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*Keywords*: labor mobility restrictions, place-based policies, spatial misallocation, firm location, agglomeration

*JEL Classification*: D2, J60, R12, R58



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# 1 Introduction

Barriers to the movement of people within cities can have profound effects on the spatial organization of economic activity. Existing studies have shown that borders and mobility restrictions significantly distort the spatial distribution of population and economic activity, with Redding and Sturm (2008) finding that the postwar division of Germany caused substantial population decline in cities near the East-West border, and Allen, Dobbin, and Morten (2018) showing that border infrastructure redirected migration flows with consequent effects on local labor markets. However, less is known about how restrictions on labor mobility within cities shape firm location, commuting patterns, and welfare.

This paper studies these questions using a unique historical setting: the Shenzhen Wall, a physical barrier that divided the Shenzhen Special Economic Zone (SEZ) from the rest of the city for nearly three decades. Erected in the early 1980s to protect the SEZ's preferential policy regime, where export-oriented production, foreign investment, and freer trade arrangements were concentrated, the Wall helped maintain a stable operating environment inside the SEZ while regulating the cross-boundary movement of people and goods. Workers crossing the boundary were required to hold a border pass and undergo document inspection at designated checkpoints, generating meaningful costs for those commuting across it. The Shenzhen Wall thus provides a rare opportunity to study how within-city mobility frictions shape the spatial allocation of economic activity.

We begin by documenting a sharp spatial discontinuity in firm location around the Shenzhen Wall. Using high-resolution firm registration data and a spatial regression discontinuity design, we find that significantly more entrants locate just outside the boundary than just inside it. This pattern is not driven by pre-existing differences in geography, land use, firm entry regulation, or administrative boundaries. Instead, it reflects a discontinuity in access to labor; commuting flows drop sharply across the boundary, and the spatial discontinuity in firm entry is substantially larger for labor-intensive industries. These findings indicate that mobility restrictions raised effective labor costs for firms located inside the boundary by limiting their access to workers outside the SEZ, inducing them to locate just outside the boundary.

To quantify the aggregate implications of these distortions, we develop a quantitative spatial general equilibrium model with bilateral commuting frictions. In the model, the Shenzhen Wall is represented as a checkpoint-induced increase in commuting time, which raises the cost of accessing workers across locations. The model is disciplined using observed commuting flows, floorspace stock and prices in 2024 when the Wall had been removed and the road network had been improved to connect the former SEZ and non-SEZ areas.

We then ask how the allocation of economic activity would change if the Wall were still in place today. The counterfactual results show that reintroducing the Wall lowers the inclusive value of living and working in Shenzhen, generating net population outflows from the economy. Cross-boundary commuting declines substantially, with flows from the non-SEZ to the SEZ experiencing the largest decline. In the new equilibrium, workplace employment declines on both sides of the Wall, but the decline is larger inside the SEZ. Wages also increase more inside the SEZ, reflecting the higher labor costs faced by firms that lose access to the outside labor pool. These counterfactual patterns mirror the historical with-Wall economy. When endogenous agglomeration forces are included, the losses are amplified because weaker labor-market integration also reduces local productivity and amenity externalities.

Although our analysis focuses on a specific policy experiment in Shenzhen, the paper speaks to a broader class of interventions that shape the spatial pattern of population mobility worldwide. Examples include South Africa's pass laws, which limited where Black workers could live and work; Singapore's foreign-worker quota and levy system, which regulates migrant employment across sectors; and China's *hukou* system, which governs internal migration across regions. Our framework helps quantify the operational costs of such interventions, namely, the labor misallocation that arises when workers cannot freely choose occupations or workplaces, and firms cannot freely hire from the relevant labor pool. Our paper offers a useful setting for understanding how mobility restrictions can generate persistent spatial distortions in economic activity.

**Literature review.** Our paper contributes to a central strand of literature that documents labor mobility frictions driven by institutional arrangements. Prominent examples include national borders, internal migration restrictions, and the division and reunification of states. These institutional frictions transform otherwise smooth spatial distance into discrete barriers to labor-market access. In cross-city and cross-border settings, this literature documents how changes in market access shape the distribution of population, employment, wages, and welfare (Beerli, Ruffner, Siegenthaler, and Peri (2021); Brakman, Garretsen, van Marrewijk, and Oumer (2012); Clemens, Lewis, and Postel (2018); Redding and Sturm (2008)). A related China-focused literature examines administrative labor-market segmentation, *hukou*-related migration barriers, city-size distortions, and the associated productivity and welfare losses (Adamopoulos, Brandt, Chen, Restuccia, and Wei (2024); Au and Henderson (2006); Bosker, Brakman, Garretsen, and Schramm (2012); Tombe and Zhu (2019)). The studies most closely related to our setting are those on physical and institutional borders. Ahlfeldt, Redding, Sturm, and Wolf (2015) studies the Berlin Wall as a within-city shock to commuting access and shows that severing cross-border access reshaped employment density, land rents, and the internal structure of Berlin. Allen et al. (2018) examines the expansion of the U.S.–Mexico border wall and finds that border infrastructure redirected migration routes and destinations, with implications for local employment and wages.

These studies demonstrate that localized barriers can distort the spatial allocation of workers and economic activity. Our paper complements this literature by shifting attention from national, interregional, or city-level mobility barriers to a physical boundary within a single urban labor market. Unlike the Berlin Wall, which partitioned a city into separate jurisdictions and largely shut down cross-boundary interaction, the Shenzhen Wall operated as a spatial friction, restricting movement through mandatory checkpoint inspections and commuting detours rather than outright prohibition. We examine whether such a friction leaves persistent effects on the spatial distribution of population and economic activity after the original control regime is relaxed or removed. In doing so, the paper speaks to the broader debate on whether removing mobility barriers restores spatial integration, or whether historical borders continue to shape economic geography after the barriers themselves have disappeared (Brakman et al. (2012); Nitsch and Wolf (2013); Redding and Sturm (2008)).

Our paper also relates to a large strand of literature on place-based policies (see Neumark and Simpson (2015) as an useful review). In developed economies, studies of enterprise zones and empowerment zones provide much of the early evidence on the local effects of such policies. This literature evaluates how targeted tax incentives, and subsidies affect employment, investment, firm activity, and local welfare (name a few, Briant, Lafourcade, and Schmutz (2015); Busso, Gregory, and Kline (2013); Criscuolo, Martin, Overman, and Van Reenen (2019); Kline and Moretti (2014); Neumark and Kolko (2010)). A growing literature studies place-based policies in developing countries. Wang (2013) shows that SEZs increased foreign direct investment. Y. Lu, Wang, and Zhu (2019) shows that economic zone establishment increased capital investment, employment, output, productivity, wages, and the number of firms in treated areas. The estimated net benefits over three years amount to about US$15.62 billion. Other studies extend the analysis beyond firms and aggregate output, showing that such policies can also affect housing construction, household wealth, consumption, education, human capital, amenities, and local welfare (Abagna, Hornok, and Mulyukova (2025); Dell (2010); Harari and Wong (2025); F. Lu, Sun, and Wu (2023); Zheng, Sun, Wu, and Kahn (2017)). The literature has also emphasized several limits of place-based policies. One concern is that geographically targeted incentives may redirect investment and firm activity from surrounding locations, generating local gains that partly reflect displacement rather than aggregate growth (Givord, Rathelot, and Sillard (2013); Kline and Moretti (2014)). Other studies point to rent seeking, capital misallocation, and weak policy effects when local fundamentals such as infrastructure are not improved (Görg and Mulyukova (2024); Kahn, Sun, Wu, and Zheng (2021); Rothenberg, Wang, and Chari (2025)).

These studies suggest that place-based policies should be evaluated not only by their direct effects on firm entry, FDI, employment, and wages, but also by their broader and longer-run effects on productivity, consumption, human capital, amenities, and welfare. This paper complements the place-based policy literature by examining a spatial cost of the SEZ regime that operates through its boundary rather than only through preferential treatment inside the zone. In our case, the SEZ boundary and its associated buffer zone shaped long-run economic geography by raising cross-boundary commuting costs, thereby linking place-based incentives to the spatial allocation of firms, employment, and welfare beyond the policy-targeted area itself.

Our paper is also related to the research on quantitative spatial models (see Redding and Rossi-Hansberg (2017) for an useful review), including Ahlfeldt et al. (2015); Allen and Arkolakis (2014); Allen et al. (2018); Bird and Venables (2020); Burstein, Morales, and Vogel (2020); Desmet, Nagy, and Rossi-Hansberg (2018); Dingel and Tintelnot (2020); Fajgelbaum, Morales, Suárez Serrato, and Zidar (2018); Gaubert (2018); Heblich, Redding, and Sturm (2020); Monte, Redding, and Rossi-Hansberg (2018); Redding and Sturm (2008); Tsivanidis (2026). Their work incorporate residence-workplace choice, commuting costs, land markets, and agglomeration effect, and talk about welfare effect in a equilibrium framework.

The studies most closely related to our framework are Ahlfeldt et al. (2015); Heblich et al. (2020); Severen (2023); Tsivanidis (2026), which use single-city settings to examine how changes in market access reshape urban structure, commuting patterns, wages, rents, and welfare across workers and locations. We build on this framework by modeling the Shenzhen Wall as a discontinuous change in commuting costs at the policy boundary. The Wall is treated as a network friction that raises bilateral commuting costs through checkpoint-induced detours and inspection delays. The logic is analogous to the transportation literature on bridges, where sparse crossing points affect bilateral travel costs by connecting otherwise separated areas and by channeling flows through bridge endpoints (Nagy (2021); Tompsett (2025)). In our setting, however, checkpoints work in the opposite direction by concentrating cross-boundary commuting at designated crossings and forcing commuters to make detours before reaching those crossings. Another helpful work should be Allen et al. (2018) who framed migration decisions under the labor mobility control over Mexico-US border walls. Different from their "wall" as a one-time international migration barrier, the "wall" in our setting is a repeated daily commuting costs through checkpoints, identity inspections, and detours. This allows us to examine how an internal policy-induced border shaped firm location, commuting, wages, rents, and welfare within a common urban labor market.

Finally, our paper speaks to a strand of literature on China economy. China's growth miracle originate from the interaction between gradualist reforms and outward-oriented industrialization (a helpful summary can be Chen and Zha (2025)). This process was reflected in private-sector expansion, firm entry and exit, labor reallocation across sectors, manufacturing productivity growth, processing trade, and integration into global value chains (Brandt, Van Biesebroeck, and Zhang (2012); Khandelwal, Schott, and Wei (2013); Song, Storesletten, and Zilibotti (2011)). Rather than liberalizing trade and foreign investment nationwide at once, the government used SEZs such as Shenzhen as targeted experiments in market-oriented industrialization. These early activities provided Shenzhen with industrial know-how, supplier networks, a large pool of migrant workers, and lay the human- and physical-capital foundations for its later transformation into an agglomeration of high-technology industries. However, the rapid economic growth may come up with a cost. Some literature then emphasizes labor, land and capital misallocation, migration restrictions, as the source of TFP loss in China (Au and Henderson (2006); Bosker et al. (2012); Brandt, Tombe, and Zhu (2013); Tombe and Zhu (2019)). We contribute to this strand of literature by emphasizing the spatial cost as a historical legacy of a specific labor mobility control adopted before 2010 in Shenzhen, which is used to prevent smuggling and ensure stable commercial environment during transition period from planned economy to market economy. We will show that the previously existed labor mobility control system has a long-run effect on commuting and firm entry today. We will quantify the effect with a quantitative spatial model.

The rest of the paper is organized as follows. Section 2 describes the historical background of the Shenzhen Wall and introduce the data. Section 3 introduces the empirical design. Section 4 presents and check the robustness of results, and show the labor accessibility mechanism underlying the baseline results. We build a quantitative spatial model with bilateral commuting frictions in Section 5, and do calibration in Section 6. Section 7 reports the counterfactual results. Section 8 concludes.

## 2 Background, Data and Sample

### 2.1 Background

**Shenzhen special economic zone.** Shenzhen was designated as one of China's first Special Economic Zones in 1980. The SEZ was created as a geographically bounded experiment in reform and opening-up. Leveraging Shenzhen's proximity to Hong Kong, the government aimed to attract external capital, technology, and managerial know-how, promote export-oriented industrialization, and test more market-oriented rules within a limited area. To attract firms and investment, the SEZ offered preferential treatment in land use, customs, taxation, profit repatriation, infrastructure provision, and labor contracting. In particular, enterprises inside the SEZ faced a reduced income tax rate of 15 percent, enjoyed import-duty exemptions on production-related inputs, and received tax reductions for profits reinvested in the zone. These policies did not apply to the whole municipality. Before the 2010 expansion, the SEZ was limited to southern Shenzhen, roughly today's Luohu, Futian, Nanshan, and Yantian districts, while the areas that later became Bao'an, Longhua, Guangming, Longgang, and Pingshan remained outside the zone. Figure 1 shows this pre-2010 spatial division: the original SEZ is shaded in dark grey, the non-SEZ area in light grey, and the former SEZ management line and checkpoints separate the two.

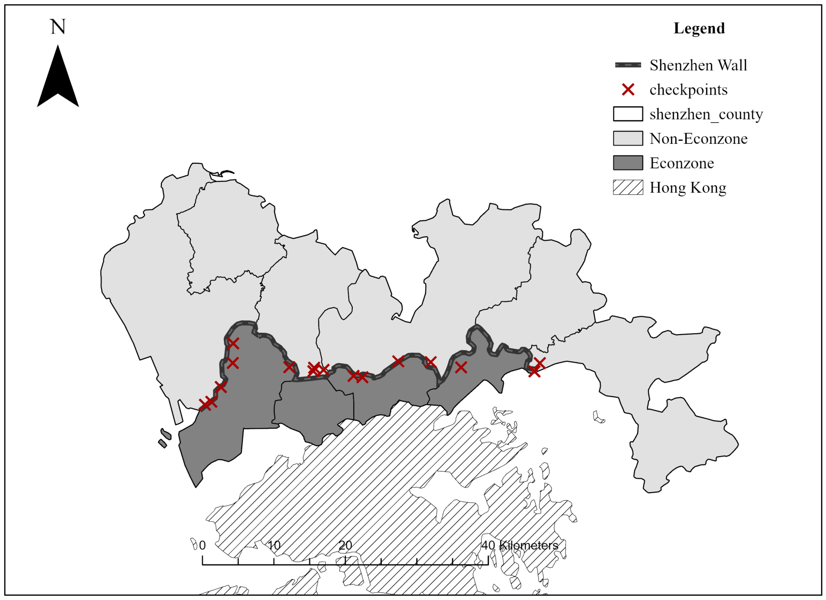



Figure 1: Shenzhen SEZ

NOTES: This figure shows the geography of Shenzhen and the pre-2010 boundary of the Shenzhen Special Economic Zone (SEZ). The dark grey area denotes the original SEZ in southern Shenzhen, and the light grey area denotes the part of Shenzhen that remained outside the SEZ until the 2010 expansion. The hatched area to the south denotes Hong Kong. The dashed line marks the former SEZ management line, which we refer to as the "Shenzhen Wall" in this paper. The red crosses indicate the 16 checkpoints along the wall. These checkpoints were the official crossing points between the SEZ and the non-SEZ area.

**The Shenzhen Wall as the boundary of the SEZ regime.** To make this spatial policy regime enforceable, the government built an internal control line between the SEZ and the non-SEZ area. This line was commonly called the "er xian guan," in contrast to the "yi xian guan" at the Hong Kong border, and is referred to in this paper as the Shenzhen Wall. The line was not merely symbolic. It consisted of fences, patrol roads, sentry facilities, road checkpoints, and customs and border-control stations. Its institutional purpose was twofold. First, it safeguarded the SEZ's preferential policy regime by regulating the flow of goods: firms operating within the zone enjoyed favorable import and tax treatment, and their output was predominantly export-oriented; sales to the domestic market required prior approval and customs clearance. Second, it served a security and social-stability function by managing population movements and alleviating pressure on the Hong Kong border. In this sense, the Shenzhen Wall was the physical infrastructure that transformed the SEZ from an administrative designation into an enforceable spatial treatment.

**Labor mobility restrictions.** The Shenzhen Wall directly raised the cost of moving between the SEZ and the non-SEZ area. Under the 1986 personnel-movement regulation, travelers were permitted to cross the boundary only through designated checkpoints or special passages and were required to present valid documents for inspection. For mainland residents, the primary document was a border pass, the acquisition of which required administrative approval from local authorities: workers seeking entry for employment purposes had first to secure a factory introduction letter before applying for a border pass at the county public security bureau, and the pass was valid only for a limited period depending on the purpose of entry—generally less than one year prior to the 2003 reform. Beyond documentation requirements, the wall imposed additional commuting costs through checkpoint procedures, queuing, and route restrictions: vehicles were required to enter and exit through designated road checkpoints, drivers and passengers were processed separately, and passengers had to disembark, proceed through the verification hall to have their border passes inspected, and then re-board. Consequently, the cost of mobility did not rise smoothly with distance but increased discretely at the Shenzhen Wall.

**Relaxation and removal.** The intensity of this friction diminished over time. In 2003, the border-management system was streamlined: mainland residents could apply directly for a one-year border pass using their national ID card, factory introduction letters were eliminated, certain groups were granted exemptions, and vehicle-related inspection certificates and fees were abolished. In 2010, the State Council expanded the Shenzhen SEZ to encompass the entire city, explicitly citing uneven development between the SEZ and non-SEZ areas, constraints on development space, and the problem of governing one city under two legal regimes. The physical barrier was nonetheless retained on a transitional basis. Even as its formal policy function receded, the remaining checkpoints continued to function as transport bottlenecks. In 2013, the 16 land checkpoints processed over 1.1 million vehicle crossings and 5 million person crossings per day, with severe congestion during peak hours.[1]The commuting burden was further reflected in local parlance: residents described Meilin Checkpoint as a place "even heroes found hard to pass" and Buji Checkpoint as somewhere they "dreaded going to." While anecdotal, these expressions capture the perceived congestion and delay costs associated with crossing into the original SEZ zone. The State Council formally approved the abolition of the SEZ management line in 2018.

To conclude, the Shenzhen Wall was not just an administrative line, but also a treatment of spatial mobility friction. Table 1 summarizes the main changes in SEZ policies and mobility controls.

[1]The statistics are taken from *A Study of the Historical Evolution of the Shenzhen Special Economic Zone Management Line* (in Chinese).

Table 1: Key Policy Changes of the Shenzhen SEZ

| **Year** | **Policy change** | **Institutional difference across the wall and mobility control** |
|---|---|---|
| 1980 | Shenzhen was designated as a Special Economic Zone. | The SEZ introduced place-based preferential policies within a limited area, including favorable customs treatment, a reduced enterprise income tax rate, land-use rules, and more flexible labor contracting. These policies did not apply to the rest of Shenzhen. |
| 1982 | The SEZ management line (referred to as "Shenzhen Wall" in our paper) was approved and construction began. | The line physically separated the SEZ from the non-SEZ area through fences, patrol roads, and checkpoints. It made the within-city policy boundary enforceable. |
| 1986 | The labor mobility control system between the SEZ and outside SEZ came into effect. | Travelers had to cross through designated gates, docks, or special passages and present valid documents for inspection. Mainland residents generally needed a border pass to enter the SEZ. |
| 2003 | Border-pass procedures were simplified. | Mainland residents could apply for a one-year border pass with an ID card; introduction letters were abolished; some groups became exempt; and some vehicle-related certificates and fees were cancelled. Mobility restrictions were relaxed but not removed. |
| 2005 | Routine entry into the SEZ became ID-based in practice. | For ordinary travelers, the border-pass burden was largely reduced. However, the checkpoints and the physical management line remained in place. |
| 2008 | The *Enterprise Income Tax Law of the People's Republic of China* took effect. | The statutory corporate income tax rate was unified at 25 percent in 2008. Earlier SEZ-specific low-rate preferences were gradually phased out, narrowing the tax-policy gap across the Shenzhen Wall. |
| 2010 | The Shenzhen SEZ was expanded to cover the entire city. | Bao'an, Longgang, Guangming, and Pingshan were incorporated into the SEZ, eliminating the formal SEZ boundary. The Shenzhen Wall, however, remained in place temporarily. |
| 2018 | The Shenzhen Wall was formally abolished by official policy documents. | The State Council approved the abolition of the SEZ management line in 2018. |

*Notes:* This table reports the main institutional changes relevant to the original Shenzhen SEZ boundary. "Inside SEZ" refers to the original SEZ before the 2010 expansion, mainly today's Luohu, Futian, Nanshan, and Yantian districts. "Outside SEZ" refers to the rest of Shenzhen, including areas that later became Bao'an, Longhua, Guangming, Longgang, and Pingshan.

## 2.2 Data

This section describes the data sources used to characterize the spatial distribution of economic activity in Shenzhen and local conditions at the firm level. The main analysis uses 500-meter by 500-meter grid cells as the spatial unit of observation, overlaid on the administrative boundary of Shenzhen, a municipality covering approximately 2,050 square kilometers. Each complete cell spans 250,000 square meters, and we retain only cells with a clipped area of at least 200,000 square meters, dropping smaller boundary fragments and yielding 7,550 grid cells in total. For the quantitative model, data are aggregated to 1-kilometer by 1-kilometer grid cells. Firm-level, commuting, and geospatial data are harmonized to the relevant spatial unit, and where the underlying data vary over time, we construct grid-year panel measures of firm entry, firm stock, employment, firm performance, and other local characteristics.

**Firm entry and firm stock.** We measure the location and dynamics of firms using registration records from *China's State Administration for Industry and Commerce* (SAIC). The database contains registration information for firms in mainland China, regardless of firm size, ownership type, or revenue. For Shenzhen, the data cover newly registered firms from 1970 to 2020. We remove duplicate records using organization codes and firm names. The cleaned sample contains approximately 5.5 million firm-entry records. We geocode each firm using its registered address and assign it to the corresponding grid cell. Firm entry is measured as the number of newly registered firms in a grid cell and year. Firm stock is constructed from the set of registered firms located in each grid cell. For the quantitative model, the same geocoded firm records are aggregated to the 1-kilometer grid.

**Employment and firm performance.** We construct employment and firm-performance measures from the *Economic Census* and the *Tax Survey*. The Economic Census provides firm-level information for 2004, 2008, and 2013. We use the census waves as the main source for firms' employment. The Tax Survey is available from 2008 to 2020. Because the coverage of the Tax Survey depends on the sampling scale in each year, we focus on the years in which the number of sampled Shenzhen firms is relatively stable: 2008--2011 and 2014--2015. Both datasets report a rich set of firm operating variables. Key variables include assets, liabilities, owners' equity, operational revenue, cost, profit, taxes payable, industrial output, cash flow, etc.. These variables allow us to measure the scale, profitability, and export-related performance of firms. For each firm in the Economic Census and the Tax Survey, we link the record to the firm registration data to obtain business address.

**Commuting flows and commuting time.** We use commuting flow data provided by *Baidu Map*, a major digital mapping and navigation company in China. The company passively collects high-frequency location information from smartphones through its own map application and thirdparty applications that rely on its location services. Based on repeated location observations, the company infers each device's modal nighttime and daytime locations, interpreted as home and workplace locations, respectively. The commuting matrix used in this paper is constructed from home--workplace pairs observed during the three-month period ending in November 2024. The original data are recorded at a 10-meter by 10-meter spatial resolution. We map home and workplace locations to the relevant grid system and construct bilateral commuting flows between residence cells and workplace cells.

To measure bilateral commuting costs, we collect driving travel times using the API services provided by the same navigation provider. For each ordered pair of grid cells, we use the grid-cell centroids as the origin and destination and request the fastest driving route between them. The API requests were made on weekdays from March 3 to March 25, 2026, between 6:00 a.m. and 8:00 p.m. For each origin--destination pair, the API returns driving travel time measured by minutes and driving distance. To reduce computational burden, travel distances and times are computed between the centroids of 1-kilometer grid cells, yielding a total of 1,850 $\times$ 1,850 origin-destination pairs. This procedure produces travel-time information for all ordered grid-cell pairs.

**Building height, land use, floorspace stock and price** We measure the built environment using the Global Human Settlement Layer (GHSL), which provides building height for 2018 and built-up volume for every five years from 1975 to 2020. We aggregate the original raster cells to our grid cells using intersection-area weights rather than resampling the data. Built-up volume is summed within each grid cell, while building height is constructed as an area-weighted average.

We also use LUCC and CLCD land-use data, both available at 30-meter resolution. From LUCC, we identify urban construction land, rural residential land, and other industrial land; from CLCD, we use impervious surface as an alternative measure of built-up land. We combine these land-use measures with 30-meter building-height data from Zhang et al. (2025) to construct grid-level floor-space stock. Specifically, for built-up pixels within each grid cell, we compute floor-space stock as built-up area multiplied by building height divided by three meters per floor.

We measure floor-space prices for residential and industrial use using official guide prices published by the *Shenzhen Housing Leasing Industry Association* and the *Shenzhen Housing and Construction Bureau*. These data cover 1994--2017 and 2022. Prices are reported at a fine spatial resolution, defined by boundary descriptions approximating the street level. For residential properties, the guide prices are based on housing characteristics and rental transactions in the previous year. For industrial properties, the guide prices is made by taking into account factors such as regional development, local rental-market conditions, and industrial park characteristics. They are measured per unit of floor area, include taxes, and exclude water, electricity, gas, and property-management fees. We also use rental quotes from the LOULAN CRE database to check the official guide prices. The LOULAN data cover 2022--2024 and include 217 industrial parks with rental prices observed in multiple periods. The official guide prices and the LOULAN rental quotes are highly positively correlated. We therefore use the official guide prices as the main measure of floor-space prices in the analysis.

**Other Data** We also construct auxiliary measures of residential population, terrain, and road access. Residential population is measured using GlobPOP population counts for 1990--2022. GlobPOP is a global gridded population dataset that integrates several existing population products and reports aggregate raster-level population counts and densities. We use the population-count product and aggregate it to our grid cells using intersection-area weights. We use DEM data to measure local topographic conditions. For each grid cell, we compute terrain ruggedness based on the variation in elevation within the cell. We also use OpenStreetMap road network data to construct road density, defined as the total length of roads within a grid cell divided by the cell's area.

Table 2 reports descriptive statistics for the main variables used in the paper.

Table 2: Summary Statistics

| Variable Name | Meaning | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| $Num\_firm$ | Number of firm entry | 317,100 | 16.190 | 79.167 | 0 | 5418 |
| $flow$ | Number of commuters | 57,002,500 | 0.089 | 1.887 | 0 | 1231 |
| $emp$ | Number of employment | 22,650 | 381.147 | 1476.340 | 0 | 79250 |
| $firm\_stock$ | Number of firm stock | 22,650 | 14.351 | 63.792 | 0 | 2248 |
| $distance$ ($m$) | Distance to Shenzhen Wall | 317,100 | 7363.691 | 7720.782 | -9750 | 29560 |
| $Non\_SEZ$ | Dummy variable, 1 if outside SEZ | 317,100 | 0.799 | 0.401 | 0 | 1 |
| $Terrain$ | terrain ruggedness | 317,100 | 74.122 | 64.953 | 0 | 403 |

# 3 Empirical Design

## 3.1 Baseline model

We adopt a spatial regression discontinuity design to test whether firm entry jumps when crossing the Shenzhen Wall. The unit of observation is a 500m $\times$ 500m grid cell. Our baseline specification is

$$y_{it} = \alpha + \beta \text{Non\_SEZ}_i + f(Distance_i) + \theta \text{Terrain}_i + \tau_t + \varepsilon_{it}, \qquad |Distance_i| \leq h, \tag{1}$$

where $y_{it}$ denotes the outcome of grid cell $i$ in year $t$. The main outcomes include firm entry, $Num\_firm_{it}$, and employment, $Num\_Emp_{it}$. $Non\_SEZ_i$ is the treatment variable, which equals one if grid $i$ is outside the original SEZ and zero otherwise. $Distance_i$ is the signed distance from the centroid of grid $i$ to the Shenzhen Wall. We define the distance to be positive on the non-SEZ side and negative on the SEZ side. Following Harari and Wong (2025), $f(Distance_i)$ allows for separate cubic distance controls on either side of the nearest boundary. The term $\text{Terrain}_i$ controls for local topographic conditions. $\tau_t$ denotes year fixed effects. The baseline bandwidth is $h = 10{,}000$ meters. We assess the robustness of the results by varying the polynomial order and the bandwidth around the boundary. Standard errors are clustered at the grid level.

The coefficient of interest is $\beta$. Since the treatment variable is coded as $Non\_SEZ_i$, a positive $\beta$ means that the number of new firms is higher outside the wall, while a negative $\beta$ means that firm entry is higher inside the wall. The identifying assumption is that, within a narrow window around the Wall, other determinants of firm entry change smoothly with distance to the boundary. The discontinuous jump at the wall can be interpreted as the effect of being located on the non-SEZ side relative to the SEZ side.

### 3.2 Gravity model

We also adopt a gravity equation to test whether the Shenzhen Wall creates additional commuting friction. To be consistent with the discrete-choice model in Section 5, we aggregate commuting flows and travel times to 1,000m $\times$ 1,000m grid cells. The observation in this specification is an ordered residence--workplace grid pair $(i, j)$.

$$\begin{aligned}\mathbb{E}\left[\text{Flow}_{ij}\right] &= \exp\left(\nu \text{TravelTime}_{ij} + \lambda_i + \delta_j\right) \\ &= \exp\left(\nu \text{BaseTravelTime}_{ij} + \mathbf{1}\{\text{CrossWall}_{ij}\} + \lambda_i + \delta_j\right),\end{aligned}$$

where $Flow_{ij}$ is the number of commuters from residence grid $i$ to workplace grid $j$. $TravelTime_{ij}$ is the driving travel time between the centroids of the two grids, measured in minutes. This travel time can be viewed as the base travel time between the two locations plus any additional delay associated with crossing the Shenzhen Wall. The dummy variable $\mathbf{1}\{CrossWall_{ij} = 1\}$ equals one if the residence and workplace grids are located on different sides of the wall, and zero otherwise. $\mu_i$ and $\nu_j$ are origin and destination fixed effects, which absorb differences in residential size and workplace attractiveness across locations, including amenities and productivities.

We expect $\beta$ to be negative, indicating that, after controlling for commuting time, cross-wall location pairs have lower commuting flows than same-side pairs. We are also interested in $\nu$, which captures the semi-elasticity of commuting flows with respect to commuting time.

# 4 Empirical Result

## 4.1 Baseline Result

We use an RD-style binned scatter plot to show how firm entry changes with distance from the wall. In Figure 2, the horizontal axis reports the signed distance from each grid cell's centroid to the wall, with positive values for grids outside the SEZ and negative values for grids inside the SEZ. The vertical axis reports the logarithm of firm entry. The figure shows that firm entry peaks inside the SEZ, especially around Huaqiang South, Huaqiang North, and Shangbu, where firms in Shenzhen's key pillar industry, electronics and information technology, are highly concentrated. Moving from the SEZ interior toward the wall, firm entry gradually declines. After crossing the wall, firm counts display a visible upward jump and then gradually decline again as distance from the wall increases on the non-SEZ side. The jump in the firm count is around 5 in absolute level. This pattern shows that within the buffer zone around Shenzhen Wall, there are more new firms located outside the SEZ than inside the SEZ near the boundary.

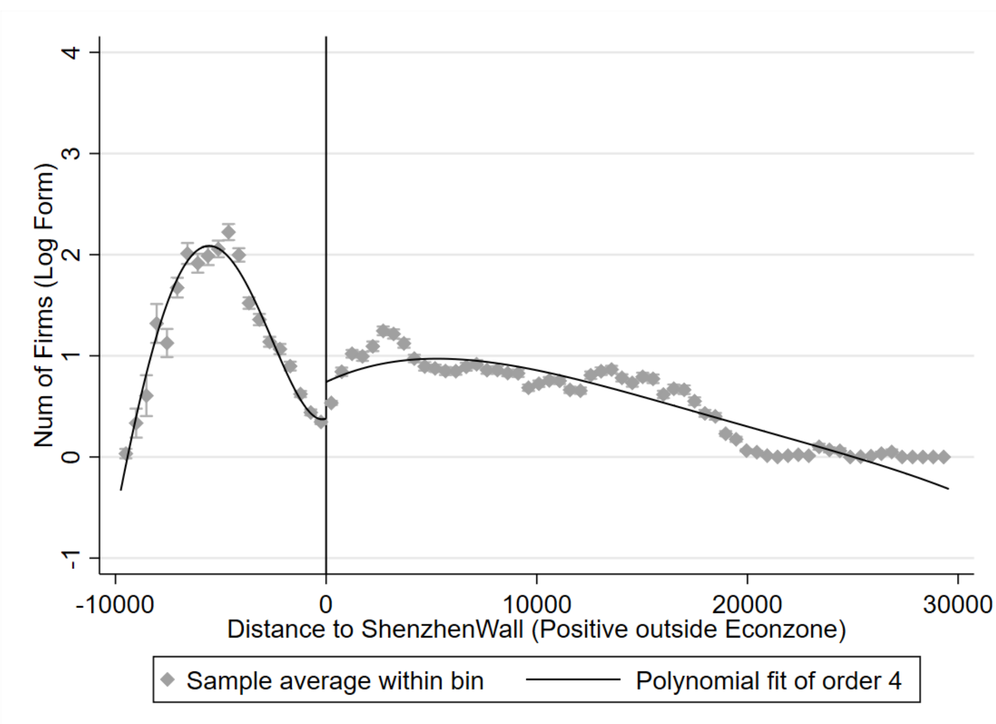



Figure 2: Spatial Discontinuity in Firm Entry

NOTES: The vertical axis is the number of firms in logarithm level. The horizontal axis is the distance of grid centriod to the wall. We keep positive distance for grids outside SEZ, and negative distance for grids inside SEZ. The vertical line $x = 0$ refers to Shenzhen Wall.

Table 3 reports the effect on employment size using the Economic Census in 2004, 2008, and 2013. We link census firms to grid cells and estimate the baseline regression separately for each census year using cross-sectional data. Because a bandwidth restriction would leave a smaller sample while the polynomial distance controls are relatively high-dimensional, we run the regressions without imposing a bandwidth restriction. Across all three census years, the coefficient on $Non\_SEZ$ is positive and statistically significant. The estimates range from 0.649 to 0.784, implying that employment is substantially higher on the non-SEZ side of the wall. This pattern is consistent with the idea that firms outside the SEZ have better access to the local labor pool than those inside the SEZ. It also aligns with Figure 2, which shows a concentration of firms outside the SEZ along the wall.

Table 3: Spatial Discontinuity in the Employment Size

| *Dep.Var.*: $\log(1 + Num\_Emp_{it})$ | (1) 2004 | (2) 2008 | (3) 2013 |
|---|---|---|---|
| $Non\_SEZ$ | 0.656*** | 0.649*** | 0.784*** |
| | (0.197) | (0.162) | (0.205) |
| Baseline controls | Yes | Yes | Yes |
| Bandwidth restriction | No | No | No |
| $N$ | 7,550 | 7,550 | 7,550 |

NOTES: The data are sourced from the *Economic Census*, which gives information about # of employment at the firm level and is available in 2004, 2008, and 2013. The specification is the same as the baseline model. The regression is run without bandwidth on cross-sectional data. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Based on the same dataset and the same cross-sectional baseline regression design, Table 4 reports the results for firm stock. The coefficient on $Non\_SEZ$ remains positive and statistically significant in all three census years. The weighted average increase in log firm stock across the three years is 0.332. Under a two-tier CES demand system with monopolistic competition and free entry, this jump corresponds to approximately a 7-minute increase in commuting time. [2]

Table 4: Spatial Discontinuity in the Firm Stock

| *Dep.Var.*: log (#firm stock) | (1) 2004 | (2) 2008 | (3) 2013 |
|---|---|---|---|
| $Non\_SEZ$ | 0.185*** | 0.406*** | 0.580*** |
| | (0.061) | (0.079) | (0.121) |
| Baseline controls | Yes | Yes | Yes |
| Bandwidth restriction | No | No | No |
| $N$ | 7,550 | 7,550 | 7,550 |

NOTES: The data are sourced from the *Economic Census*, which provides firm-level information on active enterprises for the years 2004, 2008, and 2013. The 2004 dataset covers the universe of manufacturing firms, whereas the 2008 and 2013 datasets are cross-industry samples. The specification is the same as the baseline model. The regression is run without bandwidth on cross-sectional data. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[2] The 2004 census covers the universe of manufacturing firms, while the 2008 and 2013 census waves are cross-industry samples, so the change in magnitudes across years should be interpreted with this difference in coverage in mind.

### 4.2 Robustness Check

Before jumping into the mechanism tests showing that labor accessibility is key to understanding the spatial discontinuity in firm counts and employment, we conduct a series of robustness checks. These checks show that the discontinuity in firm entry around the Shenzhen Wall is not driven by landscape, land regulations, administrative factors, or the RDD specification. We also conduct falsification tests by assuming "fake" walls located 2,000 meters away from the actual wall.

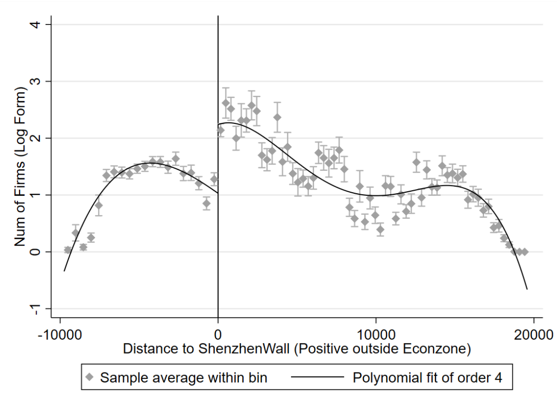
**Terrain.** Shenzhen's terrain contains substantial mountain ranges. The city is generally higher in the southeast and lower in the northwest, and its main mountain ranges run broadly from east to west through the central part of the city. The alignment of the historical SEZ management line was also partly shaped by construction constraints. Because of funding constraints and ease of construction, the Shenzhen Wall did not fully coincide with administrative boundaries, and some sections were drawn with reference to mountain ranges. One may therefore worry that the observed jump in firm entry is driven by geographical barriers rather than by the inspection system at the boundary.

To address this concern, we split the sample into the relatively flat western part of Shenzhen and the more mountainous eastern part. If mountains were driving the discontinuity, we would expect to see no significant jump in the flat subsample and a possibly significant jump in the mountainous subsample. The results point in the opposite direction: the jump in firm entry is larger and more statistically significant in the flat western subsample than in the mountainous eastern subsample.

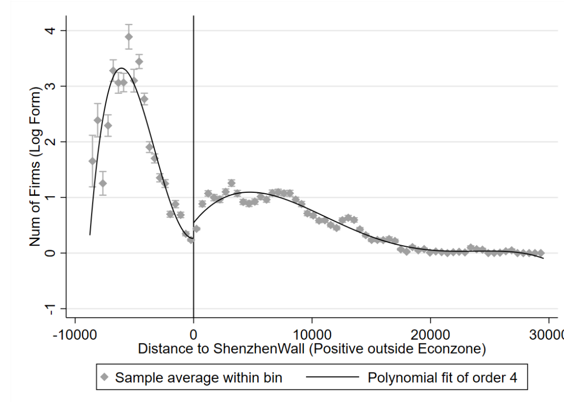
This pattern also helps address a key concern about the spatial RD design, namely that the apparent discontinuity in firm entry might simply reflect firms on both sides avoiding inspection building along the wall. The flat western subsample provides a cleaner setting because firms face weaker topographic constraints and have less incentive to avoid the boundary for geographical reasons. The clear jump in this subsample suggests that the discontinuity is not driven by geographical constraint along the wall.

**Polynomial Order.** Our baseline specification controls for smooth spatial trends using third order polynomials in distance on the two sides of the wall. We re-estimate the spatial RD specification using alternative polynomial orders, including linear and quadratic, and compare the result with that in baseline regression. The coefficient on $Non\_SEZ$ remains positive and statistically significant across specifications.

**Land-Use Constraints.** Another concern is that the discontinuity in firm entry may reflect differences in land use planning inside and outside SEZ. We therefore test whether land-use composition itself changes discontinuously at the wall. Table 6 reports spatial RD estimates using land-use




(a) Western part: without mountains




(b) Eastern part: with mountains

Figure 3: Western and Eastern Subsamples of Shenzhen

NOTES: The vertical axis is the number of entering firms in logarithm level. The horizontal axis is the geographical distance from the Shenzhen Wall. Positive values refer to grids outside the SEZ, and negative values refer to grids inside the SEZ. The vertical line at zero denotes the Shenzhen Wall. The left panel uses the relatively flat western subsample, while the right panel uses the mountainous eastern subsample.

Table 5: Alternative Polynomial Specifications

*Dep.Var.*: log (#firm entry)

| | (1) | (2) | (3) |
|---|---|---|---|
| | 1st order | 2nd order | 3rd order (baseline) |
| *Non_SEZ* | 0.301*** | 0.506*** | 0.172** |
| | (0.051) | (0.062) | (0.071) |
| *N* | 198,072 | 198,072 | 198,072 |

*Notes:* Column (3) presents our baseline specification using a third-order polynomial. Columns (1) and (2) report alternative specifications using first- and second-order polynomials, respectively.

shares as dependent variables. We focus on urban built-up land, rural residential land, and suburban industrial land. The results show no meaningful positive jump in urban built-up land or rural residential land on the non-SEZ side of the wall. Even though the suburban industrial land has a significant smaller share outside SEZ than inside SEZ, the difference indicate our baseline result could be underestimated. These results suggest that the higher firm entry outside the SEZ is not simply explained by a larger supply of industrial land at the boundary.

Table 6: Landuse type

*Dep.Var.*: Share of land use

| | (1) Urban built-up land | (2) Rural residential land | (3) suburban industrial land |
|---|---|---|---|
| $Non\_SEZ$ | 0.032 | 0.004 | -0.012* |
| | (0.023) | (0.003) | (0.006) |
| $N$ | 42,444 | 42,444 | 42,444 |

*Notes:* Data are sourced from the 30-meter resolution Land Use and Cover Change (LUCC) dataset. The three columns report urban built-up land, rural residential land, and other construction land, respectively.

**Administrative Borders.** Since the initial scope of the SEZ corresponded to the current southern four districts, the wall also partly coincided with county-level administrative boundaries. One may therefore worry that the discontinuity in firm entry outside the wall reflects a general border effect of county-level jurisdictions rather than the role of the SEZ management line itself. To address this concern, we conduct border-discontinuity tests along other county-level administrative borders. Specifically, we examine the three administrative boundaries among the four districts inside the SEZ and five administrative boundaries outside the SEZ. The county-level borders do not generally generate discontinuities in firm entry, either within or outside the SEZ. This suggests that the observed jump around the Shenzhen Wall is not driven by administrative border effects.

Table 7: Administrative Boundary Effects

**Panel A: Inside SEZ administrative boundaries**

| | (1) Futian–Luohu | (2) Luohu–Yantian | (3) Nanshan–Futian |
|---|---|---|---|
| *Treatment* | -0.283 | 0.058 | -0.538*** |
| | (0.372) | (0.194) | (0.206) |
| $N$ | 13,860 | 10,080 | 17,136 |

**Panel B: Outside SEZ administrative boundaries**

| | (1) Baoan–Guangming | (2) Baoan–Longhua | (3) Guangming–Longhua | (4) Longhua–Longgang | (5) Longhua–Pingshan |
|---|---|---|---|---|---|
| *Treatment* | 0.073 | -0.233 | -0.008 | -0.243* | 0.218*** |
| | (0.096) | (0.162) | (0.138) | (0.144) | (0.072) |
| $N$ | 49,014 | 16,590 | 18,186 | 31,710 | 53,970 |

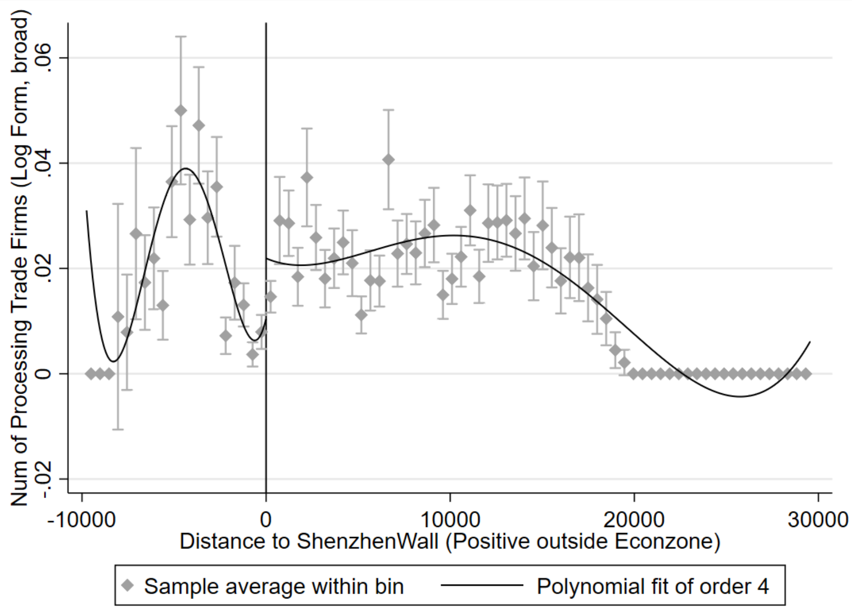



Figure 4: Spatial discontinuity for processing trade registered before 1995

**Policy Restrictions on Firm Entry.** A further concern is that the discontinuity in firm entry may be mechanically generated by later restrictions on market access inside the SEZ. In 1994, the Shenzhen government announced that, in order to promote high-tech industries and upgrade the industrial structure, new projects related to processing trade would no longer be approved inside the SEZ. The same policy also required existing processing trade firms inside the SEZ to gradually move outside the SEZ. This policy creates a direct concern for our interpretation: the larger number of firms outside the wall may reflect post-policy entry restrictions, rather than the underlying labor-access advantage of locations outside the wall.

To address this concern, we focus on processing trade firms established before the policy became effective. Before entry restrictions for this sector took effect, the location choices of processing trade firms were largely shaped by non-policy factors. The RD plot shows that, in years earlier than 1994, these firms were already more likely to locate outside the wall. This pattern reinforces the importance of labor accessibility for understanding the discontinuity in firm counts around the boundary.

**Falsification Test.** Finally, we conduct a falsification test by shifting the Shenzhen Wall two kilometers north and south and re-estimating the baseline specification at these placebo boundaries. The placebo estimates are not statistically significant, suggesting that the baseline discontinuity is not generated by an arbitrary boundary placement.

Table 8: Falsification Test

*Dep.Var:* log(#firm entry)

| | (1) Shift 2km North | (2) Shift 2km South |
|---|---|---|
| $Falsi\_Non\_SEZ$ | 0.064 | -0.083 |
| | (0.090) | (0.118) |
| Baseline controls | Yes | Yes |
| Bandwidth restriction | Yes | Yes |
| $N$ | 198,072 | 198,072 |

*Notes:* Data are sourced from registration data. Columns (1) and (2) present the estimated discontinuities in firm counts across counterfactual boundaries shifted 2,000 meters to the north and south, respectively.

### 4.3 Mechanism Test

We argue that the higher concentration of firms on the outside-SEZ side of the wall is primarily driven by a discontinuous improvement in labor accessibility when moving from inside to outside the SEZ. Firms outside the SEZ can draw on a large local labor pool without requiring workers to hold border passes or commute across the wall. By contrast, firms inside the SEZ face additional commuting frictions when hiring workers from outside the wall. These frictions increase effective labor costs and strengthen firms' incentives to locate on the outside-SEZ side.

To test this mechanism, we proceed in two steps. First, we classify firms into labor-intensive and capital-intensive sectors and use the same spatial RD specification as in Equation 1 to compare the size of the discontinuity across industries. If labor accessibility is the key mechanism, the discontinuity should be stronger for firms whose production relies more heavily on labor input.Second, we estimate the gravity equation in Equation 2 to examine whether the wall reduces commuting flows between the two sides of the SEZ boundary.

Table 9 shows that the jump in firm entry around the wall is larger for labor-intensive industries than for capital-intensive industries. This pattern is consistent with our hypothesis: when firms rely more heavily on labor input, access to the local labor pool becomes more important, making outside-SEZ locations more attractive relative to inside-SEZ locations.

Table 10 shows that the wall imposes a significant friction on commuting flows. Conditional on commuting time and origin and destination fixed effects, cross-wall residence--workplace pairs have significantly lower commuting flows than same-side pairs. It should be noted that the gravity equation is estimated using commuting data from 2024, by which point Shenzhen had already undertaken substantial integration efforts across the SEZ boundary—including the removal of legacy checkpoints, the construction and widening of roads connecting the SEZ and non-SEZ areas, and improvements to public transit and metro infrastructure linking the two zones. That our results nonetheless reveal significantly lower commuting flows across the Wall than within either side suggests that the barrier's influence on spatial mobility persists even as integration progresses.

Table 9: Heterogeneous Effects on Labor- and Capital-Intensive Industries

| *Dep.Var.*: log (firm entry) | (1) Labor-intensive | (2) Capital-intensive |
|---|---|---|
| $Non\_SEZ$ | 0.066*** | 0.034** |
| | (0.025) | (0.016) |
| Baseline controls | Yes | Yes |
| Bandwidth restriction | Yes | Yes |
| $N$ | 198,072 | 198,072 |

NOTES: Data source is firm registration data. The discontinuity design is run at a bandwidth of 10 $km$. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 10: Commuting Across the Wall (Nov 2024)

| | (1) log $(flow)$ | (2) $flow$ |
|---|---|---|
| TravelTime | -0.0080*** | -0.1301*** |
| | (0.0003) | (0.0020) |
| CrossWall | -0.1624*** | -0.3609*** |
| | (0.0130) | (0.0635) |
| Specification | ols | ppml |
| Origin Grid FE | Yes | Yes |
| Dest Grid FE | Yes | Yes |
| $N$ | 3,422,500 | 2,535,966 |

NOTES: Data are drawn from *Baidu Map*. The dependent variable in Column (1) is # of flows in logarithmic level, and that in Column (2) is # of flows in absolute level. Each regression is run at the 1,000$m$ $\times$ 1,000$m$ grid-pair level. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

### 4.4 Dynamic Patterns

We argue that the Shenzhen Wall had persistent effects on commuting costs and, through this channel, on employment distribution and firm dynamics. Because long-run commuting and employment data are limited, we use firm registration records from 1970 to 2020 to trace the long-run spatial pattern around the wall. Specifically, we estimate the cross-sectional spatial RDD year by year and report the coefficient on *Non_SEZ* in Figure 5. Registration records before 1979 are sparse, so we pool firm entries from the first ten years and label them as observations in 1979. For each year, the figure reports the estimated coefficient and its 90 percent confidence interval. A coefficient significantly above zero indicates a positive jump in firm entry, with more firms located outside the SEZ in that year. The results show that the discontinuity persists well beyond 2010 and into the post-removal period, indicating a long-term effect of committing frictions around the wall. The agglomeration forces helped sustain the spatial pattern even after the wall was removed.

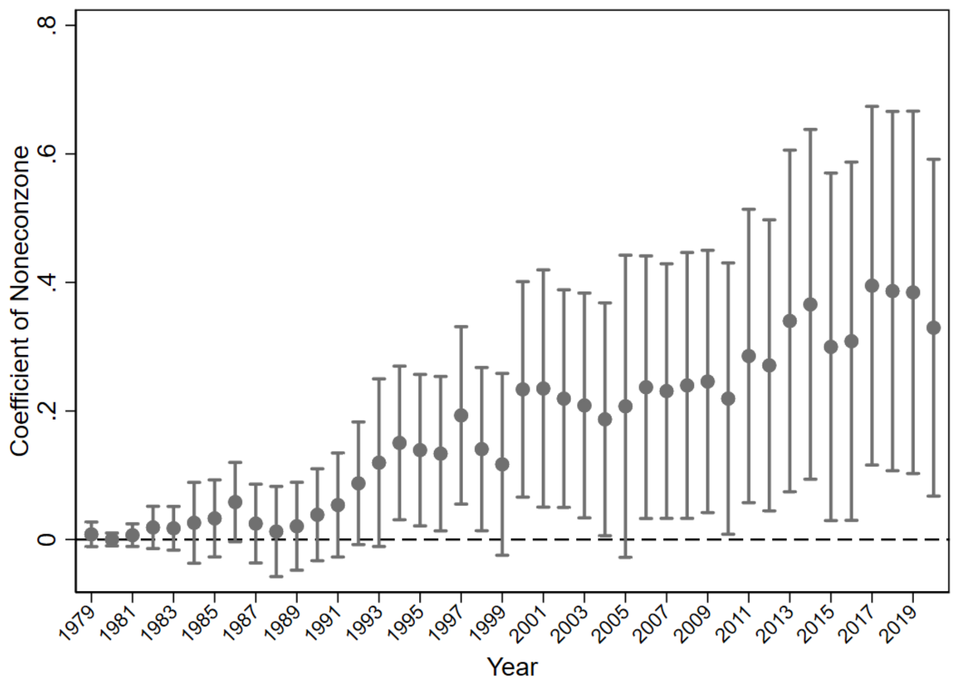



Figure 5: Spatial Discontinuity Across Years

### 4.5 Extensive Discussion

We also test for the distribution of firm performance along the wall, including sales, profits, Total Factor Productivity (TFP). Since firms choose their locations after observing local business conditions and on the basis of their own unobserved "managerial ability," the presence of the wall may induce spatial sorting, with less productive firms remaining outside the wall. To examine this possibility, we use Annual Survey of Industrial Firms (ASIF), Tax Survey to compare firms located on either side of the wall in terms of performance, size, and productivity.

We did not find any spatial discontinuity in firms' TFP, sales, profits and cash flow. That is, we cannot find any evidence of spatial sorting by firms' own operating ability across the wall.

Table 11: Spatial Discontinuity in TFP

| | (1) gmm | (2) op | (3) lp |
|---|---|---|---|
| $Non\_SEZ$ | -0.033 | 0.053 | 0.052 |
| | (0.162) | (0.167) | (0.167) |
| Baseline controls | Yes | Yes | Yes |
| Bandwidth restriction | Yes | Yes | Yes |
| $N$ | 8,756 | 8,756 | 8,756 |

*Notes:* Our data are sourced from the Annual Survey of Industrial Firms (ASIF), covering detailed firm-level characteristics of mainland Chinese manufacturing enterprises with annual sales above 20 million RMB during 1998–2007. The three columns present TFP estimates obtained via the GMM, LP, and OP approaches, respectively.

Table 12: Spatial Discontinuity in Firm Performance

| | ExportSales | TotProfit | NetProfit | OptCashOutflow |
|---|---|---|---|---|
| noneconzone | 0.909 | 0.077 | 0.097 | 0.461 |
| | (0.792) | (0.503) | (0.506) | (0.613) |
| $N$ | 12,626 | 8,616 | 8,736 | 12,626 |

*Notes:* Our data are sourced from the tax survey data. Because firms are relatively sparsely distributed across space, we run the regression at the firm level.

# 5 Model

The reduced-form evidence shows that firm counts and employment display a sharp discontinuity around the Shenzhen Wall, and the mechanism tests suggest that this pattern is closely related to a discontinuous change in labor accessibility. The wall raises the cost of cross-boundary commuting through detours and delays: workers can still cross the boundary, but doing so becomes more costly than commuting within the same side of the wall. We now develop a quantitative spatial model to discipline how this spatial variation in commuting costs affects workers' residence and workplace choices, firms' access to labor, the equilibrium distribution of economic activity, and welfare.

The model follows the quantitative spatial general equilibrium framework used to study the internal structure of cities, as in Ahlfeldt et al. (2015); Heblich et al. (2020); Nagy (2021); Tsivanidis (2026). Shenzhen is represented by a finite set of discrete locations, indexed by $i, j \in \mathbb{N}$. Locations differ in exogenous residential amenities $B_i$, baseline productivity $A_i^0$, residential and commercial floor-space supplies $L_{Ri}$ and $L_{Mi}$, and bilateral commuting time $t_{ij}$ to every other location. The Shenzhen Wall enters the model as an additional bilateral commuting friction for residence--workplace pairs located on different sides of the boundary. This formulation captures the empirical fact that the wall did not eliminate cross-boundary movement, but increased the effective cost of such movement.

The economy contains three types of agents: workers, firms, and absentee landlords. Workers choose where to live and where to work, taking wages, amenities, floor-space prices, and commuting costs as given. Firms choose where to produce and hire labor, taking local productivity, wages, commercial floor-space prices, and access to workers as given. Absentee landlords own residential and industrial floor space and receive rental income.

To reduce computational complexity, the quantitative model uses 1km $\times$ 1km grid cells. This gives 2,050 locations in total. These locations can be interpreted as fine spatial units comparable to neighborhoods, or blocks.

### 5.1 Workers

Workers are perfectly mobile across Shenzhen and the broader economy. Before moving to Shenzhen, a worker compares the expected utility from all possible residence--workplace pairs in the city with the reservation utility in the outside economy. Conditional on moving to Shenzhen, the worker observes idiosyncratic preference shocks for all residence--workplace pairs and chooses where to live and where to work. This discrete-choice structure allows workers to sort across locations according to wages, residential amenities, floor-space prices, commuting costs, and idiosyncratic tastes.

Consider worker $o$ who lives in location $i$ and works in location $j$. The worker's indirect utility is

$$V_{ijo} = B_{ij} \frac{w_j}{d_{ij} r_{Ri}^{1-\alpha}} \nu_{ijo}, \tag{2}$$

where $w_j$ is the wage paid in workplace location $j$, $r_{Ri}$ is the residential floor-space price in location $i$, and $1-\alpha$ is the expenditure share on residential floor space. The term $B_{ij}$ is a bilateral amenity shifter common to all workers choosing pair $(i, j)$. We allow it to contain a residence component, a workplace component, and a match-pair component: $B_{ij} = \mathcal{B}_i^R \mathcal{B}_j^M \mathcal{B}_{ij}$.

The idiosyncratic term $\nu_{ijo}$ captures worker $o$'s match-specific preference for living in $i$ and working in $j$. We assume that $\nu_{ijo}$ is independently drawn from a Fréchet distribution,

$$F(\nu_{ijo}) = \exp\{-\nu_{ijo}^{-\epsilon}\},$$

where the scale parameter is normalized to one and the shape parameter $\epsilon > 1$ governs the dispersion of idiosyncratic preferences. A smaller $\epsilon$ implies more heterogeneity in tastes and weaker sorting in response to systematic utility differences; a larger $\epsilon$ implies stronger sorting toward locations with higher wages, better amenities, lower rents, and lower commuting costs.

The commuting cost between residence $i$ and workplace $j$ is $d_{ij} = \exp\{\kappa \tau_{ij}\}$, where $\kappa$ converts commuting time into utility cost. The key role of the Shenzhen Wall is to change the effective commuting time $\tau_{ij}$. If the residence and workplace are on the same side of the wall, workers take the direct route. If they are on different sides, workers must detour through a checkpoint and may also face an inspection delay. Formally,

$$\tau_{ij} = \begin{cases} t_{ij}, & \text{if } i \text{ and } j \text{ belong to the same zone,} \\ \min_{m \in \mathcal{M}} \{t_{im} + t_{mj} + t_{m0}\}, & \text{if } i \text{ and } j \text{ belong to different zones,} \end{cases} \tag{3}$$

where $\mathcal{M}$ denotes the set of checkpoints, $t_{im} + t_{mj}$ captures the detour required to cross the wall through checkpoint $m$, and $t_{m0}$ denotes the inspection delay at that checkpoint. This formulation captures the central friction in the model: the wall does not shut down cross-boundary commuting, but it raises the effective cost of cross-wall residence--workplace matches.

Workers face a clear tradeoff. A high-wage workplace raises utility, but reaching it may require a costly commute. A residence with high amenities is attractive, but it may have higher residential floor-space prices or weaker access to jobs. The wall affects this tradeoff by increasing $d_{ij}$ for cross-wall pairs. Given the Fréchet taste shocks, the probability that a worker chooses to live in $i$ and work in $j$ takes the gravity form:

$$\pi_{ij} = \frac{(B_{ij} w_j)^{\epsilon} \left(d_{ij} r_{Ri}^{1-\alpha}\right)^{-\epsilon}}{\sum_{k \in \mathbb{N}} \sum_{\ell \in \mathbb{N}} (B_{k\ell} w_\ell)^{\epsilon} \left(d_{k\ell} r_{Rk}^{1-\alpha}\right)^{-\epsilon}}. \tag{4}$$

This gives the conditional probability of working in location $j$ given residence $i$, and that of residing in $i$ given workplace $j$ as:

$$\pi_{j|i} = \frac{(B_{ij} w_j / d_{ij})^{\epsilon}}{\sum_{\ell \in \mathbb{N}} (B_{i\ell} w_\ell / d_{i\ell})^{\epsilon}}, \quad \pi_{i|j} = \frac{(B_{ij} r_{Ri}^{\alpha-1} / d_{ij})^{\epsilon}}{\sum_{k \in \mathbb{N}} (B_{kj} r_{Rk}^{\alpha-1} / d_{kj})^{\epsilon}},$$

where the denominator correspond to residential commuter market access (RCMA) and firm commuter market access (FCMA) defined in Tsivanidis (2026):

$$RCMA_i \equiv \sum_{\ell \in \mathbb{N}} \left( \frac{B_{i\ell} w_\ell}{d_{i\ell}} \right)^{\epsilon}, \quad FCMA_j \equiv \sum_{k \in \mathbb{N}} \left( \frac{B_{kj} r_{Rk}^{\alpha-1}}{d_{kj}} \right)^{\epsilon}.$$

$RCMA_i$ summarizes the set of job opportunities accessible to residents of location $i$. It is higher when the nearby workplaces offer higher wages or better amenities, and it is lower when commuting costs are high. $FCMA_j$ summarizes a workplace location's access to potential workers across residential origins. It is higher when a workplace can draw workers from low-rent and easily accessible residential locations.

Cross-wall commuting frictions leads to discontinuity in commuting cost ($d_{ij}$) across the border, and affect employment through discontinuous $RCMA_i$ and $FCMA_j$.

Aggregating individual choices gives the consistency conditions for residential population and workplace employment. Let $H_{Ri}$ denote the number of residents in location $i$ and $H_{Mj}$ denote workplace employment in location $j$. We have:

$$H_{Mj} = \sum_{i \in \mathbb{N}} \frac{(B_{ij} w_j / d_{ij})^{\epsilon}}{RCMA_i} H_{Ri}, \quad H_{Ri} = \sum_{j \in \mathbb{N}} \frac{(B_{ij} r_{Ri}^{\alpha-1} / d_{ij})^{\epsilon}}{FCMA_j} H_{Mj}.$$

Finally, free mobility between Shenzhen and the rest of the economy pins down the expected utility of moving to the city. Let $\bar{U}$ denote the reservation utility in the broader economy. In equilibrium,

$$\bar{U} = \mathbb{E}(U) = \Gamma_{\epsilon} \left[ \sum_{k \in \mathbb{N}} \sum_{\ell \in \mathbb{N}} (B_{k\ell} w_{\ell})^{\epsilon} \left( d_{k\ell} r_{Rk}^{1-\alpha} \right)^{-\epsilon} \right]^{1/\epsilon}, \tag{5}$$

where $\Gamma_{\epsilon}$ is the Fréchet expectation constant. Equation 5 implies that higher commuting costs reduce the inclusive value of living and working in Shenzhen. With free mobility, workers move out and wages and rents adjust until expected utility again equals the outside reservation utility. This mechanism motivates the counterfactual exercises below, in which we start from a wall-free benchmark and increase $d_{ij}$ for cross-wall residence--workplace pairs to quantify the effects of boundary frictions.

Throughout the model, workers spend on residential floor space and the numeraire good. We interpret non-housing consumption as taking place outside Shenzhen, or equivalently as remitted income, so wage income does not generate local demand for firms' output. [3]

### 5.2 Firms

A firm located in $j$ combines labor $H_{Mj}$ and industrial floor space $L_{Mj}$ using a constant-returns Cobb--Douglas technology:

$$y_j = A_j \left( \frac{H_{Mj}}{\beta} \right)^{\beta} \left( \frac{L_{Mj}}{1-\beta} \right)^{1-\beta}, \tag{6}$$

[3] This assumption is motivated by the fact that Shenzhen is predominantly an export-oriented economy: most of its output is produced for foreign markets rather than for local sale. In addition, diverting export-designated goods to the domestic market is typically subject to strict regulation: Products originally intended for export must pay additional duties and related taxes if sold domestically. Therefore, export-oriented firms generally do not enjoy a price advantage in the local market. To highlight the key mechanism and keep the analysis tractable, we abstract from this "export-to-domestic" channel in the model, and therefore treat wage income as not generating local consumption demand.

where $A_j$ is location-specific productivity and $\beta$ is the labor share in production. Firms take wages ($w_j$), industrial floor-space rents ($r_{Mj}$), output prices, and trade costs as given. Consistent with Shenzhen's role as an export-oriented economy, we assume that output is sold to outside markets at a fixed price $p$. Delivering goods from location $j$ to outside markets requires a location-specific trade cost $\tau_{0j}$. The effective revenue productivity of location $j$ is therefore $\mathbb{A}_j \equiv \frac{A_j p}{\tau_{0j}}$.

A firm in location $j$ chooses labor and industrial floor space to maximize profits:

$$\Pi_j = \frac{p}{\tau_{0j}} A_j \left( \frac{H_{Mj}}{\beta} \right)^{\beta} \left( \frac{L_{Mj}}{1-\beta} \right)^{1-\beta} - w_j H_{Mj} - r_{Mj} L_{Mj}. \tag{7}$$

Free entry and constant returns imply zero profits in any location with positive production. The zero-profit condition implies:

$$\mathbb{A}_j = w_j^{\beta} r_{Mj}^{1-\beta}.$$

A location with higher effective productivity can support higher wages or higher floorspace rents.

The first-order conditions gives the optimal factor input level:

$$\frac{w_j H_{Mj}}{r_{Mj} L_{Mj}} = \frac{\beta}{1-\beta}. \tag{8}$$

### 5.3 Absentee Landlord

Floor space in each location can be used either for residential or industrial purposes. We assume that floor space is owned by absentee landlords, who collect residential and industrial rents and spend this income outside Shenzhen.

Let $L_i$ denote the total supply of floor space in location $i$, and let $\theta_i$ $(1-\theta_i)$ denote the share of floor space allocated to industrial (residential) use. $r_{Ri}$ is the residential floor-space rent, and $r_{Mi}$ is the commercial floor-space rent. Land-use regulations may restrict the conversion of residential floor space into commercial use. We capture this restriction by a location-specific wedge $\xi_i \geq 1$, which can be interpreted as one plus the tax equivalent of land-use regulations that restrict industrial use relative to residential use.

Land-market equilibrium requires no arbitrage between residential and industrial uses after accounting for this regulatory wedge. The allocation of floor space satisfies

$$\begin{aligned}
&\theta_i = 1 \quad \text{if} \quad r_{Mi} > \xi_i r_{Ri}, \\
&\theta_i \in [0,1] \quad \text{if} \quad r_{Mi} = \xi_i r_{Ri}, \\
&\theta_i = 0 \quad \text{if} \quad r_{Mi} < \xi_i r_{Ri}.
\end{aligned}$$

Thus, floor space is allocated entirely to the use that delivers the higher effective rent. Mixed land use arises only when commercial and residential uses yield the same return after adjusting for the regulatory wedge.

Residential floor-space demand follows from workers' utility maximization. The total residential floor-space demand in location $i$ is proportional to the expected wage income of residents in that location:

$$L_{Ri} = (1-\alpha)\frac{\mathbb{E}(w_j \mid i) H_{Ri}}{r_{Ri}} = (1-\theta_i)L_i. \tag{9}$$

where $\mathbb{E}(w_j \mid i)$ is the expected wage of residents living in $i$, averaging across their possible workplace choices.

Industrial floor-space demand follows from firms' cost minimization. The demand for commercial floor space in location $i$ is

$$L_{Mi} = \frac{1-\beta}{\beta}\frac{w_i H_{Mi}}{r_{Mi}} = \theta_i L_i, \tag{10}$$

Equation 9 and Equation 10 close the floor-space market: residential and industrial demands must add up to the fixed local supply of floor space,

$$L_{Ri} + L_{Mi} = L_i. \tag{11}$$

These conditions connect commuting frictions to floor-space prices. When the wall raises commuting costs, it changes the residential demand generated by workers and the commercial demand generated by firms across locations. Rents and the allocation of floor space between residential and commercial use adjust until both floor-space markets clear and no arbitrage remains between the two uses.

**Define equilibrium.** Given parameters $\{\alpha,\beta,\kappa,\epsilon\}$, the reservation utility in the broader economy $\bar{U}$, and location fundamentals $\{A_j, B_{ij}, L_i, \xi_i, \tau_{0j}, d_{ij}\}$, an equilibrium consists of residential and workplace distributions $\{\pi_{Ri}, \pi_{Mj}\}$, prices $\{w_j, r_{Ri}, r_{Mi}\}$, floor-space allocations $\theta_i$, and total city population $H_{\mathbb{N}}$ such that the following conditions hold.

1. Workers choose residence--workplace pairs optimally. Residential and workplace distributions are consistent with these probabilities (Equation 4).

2. Firms choose labor and industrial floor space to maximize profits (Equation 8).

3. The market reaches equilibrium when firms sufficiently enter into markets with zero profits (Equation 8).

4. Floor-space markets clears (Equation 9 and Equation 10).

5. There is no-arbitrage across residential and commercial uses (Equation 11).

6. Population freely enter into Shenzhen and total population $H_{\mathbb{N}}$ adjusts until the expected utility from moving to Shenzhen equals the outside reservation utility (Equation 5).

# 6 Structural Calibration

We calibrate a set of model parameters, $\{\alpha, \beta\}$, so that the model is consistent with the aggregate economic performance of Shenzhen. Specifically, using information on per capita monthly household consumption across income groups in Shenzhen, we set the expenditure share on floor space $(1-\alpha)$ to 0.2. Based on the composition of Guangdong Province's gross regional product, we set the labor-cost share in firms' total costs $(\beta)$ to 0.55.

We calibrate the Fréchet shape parameter $(\epsilon)$ and the elasticity of commuting costs with respect to commuting time $(\kappa)$ using the Equation 2. The coefficient on TravelTime identifies the composite parameter governing the decay of commuting flows with travel time, $\nu = \epsilon\kappa$. We then calibrate $\epsilon$ to match the dispersion of wages, following the wage-based approach in Ahlfeldt et al. (2015); Gu, Wang, Wang, and Zhang (2025). This procedure gives $\epsilon = 5.09$ and $\kappa = 0.0256$, which are close to the estimates in the Shenzhen subsample mentioned in Gu et al. (2025).

We allow productivity to depend on production fundamentals, $a_j$, and production externalities, $\Upsilon_j$:

$$A_j = a_j \Upsilon_j^{\mu_A}, \qquad \Upsilon_j \equiv \sum_{s=1}^{S} e^{-\delta\tau_{js}} \left(\frac{H_{Ms}}{K_s}\right). \tag{12}$$

Similarly, residential amenities depend on residential fundamentals, $b_i$, and residential externalities, $\Omega_i$:

$$B_i = b_i \Omega_i^{\mu_U}, \qquad \Omega_i \equiv \sum_{r=1}^{S} e^{-\rho\tau_{ir}} \left(\frac{H_{Rr}}{K_r}\right). \tag{13}$$

The parameters $\mu_A$ and $\mu_U$ capture the strength of production and residential externalities, respectively. We calibrate the externality parameters $\mu_A$ and $\mu_U$ using the average values reported in Ahlfeldt et al. (2015). Table 13 summarizes the parameter values used in the quantitative analysis.

Table 13: Calibrated Model Parameters

| Parameter | Definition | Value | Notes |
|---|---|---|---|
| $1-\alpha$ | Share of workers' expenditure on housing consumption | 0.20 | SZ Stat. Yearbook |
| $\beta$ | Share of firms' expenditure on labor | 0.55 | GD Stat. Yearbook |
| $\epsilon$ | Fréchet shape parameter | 5.09 | Wage-based calibration |
| $\kappa$ | Size of commuting costs | 0.0256 | Gravity and wage-based calibration |
| $\mu_A$ | Workplace agglomeration elasticity | 0.07 | Ahlfeldt et al. (2015) |
| $\mu_U$ | Residential agglomeration elasticity | 0.15 | Ahlfeldt et al. (2015) |
| $\rho$ | spatial decay of amenity externalities | 0.75 | Ahlfeldt et al. (2015) |
| $\delta$ | Spatial decay of productivity externalities | 0.36 | Ahlfeldt et al. (2015) |

NOTES: This table reports the calibrated parameters used in the quantitative model. $\alpha$ and $\beta$ are calibrated to match the statistical yearbook. $\epsilon$ and $\kappa$ are calibrated to match the gravity model and wage dispersions obtained from a job-posting dataset. We set up externality terms ($\mu_A, \mu_U, \rho$ and $\delta$ ) follwing Ahlfeldt et al. (2015).

# 7 Counterfactual Analysis

## 7.1 Counterfactual Settings

We use the calibrated model to ask how today's wall-free Shenzhen would change if the Shenzhen Wall were still in place. The baseline economy is calibrated to match the 2024 allocation and price levels, after the wall had been removed and the road network had been improved to connect the former SEZ and non-SEZ areas. We then construct a counterfactual economy by reintroducing the wall as a higher commuting cost for residence--workplace pairs located on different sides of the historical boundary. This exercise quantifies both the aggregate effects of boundary frictions on labor allocation and factor prices and their distributional consequences across the two sides of the wall. In particular, we ask whether the SEZ or the non-SEZ would experience a larger decline in labor supply if the wall were still in operation.

We do the counterfactual analysis in an open economy. Let $x$ denote the value of the benchmark equilibrium and $x'$ its value in the counterfactual equilibrium. We use hats to denote proportional changes, $\widehat{x} = \frac{x'}{x}$. The counterfactual shock is a change in bilateral commuting costs, $\widehat{d_{ij}}$. In the counterfactual, $\widehat{d_{ij}} = 1$ for same-side residence--workplace pairs and $\widehat{d_{ij}} > 1$ for cross-wall pairs. The magnitude of shock is measured with the increase in commuting time $\Delta\tau_{ij}$, i.e., $\widehat{d_{ij}} = \exp\{\kappa\Delta\tau_{ij}\}$. We model the additional commuting time induced by the wall as the sum of two components: the detour required to reach a checkpoint and the inspection delay at the checkpoint. The inspection delay, denoted by $t_{m0}$, is allowed to vary from 0 to 30 minutes. Therefore, the counterfactual with $t_{m0} = 0$ captures the effect of the detour alone.

Specifically, let $m(i, j)$ denote the closest checkpoint for a cross-wall residence--workplace pair

$(i, j)$. The additional commuting time is

$$\Delta \tau_{ij} = \begin{cases} t_{im(i,j)} + t_{m(i,j)j} - t_{ij} + t_{m0}, & \text{if } i \text{ and } j \text{ belong to different zones,} \\ 0, & \text{if } i \text{ and } j \text{ belong to the same zone.} \end{cases}$$

The counterfactual change of the endogenous variables can be summarized with the function system:

1. The change in the joint probability of living in $i$ and working in $j$ is

$$\widehat{\pi}_{ij} = \frac{\widehat{B}_{ij}^{\epsilon} \widehat{w}_j^{\epsilon} \widehat{d}_{ij}^{-\epsilon} \widehat{r}_{Ri}^{-\epsilon(1-\alpha)}}{\sum_{m \in \mathcal{N}} \sum_{n \in \mathcal{N}} \pi_{mn}^0 \widehat{B}_{mn}^{\epsilon} \widehat{w}_n^{\epsilon} \widehat{d}_{mn}^{-\epsilon} \widehat{r}_{Rm}^{-\epsilon(1-\alpha)}}. \tag{14}$$

2. On the firm side, zero profits imply that workplace wages adjust with effective productivity, commercial floor space, and workplace employment:

$$\widehat{w}_j = \widehat{\mathbb{A}}_j \left( \frac{\widehat{L}_{Mj}}{\widehat{H}_{Mj}} \right)^{1-\beta}, \tag{15}$$

3. Industrial and residential floor-space rents are pinned down by:

$$\widehat{r}_{Mj} = \left( \frac{\widehat{\mathbb{A}}_j}{\widehat{w}_j^{\beta}} \right)^{\frac{1}{1-\beta}}, \quad \widehat{r}_{Ri} = \frac{\widehat{\mathbb{E}[w \mid i]} \widehat{H}_{Ri}}{\widehat{L}_{Ri}}, \tag{16}$$

   where $\mathbb{E}[w \mid i]$ is the expected wage of residents in location $i$, averaging across their workplace choices, and Residential and commercial floor-space demands must add up to the constant local floor-space supply ($\widehat{L}_i = 1$).

4. The counterfactual allocation between residential and industrial use continues to satisfy the no-arbitrage condition in Equation 9.

5. When amenities and productivity are held fixed without considering agglomeration externalities, we set $\widehat{B}_{ij} = 1$ and $\widehat{\mathbb{A}}_j = 1$. When agglomeration forces are active, effective productivity and amenities also adjust with the counterfactual employment and residential population distributions. Production externalities imply

$$\widehat{A}_j = \widehat{\Upsilon}_j^{\mu_A}, \qquad \widehat{\Upsilon}_j = \frac{\sum_{s \in \mathcal{N}} e^{-\delta \tau_{js}^1} \left( H_{Ms}^0 \widehat{H}_{Ms} / K_s \right)}{\sum_{s \in \mathcal{N}} e^{-\delta \tau_{js}^0} \left( H_{Ms}^0 / K_s \right)}. \tag{17}$$

   Similarly, residential externalities imply

$$\widehat{B}_i = \widehat{\Omega}_i^{\mu_U}, \qquad \widehat{\Omega}_i = \frac{\sum_{r \in \mathcal{N}} e^{-\rho \tau_{ir}^1} \left( H_{Rr}^0 \widehat{H}_{Rr} / K_r \right)}{\sum_{r \in \mathcal{N}} e^{-\rho \tau_{ir}^0} \left( H_{Rr}^0 / K_r \right)}. \tag{18}$$

6. Free mobility pins down total population. Since the reservation utility in the broader economy is held fixed, the inclusive value of residence--workplace choices must remain unchanged:

$$1 = \left[ \sum_{m \in \mathcal{N}} \sum_{n \in \mathcal{N}} \pi^0_{mn} \widehat{B}^{\epsilon}_{mn} \widehat{w}^{\epsilon}_{n} \widehat{d}^{-\epsilon}_{mn} \widehat{r}^{-\epsilon(1-\alpha)}_{Rm} \right]^{1/\epsilon} . \tag{19}$$

## 7.2 Counterfactual Results

**Total population.** When the wall is in place, higher commuting costs reduce the inclusive value of living and working in Shenzhen. In an open-city equilibrium, some workers leave Shenzhen when the outside economy offers the fixed reservation utility. As a result, the scale of the city falls as commuting frictions increase. Table 14 reports the relative size of the city's population under different counterfactual scenarios, with a value of one indicating no change relative to the 2024 benchmark, a value below one indicating population decline, and a value above one indicating population growth. The results show that, when the wall only creates route detours without inspection delays, the total population falls to about 95 percent of the benchmark level. When the inspection delay is large, the outflow becomes stronger, and the population falls further to about 92.3 percent.

The population loss is smaller when we shut down agglomeration effects by holding productivity and amenities fixed at their 2024 levels. In this case, higher commuting frictions still induce out-migration, but the decline in population is less pronounced than in the model with endogenous agglomeration. Even under the longest delay scenario, however, the city still loses about 5 percent of its population. This comparison suggests that agglomeration forces amplify the aggregate effect of boundary frictions: higher commuting costs not only make cross-wall commuting more expensive directly, but also weaken local productivity and amenity feedbacks through the resulting reallocation of workers.

Table 14: Total Population Ratio ($\widehat{H_{\mathbb{N}}}$)

| | Delay 0 | Delay 10 | Delay 20 | Delay 30 |
|---|---|---|---|---|
| With agglomeration ($\mu_A = 0.07, \mu_U = 0.15$) | 0.950 | 0.930 | 0.925 | 0.923 |
| Without agglomeration ($\mu_A = 0, \mu_U = 0$) | 0.968 | 0.955 | 0.951 | 0.950 |

*Notes:* Entries are total population in millions. In the open-city fixed-utility closure, utility is held at the 2024 baseline level and total population adjusts endogenously. The observed 2024 baseline population is 17.990 million.

We next examine how boundary frictions reshape commuting patterns across and within the two sides of the wall. Table 15 reports relative changes in commuting shares, with positive entries indicating an increase relative to the 2024 benchmark. The results show that the share of cross-zone commuting falls by 7.71 percent in the detour-only scenario and by 12.35 percent when the detour is combined with a 30-minute inspection delay. At the same time, despite the net outflow of workers from Shenzhen, a larger share of remaining commuters choose residence--workplace pairs on the same side of the wall. The increase in within-zone commuting becomes larger as the delay increases. This pattern is consistent with the intuition that wall-induced commuting frictions reduce workers' willingness to commute across the boundary, inducing more workers to live and work on the same side in order to lower commuting costs. Similarly, when we hold productivity and amenities fixed and ignore endogenous agglomeration responses, the model understates the relative changes in commuting shares. This comparison highlights the importance of accounting for agglomeration effects.

Table 15: Commuting Patterns within/out of the City (%)

| | Delay 0 | Delay 10 | Delay 20 | Delay 30 |
|---|---|---|---|---|
| **Panel A. With agglomeration** ($\mu_A = 0.07, \mu_U = 0.15$) | | | | |
| Cross-zone commuting | -7.71 | -11.05 | -12.07 | -12.35 |
| Within-zone commuting | 2.67 | 4.06 | 4.53 | 4.67 |
| Net exit | 5.04 | 6.99 | 7.54 | 7.69 |
| **Panel B. Without agglomeration** ($\mu_A = 0, \mu_U = 0$) | | | | |
| Cross-zone commuting | -7.34 | -10.72 | -11.81 | -12.13 |
| Within-zone commuting | 4.17 | 6.23 | 6.94 | 7.15 |
| Net exit | 3.17 | 4.49 | 4.88 | 4.99 |

*Notes:* Entries are percentage-point changes relative to the observed 2024 baseline population. Cross-zone commuting pools EN and NE flows; within-zone commuting pools EE and NN flows. "Net exit from the economy" is the open-city population adjustment, computed as the decline in total counterfactual population relative to the 2024 baseline.

**Commuting shares.** Conditional on the total population in Shenzhen, we further examine how commuting shares change across different directions. We distinguish four types of residence--workplace pairs: from the SEZ to the SEZ (EE), from the non-SEZ to the non-SEZ (NN), from the SEZ to the non-SEZ (EN), and from the non-SEZ to the SEZ (NE). The first two correspond to within-zone commuting, while the last two correspond to cross-zone commuting. This decomposition allows us to examine whether the increase in within-zone commuting and the decline in cross-zone commuting are symmetric across different directional pairs.

Table 16 reports the results. With agglomeration forces, the increase in within-zone commuting is relatively balanced between EE and NN pairs: both groups experience a 3–6 percent increase in commuting shares across the counterfactual scenarios. In contrast, the decline in cross-zone commuting is asymmetric between EN and NE pairs. The share of EN commuting falls by 1.83–2.76 percent across different delay scenarios, while the share of NE commuting falls by 5.45–9.31 percent. We find a similar relative pattern when agglomeration effects are shut down: more commuters switch to NN relative to EE, and fewer commuters choose NE relative to EN.

This directional pattern is consistent with the commuting pattern in the early period of the SEZ. When the wall raises cross-boundary commuting costs, some workers find it costly to commute into the SEZ and instead choose jobs outside the SEZ. This increases the relative labor pool outside the SEZ and makes wages outside the SEZ lower relative to wages inside the SEZ.

Table 16: Commuting Share Within the City (%)

| | Delay 0 | Delay 10 | Delay 20 | Delay 30 |
|---|---|---|---|---|
| **Panel A. With agglomeration** ($\mu_A = 0.07, \mu_U = 0.15$) | | | | |
| Econzone → Econzone | 3.41 | 5.20 | 5.78 | 5.95 |
| Non-Econzone → Non-Econzone | 3.87 | 5.50 | 5.98 | 6.11 |
| Econzone → Non-Econzone | -1.83 | -2.52 | -2.71 | -2.76 |
| Non-Econzone → Econzone | -5.45 | -8.17 | -9.06 | -9.31 |
| **Panel B. Without agglomeration** ($\mu_A = 0, \mu_U = 0$) | | | | |
| Econzone → Econzone | 3.11 | 4.74 | 5.30 | 5.47 |
| Non-Econzone → Non-Econzone | 3.96 | 5.74 | 6.31 | 6.48 |
| Econzone → Non-Econzone | -1.91 | -2.61 | -2.80 | -2.85 |
| Non-Econzone → Econzone | -5.16 | -7.87 | -8.82 | -9.10 |

*Notes:* Entries are percentage-point changes in each OD direction's share of total commuting flows, relative to the observed 2024 baseline share. We ignore the difference in the scale of population in baseline and counterfactual. EE and NN are within-zone flows; EN and NE are cross-zone flows.

**Distributional effects.** We aggregate the endogenous variables to the zone level to examine relative changes in labor allocation and prices in the Econzone and the Non-SEZ. For quantity variables, such as residential population and workplace employment, we construct zone-level hats relative to the 2024 baseline by first summing the corresponding variable within each zone and then computing the proportional change. For price variables, we first compute location-specific hats and then report zone-level averages weighted by baseline price levels.

Table 17 reports the counterfactual results with agglomeration. In the Econzone, residential population increases, which is consistent with more workers choosing to both live and work inside the Econzone in order to avoid crossing the wall. The increase in residential demand raises residential floor-space prices. At the same time, higher commuting costs reduce the labor pool available to firms inside the SEZ, leading to lower workplace employment and higher labor costs. This pattern is consistent with the historical narrative that firms in the early years of Shenzhen found it difficult to hire workers inside the SEZ. Industrial rents decline as manufacturing demand falls.

In the Non-SEZ, higher commuting costs also reduce the number of workers who find it attractive to live and work there, leading to declines in both residential population and workplace employment. To restore equilibrium, the Non-SEZ offers higher wages and lower floor-space rents, which partly offsets the higher cost of commuting. However, the decline in workplace employment is smaller in the Non-SEZ, ranging from 2.2 to 3.2 percent across scenarios, compared with 11.4 to 17.8 percent in the Econzone. The increase in labor costs is also more modest in the Non-SEZ, ranging from 0.8 to 1.3 percent, compared with 4.3 to 8.6 percent in the Econzone. These results are again consistent with the historical development of Shenzhen: the wall had a larger negative effect on labor accessibility inside the SEZ than outside it, making labor-intensive production more likely to locate outside the SEZ to avoid higher labor costs.

Table 17: Employment ($\hat{H}$), Wage ($\hat{w}$) and Rent Ratio ($\hat{r}$) under Agglomeration

| | Delay 0 | Delay 10 | Delay 20 | Delay 30 |
|---|---|---|---|---|
| **Panel A: Econzone** | | | | |
| Residential employment | 1.018 | 1.044 | 1.055 | 1.058 |
| Workplace employment | 0.886 | 0.840 | 0.826 | 0.822 |
| Wages | 1.043 | 1.066 | 1.077 | 1.086 |
| Residential rents | 1.015 | 1.045 | 1.056 | 1.060 |
| Industrial rents | 0.913 | 0.884 | 0.874 | 0.869 |
| **Panel B: Non-Econzone** | | | | |
| Residential employment | 0.930 | 0.898 | 0.888 | 0.885 |
| Workplace employment | 0.978 | 0.970 | 0.968 | 0.968 |
| Wages | 1.008 | 1.011 | 1.012 | 1.013 |
| Residential rents | 0.956 | 0.938 | 0.932 | 0.930 |
| Industrial rents | 0.983 | 0.978 | 0.976 | 0.976 |

*Notes:* The counterfactual is open-city with fixed utility, so the common utility ratio is normalized to one. Employment rows report zone-level aggregate hats relative to the 2024 baseline. Wage and rent rows report unweighted zone-level averages of location-specific hats. Delay 0 includes the detour-time counterfactual without additional delay; Delay 10, 20, and 30 additionally impose 10-, 20-, and 30-minute delays on cross-zone commuting pairs.

# 8 Conclusion

This study examines the impact of the former physical boundary of the Shenzhen Special Economic Zone (SEZ), known as the "Shenzhen Wall," on the spatial distribution of firms and employment. The Shenzhen Wall was a labor-mobility control system introduced in the early period of the SEZ, partly to prevent smuggling and stabilize business environment in SEZ. By requiring workers to detour to designated checkpoints and accept ID inspections when crossing the Wall, the system increased commuting costs between the SEZ and the non-SEZ areas. Using high-resolution, long-run firm-level data and a spatial regression discontinuity design, we document sharp discontinuities in firm entry and employment at the boundary, with more firms and workers located immediately outside the SEZ than just inside it. We interpret this pattern as the result of a discontinuous change in labor accessibility induced by the Wall. We show that the results are not explained by terrain, land-use regulations, county-level border effects, or firm-entry regulations. Falsification tests further suggest that the observed jump is not a general spatial pattern.

We then develop a quantitative spatial model with bilateral commuting frictions to formalize the link between firm location and labor accessibility. In the model, the Wall enters as an additional commuting cost for residence--workplace pairs located on different sides of the historical boundary. This framework allows us to study how commuting frictions affect the allocation of workers and firms, as well as wages, floor-space prices, and total population in general equilibrium. We use the model to ask how Shenzhen's 2024 economy would have changed if the commuting frictions associated with the former Wall had still been in place.

The counterfactual results show that higher commuting costs reduce the inclusive value of living and working in Shenzhen. In response, total population declines, and more remaining workers choose to live and work on the same side of the Wall rather than commute across it. Both the SEZ and the non-SEZ experience declines in labor supply, but the decline is larger inside the

SEZ. Wages also increase more inside the SEZ, reflecting the greater difficulty that firms there face in accessing workers from outside the Wall. This pattern is consistent with the early development of Shenzhen, when the Wall restricted labor supply inside the SEZ and firms inside the boundary found it harder to hire workers. The adverse effects of commuting frictions are further amplified when endogenous agglomeration forces are active.

These findings speak to a broader class of policies that increase mobility frictions, including migration controls, checkpoints, and other barriers to labor-market integration. Even when such policies are temporary or later removed, they can leave persistent effects on the spatial allocation of labor and economic activity. Policymakers should therefore carefully evaluate the potential of mobility restrictions to generate long-run spatial misallocation within cities.

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