: Comparative statics: formalization cost

First, I analyze how changes in the formalization cost affect the spatial equilibrium. I assume three equidistant regions and changes in F_f for Region 1. Figure 19 illustrates that downward changes in the fixed cost of formalization lead to a higher mass of informal entrants in the economy, thereby increasing informality. The effect on wages and population is similar, that is when there are lower formalization costs, wages and population are higher in Region 1 than in Region 2.

In addition, I analyze how changes in the marginal cost affect the spatial equilibrium. Figure 20 illustrates upward changes in c for Region 1, representing a lower marginal cost of production

²⁰By simplifying these processes, FEZs lower the barriers to formalizing business operations, which can include registering the company, obtaining necessary licenses, and complying with tax regulations

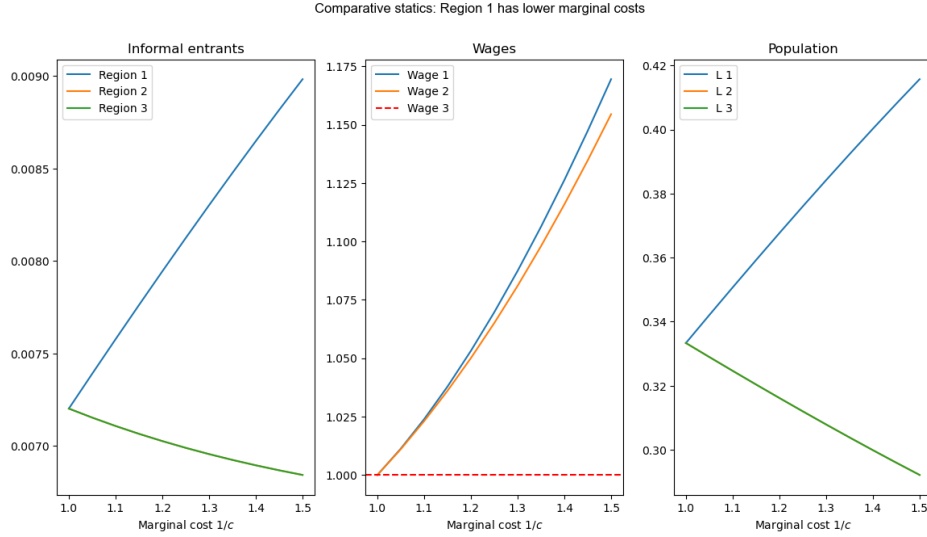


Figure 20: Comparative statics: marginal cost

$c_i = \frac{1}{c}$. It shows a negative relationship between informality and the marginal cost in Region 1. The results are similar for wages and population.

Finally, I analyze how changes in the marginal cost in Region 1 and other closer regions (Region 2) affect the spatial equilibrium. Figure 21 illustrates changes in c , representing a lower marginal cost in Region 1, but Region 2 is closer. In this case, informality increases in the region hosting the FEZs and to a lesser extent in Region 2, illustrating how informality spills over across space. In addition, wages and population also increase in Region 1 and 2.

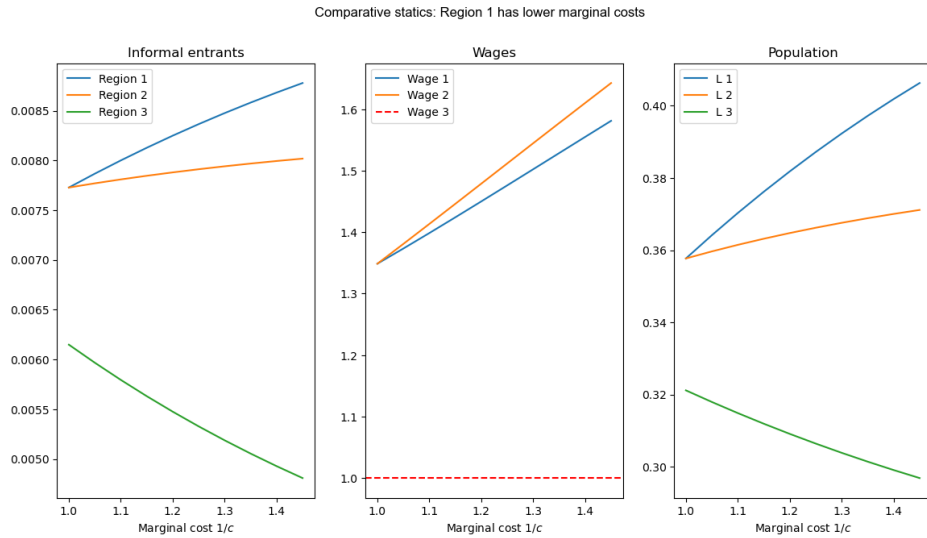


Figure 21: Comparative statics: Region 1 and 2 closer

In theory, a change in the formalization cost and the marginal directly affects the decisions of firms to enter, exit, and produce formally or informally. Consequently, initially higher-paying

formal firms experience greater profitability, prompting them to further raise wages and expand their workforce. However, the higher labor costs prompt low-productivity formal firms to exit the formal segment of firms due to an inability to meet the costs, and the productivity threshold for new firm entry to produce as a formal form is raised, which leads to an increase in informality. These effects are transmitted similarly to closer regions through lower price indices and more varieties, increasing revenues.

7 Conclusion

In conclusion, this study explores the impact of Free Economic Zones (FEZs) on labor market outcomes in Colombia, a country facing significant regional disparities in economic development. While place-based policies are globally implemented to address regional inequalities, much of the research has focused on developed economies, leaving a gap in understanding their efficacy in less-developed contexts.

The findings underscore the significant influence of FEZs on Colombia's labor market dynamics. The establishment of FEZs is correlated with a persistent increase in informality rates, primarily driven by a shift from the formal to the informal sector. There is also evidence of a spillover effect on neighboring municipalities, though this effect is less pronounced. Despite these shifts, the overall impact on wages and total employment remains insignificant, highlighting the complex interplay between policy interventions and labor market dynamics. These results align with the "jobless industrialization" phenomenon highlighted by Alfaro et al. (2023), which describes a disconnect between value-added and employment in late industrialized economies. This phenomenon is characterized by large, primarily formal manufacturing firms that increase their contribution to manufacturing value-added over their life cycle without a corresponding increase in employment.

The study also highlights the positive effects of FEZs on economic indicators, evidenced by improvements in nighttime illumination intensity and state capacity indicators. Notably, FEZs contribute to increased government revenue, bolstering municipal tax revenues and potentially enhancing local fiscal capacities.

These findings have important policy implications for economic growth and regional disparities. While FEZs are often part of broader strategies to foster economic growth and reduce regional inequalities, policymakers must consider their unintended consequences on informality. Balancing the economic benefits of FEZs with measures to mitigate informal employment is crucial for promoting inclusive and sustainable development across regions.

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Appendices

A Definition of informality

Table 11 outlines the three criteria used to define informality. These criteria are based on self-reported measures from household surveys. Workers are asked to report the number of employees in the firm where they work, whether they or their employer contribute to social security and the type of contract they hold.

These definitions are crucial as they capture two key aspects of informality: workers in small and unproductive firms, and workers experiencing the worst labor market conditions.

Table 11: Definitions of Informality

<i>Definition</i>	<i>Description</i>
No. of workers	- A worker that is part of a firm with no more than 5 or 10 workers. - A firm that has no more than 5 or 10 workers.
Social security	- A worker who does not contribute to social security (either health or pension) - A firm that does not pay for the social security of its workers.
Employment contract	- A worker that does not have a written employment contract. - A firm that does not provide its workers with written employment contracts.

I use these to calculate the informality rate of municipality i at time t . An important data limitation is that I observe the place of residence rather than the workplace. Therefore, this could lead to a bias.

B Other economic outcomes

Figure 22 - 25 show the estimates for the municipalities hosting FEZs. Parallel trends don't hold for most of the outcomes. Therefore, I cannot infer anything from these results. This lack of parallel trends suggests that FEZs were predominantly established in areas that were already experiencing development before their implementation.

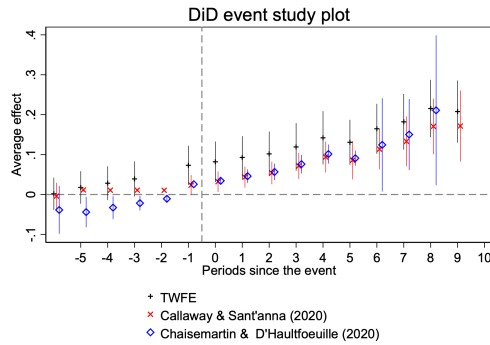


Figure 22: Population density

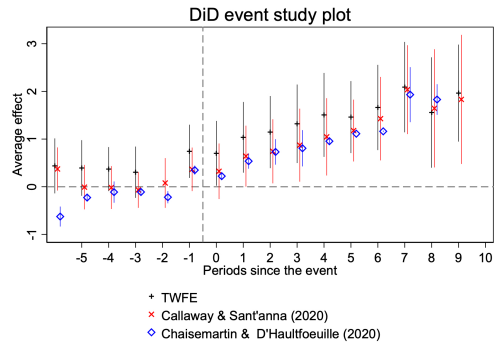


Figure 23: Night-time light

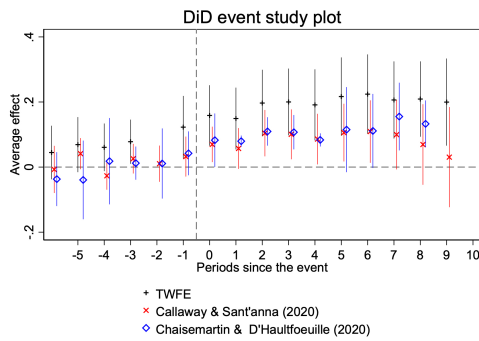


Figure 24: Total tax revenue

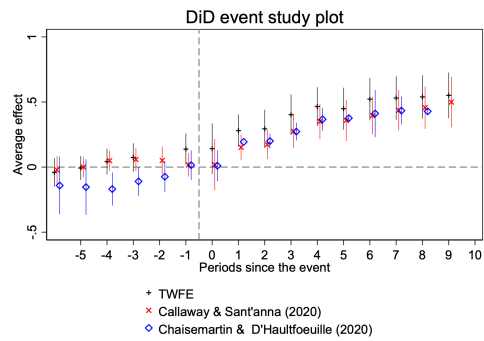


Figure 25: Total property tax revenue

Note: The dots indicate the estimated parameters $\hat{\beta}_j$. Each subscript j refers to the leads and lags. The bars represent 95% confidence intervals with SEs clustered at the department level. This figure overlays the event-study plots constructed using four different estimators: a dynamic version of the TWFE model (2), estimated using OLS; Callaway and Sant'Anna (2021) (cross markers); De Chaisemartin and D'Haultfoeuille (2021); and Cengiz et. al (2019). The time variable is the year of the declaration, and the treatment group is defined by municipalities with an FEZ. The omitted category is the year before treatment.

C Detailed derivation of the simple model

Consumer problem. To solve the simple model, I begin with the optimization problem of workers/consumers:

$$c_i(x) = \left(\frac{p_i(x)}{P_i} \right)^{-\sigma} c_i$$

Since trade is costly between locations, P_i represents the price index of the tradable good in location i .

Consumer expenditure on housing and the consumption composite is given by

$$\begin{aligned} c_i &= \beta v_i \\ h_i &= (1 - \beta) \frac{v_i}{p_i^h} \end{aligned} \tag{A.2}$$

where v_i is defined in equation (19).

Firm Problem and Firm Entry. Given that the firm problem is symmetric for all firms of a given productivity ψ_i^j at each location i of type j , I perform a change of notation and write the demand faced by a firm of productivity ψ_i^j at location i as

$$q_i^j(\psi_i^j) = p_i^j(\psi_i^j)^{-\sigma} P_i^{1-\sigma} \beta v_i \tag{A.3}$$

While firm-level revenues are given by

$$r_{ni}^j(\psi_i^j) = p_{ni}^j(\psi_i^j) q_i^j(\psi_i^j) = p_{ni}^j(\psi_i^j)^{1-\sigma} P_i^{1-\sigma} \beta v_i \tag{A.4}$$

For the informal and formal firms aim to maximize profits given by

$$\max \pi_{ni}^j = p_{ni}^j q_{ni}^j(\psi_i^j) - w_i l_i(\psi_i^j) = p_{ni}^j q_{ni}^j(\psi_i^j) - w_i \left(F_j + \frac{q_i(\psi_i^j)}{\psi_i^j} \right) \tag{A.5}$$

Plugging (A.9) into (A.11) and taking the FOC with respect to prices yields the familiar optimality condition that profit maximization involves setting prices at a constant mark-up over marginal costs in the case of monopolistically competitive firms and CES demand:

$$p_{ni}^j(\psi_i^j) = d_{ni} \frac{\sigma}{\sigma - 1} \frac{w_i}{\psi_i^j} = \frac{d_{ni} w_i}{\psi_i^j \rho} \tag{A.6}$$

Instead, the bounded informal firms have to scale back production and adjust their prices to satisfy their residual demand and maximize their profits, hiring up to \bar{l} workers.

Plugging optimal prices into the formulas for firm-level revenues (equation (A.4)) yields:

$$r_{ni}^j(\psi) = \left(\frac{\psi_i^j \rho}{w_i d_{ni}} \right)^{\sigma-1} P_i^{1-\sigma} \beta v_i \tag{A.8}$$

Plugging the pricing rule into the formula for profits (A.5) leads to the expressions in equation (11).

As in Melitz (2003), in the presence of firm heterogeneity, fixed costs, and free entry there are three general equilibrium objects for each location i that play a key role in the characterization of equilibrium: ψ_i^{u*} - the productivity threshold for a firm in location i to serve the informal sector, ψ_i^{b*} - the productivity threshold for a bounded informal firm in location i to serve the informal sector, ψ_i^{f*} - the productivity threshold for a firm at location i to serve the formal sector, and M_i^e - the mass of firms entering (i.e. paying F_e) at each location. The cutoffs are pinned down by the zero profit conditions outlined in equation (14), while the latter is pinned down by the labor market clearing condition:

$$M_i^e * \bar{l}_i = M_i^e \frac{\bar{r}_i}{w_i} = L_i \quad (\text{A.9})$$

where \bar{r}_i is the average revenue of a firm that enters at location i and is given by

$$\bar{r}_i = \left(\int_{\psi_i^{u*}}^{\psi_i^{b*}} r_i^u(\psi) g_i(\psi) d\psi + \int_{\psi_i^{b*}}^{\psi_i^{f*}} r_i^b(\psi) g_i(\psi) d\psi + \int_{\psi_i^{f*}}^{\infty} r_i^f(\psi) g_i(\psi) d\psi \right) \quad (\text{A.10})$$

To understand the intuition of equation (A.9) it is important to note that, because of free entry expected profits are zero, such that firms' revenues are equal to total payments to labor, accounting for both fixed and variable input costs.

I obtain the thresholds of bounded informal and formal firms using the relative revenue equation and the no-arbitrage conditions (zero profit conditions).²¹ Both thresholds are functions of the entry cutoff.

In line with Melitz (2003) it will be useful to define a notion of average productivity among different types of firms:

$$\tilde{\psi}_i^u(\psi_i^{u*}) = \left[\frac{1}{G_i(\psi_i^{b*}) - G_i(\psi_i^{u*})} \int_{\psi_i^{u*}}^{\psi_i^{b*}} \psi^{\sigma-1} g_i(\psi) d\psi \right]^{\frac{1}{\sigma-1}} \quad (\text{A.13})$$

$$\tilde{\psi}_i^t(\psi_i^{d*}) = \left[\frac{1}{G_i(\psi_i^{f*}) - G_i(\psi_i^{t*})} \int_{\psi_i^{t*}}^{\psi_i^{f*}} \psi^{\sigma-1} g_i(\psi) d\psi \right]^{\frac{1}{\sigma-1}} \quad (\text{A.14})$$

$$\tilde{\psi}_i^f(\psi_i^{d*}) = \left[\frac{1}{1 - G_i(\psi_i^{f*})} \int_{\psi_i^{f*}} \psi^{\sigma-1} g_i(\psi) d\psi \right]^{\frac{1}{\sigma-1}} \quad (\text{A.15})$$

Noting that the assumed productivity distributions are standard Pareto with shape parameters α_i , I can derive closed-form expressions for the average productivities of the different types of functions as a function of the entry cutoffs.

²¹The ratios of revenues of two firms producing in the same region only depend on their productivity levels, so that $\frac{r_i^j(\psi^j)}{r_i^j(\psi^{j'})} = \frac{\psi^j}{\psi^{j'}}^{(\sigma-1)} \rightarrow r_i^j(\psi^j) = \frac{\psi^j}{\psi^{j'}}^{(\sigma-1)} r(\psi^{j'})$

With the above definitions in place, I can rewrite the free entry condition (equation (15)) and the expression for average revenues (equation (A.10)) as

$$\bar{\pi}_i = \chi_i^d \pi_i^d \left(\tilde{\psi}_i^d \right) + \chi_i^t \pi_i^t \left(\tilde{\psi}_i^t \right) + \chi_i^f \pi_i^f \left(\tilde{\psi}_i^f \right) = \frac{\delta w_i F_e}{1 - G_i(\psi_i^{d*})} \quad (\text{A.16})$$

$$\bar{r}_i = \chi_i^d r_i^d \left(\tilde{\psi}_i^d \right) + \chi_i^t r_i^t \left(\tilde{\psi}_i^t \right) + \chi_i^f r_i^f \left(\tilde{\psi}_i^f \right) \quad (\text{A.17})$$

where $\chi_i^d = \frac{G_i(\psi_i^{t*}) - G_i(\psi_i^{d*})}{1 - G_i(\psi_i^{d*})}$, $\chi_i^t = \frac{G_i(\psi_i^{f*}) - G_i(\psi_i^{t*})}{1 - G_i(\psi_i^{d*})}$ and $\chi_i^f = \frac{1 - G_i(\psi_i^{f*})}{1 - G_i(\psi_i^{d*})}$ represent the conditional probability of being unbounded informal, bounded informal and formal, respectively.

Price index. The price index P_i (21) in that destination is the CES aggregate of the prices of all the tradable varieties sold in location i by the different types of firms. Therefore, this aggregates two margins: (i) type of firm and (ii) location.²²

I can rewrite equation (21) in terms of both the domestic and external prices.

$$P_i^{1-\sigma} = \underbrace{\chi_i^u M_i \left(\frac{w_i}{\rho} \right)^{1-\sigma} \tilde{\psi}_i^{u\sigma-1} + \chi_i^b M_i \left(\frac{w_i}{\rho} \right)^{1-\sigma} \tilde{\psi}_i^{b\sigma-1} + \chi_i^f M_i \left(\frac{w_i}{\rho} \right)^{1-\sigma} \tilde{\psi}_i^{f\sigma-1}}_{\text{Domestic}} + \underbrace{\sum_{k \in N} \chi_k^u M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{u\sigma-1} + \sum_{k \in N} \chi_k^b M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{b\sigma-1} + \sum_{k \in N} \chi_k^f M_k \left(\frac{w_k d_{ik}}{\rho} \right)^{1-\sigma} \tilde{\psi}_k^{f\sigma-1}}_{\text{External}} \quad (\text{A.18})$$

²²This price index is analogous to the one in a hypothetical monopolistic competition equilibrium with M representative firms sharing a common productivity $\tilde{\psi}$.