How Housing Supply Expansions Reshape Cities*

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Abstract

We study a large-scale policy relaxing residential land supply constraints near major Dutch cities in the mid-1990s. Land allocation was determined centrally and was unrelated to pre-policy local market dynamics. Using administrative data, we explore effects on housing, mobility, and labor markets. New supply attracted high-income individuals, primarily from nearby high-income neighborhoods, where house prices decreased. New supply also increased local employment in surrounding areas, especially in high-earning occupations. We develop a rich quantitative spatial equilibrium model and show that the impact of relaxing supply constraints on housing markets and welfare crucially depends on job reallocation and on in-migration flows.

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1 Introduction

What happens when supply constraints in major cities are loosened at scale? The sluggish expansion of housing supply in many developed countries since the Great Recession, despite a strong recovery in demand, has put this question at the center of policy and academic debates. A large literature argues that physical and regulatory limits on development suppress new construction, with broad implications for prices and growth (e.g. Gyourko, Saiz, and Summers, 2008; Saiz, 2010; Hsieh and Moretti, 2019; Baum-Snow and Han, 2023). Measuring the effect of relaxing restrictions is difficult because the relevant policies are enacted locally and are often endogenous to local economic conditions. Recent studies identify price reductions within narrow radii around new construction (e.g. Mast, 2022; Pennington, 2022), but the aggregate implications of large-scale relaxations of supply constraints—for prices, mobility, and economic activity—remain poorly understood.

To understand these effects, we exploit the Vinex program, a large, nationally planned urban expansion in the Netherlands.[1] Vinex is a powerful setting to identify the consequences of major housing-supply expansions for three reasons. First, after decades of limiting construction near major cities, the Dutch government allocated large tracts of land for development. This enabled the construction of hundreds of thousands of mostly owner-occupied homes, triggering moving chains that relocated 10% of Dutch residents. Few supply shocks rival this scale. Second, Vinex sites were chosen to satisfy national planning goals rather than local demand or pre-policy price trends, so their placement within urban regions was plausibly exogenous to nearby market conditions, allowing us to compare more- and less-exposed neighborhoods within the same region. Third, rich administrative microdata on all properties, residents, and jobs allow us to trace adjustments with exceptional granularity.

Our paper offers two key contributions. Empirically, we show that easing supply constraints has significant spillover effects on nearby neighborhoods. Relative to less exposed neighborhoods, Vinex supply lowered nearby prices by 2-3%, boosted employment by over 10%, and increased mobility. We find stronger price declines in high-income neighborhoods, but little impact in low-income areas, where housing competes less directly with newly built single-family homes. Theoretically, we develop a quantitative spatial equilibrium model, calibrated on administrative data, to capture general equilibrium mechanisms behind our empirical findings. The model shows how large, spatially concentrated housing expansions propagate beyond their footprint, with differential effects on wages and prices that depend on city openness: in a closed city, adjustment occurs mainly through workers' residential and workplace re-sorting and firms' reallocation of land and labor across neighborhoods, whereas in an open city, in-migration plays a larger role.

[1] Vinex is an acronym for VIerde Nota Ruimtelijk Ordening EXtra, "Addition to the Fourth Spatial Planning Memorandum."

We first document that Vinex generated a large, discrete shock to housing development. Before the start of the program, Vinex neighborhoods saw little to no construction relative to non-Vinex neighborhoods. After 1995, trends diverged, and housing construction accelerated rapidly to more than five times the rate of development in non-Vinex areas, only to decline again after the program ended. We establish that Vinex construction also went hand in hand with new job creation, with the number of jobs in Vinex neighborhoods increasing tenfold, compared with 25% in non-Vinex neighborhoods.

Using administrative microdata on all Dutch residents, we demonstrate that the Vinex housing supply led to a sizable reallocation of residents. Vinex construction consisted mostly of owner-occupied single-family homes. These attracted 600,000 new residents who, on average, were more likely than the average Dutch person to work in higher-wage sectors, i.e., tradable services, consistent with evidence for the U.S. from Hanson and Moretti (2025). However, these moves also freed up lower-value homes for lower-income households, causing a moving chain that led to the relocation of at least 900,000 additional residents, about 6% of the Dutch population. These stylized facts on the sprawling effects of moving chains align with evidence from market-rate construction in the U.S. or Finland (Mast, 2022; Bratu, Harjunen, and Saarimaa, 2022), although at a much larger scale.

We then focus on estimating the effects of the new Vinex supply on existing neighborhoods. The planning of Vinex sites was based on aggregate regional housing demand, but explicitly did not account for prices or demand in areas near the sites. We therefore measure exposure using the (not market-driven) land allocations set by planners. We do not rely on the number of housing units built on allocated land, as this was still driven by market forces. We exploit variation in exposure within a municipality by defining 'highly exposed' neighborhoods as those in the top quartile of Vinex land share within 5 km in their municipality, and comparing their outcomes to neighborhoods in the same municipality without Vinex sites nearby.[2]

High exposure to a Vinex neighborhood persistently reduces house prices by 2–3 percentage points relative to other areas in the same municipality. Consistent with our qualitative evidence, these effects only materialize after Vinex construction begins, with parallel trends before. Using proximity to Vinex neighborhoods as an instrument, we estimate a local price elasticity of approximately –0.05: a 10 percentage point increase in supply lowers prices by roughly 0.5 percentage points. These effects are smaller than those found by Asquith, Mast, and Reed (2023) for large apartment developments, but they operate over much larger geographic areas, highlighting how large-scale development can affect broader housing markets. The magnitude of the effects is highly heterogeneous: point estimates are about 50% larger in above-median-income neighborhoods and statistically insignificant in below-median-income neighborhoods, consistent with Vinex primarily

[2]We choose the 5 km radius because it captures both direct migration to Vinex and competition for new residents between Vinex and surrounding non-Vinex neighborhoods.

competing with affluent pre-existing neighborhoods.

We then show that the Vinex program had substantial direct and indirect effects on the spatial distribution of jobs. In highly exposed non-Vinex neighborhoods, employment growth was 11.2 percentage points higher than in other neighborhoods. Strong job growth was driven primarily by the Tradable Services sector, for which the number of jobs in highly exposed neighborhoods increased by nearly 30% more than in the rest of the country. To the extent that the local pooling of workers with similar skills can lead to agglomeration economies, the labor market effects, combined with the results showing that Vinex mainly attracted high-income movers, highlight that the program may have substantially stimulated local economies.

To interpret these patterns and quantify their broader implications, we develop a quantitative spatial equilibrium model that embeds heterogeneous workers and firms, two production sectors (tradable goods and non-tradable local services), and an integrated neighborhood-level land market. Workers choose both a residential neighborhood and a workplace, trading off amenities, commuting costs, housing prices, and access to local services. Firms combine land and labor to produce, with firms in the tradable sector operating under perfect competition and local service firms under monopolistic competition. A key feature of the model is a unified land market in which residential use, tradable production, and service production compete for land, with upward-sloping, location-specific housing supply schedules that capture regulatory and physical constraints. A Vinex-type policy is modeled as making previously undeveloped suburban land available and more elastic, thereby shifting the housing supply elasticity profile across neighborhoods.

The model rationalizes the main mechanisms suggested by the empirical data and links them to general equilibrium outcomes. New Vinex neighborhoods attract high-income households, particularly those employed in the tradable sector, because the new supply offers larger, higher-amenity housing. This relocation reduces demand for housing in nearby affluent neighborhoods, lowering local rents and freeing up housing that becomes relatively more attractive to lower-income workers. Although the model abstracts from explicit multi-round moving chains, it captures the first-order reallocation margin that underlies them: high-income households shift toward Vinex, while lower-income households re-sort into the now cheaper nearby neighborhoods. On the production side, the inflow of high-income residents into Vinex areas raises demand for non-tradable services locally and makes tradable sectors nearby more attractive to workers. This contributes to the employment growth we observe in more exposed neighborhoods, and the associated rise in commercial land demand tempers pressure on land rents from reduced residential demand.

A central insight from the model is that the magnitude and spatial reach of these effects depend critically on the city's openness. We compare equilibria in a "No Vinex" counterfactual world and in the observed post-policy city under three scenarios: a closed

city with fixed sectoral populations, a semi-open city calibrated to pre-policy population, and a fully open city where population adjusts endogenously. In a closed city, the Vinex shock is absorbed entirely by reshuffling incumbent residents, producing sizable and relatively diffuse rent declines and clear welfare gains for many non-tradable workers, while some tradable-sector workers experience modest welfare losses as higher commuting burdens and local service prices partially offset cheaper housing. In more open cities, in-migration absorbs part or all of the shock, aggregate rents and service prices rise as the city expands, and affordability gains are weaker or even reversed, even as total output increases. Our empirical findings of local price declines are most consistent with a closed to semi-open city over our sample period, suggesting Vinex primarily operated through internal re-sorting rather than as an open-city growth engine.

Related literature. Our paper contributes to the literature on the effects of new housing supply on local housing and labor markets, providing novel evidence on the broad effects of a large housing development program. It also contributes to a large literature in financial economics studying the determinants of house price fluctuations and, in particular, the relative importance of supply and demand side drivers, for example Bayer, Magnum, and Roberts (2021), Favilukis, Ludvigson, and Van Nieuwerburgh (2017), Favilukis and Van Nieuwerburgh (2021), Louie, Mondragon, and Wieland (2025) and Chorodow-Reich, Guren, and McQuade (2024).

The combination of our empirical findings with a new quantitative spatial-equilibrium model introduces several advances relative to existing work. First, while recent "local effects" studies examine micro-level supply shocks within a few hundred meters (e.g. Mast, 2022; Pennington, 2022; Asquith, Mast, and Reed, 2023), our framework captures the citywide consequences of large, government-mandated expansions in developable land, including migration chains and job reallocation.[3] Second, we integrate residential sorting, workplace relocation, and neighborhood-specific firm behavior into a unified equilibrium model, bridging housing and labor market adjustments at an unusually detailed level of granularity. Third, our model provides one of the first frameworks capable of rationalizing simultaneous price declines and heterogeneous employment growth around large-scale, market-rate housing expansions. Relative to classic city-level models of supply constraints (e.g. Hsieh and Moretti, 2019), our approach incorporates far richer spatial detail and sectoral heterogeneity, and makes an explicit distinction between closed- and open-city environments.

In doing so, we contribute to the broader literatures on urban migration (e.g. Boustan, 2010; Howard, 2020; Derenoncourt, 2022; Schubert, 2022), agglomeration and TFP spillovers (e.g. Arzaghi and Henderson, 2008; Baum-Snow, Gendron-Carrier, and Pavan,

[3]See also Bratu, Harjunen, and Saarimaa (2022), who study citywide effects of new housing supply.

2024; Moretti, 2021), showing how large housing-supply expansions reshape both the housing market and the spatial distribution of economic activity.

The remainder of the paper is organized as follows. Section 2 describes the institutional background of the Vinex program and our data. Section 3 documents the development of Vinex neighborhoods and presents stylized facts on housing supply, mobility, and employment. Section 4 estimates the effects of Vinex on pre-existing neighborhoods. Sections 5 and 6 introduce the model and calibration strategy. Section 7 uses the model to quantify the effects of the Vinex programme. Section 8 concludes.

2 Institutional Background and Data

2.1 Urban Planning in the Netherlands and the Vinex Program

From the 1960s onward, the Netherlands—like much of Western Europe and the United States—experienced rapid suburbanization. Unlike the more sprawling patterns seen elsewhere, Dutch growth was tightly directed: national planners determined what would be built and where, while municipalities implemented these centrally defined plans. This approach earned the country a reputation as a "planner's paradise" (Faludi and Van der Valk, 1994; Van der Wouden, 2015).

Major shifts in national spatial policy were laid out in periodic *nota's ruimtelijke ordening* (spatial planning memoranda), published roughly every 10–30 years. These documents articulated national objectives and specified priority development areas. Vinex is the acronym for the addendum to the Fourth Memorandum (Ministerie van VROM, 1991), which planned a supply expansion of roughly half a million homes in the late 1990s and 2000s, 8% of the 1995 housing stock, largely at urban fringes.[4] Although other countries pursued top-down housing programs, none matched the scope of Vinex, which encompassed all major Dutch urban regions (van der Krabben and Jacobs, 2013).

Vinex locations were selected through a national planning process. The government projected household growth—considering migration, economic conditions, household formation, and aging—and allocated the resulting demand across 27 regional housing markets. This distribution assumed stable patterns of employment and population, with additional growth directed toward the Randstad, the urbanized western region of the Netherlands, and the focus of this paper.

The memorandum emphasized that new housing should primarily be located within major urban areas, arguing that "prioritizing the development potential of existing urban areas is essential." This marked a radical shift from earlier policies that discouraged

[4]Vinex also supported redevelopment within existing cities, which we exclude from our analysis.

expansion near major cities in favor of new towns. Vinex developments were expected to have strong "spatial quality": access to employment, transport connections, recreational areas, natural spaces, and essential services, making urban fringes the preferred locations.

At the same time, prospective sites had to comply with preexisting national planning constraints. Earlier policies had imposed strict development restrictions on large parts of the country, which remained in force unless explicitly revised by Vinex. The memorandum also reaffirmed green buffer zones between major cities and protections for the "Green Heart," the agricultural interior of the Randstad. Appendix Figure A.1 provides an overview of these constraints.

Although Vinex articulated strategic priorities and broad criteria, the precise locations were negotiated between the national government and regional jurisdictions and formalized in covenants in 1994 and 1995. Municipalities retained zoning authority, but these agreements were binding. Local residents could appeal zoning changes, and sometimes did so (Ruimtelijk Planbureau, 2006), but could not block the construction of Vinex neighborhoods.

A key feature of this planning tradition is that site selection was not guided by short-run profitability or market demand, for instance, by comparing local house prices with construction costs. The memorandum and covenants focus exclusively on matching housing needs with sites that conform to regional and national planning objectives; they do not discuss the characteristics of nearby neighborhoods or potential spillovers from Vinex construction.

Indeed, relative price levels appear only once in the nearly 200-page memorandum, noting that development within Vinex locations could be financially feasible because restrictions elsewhere would raise prices and make Vinex more competitive.[5] The state also provided subsidies to offset high land or remediation costs. This did not prevent the selection of expensive sites: for example, in The Hague, the government chose to develop a former military airfield requiring major cleanup, explicitly rejecting a cheaper peripheral alternative as "too eccentric" and disruptive to the Green Heart.

In sum, the Vinex program led to a relaxation of the supply constraint for building in or near major cities, with sites selected through a top-down process guided by planning principles rather than profitability, market conditions, or nearby neighborhood characteristics. Feasibility was ensured through restricting large developments elsewhere and subsidization when needed. These institutional features are central to our empirical strategy.

[5]Page 20: "Strong planning restrictions are needed with regard to new locations that do not fit within this (i.e., Vinex) policy. Not only because such locations do not align with the tightened urbanization policy, but also because restrictive measures improve the feasibility of urban locations. Without limiting housing development in areas outside the urban regions, the relatively high land costs in the urban regions would create too great a competitive disadvantage. Restrictive policy should contribute to equalizing price relations." (Ministerie van VROM, 1991)

2.2 Data

Our analysis focuses on the Randstad, the country's most populous and economically significant area. It contains more than half of the Dutch population and includes the metropolitan regions of Amsterdam, Rotterdam, The Hague, and Utrecht, as well as surrounding cities.[6] For this area, we construct five datasets that allow us to study the effects of the Vinex program comprehensively.

First, we use the Vinex Atlas (Boeijenga and Mensink, 2008) to identify which buurts, the smallest administrative unit for a neighborhood, were part of the Vinex program and to map them onto the 2022 buurt boundaries defined by Statistics Netherlands. We classify a buurt as a Vinex buurt if it experienced Vinex construction after 1995, if it was designated as an outlying development site in the Vinex covenants reported by Boeijenga and Mensink (2008), and if Vinex properties ultimately constituted at least 50 percent of its housing stock. Figure 1 shows the locations of Vinex buurts in the Randstad. All major outlying Vinex sites in the Randstad were fully developed, so our sample does not suffer from survivorship bias.[7]

Second, we measure housing supply using the *Basisregistratie Adressen en Gebouwen* (BAG), the universe of Dutch housing units. For each property, the BAG records the address, size, and construction year. We assign properties to 2022 buurts and track new construction based on building years from 1984 onward.[8] Panel A of Table 1 reports summary statistics by buurt and year.

Third, to estimate effects on house prices, we use transaction-level data from the Dutch Association of Realtors, which covers roughly 70% of national housing transactions. The dataset spans 1991–2015 and includes addresses, property characteristics, sales and listing prices, and transaction dates. Panel B of Table 1 summarizes these data.

Fourth, to study how Vinex supply affected the spatial distribution of employment, we use microdata on all jobs and job locations from Stichting LISA, the Dutch employment register, covering 1996–2015. Panel C of Table 1 provides summary statistics by buurt and year.

Fifth, we draw on administrative population, property, and employment data from Statistics Netherlands. These data include residential addresses and birth years for the full Dutch population from 1995 to 2015. For working residents, we observe wages and sector of employment—based on administrative records for 1999–2015 and survey data covering

[6] In our main analysis, we focus on the provinces of Noord-Holland, Zuid-Holland, Utrecht, and the city of Almere, which is in another province (Flevoland) but seen as part of the Amsterdam urban region.

[7] Some Vinex sites in lower-cost peripheral areas of the Netherlands were not fully realized due to insufficient demand, making Vinex exposure endogenous to prices in those locations. Our data do not include these areas.

[8] Properties built after 1984 and demolished before 2022 are not observed, but such demolitions are extremely rare.

one-third to one-half of workers in 1995–1998. Panel D of Table 1 presents summary statistics on demographics, mobility, and occupations. Some buurt-level observations are censored because Statistics Netherlands suppresses characteristics observed for fewer than ten individuals (e.g., residents who moved in during the previous year or who work in Tradable Services). This has only minor implications given that buurts typically contain hundreds to thousands of residents.

We supplement these data with the Woonbase, which provides basic information on the primary residence of each individual—such as construction year, floor area, building type, and tax value—for all Dutch properties.[9] For all movers between 1995 and 2015, we compute the straight-line distance between their current and previous residences.

3 Stylized Facts on the Impact of Vinex

This section assembles a series of stylized facts about the impact of Vinex. Using comprehensive data on housing supply, residential moves, and employment, we identify key patterns in construction dynamics, household mobility chains, and labor market adjustments. These facts provide grounding for the empirical analysis and structural model introduced later.

3.1 Housing Supply

We first document the scale and timing of the housing supply shock generated by the Vinex program. Using the Vinex Atlas to identify Vinex buurts and the BAG housing registry to measure construction years, we compare annual new construction in Vinex and non-Vinex neighborhoods within the Randstad.

Large construction surge in Vinex areas: Figure 2, Panel A shows that Vinex buurts saw little development prior to the early 1990s. Once sites were designated, however, construction accelerated rapidly: by the late 1990s, treated buurts were adding nearly twice as many dwellings as comparable areas, and during the early 2000s, they built 7–8 times more units. This boom was transitory. By the mid-2000s, the gap began to close, as the Vinex programme was coming to an end, and by 2014–15, new construction in Vinex and non-Vinex buurts had largely converged.

Equation 1 formalizes this comparison by estimating, for each year t and buurt (b), the difference in new completed $y_{b,t}$ dwellings between Vinex buurts, identified by a dummy I_{Vinex} over time I_t, and non-Vinex buurts, while controlling for fixed differences across neighborhoods (a_b) and municipality-year ($a_{muni,t}$) shocks:

[9] Properties demolished between 1995 and 2014 are not included in the Woonbase.

$$y_{b,t} = \sum_{t=1984}^{2015} \gamma_{t,Vinex} \left(I_t \times I_{Vinex}\right) + a_b + a_{muni,t} + e_{b,t}, \tag{1}$$

The coefficients of interest $\gamma_{t,Vinex}$, reported in Panel B of Figure 2, trace the sharp rise and gradual decline of the construction gap relative to the baseline year 1994. During this year, most covenants containing land allocations were signed, and Vinex construction started shortly after. In line with the descriptive evidence, housing construction displays parallel trends before 1994 but takes off in 1995, with construction peaking in the late 1990s and early 2000s at about 60 additional units per year, and slowing down gradually when the program came to an end.

Additionally, Appendix Table A.1 shows that Vinex areas in aggregate built 4,000 m^2 more living space per year than other areas, with new units that were roughly 20 m^2 larger on average. Appendix Table A.2 confirms that these new housing units led to sizable population growth, especially during the main Vinex development period, from 1995 to 2005.

These patterns underscore that Vinex delivered a significant expansion in suburban housing supply, producing larger homes targeted at family buyers and leading to sizable population inflows, consistent with the aim of the program.

3.2 Moving Chains

After documenting the Vinex supply shock, we now show stylized facts on how it shaped the mobility of different residents. Using Statistics Netherlands' address-registry microdata, we trace who moved into newly-built Vinex properties and who subsequently occupied the homes left behind. This approach reveals a chain of moves through which a large, new supply of housing reverberated across the broader market. Note that in this section, we focus on Vinex properties and residents nationwide, as the moving chains extend beyond the Randstad.

To construct the moving chains, we first identify first-round movers—households that occupy a newly built Vinex dwelling as soon as it comes on the market.[10] For these movers, we tally the number of persons, compute the median value of the Vinex properties they move to, and record the share that become owner-occupiers. We also summarize their demographic and labor-market characteristics by calculating the average age and full-time wage of working adults (aged 25–65) and the share employed in tradable services (the mapping of industries is in Table A.12).

We then trace subsequent rounds of moves. Whenever the entire originating household

[10]After the first registration on a new address, we treat all individuals who register at that address within 90 days as part of the same household, since members of a newly formed household may not move on the exact same date.

relocates to a Vinex dwelling, we look back to see who moves into the vacated property within the next two years; those occupants constitute the second-round movers. For them—and for each successive round up to six—we compile the same set of statistics (property values, tenure status, age, wages, and employment). Chains terminate if a new household forms (e.g., a child moving out, divorce), or, more rarely, if a property remains unoccupied for more than two years. Moving chains can also break due to data limitations, for example, if an administrative change is made to a housing unit or if multi-family properties are not yet split into individual units.

Vinex leads to at least 1.5 million moves: Panel (a) of Figure 3 displays the number of movers at each round of the chain. Roughly 600,000 people moved into 245,000 Vinex dwellings in the first round, and across six rounds, more than 1.5 million individuals—around 10% of the Dutch population in 1995—relocated as the new supply reverberated through the housing market. These numbers are lower bounds because chains also terminate when data gaps prevent us from observing subsequent occupants.

Vinex adds large owned homes, frees cheaper rentals: Panel (b) highlights that Vinex dwellings occupied by first-round movers are both more valuable and larger than the homes exchanged in later rounds: the median Vinex dwelling is nearly 40% more expensive and 20–25 square meters larger than the homes freed up later in the chain. Panel (c) shows that over 70% of first-round movers become owner-occupiers, compared with about 50% in the second round and below 40% thereafter. For context, national homeownership stood at 48% when Vinex began. As panel (d) reveals, first-round movers are also older on average (39 years versus 36 years in round 2), with the gap widening further down the chain.

Vinex entrants are high-income, second and higher round movers have lower income: Panels (e) and (f) document that the economic profile of movers shifts markedly across rounds. Workers moving into Vinex dwellings earn substantially higher wages than those in later rounds—about a 28% difference between the first and sixth rounds—and, in the subsample with household income data, median incomes fall from the 71st percentile to the 41st percentile over the chain.

These wage differences are not solely due to age: the share of movers employed in tradable services drops from 32% in the first round to 27% in the second and below 24% by the sixth round. Because tradable services jobs command higher pay than non-tradable services, agriculture, or manufacturing, this declining share underscores the downward sorting along income lines. Appendix Figure A.3 shows the job sectors of Vinex and non-Vinex residents over time, confirming the tilt towards tradable services.

3.3 Labor Market

After examining housing supply and mobility chains, we turn to how Vinex impacted local employment. The moves of mostly higher-income households into Vinex buurts not only increased demand for goods and services, but also created opportunities for new businesses to locate in these suburban neighborhoods.

We use LISA data (described in Section 2.2) to track jobs by sector in each buurt from 1996–2015. While we lack comparable data for the pre-Vinex period, it is reasonable to expect that job creation within Vinex buurts would only begin to materialize after the program's launch, particularly since construction activity accelerates only after 1998 and peaks around 2000 (see Figure 2).

Each job's 2008 industry code is mapped into a NACE Eurostat sector, which is subsequently assigned to one of three macro-sectors: Manufacturing-Agriculture, Non-Tradable Services, and Tradable Services (see Appendix Table A.12). As shown in Appendix Figure A.2, jobs in tradable services pay the highest wages, roughly 30–40% above non-tradable services and 15–20% above manufacturing or agriculture. Shifts toward tradable services thus signal higher-quality and higher-wage employment.

Strong job growth in Vinex, led by Tradable Services: Figure 4 reports the average number of jobs per buurt from 1996 to 2015 for Manufacturing-Agriculture, Non-Tradable Services, and Tradable Services, distinguishing between Vinex (left panel) and non-Vinex buurts (right panel). Unsurprisingly, employment growth in Vinex buurts outpaces that in the rest of the Randstad, though the patterns differ across sectors.

Prior to the development of new housing under the Vinex program, employment opportunities in Vinex locations were limited, with only 50 jobs per buurt. Most of these areas were rural and not densely populated. At the end of the sample, employment had increased almost tenfold to approximately 500 jobs. In non-Vinex buurts, employment averages about 500 jobs in the mid 1990s and increases to 700 jobs at the end of the sample. Thus, compared to non-Vinex neighborhoods, Vinex neighborhoods have fewer local jobs, but a higher share of jobs in tradable services and fewer jobs in industry and manufacturing. This is consistent with the suburban character of these neighborhoods.

Taken together, these patterns suggest that Vinex development is also associated with a proliferation of locally based jobs, with a tilt towards higher-income jobs. Such outcomes could reflect high-income households relocating their jobs to Vinex areas (see Section 3.2) or high-value service providers (e.g., legal or financial firms) opening offices in Vinex buurts to serve the resident population.

4 Effects of Vinex on Nearby Neighborhoods

We have now documented several stylized facts about the Vinex programme: it created a large increase in housing supply, triggered moving chains that reallocated households across the income distribution, and led to the creation of new jobs in Vinex neighborhoods.

These facts raise a broader question, which is the focus of our empirical analysis: how did this large, place-specific supply shock reverberate through the surrounding housing and labor markets? Because Vinex induced substantial reallocation of people and jobs, its ultimate impact was not confined to the neighborhoods where construction occurred.

In what follows, we examine how the influx of new supply and residents in Vinex buurts affected nearby areas. Exploiting differences in exposure to Vinex areas, we study non-Vinex neighborhoods across the Randstad and provide reduced-form evidence on the effects of Vinex on local house prices, migration patterns, and employment.

4.1 Measuring Exposure to Vinex Neighborhoods

To estimate the impact of the Vinex program on housing and labor market outcomes in nearby, non-Vinex neighborhoods, our identification strategy exploits within-city spatial variation in exposure to Vinex developments. The key insight is that, while Vinex was implemented simultaneously across all Dutch metropolitan areas, Vinex sites were irregularly scattered across space. As a result, some pre-existing neighborhoods were located near large Vinex developments, and were therefore more exposed to them, whereas others were far from any Vinex site. We then compare outcomes across non-Vinex buurts that differ in their local exposure to Vinex land assignments, while controlling for municipality-level shocks.

Importantly, our identifying variation stems from differences in proximity to Vinex-designated land, not from differences in the timing or intensity of actual construction. This avoids confounding from demand-driven differences in realized Vinex construction: neighborhoods that happen to be surrounded by more Vinex land on average see more construction nearby, whereas actual realizations depend on local demand.

Implementation. To operationalize this approach, we construct a measure of local exposure based on the share of surrounding land allocated to Vinex development after 1995. For every non-Vinex buurt i, we compute: $ShareVinex_{5km,i}$ = *share of Vinex land within 5 km of the buurts' centroid.*

We use a 5-km radius because most residential mobility occurs over very short distances. Between 1995 and 2015, approximately 75% of all moves occurred within 5 km of the origin. Even for Vinex in-movers, who move over slightly longer distances, more than half relocated from within a 5-km radius. This radius, therefore, captures the set of

neighborhoods most likely to compete with Vinex buurts for households and businesses, but also to benefit from possible amenities, and to be affected by the relocation chains described earlier. Our results are robust to using shorter or longer ranges.

Because the distribution of $ShareVinex_{5km,i}$ is highly skewed—nearly half of buurts have zero exposure, while the top decile exceeds 6.9%—we create a binary indicator that captures salient within-municipality variation.[11] We define: $I_{HighVinex,i} = 1$ if $ShareVinex_{5km,i}$ lies in the top quartile within the municipality. This allows us to compare neighborhoods within a city that face very different levels of exposure while absorbing municipality-level housing demand, planning policies, and labor-market shocks.

Exogeneity of exposure. A key assumption is that Vinex land assignments were not chosen in response to neighborhood-level excess demand. This institutionally fits the program: land assignments were determined centrally as part of a national spatial planning process based on regional—not neighborhood—housing shortages. We corroborate this in Table 2, where we regress pre-program (1991–1995) log price growth on both $ShareVinex_{5km,i}$ and $I_{HighVinex,i}$. Across specifications with and without municipality fixed effects, coefficients are small and statistically insignificant.

Figure 1 maps Vinex buurts (blue) and high-exposure non-Vinex buurts (red) in the Randstad. Although exposure varies within municipalities, the figure also shows spatial clustering of high-exposure buurts. To account for this, all regression specifications that follow use double-clustered standard errors by municipality and year.

4.2 Difference-in-Differences Design

To trace the timing and magnitude of spillovers from Vinex supply onto neighboring buurts, we estimate an event-study difference-in-differences model:

$$Y_{i,\tau} = \sum_{\tau=1991}^{2015} d_{\tau,HighV} \left(I_{\tau,i} \times I_{HighVinex,i}\right) + B\boldsymbol{X}_i + a_b + a_{muni,\tau} + v_{i,\tau} \tag{2}$$

where $Y_{i,\tau}$ is the outcome of interest for unit i in year τ; $I_{\tau,i}$ is a year indicator; and $I_{HighVinex,i}$ flags buurts whose Vinex land share exposure is positive, and lies in the top quartile within their municipality (see Section 4.1). The vector $\mathbf{X}_i$ collects unit-level covariates, a_b are buurt fixed effects, and $a_{muni,\tau}$ are municipality-by-year fixed effects.

We compare these high-exposure buurts to buurts with no Vinex land within five kilometers (zero exposure). Hence, our difference-in-difference estimates have a straightforward interpretation, showing the difference over time between two sets of neighborhoods. It is important to note that this measure only captures effects arising from *relative* differences in exposure, whereas we examine general equilibrium effects in the model section.

[11] Appendix Figure A.4 shows the distribution of exposure by neighborhood

Along with the event study specification presented above, we also estimate a more compact difference-in-differences specification:

$$Y_{i,\tau} = d_{Vinex} \left(I_{HighVinex,i} \times I_{post,i,\tau} \right) + AX_i + a_b + a_{muni,t} + e_{i,t} \tag{3}$$

where $I_{post,i,\tau}$ equals one in the post-implementation period (1995–2015). The coefficient d_{Vinex} captures the average differential change in high-exposure buurts after the programme's roll-out.

We will also examine robustness to two alternative approaches: i) estimating equation (2) and equation (3) on the full sample of non-Vinex buurts, and ii) for the same sample, substituting the indicator variable $I_{HighVinex,i}$ with the continuous measure $ShareVinex_{5km,i}$.

4.3 Price Effects

We now apply the difference-in-differences framework in Section 4.2 to study how Vinex-induced supply changes affected house prices in nearby non-Vinex buurts. While additional supply should, in principle, moderate local price growth, the magnitude and distribution of these spillovers are empirical questions. We begin with event-study estimates and then examine heterogeneity by neighborhood income. We summarize the effects using a compact DID specification, and then translate the results into inverse supply elasticities using Vinex exposure as an instrument.

4.3.1 Baseline Estimates

We estimate equation (2) using the log sales price of property i in year τ as the dependent variable. Controls include property size (volume in cubic meters), remodeling indicators, room count, property type, buurt fixed effects, municipality-by-year fixed effects, and year-built $\times$ year-of-sale fixed effects.

Figure 5 plots the event-study coefficients comparing high- and low-exposure buurts. There is no evidence of differential trends prior to 1994, consistent with the exogeneity of Vinex land assignments. Beginning in the late 1990s, prices in high-exposure buurts diverge downward, consistent with the first Vinex neighborhoods being completed, and stabilize around a 3 to 4 percent lower level than in comparable low-exposure buurts. Results are similar when restricting the comparison to buurts with either high or zero exposure, with somewhat tighter confidence intervals. These patterns indicate that nearby Vinex developments modestly dampened price growth in exposed neighborhoods, consistent with a localized supply effect.

To study distributional patterns, we estimate a triple-interaction specification, which allows the Vinex effect to differ between buurts above and below the median municipal

income:

$$
\begin{aligned}
log(p_{i,\tau}) = & \sum_{\tau=1991}^{2015} f_\tau(I_{HighVinex,i} \times I_\tau \times I_{HighInc}) + \\
& + \sum_{\tau=1991}^{2015} g_\tau(I_{HighVinex,i} \times I_\tau \times I_{LowInc}) + \\
& + BX_i + a_b + a_{muni,\tau,HighInc} + \epsilon_{i,\tau},
\end{aligned} \tag{4}
$$

Relative to equation 2, $I_{HighInc}$ (I_{LowInc}) is a dummy for buurts that have income greater or equal (smaller) than the median in the municipality and $a_{muni,\tau,HighInc}$ are municipality by year fixed effects interacted with $I_{HighInc}$.

Figure 6 shows estimates of the coefficients f_τ and g_τ, indicating that the price effect is concentrated in higher-income buurts. Prices in high-exposure and high-income buurts fell behind by roughly 5 percent by the early 2000s. In lower-income buurts, point estimates are small—around 1 percent—and generally insignificant. This heterogeneity aligns with the fact that Vinex developments primarily attracted middle- and higher-income households, and thus competed most strongly with housing in nearby higher-income areas.

We obtain similar graphs when estimating equation (2) and equation (4) over the full sample of non-Vinex buurts. The results are reported in the Appendix, in Figure A.5 and Figure A.6.

Table 3 summarizes the average post-1995 effects using the compact DID specification in equation (3). Column (1) reports a parsimonious specification including only log volume, buurt fixed effects, and metropolitan-area-by-year fixed effects. Column (2) adds the full set of property-level controls used in the event-study estimates. Columns (3) and (4) split the sample by neighborhood income, restricting respectively to buurts above or below the median income within their municipality. Column (5) estimates a triple-interaction specification analogous to equation (4), allowing the post-Vinex effect in high-exposure buurts to differ by neighborhood income.

Across specifications, high-exposure buurts experience price declines of about 2–4 percent after Vinex's roll-out. The effect is roughly 3.3 percent in above-median-income buurts and substantially smaller (below 1 percent and statistically insignificant) in below-median-income buurts. The triple-interaction specification confirms that high-income neighborhoods experience systematically larger price effects. We find similar magnitudes when the regression sample is extended to all non-Vinex buurts, and when we replace the high-exposure dummy with the continuous share of Vinex land within 5 km (Appendix Table A.3 and Appendix Table A.4).

4.3.2 Inverse Supply Elasticities (IV Estimates)

We next relate our reduced-form price effects to inverse supply elasticities, defined as the elasticity of local house prices with respect to changes in nearby housing supply induced by Vinex. We begin by estimating how exposure to Vinex land assignments affected the change in new construction around each non-Vinex buurt. For buurt b, let

$$\Delta \log(S_{b,k}) = \log\left(\frac{S_{b,5km}^{1995:2015}}{S_{b,5km}^{1984:1994}}\right),$$

where $S_{b,5km}^{1995:2015}$ is the number of new units built within 5 km of b during the Vinex period and $S_{b,5km}^{1984:1994}$ is the corresponding pre-Vinex measure. Across all buurts in the Randstad, the mean of $\Delta \log(S_{b,k})$ is roughly 10 percentage points.

We then estimate:

$$\Delta \log(S_{b,k}) = \gamma \, ExposureVinex_{b,5km} + g_{muni} + v_b, \tag{5}$$

where $ExposureVinex_{b,5km}$ is either the share of Vinex land within 5 km or the high-exposure indicator $I_{HighVinex}$. The coefficient γ captures how much more construction occurred around buurts with greater Vinex exposure.

Table 4 shows that γ is large and statistically significant across specifications. With municipality fixed effects, a 1 p.p. increase in Vinex land share is associated with a 6.7 p.p. larger increase in nearby construction. Buurts in the top-quartile exposure group ($I_{HighVinex} = 1$) experienced, on average, a 21 p.p. larger pre–post increase in supply relative to other buurts. This confirms that Vinex land assignments generated substantial differential growth in local housing supply.

To translate these supply differences into inverse elasticities, we estimate the following two-stage least-squares specification, using $I_{HighVinex}$ as an instrument for Vinex-induced changes in supply:

$$\log(p_{i,t}) = \delta_S \left(\widehat{\Delta \log(S_{b(i),k})} \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t}, \tag{6}$$

$$\Delta \log(S_{b(i),k}) \times I_{post,i,t} = I_{HighVinex,i} \times I_{post,i,t} + HX_i + h_b + h_{muni,t} + j_{i,t}. \tag{7}$$

Here, the instrument captures the Vinex-induced differential increase in construction around high-exposure buurts after 1994, and δ_S is the inverse supply elasticity: the causal effect of a Vinex-driven increase in nearby supply on local prices.

Table 5 reports the results. Column (1) presents OLS estimates of (6), which—as expected—are attenuated toward zero: a 10% increase in nearby supply is associated with only a 0.3% decline in prices. Column (2) presents the 2SLS estimates, which are larger in magnitude. In the full sample, instrumented supply increases produce a price elasticity

of approximately −0.05: a 10% Vinex-induced increase in supply within five kilometers lowers prices by about 0.5%.

Columns (3) and (4) split buurts by income. Consistent with our reduced-form evidence, inverse elasticities are concentrated in above-median-income buurts. For these areas, a 10% increase in supply reduces prices by 0.8%. In contrast, point estimates for below-median-income buurts are small and statistically insignificant.[12]

Taken together, these results show that Vinex induced substantial growth in nearby supply, and that this growth exerted meaningful downward pressure on prices, especially so in higher-income neighborhoods. This heterogeneity likely reflects the composition of households moving into Vinex and the structure of local housing demand documented in Section 3.2.

4.4 Mobility Effects

To better understand the mechanisms behind the price responses documented above, we examine how Vinex development affected residential mobility in surrounding non-Vinex neighborhoods. Mobility is a key adjustment margin in our conceptual framework: by expanding nearby for-sale inventory, Vinex is more likely to attract households from nearby neighborhoods, despite the program not targeting these neighborhoods specifically. Given that Vinex supplies mostly larger owner-occupied homes, this applies in particular to residents with higher incomes.

Unlike house price data, individual address registration data begin only in 1995; we cannot implement a difference-in-differences design analogous to our price analysis. Instead, we exploit cross-sectional variation in exposure to Vinex within municipalities and estimate how proximity to Vinex correlates with local in- and out-flows during the main construction years (1995–2005). We aggregate Statistics Netherlands address-registration records into buurt-year observations and estimate

$$m_{x,b,\tau} = M_{Vinex} I_{HighVinex,b} + n_{muni,\tau} + v_{b,\tau}, \tag{8}$$

where $m_{x,b,\tau}$ is a mobility measure scaled by buurt population, $I_{HighVinex,b}$ identifies buurts with high exposure within their municipality and M_{Vinex} their coefficient, and $n_{muni,\tau}$ are municipality-by-year fixed effects. As before, we focus on non-Vinex buurts only and use buurts with zero exposure as a baseline. Note that for data reasons, we are only allowed to include neighborhoods with at least 10 movers per year. Table 6 provides the main results for the 1995-2005 period.

[12]Appendix Table A.5 repeats the same exercise on the full sample of non-Vinex buurts, finding very similar results. Appendix Table A.6 uses the continuous Vinex land share measure as the instrument (interacted with the post-period). The resulting inverse elasticities are somewhat larger but qualitatively similar to those in Table 5.

Mobility toward Vinex. We first consider outflows from surrounding buurts into Vinex neighborhoods (Columns 1 and 2), setting the dependent variable equal to the ratio of the number of individuals who moved from buurt b to a Vinex neighborhood over the total population of buurt b, $m^{Vinex}_{out,b,\tau}$. High-exposure buurts exhibit substantially higher flows of residents into Vinex: the share of outgoing movers relocating to Vinex is 0.4 percentage points higher relative to other buurts with zero exposure in the same municipality and year, compared to a mean of 0.8 percentage points. This magnitude is economically significant and aligns with descriptive evidence that most Dutch moves occur over short distances. These findings support the interpretation that Vinex construction expanded local housing supply, drawing residents from nearby, more constrained areas and contributing to the localized price declines documented earlier. In Column 2, we split mobility by high and low-income neighborhoods. We find an effect of 0.5 percentage points in high-income neighborhoods and 0.3 percentage points in low-income neighborhoods, but this effect is not statistically significant.

Net population changes. Next, we analyze whether exposure to Vinex leads to differential population growth (Columns 3 and 4). Setting the dependent variable equal to the ratio of the difference between individuals moving in and out of a buurt relative to total population ($m_{in-out,b,\tau}$), we find no statistically differences between high-exposure and other buurts both when looking at all neighborhoods (Column 3) and when separating high- and low-income neighborhoods (Column 4). Thus, despite higher outflows to Vinex, these neighborhoods do not experience persistent population losses, suggesting that inflows from other sources offset moves to Vinex. This pattern aligns with Vinex acting primarily as a new substitute for nearby high-demand neighborhoods, without triggering broader out-migration.

In-migration. Finally, we analyze whether exposure to Vinex leads to lower in-migration relative to the total population ($m_{in,b,\tau}$, Columns 5 and 6). While we find no differential effect on highly-exposed neighborhoods on average, we do find weakly statistically significant differences between high- and low-income neighborhoods. In low-income neighborhoods, in-migration in high-exposure neighborhoods increases by about 0.9 percentage points of the population per year relative to a baseline of 11% per year, whereas it decreases by about 0.5 percentage points in high-income neighborhoods. This reduced turnover is consistent with the sharper price declines experienced by high-income, high-exposure neighborhoods: as Vinex expands nearby inventory, potential in-movers increasingly choose Vinex over these high-income buurts, lowering turnover and contributing to price adjustments.

Robustness. Appendix Table A.7 provides analogous results, including all buurts as baseline, instead of only zero-exposure buurts. Appendix Table A.8 provides results for the entire 1995-2015 period. Finally, Appendix Table A.9 repeats all the tests, replacing the dummy selecting high exposure buurts ($I_{HighVinex}$) with the continuous measure of the land share within a 5-Km radius allocated to Vinex buurts ($ShareVinex$). Qualitatively, the results align with those from the main specification.

4.5 Labor Market Effects

The mobility responses documented above suggest that Vinex construction reshaped residential patterns in surrounding neighborhoods, particularly through increased moves toward Vinex and reduced turnover in high-income buurts. These mobility patterns can help explain downward pressure on prices. However, housing supply expansions may also generate counteracting forces that dampen price declines. In particular, new supply plausibly influences firm location choices and job density by improving access to workers and changing market size. To assess these labor market spillovers, we study how employment growth in non-Vinex buurts varies with exposure to Vinex land.

Jobs growth. We use LISA register data on the location of all jobs in the Netherlands and estimate Poisson regressions that compare job trajectories in high-exposure buurts with those in other buurts within the same municipality:

$$NJobs_{b,\tau} = \exp\left(\sum_{\tau=1997:2015} g_\tau (I_{HighVinex,b} \times I_\tau) + a_b + a_{muni,\tau} \right), \tag{9}$$

where $NJobs_{b,\tau}$ is the number of jobs in buurt b in year τ, $I_{HighVinex,b}$ identifies buurts in the top quartile of Vinex exposure within the municipality, and fixed effects absorb all time-invariant buurt characteristics and municipality-year shocks. Standard errors are clustered by municipality and year. Because the LISA data begin in 1996, we do not have pre-period data, and these Poisson estimates document diverging employment trajectories during the Vinex construction period rather than a classical difference-in-difference design. The year 1996 is used as a baseline.

Figure 7 shows that job growth diverged sharply across buurts during the Vinex construction period. Between the late 1990s and early 2000s, when Vinex building peaked, high-exposure buurts gained roughly 12–15% more jobs than other buurts with zero exposure in the same municipality. Given that total employment in non-Vinex buurts in the Randstad grew by about 30% between 1996 and 2015, this additional 12–15% represents a sizable local spillover. Estimates are similar when equation (9) is estimated over the full sample of non-Vinex buurts (in Appendix Figure A.7).

Sectoral decomposition. To identify which types of jobs drive the spillovers, we estimate a more parsimonious two-period *Poisson* specification comparing 1996 (start) and 2015 (end):

$$NJobs_{b,\tau} = \exp(g_{end}(I_{HighVinex,b} \times I_{\tau=2015}) + a_b + a_{muni,\tau}), \tag{10}$$

where g_{end} captures differential job growth in high-exposure buurts over the full period.

Column 1 of Table 7 provides estimates of equation (10), setting $NJobs_{b,\tau}$ equal to the total number of jobs per buurt. High-exposure buurts experienced 14% more total job growth than other buurts, consistent with the evidence in Figure 7. Job growth does not differ meaningfully between high- and low-income neighborhoods (Column 2). However, the sectoral decomposition reveals substantial heterogeneity. We find no effects for Agriculture or Manufacturing (Column 3), which is not surprising given the lower number of jobs overall. Non-tradable services do not exhibit significant gains either (Column 4). In contrast, Tradable Services—sectors typically requiring higher-skilled labor—account for nearly all of the differential growth, with highly significant point estimates of 32%.

These sectoral patterns indicate that the overall job spillover is driven almost entirely by growth in higher-wage, higher-productivity Tradable Services. This aligns with the occupational composition of households moving to Vinex areas, and suggests that housing supply expansions may have encouraged firms in these sectors to locate or expand in adjacent neighborhoods.

Robustness. Appendix Table A.10 reports estimates using the full set of non-Vinex buurts as the comparison group, with results very similar to the baseline. Appendix Table A.11 replaces the high-exposure dummy with the continuous share of Vinex land within 5 km. The main patterns remain: while the total job effect becomes less precisely estimated, the strong and significant growth in Tradable Services persists. Overall, the labor market results are robust to alternative exposure measures and sample definitions.

5 Model

To understand the general equilibrium mechanisms behind our empirical findings—particularly the heterogeneous house price effects across neighborhoods and the positive local employment spillovers—we develop a spatial equilibrium model. A key feature of the model is the integration of heterogeneous workers by production sector, with an integrated land market, where residential, tradable goods production, and local service production compete for land. Workers endogenously choose their residential and workplace locations to maximize

utility, facing both commuting costs and shopping frictions for local services. This structure allows us to trace how a local housing supply shock, like the Vinex program, can, by attracting specific types of workers (e.g., high-income tradable service workers), alter local demand, firm location, and land prices, thereby generating the complex spillovers on prices and employment observed in the data.

5.1 Environment

The city comprises N discrete spatial locations indexed by n or i, where $n, i \in \mathcal{N} = \{1, 2, ..., N\}$. Throughout the analysis, we use the subscript n to denote residential locations and the subscript i to denote workplace or production locations, although both range over the same set of locations. We study the economy in two periods: the pre-policy period and the post-policy period.

Economic activity is organized into two distinct production sectors: a tradable sector (denoted $s = G$) and a non-tradable (or local) services sector (denoted $s = S$). Empirically, the non-tradable sector S corresponds to the Non-Tradable Services identified in our data. The tradable sector G groups all remaining sectors, namely Tradable Services and Agriculture-Manufacturing. We group these sectors based on their inherent tradability, assuming their output can be freely transported across locations within and outside the city at zero cost.[13] We normalize the price of the composite tradable good to unity, $p^G = 1$, which serves as the numeraire throughout. While non-tradable services are produced at a specific location j, residents from any location n can consume them, subject to "shopping frictions". Each production location j has a local service price p_j that reflects both production costs and local demand conditions.

The city's labor force consists of workers who are categorized into two types, indexed by $g \in \{G, S\}$, based on their employment sector. Each worker's sectoral assignment is exogenous and fixed. The total population of type-g workers is denoted by $\overline{L}^g$ and is fixed, reflecting the assumption that workers can relocate within the city but cannot migrate to other cities. We later relax this assumption in a counterfactual exercise to allow the city to attract more workers. Workers choose both where to live and where to work within the city. Let λ^g_{ni} denote the probability that a randomly selected type-g worker chooses to reside in location n and work in location i. The residential population of type-g workers at location n is then given by $L^g_{R,n} = \sum_{i=1}^{N} \lambda^g_{ni} \overline{L}^g$, while the workplace population at location i is $L^g_{W,i} = \sum_{n=1}^{N} \lambda^g_{ni} \overline{L}^g$.

[13] This aggregation is also a practical necessity: the Agriculture-Manufacturing sector represents a very small share of the urban population, which causes severe zero share problems during model solution and estimation.

5.2 Worker Preferences and Behavior

Utility Function. Consider a representative worker ω of type g who resides in location n and commutes to workplace i. This worker derives utility from consuming three goods: tradable goods ($C^G_{\omega ni}$), local services ($C^S_{\omega ni}$), and housing ($H_{\omega ni}$). We adopt a Stone-Geary specification with a minimum subsistence level of housing $\bar{h}^g \geq 0$:

$$U^g_{\omega ni} = \frac{z_{\omega ni} B^g_n}{d^g_{ni}} \left(C^G_{\omega ni}\right)^{\beta^g} \left(C^S_{\omega ni}\right)^{\gamma^g} \left(H_{\omega ni} - \bar{h}^g\right)^{1-\beta^g-\gamma^g}, \tag{11}$$

Here, $z_{\omega ni}$ is an idiosyncratic preference shock for the location pair (n, i). $B^g_n > 0$ captures type-g workers' valuation of residential amenities at location n (e.g., schools, parks). Finally, $d^g_{ni} = \exp(\kappa^{\text{work},g}\bar{\tau}_{ni}) \geq 1$ represents an iceberg commuting cost from residing in n and working in i, where $\bar{\tau}_{ni}$ is the baseline travel impedance (e.g., distance or travel time) and $\kappa^{\text{work},g} > 0$ scales the sensitivity to this cost. The expenditure share parameters $\beta^g, \gamma^g \in (0, 1)$ govern the allocation of above-subsistence income.

Heterogeneity in Location Preferences. The idiosyncratic preference shocks $z_{\omega ni}$ follow a Fréchet distribution:

$$F(z_{\omega ni}) = \exp\left[-T^g_n E^g_i z^{-\epsilon^g}_{\omega ni}\right], \tag{12}$$

where $E^g_i > 0$ captures the attractiveness of location i as a workplace for type-g workers, and $\epsilon^g > 1$ governs the dispersion of preferences. Note that the residential baseline attractiveness T^g_n and the residential amenity B^g_n (from Eq. 11) are not separately identifiable in the final choice probability. We therefore follow standard practice and normalize $T^g_n = 1$ for all n, g. The B^g_n term thus absorbs and captures all residential location characteristics.

Consumption of Local Services. Workers can access services from any location j, but face shopping frictions. At each location j, a mass $M_j > 0$ of differentiated service varieties exists at a common price p_j. Shopping frictions take an iceberg form: to consume one unit of a service from j while residing at n, a worker must purchase $t^g_{nj} = \exp(\kappa^{\text{shop},g}\bar{\tau}_{nj}) \geq 1$ units. Here, $\kappa^{\text{shop},g} > 0$ scales the travel impedance $\bar{\tau}_{nj}$ for shopping. As we do not observe bilateral shopping flows to empirically calibrate this parameter, we assume it is identical to the work commuting cost sensitivity, i.e., $\kappa^{\text{shop},g} = \kappa^{\text{work},g}$.

Workers aggregate service varieties via a CES function. The effective service price index faced by a type-g worker residing in location n is:

$$P^{S,\text{eff}}_{n,g} = \left(\sum_{j=1}^{N} M_j (t^g_{nj} p_j)^{1-\sigma_S}\right)^{\frac{1}{1-\sigma_S}}, \tag{13}$$

where $\sigma_S > 1$ is the elasticity of substitution.

Budget Constraint and Optimal Choices. A type-g worker residing in n and working in i earns wage w_i^g. The worker must purchase the minimum housing $\bar{h}^g$ at price q_n. The budget constraint for remaining "discretionary" income $w_i^g - q_n\bar{h}^g$ is:

$$C_{\omega ni}^G + P_{n,g}^{S,\text{eff}} C_{\omega ni}^S + q_n(H_{\omega ni} - \bar{h}^g) = w_i^g - q_n\bar{h}^g. \tag{14}$$

Given the Cobb-Douglas form of preferences (Eq. 11), optimal demands are constant expenditure shares of this discretionary income: $C_{\omega ni}^{G*} = \beta^g(w_i^g - q_n\bar{h}^g)$, $C_{\omega ni}^{S*} = \gamma^g(w_i^g - q_n\bar{h}^g)/P_{n,g}^{S,\text{eff}}$, and total housing is $H_{\omega ni}^* = \bar{h}^g + (1-\beta^g-\gamma^g)(w_i^g - q_n\bar{h}^g)/q_n$.

Location Choice Probabilities. Substituting optimal demands into the utility function yields the indirect utility $u_{\omega ni}^g = z_{\omega ni} \cdot \Theta_{ni}^g \cdot (w_i^g - q_n\bar{h}^g)$, where Θ_{ni}^g is the composite attractiveness index:

$$\Theta_{ni}^g := \frac{c^g B_n^g}{d_{ni}^g} (P_{n,g}^{S,\text{eff}})^{-\gamma^g} (q_n)^{\beta^g+\gamma^g-1}, \tag{15}$$

and c^g is a constant derived from the preference shares. Given the Fréchet shocks, the probability that a type-g worker selects residence n and workplace i is $\lambda_{ni}^g = \Phi_{ni}^g/\Phi^g$, where $\Phi^g = \sum_{n=1}^N \sum_{i=1}^N \Phi_{ni}^g$, and the numerator (reflecting our normalization $T_n^g = 1$) is:

$$\Phi_{ni}^g = E_i^g \left[\Theta_{ni}^g (w_i^g - q_n\bar{h}^g)\right]^{\epsilon^g}. \tag{16}$$

This expression shows that the choice probability increases with residential amenities (B_n^g), workplace attractiveness (E_i^g), and net disposable income, and decreases with commuting costs (d_{ni}^g), housing prices (q_n), and service prices ($P_{n,g}^{S,\text{eff}}$).

5.3 Production Technologies and Factor Prices

Tradable Goods Sector. Firms in the tradable goods sector operate under perfect competition with free entry. Production at location i combines labor L_i^G and land D_i^G using a Cobb-Douglas technology:

$$Y_i^G = A_i^G (L_{W,i}^G)^{\alpha_G} (D_i^G)^{1-\alpha_G}, \tag{17}$$

where $A_i^G > 0$ represents location-specific productivity and $\alpha_G \in (0,1)$ is the labor share. Under perfect competition, firms earn zero profits. With the tradable goods price normalized to unity, the zero-profit (or unit-cost) condition implies that the wage for

goods-sector workers is:

$$w_i^G = \alpha_G (A_i^G)^{1/\alpha_G} \left(\frac{1-\alpha_G}{q_i} \right)^{(1-\alpha_G)/\alpha_G}. \tag{18}$$

This expression shows that wages increase with productivity A_i^G but decrease with local land prices q_i. The cost-minimizing input ratio is $D_i^G / L_{W,i}^G = [(1-\alpha_G)/\alpha_G] \cdot (w_i^G / q_i)$.

Local Services Sector. The local services sector features monopolistic competition with free entry. Each service location i hosts a continuum of differentiated varieties $\nu \in [0, M_i]$, with each variety produced by a single firm. Firm-level production combines labor $\ell_i(\nu)$ and land $d_i(\nu)$ according to:

$$y_i(\nu) = a_i^S (\ell_i(\nu))^{\alpha_S} (d_i(\nu))^{1-\alpha_S}, \tag{19}$$

where $a_i^S > 0$ is firm-level productivity and $\alpha_S \in (0,1)$ is the labor share. Each firm faces a constant elasticity of demand $\sigma_S > 1$ and sets prices as a markup over marginal cost: $p_i = [\sigma_S/(\sigma_S - 1)] \cdot c_i$. The unit variable cost c_i is determined by the firm-level productivity and the composite factor price r_i^S, such that $c_i = r_i^S / a_i^S$. This composite factor price is given by $r_i^S = \alpha_S^{-\alpha_S} (1-\alpha_S)^{-(1-\alpha_S)} (w_i^S)^{\alpha_S} q_i^{1-\alpha_S}$. Entry is free but requires a fixed cost $F_i = r_i^S f$ paid in the same factor bundle. We normalize the fixed cost parameter $f = 1$, as it is not separately identified from firm-level productivity a_i^S.

Under the zero-profit condition from free entry, the mass of active varieties at location i is determined by:

$$M_i = \frac{1}{\sigma_S} (L_{W,i}^S)^{\alpha_S} (D_i^S)^{1-\alpha_S}, \tag{20}$$

where $L_{W,i}^S$ and D_i^S denote the aggregate labor and land employed in the service sector at location i. This shows that variety proliferation increases with the scale of the local service sector.

The wage for service-sector workers at location i is derived by inverting the pricing and unit cost equations:

$$w_i^S = \alpha_S \left(\frac{\sigma_S - 1}{\sigma_S} \right)^{1/\alpha_S} (a_i^S p_i)^{1/\alpha_S} \left(\frac{1-\alpha_S}{q_i} \right)^{(1-\alpha_S)/\alpha_S}. \tag{21}$$

As in the goods sector, service wages increase with productivity and decrease with land prices. Additionally, wages rise with the local service price p_i, which reflects local demand conditions.

5.4 Housing Market

Each location features a local housing market with an upward-sloping supply curve. The inverse housing supply function at location n takes the form:

$$q_n = \pi_n D_n^{1/\eta_n}, \tag{22}$$

where q_n denotes the equilibrium housing price (or rent per unit of housing), D_n represents the total quantity of housing demanded at that location, $\pi_n > 0$ is a location-specific supply shifter that captures fundamental land availability and regulatory constraints, and $\eta_n > 0$ is the price elasticity of housing supply. Higher values of η_n indicate a more elastic housing supply, meaning housing prices rise more slowly in response to increased demand. This formulation nests both perfectly elastic supply ($\eta_n \to \infty$, implying constant housing prices) and perfectly inelastic supply ($\eta_n \to 0$, implying fixed housing stock).

5.5 Market Equilibrium

Labor Market Clearing. For each worker type $g \in \{G, S\}$ and each location i, the workplace labor $L_{W,i}^g$ must equal the sum of workers who choose to work there from all residential locations:

$$L_{W,i}^g = \sum_{n=1}^{N} \lambda_{ni}^g \overline{L}^g. \tag{23}$$

This condition ensures that workplace labor demand is met by workers' location choices. Similarly, the residential population of type-g workers at location n is $L_{R,n}^g = \sum_{i=1}^N \lambda_{ni}^g \overline{L}^g$.

Land Market Clearing. A key feature of our model is that land serves three distinct uses at each location: residential housing, goods production, and service production. Total land demand at location n is $D_n^{\text{total}} = D_n^R + D_n^G + D_n^S$.

Residential land demand aggregates housing consumption across all workers residing at location n:

$$D_n^R = \sum_{g \in \{G,S\}} L_{R,n}^g \left[\bar{h}^g + (1 - \beta^g - \gamma^g) \frac{\mathbb{E}_n[w^g] - q_n \bar{h}^g}{q_n} \right], \tag{24}$$

where $\mathbb{E}_n[w^g] = \sum_{i=1}^N w_i^g \lambda^g(i|n)$ denotes the expected wage for type-g workers residing at n, with $\lambda^g(i|n) = \lambda_{ni}^g / \sum_j \lambda_{nj}^g$. This captures land demand from both minimum and discretionary housing.

Production land demands follow from firms' cost-minimization. For the tradable goods sector at location n:

$$D_n^G = \frac{(1 - \alpha_G) w_n^G L_{W,n}^G}{\alpha_G q_n}. \tag{25}$$

For the services sector at location n, factor exhaustion yields:

$$D_n^S = \frac{(1-\alpha_S)R_n^S}{q_n}, \tag{26}$$

where R_n^S denotes the total revenue of service firms at location n.

The land market clears when total demand equals the quantity supplied (from the supply function defined in Section 6.4):

$$D_n^R + D_n^G + D_n^S = \left(\frac{q_n}{\pi_n}\right)^{\eta_n}. \tag{27}$$

This condition jointly determines the equilibrium land price q_n. The unified land market creates a general equilibrium linkage: for instance, an increase in goods-sector employment at location n (higher $L_{W,n}^G$) raises production land demand, which in turn increases q_n, thereby pushing up housing costs.

Service Market Clearing. Services are produced at location j and consumed by residents from all locations n, subject to shopping frictions. Total service expenditure at service destination j ($\mathcal{E}_j^S$) aggregates the shopping flows from all residential locations n:

$$\mathcal{E}_j^S = \sum_{g\in\{G,S\}} \sum_{n=1}^{N} \pi_{n\to j|g}^S \cdot \gamma^g L_{R,n}^g (\mathbb{E}_n[w^g] - q_n \bar{h}^g), \tag{28}$$

where the term $\gamma^g L_{R,n}^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g)$ represents the total service budget of type-g workers residing at location n. The expenditure share flowing from residence n to service destination j is:

$$\pi_{n\to j|g}^S = \frac{M_j (t_{nj}^g p_j)^{1-\sigma_S}}{\sum_{k=1}^N M_k (t_{nk}^g p_k)^{1-\sigma_S}}, \tag{29}$$

which reflects the gravity structure: expenditure flows increase with the variety mass at destination j (M_j) and decrease with the friction-adjusted price ($t_{nj}^g p_j$).

In practice, we only observe employed workers. To account for service expenditure by unobserved consumers (such as retirees or students), we introduce a coverage factor $\zeta \geq 1$. Because services are non-tradable, the total revenue at service destination j (R_j^S) must equal the total in-destination expenditure from all consumers. The service market-clearing condition for each location j is therefore:

$$R_j^S = \zeta \mathcal{E}_j^S, \tag{30}$$

where ζ is calibrated to ensure aggregate service revenue matches aggregate service-sector income. This approach scales up the observed worker expenditure to match the full revenue generated by service firms.

5.6 Welfare Analysis

Expected Utility. For each worker type $g \in \{G, S\}$, the expected maximum indirect utility across all location pairs is:

$$W^g = \Gamma\left(1 - \frac{1}{\epsilon^g}\right)(\Phi^g)^{1/\epsilon^g}, \tag{31}$$

where $\Gamma(\cdot)$ is the gamma function and Φ^g is the inclusive value (or option value sum) defined as:

$$\Phi^g = \sum_{n=1}^{N}\sum_{i=1}^{N} T_n^g E_i^g \left[\frac{B_n^g(w_i^g - q_n\bar{h}^g)}{d_{ni}^g (P_{n,g}^{S,\text{eff}})^{\gamma^g}(q_n)^{1-\beta^g-\gamma^g}}\right]^{\epsilon^g}. \tag{32}$$

Money-Metric Measures. The expected utility W^g is homogeneous of degree one in net disposable income, which allows us to express welfare changes in monetary terms. We employ two standard measures.

The equivalent variation (EV) measures the income transfer at pre-shock (t=0) prices and frictions that would make workers indifferent between the pre-shock (t=0) and post-shock (t=1) equilibria. For type-g workers:

$$\text{EV}^g = y_0^g\left[\left(\frac{\Phi_1^g}{\Phi_0^g}\right)^{1/\epsilon^g} - 1\right], \tag{33}$$

where y_t^g is the average net disposable income weighted by location choices in equilibrium $t \in \{0, 1\}$. A positive EV^g indicates that workers are better off in the post-shock (t=1) equilibrium.

The compensating variation (CV) measures the income transfer at post-shock (t=1) prices and frictions that would restore workers to their pre-shock (t=0) utility level:

$$\text{CV}^g = y_1^g\left[1 - \left(\frac{\Phi_0^g}{\Phi_1^g}\right)^{1/\epsilon^g}\right]. \tag{34}$$

6 Parameter Calibration

6.1 Calibration Strategy and Results

We calibrate the model's baseline equilibrium to match the observed spatial allocation in 2015, which represents the "post-shock" period *after* the Vinex policy was implemented. This approach is adopted over using "pre-shock" (1995) data primarily due to the superior availability and richness of contemporary data sources.[14]

[14]This strategy of calibrating to a post-shock equilibrium to evaluate a counterfactual—in our case, what would the spatial equilibrium look like if the policy had *not* occurred?—is long adopted in literature

Our calibration strategy proceeds in two main stages. First, we set or estimate key preferences and technological parameters. These include production factor shares (α_G, α_S) estimated from aggregate land and wage payments (Appendix C.1); Stone-Geary preference parameters $(\beta^g, \gamma^g, \bar{h}^g)$ identified from an Engel curve regression on microdata (Appendix C.2); and the Fréchet elasticity of location choice (ϵ^g) and commuting cost sensitivity (κ^g) jointly estimated from a gravity model of bilateral commuting flows (Appendix C.3). For the remaining parameters, we set the elasticity of substitution among service varieties to $\sigma_S = 4$, representing a moderate degree of substitutability between local services. Table 8 reports the complete set of calibrated parameters, which remain fixed in our baseline equilibrium and counterfactual exercises.

We then calibrate the model's unobserved fundamentals. This is an inverse calibration exercise where we find the set of fundamentals $\{w_i^g, E_i^g, A_i^G, a_i^S, B_n^g, \pi_n\}$ that ensures the model's equilibrium simultaneously matches the observed data on workplace populations (L_{Wi}^g), residential populations (L_{Rn}^g), observed wages (w_i^g), and rents (q_n). The algorithms for this inverse calibration are detailed in Online Appendix D. The resulting spatial distributions of these calibrated fundamentals, which capture the heterogeneous economic geography of the city, are visualized in Online Appendix Figures C.8, (workplace amenities), D.10 (productivity), and D.11 (residential amenities).

6.2 Model Fit

We assess the model's goodness-of-fit. By construction, the calibration ensures that the model exactly matches the observed spatial distributions of workplace employment (L_{Wi}^g), residential population (L_{Rn}^g), and land rents (q_n). To validate the model's internal consistency, we compare its endogenous predictions for wages and commuting flows against their empirical counterparts. Figure D.9 plots the model-calibrated wages $(\hat{w}_i^g)$ against observed wages, demonstrating a strong correlation and tight fit around the 45-degree line. Furthermore, Figure D.12 validates the mechanism of spatial sorting by plotting the model-predicted joint commuting probabilities against observed shares. The points cluster tightly around the 45-degree line.

7 Counterfactual Results

7.1 Counterfactual Simulation Setup

To quantify the impact of the Vinex policy, we compare the calibrated spatial equilibrium with Vinex to a counterfactual equilibrium without the policy. The baseline equilibrium

(e.g., Caliendo, Dvorkin, and Parro, 2019; Galle, Rodríguez-Clare, and Yi, 2022).

represents the observed post-policy economy in 2015, as calibrated in Section 6. In this equilibrium, all neighborhoods, including the new Vinex areas, are available for workers and firms. Housing supply elasticities η_n differ across neighborhoods as a function of Vinex designation ('Vinexshare', v_n), as specified in Table 8: $\eta_n = 0.6 + 0.15 \times v_n$. Established non-Vinex areas ($v_n = 0$) have a highly inelastic supply of $\eta_n = 0.6$, while fully designated Vinex areas ($v_n = 1$) are more elastic at $\eta_n = 0.75$, reflecting the policy.

The counterfactual equilibrium removes the Vinex expansion. We introduce two changes relative to this baseline. First, we exclude fully-designated Vinex neighborhoods ($v_n = 1$), which were undeveloped farmland, from the feasible choice set by assigning them a prohibitively high "wasteland rent" ($q_n = \overline{q} = 10^6$), which drives their equilibrium population and land demand to zero. Second, we adjust the housing supply elasticities of all remaining neighborhoods to reflect the pre-policy constraints: $\eta_n = 0.6 - 0.55 \times v_n$ This assumption reflects that neighborhoods partially targeted by the Vinex policy (i.e., $v_n > 0$) were more supply-constrained before the new land was released.

We solve this counterfactual ("No Vinex") equilibrium under three distinct "openness" scenarios to understand the role of population mobility. Our algorithms for different scenarios are detailed in Online Appendix D (see Algorithms 6, 7 and 8). The three scenarios are:

1. **Closed City:** We solve the counterfactual equilibrium holding the total population for both G- and S-sectors fixed at their 2015 baseline levels. We then compare the resulting counterfactual welfare with the baseline 2015 welfare to isolate the pure policy effect, abstracting from population change.

2. **Semi-Open City:** We solve the counterfactual equilibrium using the estimated 1995 population. We first calculate this "pre-shock" population by deflating the 2015 baseline population by the observed regional growth: $L_{G,1995} = L_{G,2015}/1.1818$ and $L_{S,1995} = L_{S,2015}/1.0818$.

3. **Open City:** We solve the counterfactual equilibrium, allowing total population to be fully endogenous. We use an outer fixed-point loop (Appendix Algorithm 8) where workers migrate until the utility for both sectors (U_G, U_S) equalizes with the external reservation utility, which we set as the utility from our 2015 baseline equilibrium.

7.2 Redistribution Effect

Rationalizing Price Effects: The Endogenous Moving Chain A primary contribution of our model is its ability to move beyond aggregate price effects and rationalize the underlying micro-mechanisms—namely the spatial re-sorting of heterogeneous agents—that are consistent with our empirical findings. The spatial distribution of residential

choices, as shown in Figure 8 (Rows 1-2, showing resident sorting) and Figure 9 (Rows 1-2, showing residential land demand), provides a clear illustration of this mechanism.

First, the model endogenously replicates the "first-mover" effect observed in the data. Figure 9 (Row 1) shows a substantial reduction in residential land demand from the G-Sector (our high-income, tradable-sector workers) in the "high-exposure" neighborhoods adjacent to the new Vinex developments (the blank, purple-outlined areas). This effect is both large in magnitude (up to -40% in the *Closed* scenario, Panel A.1) and spatially concentrated in the exact areas where G-Sector residents (see Figure 8, Row 1) were empirically observed to be the "first-round movers" leaving for the new Vinex housing.

Second, the model provides clear evidence for a "moving chain" or "back-filling" effect, driven by the S-Sector (our lower-income, non-tradable service workers). The response of the S-Sector, shown in Figure 9 (Row 2), is distinctly heterogeneous and stands in sharp contrast to the G-Sector's. In the *Closed* scenario (Panel A.2), S-Sector demand also falls, but to a much smaller degree (note the -8% scale) than the G-Sector's (-40%, Panel A.1). Critically, this trend reverses in the *Semi-open* (Panel B.2) and *Open* (Panel C.2) city scenarios, where the S-Sector's residential demand in these same Vinex-adjacent neighborhoods shows a *countervailing increase* (turning red). This back-filling, in addition to any housing price effects, is also explained by the general equilibrium re-sorting of production and employment, which we explore in the next section.

Finally, the model rationalizes the net price decline observed in our empirical analysis. As Figure 9 (Rows 1 and 2) illustrates, the change in residential land demand for both sectors in these adjacent neighborhoods remains negative (blue) in the *Closed* (Panel A.5) and *Semi-open* (Panel B.5) scenarios. The magnitude of the negative demand shock from the exiting G-Sector (first movers, see Row 1) is substantially larger than the countervailing positive demand from the in-moving S-Sector (second movers, see Row 2). This net negative shock to residential housing demand is precisely the mechanism that rationalizes the empirically observed price decline in the Vinex-adjacent communities.

Spatial Re-sorting of Production and Employment Having established the mechanisms of residential re-sorting, we now turn to the model's implications for the spatial distribution of production. Figures 9 (Rows 3-4, showing production land demand) and 8 (Rows 3-4, showing worker allocation) illustrate the change in production land demand (D_i^g) and worker allocation ($L_{W,i}^g$) for both sectors. These results provide a clear, mechanism-based rationalization for the employment agglomeration observed in our empirical findings.

The S-Sector's (non-tradable) response provides the clearest evidence of an endogenous agglomeration economy. As shown in Figures 8 (Row 4) and 9 (Row 4), the Vinex-adjacent neighborhoods experience a dramatic and highly concentrated increase in both S-Sector

workers ($L^S_{W,i}$) and land demand (D^S_i). This is a direct consequence of our monopolistic competition framework. The S-Sector is fundamentally demand-driven, and its profitability is tied to local expenditure ($\mathcal{E}^S_i$). As high-income G-Sector residents relocated to the new Vinex housing, they brought their substantial purchasing power. This localized demand shock fueled an *in-situ* expansion: it became profitable for new service varieties (M_s) to enter these suburban markets (see Figure 10, Row 5), leading to a corresponding increase in the factors of production (labor $L^S_{W,i}$ and land D^S_i) required to meet this new demand.

The G-Sector's (tradable) employment response, visualized in Figure 8 (Row 3), reveals a distinct pattern of intensification in the central business districts (CBD), which is especially pronounced in the *Closed* (Panel A.3) scenario. This outcome is driven by our modeling assumption of *perfect tradability* and *perfect competition* in the G-sector. Because the price of tradable goods is fixed nationally and independent of local demand saturation, firms in the G sector face a perfectly elastic demand curve. Consequently, employment is primarily determined by supply-side fundamentals: high workplace amenities (E^G_i) and high productivity (A^G_i), both of which are relatively higher in the CBD. The Vinex housing supply shock acts as a release valve by lowering the effective cost of living and enabling more workers to afford access to these high-productivity CBD jobs. Vinex supply therefore releases the pent-up labor supply that can now commute to or inhabit the city center to exploit its fundamental productive advantages.

However, this spatial pattern, the G-Sector's continued concentration in high-productivity central areas, does not perfectly align with the strong suburban agglomeration of tradable jobs found in our empirical section. This discrepancy is an explicit and interpretable feature of the model. We assume that firm locations, along with their baseline productivity (A^G_i) and amenities (E^G_i), are fixed both before and after the shock. The model does not capture the channel of firms physically relocating their operations. Instead, it isolates the general equilibrium effect of *worker* re-sorting across a fixed landscape of firms, who can only adjust their factor inputs (labor and land) *in situ*.

Equilibrium Adjustments in Land Rents and Wages Finally, we analyze the policy's impact on the city's price structure, focusing on land rents (q_n) and wages (w_g). The results, shown in Figure 10 (Row 3 for rents and Row 1 and 2 for wages), reveal how the spatial re-sorting of residents and production translates into a new general equilibrium.

The model's result for land rent (q_n), shown in Figure 10 (Row 3), at first appears to diverge from our empirical findings. While the *Closed* scenario (Panel A.3) shows a widespread price decline (blue), the *Semi-open* scenario (Panel B.3) shows a more complex pattern, with rents in some Vinex-adjacent areas *increasing* (red). This is a direct consequence of our model's unified land market assumption. Unlike our empirical analysis, which focused exclusively on *residential* housing prices, the model's q_n represents

a single, unified price for *all* land uses, including commercial.

This unified price is the net outcome of two powerful and opposing forces. On one hand, residential demand in the "high-exposure" areas falls as G-Sector residents (and, to a lesser extent, S-Sector residents) relocate to the new Vinex developments, placing downward pressure on q_n. On the other hand, these same neighborhoods experience a significant *increase* of commercial land demand, driven by the S-Sector's endogenous agglomeration (as shown in Figure 9, Row 4). The model's final land rent q_n reflects the net equilibrium of this trade-off: the new commercial demand partially, or in some scenarios fully, offsets the loss of residential demand. This mechanism rationalizes why our empirical results, which isolate the residential channel, show a clear price decline, whereas the model's unified price is more stable.

The wage adjustments, shown in Figure 10 (Rows 1-2), reveal a stark divergence between the two sectors, which is again a product of our model's core assumptions. The G-Sector (tradable) wage (Row 1) remains largely stable across all scenarios. Because this sector is modeled under perfect competition and is fully integrated with the external economy, its price ($p^G = 1$) and wage (w_G) are effectively pinned by the external market, leaving them largely insensitive to local demographic shocks.

In contrast, the S-Sector (non-tradable) wage (Figure 10, Row 2) exhibits a significant and widespread *increase*, particularly in the *Closed* (Panel A.2) and *Semi-open* (Panel B.2) scenarios. This is rooted in our monopolistic competition framework for the S-Sector, where profitability is local. The Vinex policy, by facilitating suburban expansion, effectively "spreads out" the city's population and economic activity. This spatial de-densification reduces the intensity of local competition among S-Sector firms. In such a framework, lower competitive density allows firms to increase markups, leading to higher service prices (p_S), as confirmed in Figure 10 (Row 4), and increased firm revenue (R_i^S). This rise in profitability is then passed on to S-Sector workers in the form of higher equilibrium wages (w_S) (Figure 10, Row 2).

7.3 Aggregate Economic Impact and Welfare Analysis

We now "zoom out" from the spatial redistribution effects to analyze the policy's city-wide aggregate and welfare consequences under our three scenarios. The key results, summarized in Tables 9 and 10, indicate that the Vinex policy had a significant net positive impact on the city's economy, albeit with unequal welfare gains and a stark trade-off between short-term affordability and long-term growth.

The "Closed" City: The *Closed* city scenario (Panel A in both tables) isolates the policy's impact on the fixed incumbent population. The results show a clear welfare gain for all residents, as W^g increases for both groups. However, these gains are distributed

highly unequally. The S-Sector (non-tradable) workers are the unambiguous winners, experiencing a per-capita welfare gain of 5,599 EUR (EV). In contrast, the G-Sector (tradable) workers see a much more modest increase of 1,343 EUR. Table 10 reveals the mechanism: S-Sector workers enjoy a "double dividend" as their average wage (w_S) rises by 7.0% while average land rent (q_n) falls by 6.6%. G-Sector workers, whose wages (w_G) are pinned by the national market and remain flat (-0.5%), only benefit from the fall in rents.

The "Semi-Open" City: The *Semi-open* scenario (Panel B) reveals a critical turning point where moderate population inflows (G: +18.2%, S: +8.2%) occur. Here, the affordability gains vanish: the influx of new demand overwhelms the supply shock, causing average land rent (q_n) to rise by 3.14%. This inflation is compounded by a surge in service prices (p_S: +12.0%) and S-Sector wages (w_S: +12.6%). This environment triggers a sharp welfare redistribution. S-Sector workers, whose wages are endogenous and rise faster than costs, remain winners (EV $\approx$ +5,639 EUR). However, the G-Sector workers (EV $\approx$ -1,196 EUR) suffer a net welfare *loss*. Their externally fixed wages cannot keep pace with the city's rising cost of both housing and local services, eroding their real purchasing power.

The "Open" City: The *Open* city scenario (Panel C) shows the long-term equilibrium, where population inflows have competed away all welfare gains (EV $\approx$ 0). The Vinex policy makes the city vastly more attractive, inducing a massive population boom (G: +37.5%, S: +33.2%). This new demand pushes average rents up by 11.5% relative to the baseline. In this long-run view, the Vinex policy is not an affordability policy but a powerful economic growth engine. It facilitates a larger, more productive city, with total output in both sectors rising dramatically.

Connecting to Empirics Our empirical findings of a *decline* in nearby local housing prices are qualitatively more in line with the *Closed* scenario and less consistent with the *Semi-open* or *Open* scenarios. This suggests that during the period of our empirical study, the impact of the Vinex policy was dominated by the internal spatial re-sorting of the incumbent population (the "Closed" case mechanism) rather than by significant population inflows that would have reversed the price declines. The long-run, "open city" equilibrium had not yet been reached.

8 Conclusion

This paper uses the Vinex program, a rare centrally planned expansion of developable land in the Netherlands, to show how large-scale housing supply shocks affect urban structure.

Vinex substantially increased suburban construction and triggered strong re-sorting of households, with high-income movers concentrating in new neighborhoods and reshaping demand in surrounding areas. Nearby affluent neighborhoods experienced persistent price declines, while low-income neighborhoods saw little change. At the same time, Vinex stimulated sizable local employment growth, especially in Tradable Services, showing that major supply expansions influence not only housing markets but also the geography of economic activity.

A quantitative spatial equilibrium model helps explain these patterns. By altering the attractiveness of different neighborhoods, Vinex draws high-income households outward, reduces demand in comparable nearby areas, and increases service demand around the new developments. The model shows that the strength and reach of these effects depend on the openness of the city. In a context like the Netherlands, adjustment operates mainly through the re-sorting of incumbents and partially through population growth, producing the localized price and employment effects we observe.

For policymakers, the results highlight both the potential and the limits of large-scale supply reforms. Expanding developable land can improve affordability in parts of the market and can stimulate local economic activity, but these benefits are uneven and concentrated in neighborhoods that compete directly with the new housing. Supply reforms alone are unlikely to lower housing costs in low-income areas without complementary policies that increase substitutability across segments of the housing market. At the same time, the absence of a house price response in some neighborhoods need not imply a lack of benefits, since amenities and job access may still improve. Large-scale housing programs should therefore be evaluated not only by the number of units delivered, but also by where they are built, who they attract, and how they reshape the broader urban equilibrium.

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Figures and Tables

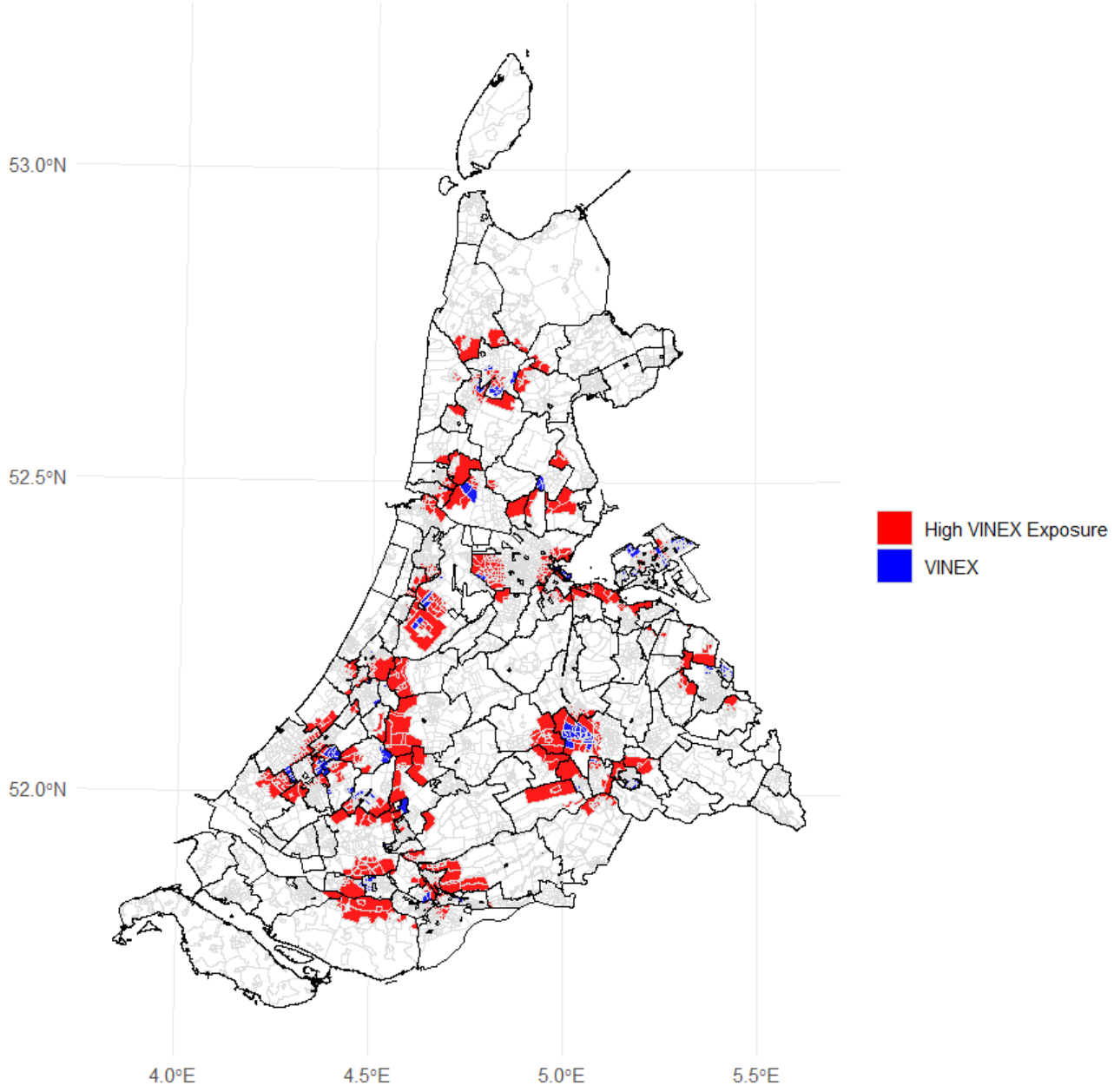
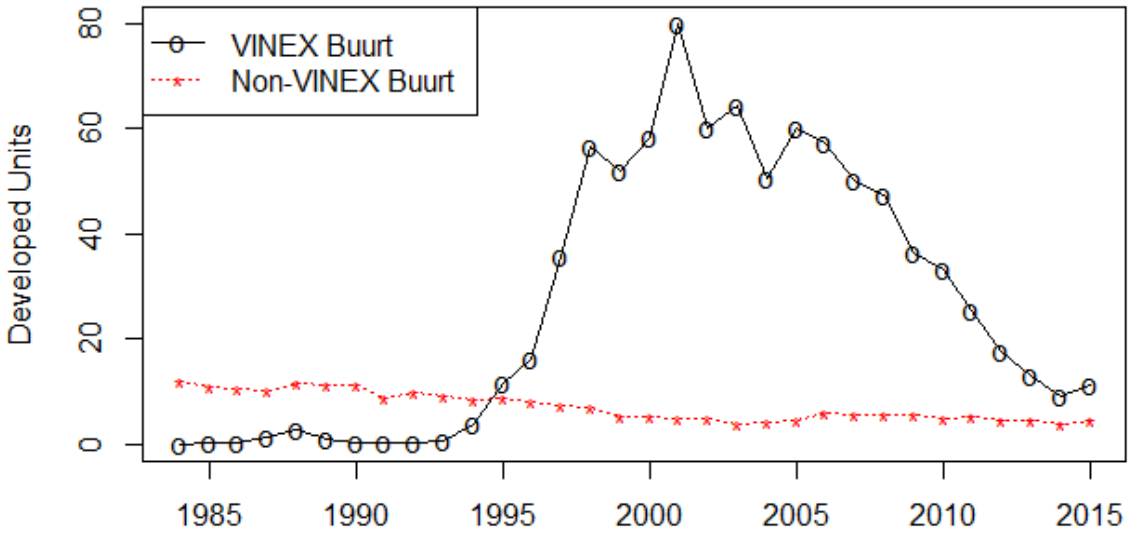
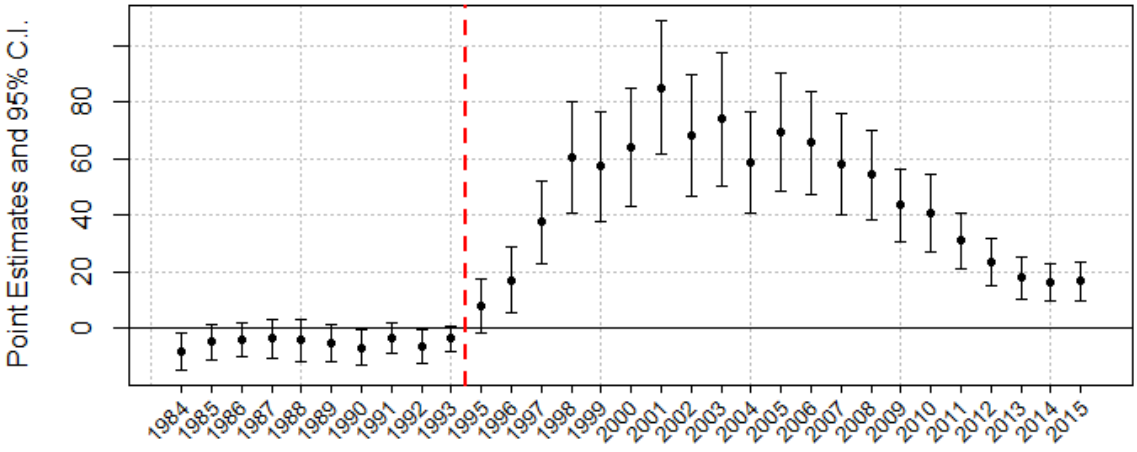


Figure 1: **Spatial Distribution of Vinex and Vinex-Exposed Neighborhoods.** The figure shows the locations of Vinex buurts and highly-exposed neighborhoods within municipalities, which are defined in Section 4.1 Vinex buurts are highlighted in blue, while buurts with high Vinex exposure (top quartile in Vinex land within 5-Km radius among buurts in the same municipality) are highlighted in red.

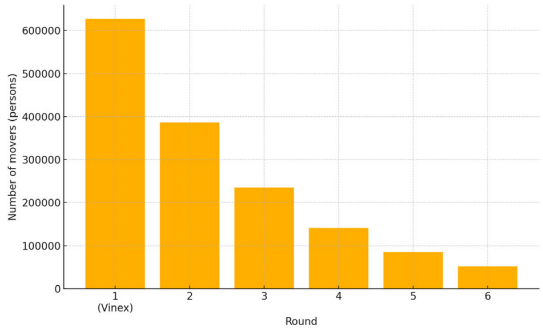


(a) Raw Averages: Developed Units

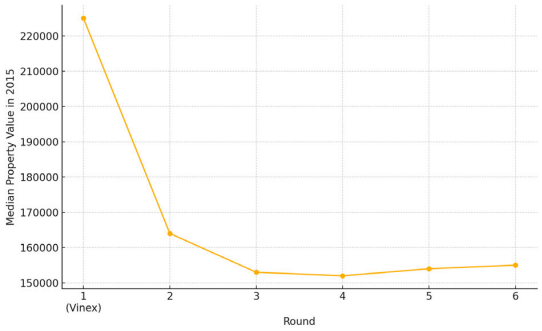


(b) Difference-in-Differences Vinex Developed Units

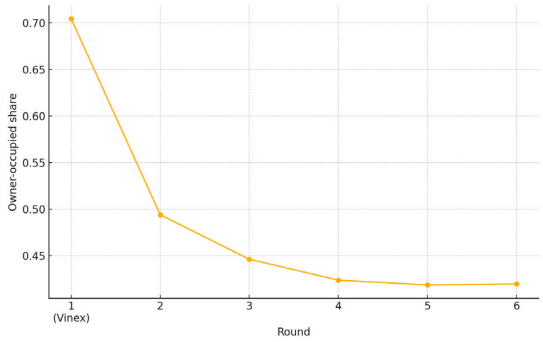
Figure 2: **The Vinex Supply Shock.** The figure displays the gap in the number of developed units between Vinex and non-Vinex buurts between 1984 and 2015. Panel (a) displays the average number of new housing units developed across buurts. Panel (b) shows the excess number of units developed on average across Vinex buurts, measured by coefficients $\gamma_{t,Vinex}$ from equation (1). The coefficient for the omitted category in 1994 is set to zero.



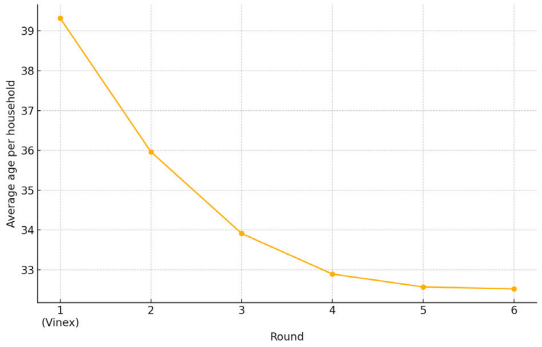
(a) Number of movers per round



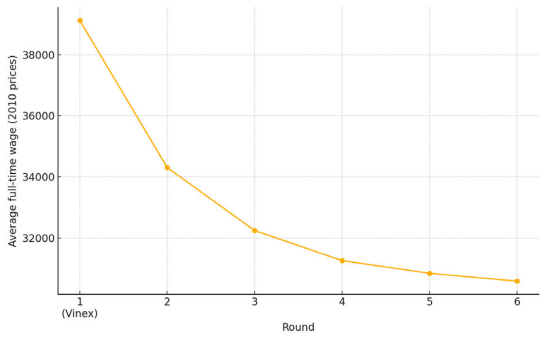
(b) Median property value per round (2015)



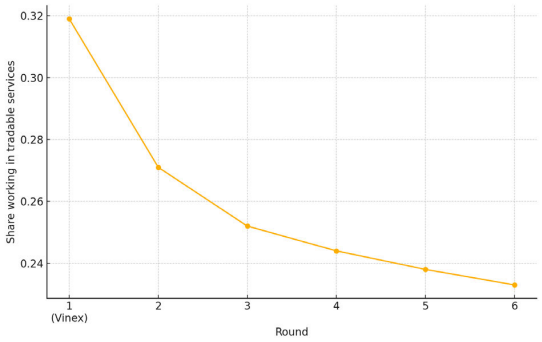
(c) Owner-occupied share per round



(d) Average age per household per round

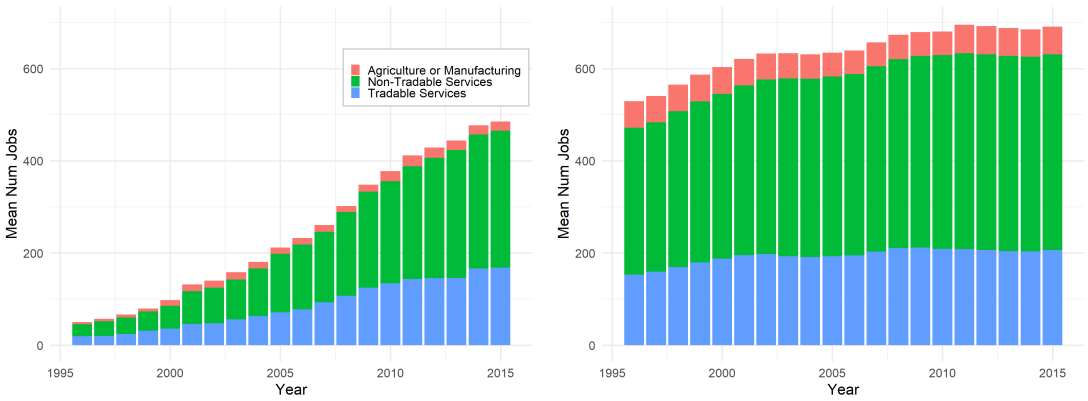


(e) Average full-time wage (2010 prices)



(f) Share employed in Tradable Services

Figure 3: **Vinex Moving Chains.** The figure displays some key facts about the individuals involved in moving chains generated by the Vinex program. The x-axis corresponds to different moving rounds, in which round 1 consists of individuals moving to Vinex, round 2 consists of individuals moving into the properties vacated by those who move to Vinex, and so on. Panel (a) shows the number of movers we track in each round, panel (b) shows the median property value of the move-in properties (for round 1, these are Vinex houses), panel (c) shows the share of individuals who are owner-occupiers after move-in, panel (d) shows the average age of movers per household, panel (e) shows the average full-time wage in 2010 prices, and panel (f) shows the share of movers employed in Tradable Services occupations. The results are based on information on address registration available from Statistics Netherlands over the period from 1995 to 2015.



(a) Vinex Mean Number of Jobs (b) Non-Vinex Mean Number of Jobs

Figure 4: **Jobs in Vinex and Non-Vinex Neighborhoods.** The figure displays the composition of jobs in Vinex (a) and non-Vinex buurts (b), across sectors belonging to agriculture or manufacturing, non-tradable services, and tradable services, and for the years from 1996 to 2015. All estimates are based on the LISA dataset.

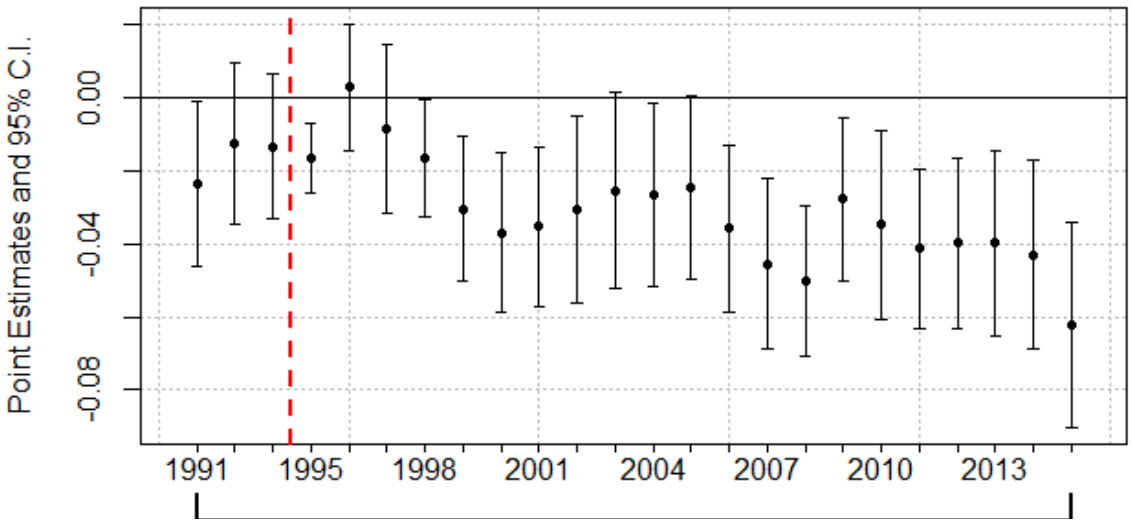
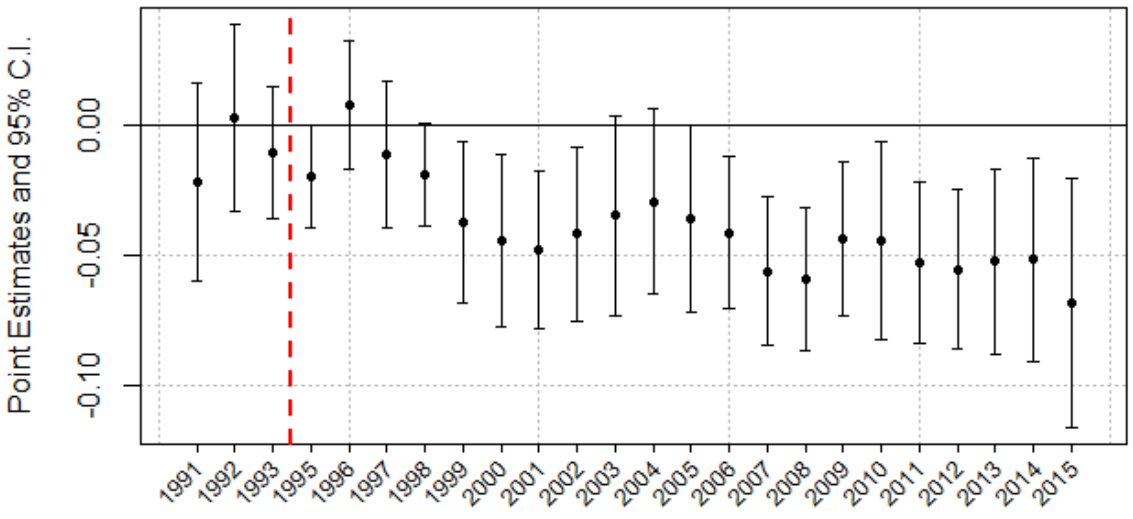


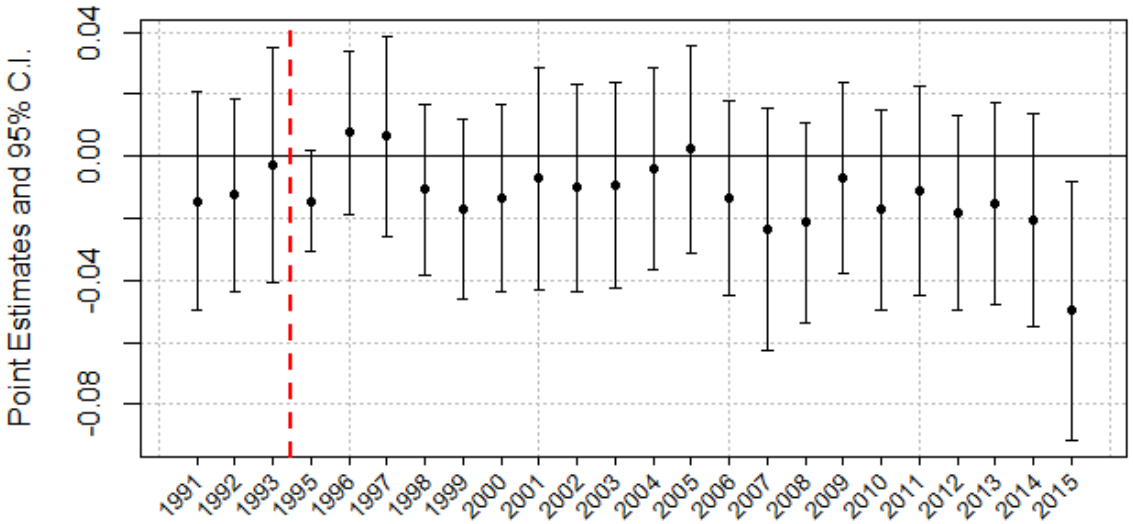
Figure 5: **Effects on Prices in Non-Vinex Neighborhoods.** The figure displays estimates from the following regression equation:

$$log(p_{i,\tau}) = \sum_{\tau=1991:2015} d_\tau(I_{HighVinex,i} \times I_\tau) + BX_i + a_b + a_{muni,\tau} + \epsilon_{i,\tau},$$

where $log(p_{i,\tau})$ is the log sales price of property i in year τ, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, I_τ is a dummy equal to one for sales in year τ, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for d_τ based on the restricted sample of burts with high exposure to Vinex ($I_{HighVinex,i} = 1$) or zero exposure. The omitted coefficient d_{1994} is equal to zero.



(a) Above Median Income Buurts



(b) Below Median Income Buurts

Figure 6: **Effects on Prices in Non-Vinex Neighborhoods, by Income.** The figure displays estimates from the following regression equation:

$$log(p_{i,\tau}) = \sum_{\tau=1991:2015} f_\tau(I_{HighVinex,i} \times I_\tau \times I_{HighInc}) + \sum_{\tau=1991:2015} g_\tau(I_{HighVinex,i} \times I_\tau \times I_{LowInc}) +$$

$$+BX_i + a_b + a_{muni,\tau,HighInc} + \epsilon_{i,\tau},$$

where $log(p_{i,\tau})$ is the log sales price of property i in year τ, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, I_τ is a dummy equal to one for sales in year τ, $I_{HighInc}$ is a dummy equal to one for buurts with income above the median in their municipality, I_{LowInc} is a dummy for buurts that have income below median in their municipality, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Results are based on the restricted sample, including only high exposure and zero exposure buurts. Panel (a) displays point estimates and 95% confidence intervals for f_τ, while panel (b) displays estimates of g_τ. The omitted coefficients f_{1995} and g_{1995} are equal to zero.

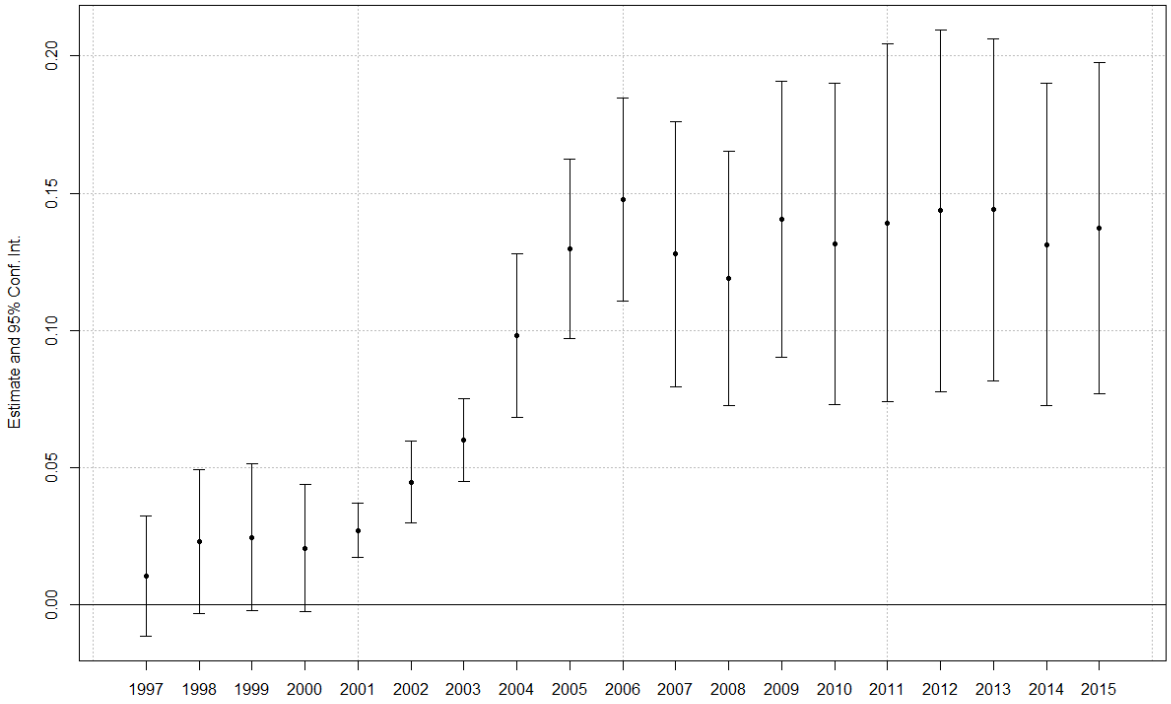


Figure 7: **Effects on Jobs in Non-Vinex Neighborhoods.** The figure displays estimates from the following Poisson regression specification:

$$NJobs_{b,\tau} = \exp\left(\sum_{\tau=1997:2015} g_\tau(I_{HighVinex,i} \times I_\tau) + a_b + a_{muni,\tau} + v_{i,\tau}\right),$$

where $NJobs_{b,\tau}$ is number of jobs located in non-Vinex buurt b in year τ, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, I_τ is a dummy equal to one for sales in year τ, and a_b and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for g_τ based on the restricted sample of buurts with high exposure to Vinex ($I_{HighVinex,i} = 1$) or zero exposure. The regression is estimated over the years from 1996 to 2015, and the omitted coefficient g_{1996} is equal to zero.

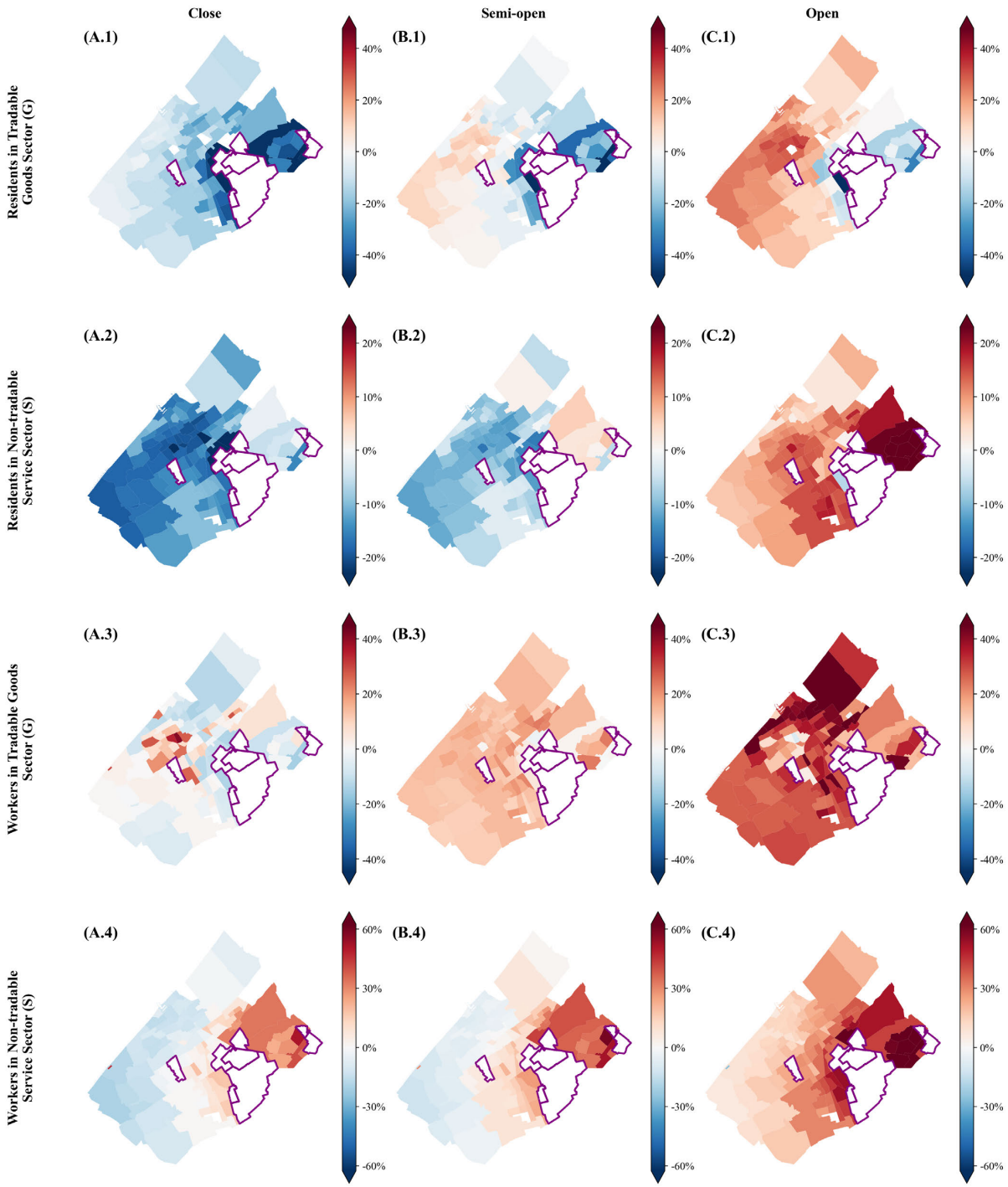


Figure 8: **Spatial Re-sorting of Workers and Residents (% Change).** This figure illustrates the percentage change in the spatial distribution of residents (Rows 1-2) and workers (Rows 3-4) by sector, comparing the post-shock equilibrium to the pre-shock baseline across the three city-openness scenarios.

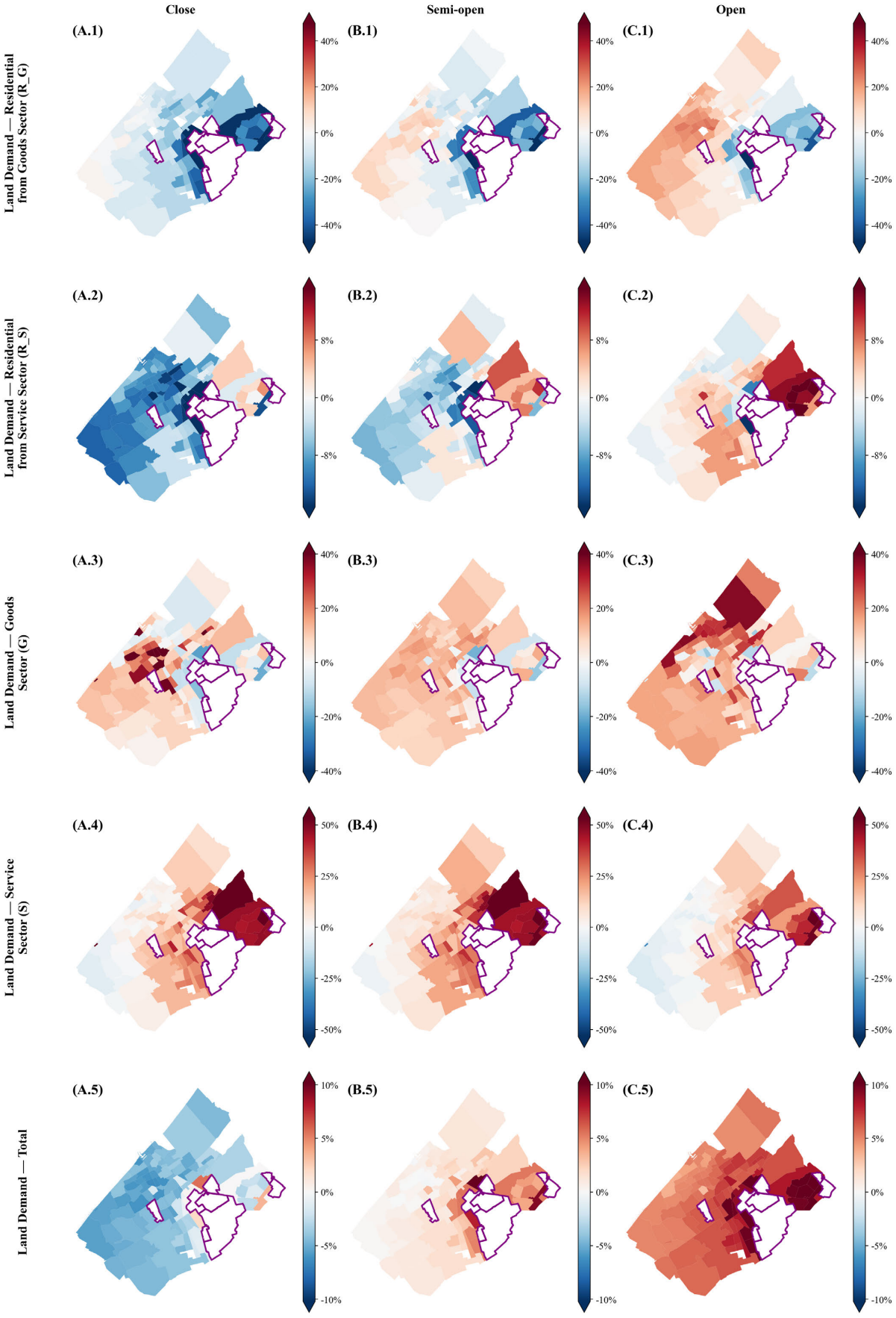


Figure 9: **Change in Residential and Production Land Demand (% Change).** This figure illustrates the percentage change in land demand for residential use (Rows 1-2), production use (Rows 3-4), and the net total change (Row 5), comparing the post-shock equilibrium to the pre-shock baseline.

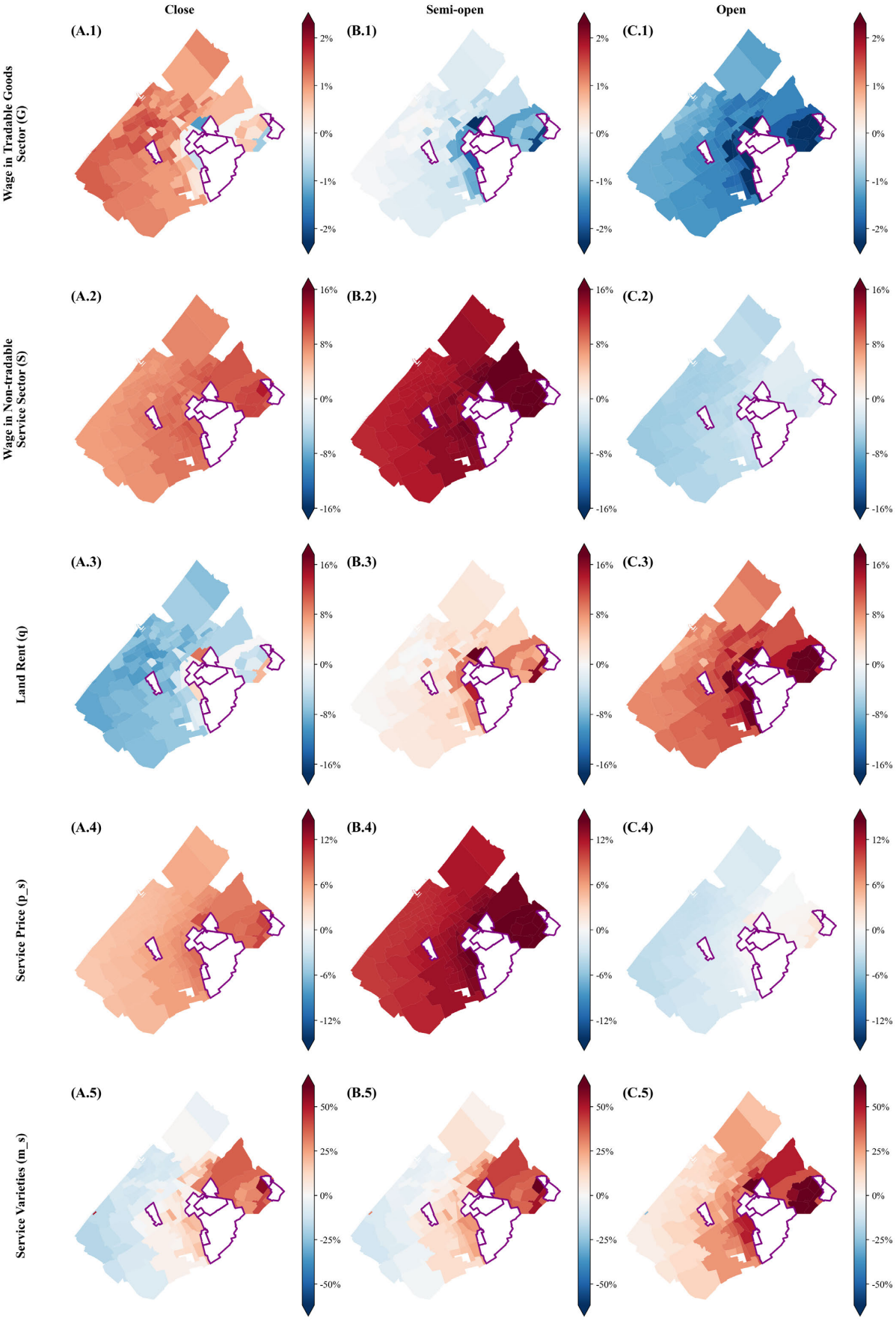


Figure 10: **Equilibrium Changes in Prices, Rents, and Variety (% Change).** This figure illustrates the percentage change in key equilibrium prices, including wages (Rows 1-2), land rent (Row 3), the local service price index (Row 4), and the mass of service varieties (Row 5).

Table 1: Summary Statistics

	Q1	Median	Mean	Q3	Observations
Panel A: New Construction By Buurt and Year					
Number of New Units	0.00	0.00	8.03	1.00	158,048
Sqm New Units	0.00	0.00	940.80	46.00	158,048
Sqm per New Unit	43.00	53.00	74.78	72.94	43,332
Panel B: House Sales Data					
Sales Price	132,731	183,781	217,843	255,000	1,107,841
Listing Price	139,000	194,672	232,127	269,999	1,107,841
Sales Year	2000	2005	2005	2010	1,107,841
Gross Volume	240	320	332	390	1,107,841
Rooms Number	3.00	4.00	4.23	5.00	1,107,841
Is Single-Family	0.00	0.00	0.49	1.00	1,107,841
Is Townhouse	0.00	0.00	0.09	0.00	1,107,841
Built Year	1942	1972	1964	1988	1,107,841
Panel C: Employment Data by Buurt and Year					
N. Jobs	69	205	621	611	111,080
N. Jobs Agriculture and Manufacturing	1.00	5.00	54.36	22.00	111,080
N. Jobs Non-Tradable Services	34.0	121.0	377.5	383.0	111,080
N. Jobs Tradable Services	16.0	48.0	189.1	142.0	111,080
Panel D: Demographic Data by Buurt and Year					
Total Population	435	1130	1614	2094	95,980
Age	35.20	38.50	39.02	42.00	95,980
Age (25-64)	42.20	44.40	44.15	46.30	95,973
Move-in Distance (Km) Past Year	1.96	3.06	4.35	4.77	87,891
N. Move-in Past Year	52.0	122.0	201.7	240.0	87,908
N. Workers Agriculture and Manufacturing	29.00	57.00	84.69	106.00	67,750
N. Workers Non-Tradable Services	118.0	348.0	511.7	681.0	78,149
N. Workers Tradable Services	60.0	152.0	216.6	283.0	75,288

Notes: This table displays summary statistics of the main datasets used in our study. Panel A displays statistics of new construction by buurt and year between 1984 and 2015, based on the BAG data. Panel B displays statistics of the housing transactions data made available by the Dutch Association of Realtors. Panel C displays statistics for the number of jobs and businesses by buurt and year between 1996 and 2015, based on employment geo-location data made available by LISA. Panel D displays statistics for demographics, mobility by buurt and year between 1995 and 2015, and local employment information between 1999 and 2015, based on data from Statistics Netherlands. The detailed description of the datasets is in Section 2.2.

Table 2: Pre-Vinex Price Growth and Vinex Locations

	Dependent Variable: $\Delta log(\mu(P)_{1991,1995})$			
	(1)	(2)	(3)	(4)
$ShareVinex_{5km}$	0.1307		0.2233	
	(0.1831)		(0.2861)	
$I_{HighVinex}$		-0.0137		-0.0126
		(0.0163)		(0.0173)
Fixed-effects				
Municipality			Yes	Yes
Observations	2,173	2,173	2,173	2,173
R^2	0.00023	0.00033	0.06551	0.06551

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays the relationship between buurt-level mean price growth between 1991 and 1994, and post-1994 Vinex development, based on the following regression specification:

$$\Delta log(\mu(P)_{1991,1995,b}) = \delta ExposureVinex_b + a_{muni} + e_b$$

The variable $ExposureVinex_b$ is equal either to $ShareVinex_{5km}$, which is the share of land belonging to Vinex buurts within a 5-Km radius of each buurt, or $I_{HighVinex}$, which is a dummy equal to one for Vinex that are in the quartile of $ShareVinex_{5km}$ within their municipality (gemeente). a_{muni} is a municipality fixed effect, included in the specification in columns 3 and 4. The sample is restricted to buurts that were not part of the Vinex program.

Table 3: Price Effects in Non-Vinex Neighborhoods

	High and Zero Exposure Buurts Only Dependent Variable: log($Price$)				
	(1)	(2)	(3) Above Med Income	(4) Below Med Income	(5)
$I_{HighVinex} \times I_{post}$	-0.0437***	-0.0207**	-0.0328***	-0.0081	-0.0061
	(0.0146)	(0.0084)	(0.0092)	(0.0132)	(0.0127)
$I_{HighVinex} \times I_{post} \times I_{HighInc}$					-0.0277*
					(0.0156)
log(volume)	0.6200***	0.3121***	0.3481***	0.2737***	0.3109***
	(0.0834)	(0.0759)	(0.0835)	(0.0709)	(0.0761)
Additional Controls	No	Yes	Yes	Yes	Yes
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes	No
Municipality by Year by $I_{HighIncome}$	No	No	No	No	Yes
Observations	600,627	600,627	288,525	304,249	592,774
R^2	0.79507	0.87321	0.87584	0.87270	0.87468

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays estimates of the spillovers of Vinex housing supply on house prices in non-Vinex buurts. Estimates are based on the restricted sample of buurts with high or zero exposure to Vinex. Columns 1 to 4 display estimates from the specification:

$$log(p_{i,t}) = d_{Vinex} \left(I_{HighVinex,i} \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t},$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Column 5 displays estimates from the specification:

$$log(p_{i,t}) = g_{Vinex,H} \left(I_{HighVinex,i} \times I_{post,i,t} \times I_{HighInc}\right) + g_{Vinex} \left(I_{HighVinex,i} \times I_{post,i,t}\right) +$$

$$+FX_i + f_b + f_{muni,t,HI} + v_{i,t},$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

Table 4: Vinex and Local Housing Supply

Dependent Variable:	$\Delta log(S) = log(S_{1995:2015}/S_{1984:1994})$			
	(1)	(2)	(3)	(4)
$ShareVinex_{5Km}$	5.233***		6.980***	
	(0.6476)		(0.8730)	
$I_{HighVinex}$		0.2583***		0.2282***
		(0.0546)		(0.0507)
Fixed Effects				
Municipality	No	No	Yes	Yes
Observations	2,173	2,173	2,173	2,173
R^2	0.18820	0.05772	0.65547	0.57841

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays estimates from the following regression specification:

$$log(S_{b,5Km,1996:2015}/S_{b,5Km,1984:1995}) = \gamma ExposureVinex_{b,5km} + g_{muni} + v_b$$

where $S_{b,5Km,1996:2015}$ ($S_{b,5Km,1984:1995}$) is the number of new units built between 1996 and 2015 (1984 and 1995) within a 5Km radius of non-Vinex buurt b, and g_{muni} is a municipality fixed effect.

Table 5: Inverse Supply Elasticities

	High and Zero Exposure Buurts Only			
	Dependent Variable: log($Price$)			
	(1)	(2)	(3)	(4)
			Above Med Income	Below Med Income
	OLS	2SLS	2SLS	2SLS
$\Delta log(\widehat{S}) \times I_{post}$		-0.0532**	-0.0826***	-0.0120
		(0.0209)	(0.0260)	(0.0463)
$\Delta log(S) \times I_{post}$	-0.0305*			
	(0.0165)			
log(volume)	0.3330***	0.3330***	0.3549***	0.3060***
	(0.0712)	(0.0712)	(0.0762)	(0.0674)
Additional Controls	Yes	Yes	Yes	Yes
Fixed Effects				
Buurt	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes
Observations	457,222	457,222	224,695	230,453
R^2	0.87640	-	-	-

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays estimates of the inverse supply elasticity (elasticity of prices to new supply) in non-Vinex buurts. Estimates are based on the restricted sample of buurts with high or zero exposure to Vinex. Column 1 displays OLS estimates from the specification:

$$log(p_{i,t}) = \delta_S \left(\Delta log(S_{b(i),k}) \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t}$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $\Delta log(S_{b(i),k}$ is the log change in new housing construction between before and after 1994 in the 5-Km radius surrounding buurt $b(i)$, in which property i is located, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Columns 2, 3, and 4 display 2SLS estimates, in which $\Delta log(S) \times I_{post}$ is instrumented using $I_{HighVinex} \times I_{post}$ (see equations 7 and 6), where $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality.

Table 6: Mobility Effects in Non-Vinex Neighborhoods

Dependent Variables:	High and Zero Exposure Buurts Only 1995-2005					
	m_{out}^{Vinex}		m_{in-out}		m_{in}	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{HighVinex}$	0.0039***	0.0032***	0.0031	0.0026	0.0025	0.0091*
	(0.0005)	(0.0008)	(0.0027)	(0.0015)	(0.0035)	(0.0047)
$I_{HighVinex} \times I_{HighInc}$		0.0018		0.0040		-0.0142*
		(0.0014)		(0.0044)		(0.0069)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Fit statistics						
Observations	7,273	7,198	26,228	25,679	27,250	26,570
R^2	0.58655	0.62867	0.06673	0.11766	0.15009	0.20057

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays estimates of the effects of Vinex housing supply on mobility in non-Vinex buurts. The time period covers the years from 1995 to 2005. Panel A reports estimates based on the restricted sample of buurts with high or zero exposure to Vinex. Columns 1 and 3 to 5 display estimates from the specification, based on observations from 1996 and 2015 only:

$$m_{x,b,\tau} = M_{Vinex} I_{HighVinex,b} + n_{muni,\tau} + v_{b,\tau}$$

where $m_{x,b,\tau}$ is either the share of individuals moving to Vinex (m_{out}^{Vinex}), the difference between individuals moving in and out as a share of population (m_{in-out}), and the share of individuals moving in (m_{in}) in buurt b and year τ, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, and $n_{muni,\tau}$ are municipality by year fixed effects. Columns 2, 4, and 6 display estimates from the specification:

$$m_{x,b,\tau} = M_{Vinex} I_{HighVinex,i} + M_{Vinex} \left(I_{HighVinex,b} \times I_{HighIncome,b} \right) + n_{muni,\tau} + v_{b,\tau}$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and $n_{muni,t,HighInc}$ are municipality by year by above median income ($I_{HighInc}$) fixed effects.

Table 7: Effects on Jobs in Non-Vinex Neighborhoods

	High and Zero Exposure Buurts Only				
	Dependent Variable: $NJobs$				
	(1)	(2)	(3)	(4)	(5)
	All		Agric./Manuf.	Non-Trad.	Trad.
$I_{HighVinex} \times I_{\tau=2015}$	0.1397***	0.1327	0.0898	0.0654	0.3192***
	(0.0426)	(0.0902)	(0.1166)	(0.0546)	(0.1220)
$I_{HighVinex} \times I_{HighInc} \times I_{\tau=2015}$		0.0331			
		(0.1151)			
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	No	Yes	Yes	Yes
Municipality by Year by $I_{HighIncome}$	No	Yes	No	No	No
Observations	6,868	6,358	6,293	6,794	6,689
Pseudo R^2	0.95133	0.95453	0.91861	0.94781	0.92683

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Notes: The table displays estimates of the effects of Vinex housing supply on job growth in non-Vinex buurts. Estimates are based on the restricted sample of buurts with high or zero exposure to Vinex. Columns 1 and 3 to 5 display estimates from the specification, based on observations from 1996 and 2015 only:

$$NJobs_{b,\tau} = \exp\left(g_{end}(I_{HighVinex,i} \times I_{\tau=2015}) + a_b + a_{muni,\tau} + u_{i,\tau}\right)$$

where $NJobs_{b,\tau}$ is either the total number of jobs (column 1), the total number of jobs in Agriculture or Manufacturing (column 3), Non-Tradable Services (column 4), Tradable Services (column 5), Non-Specialized sectors (column 6), and Specialized sectors (column 7) in buurt b and year τ, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_{\tau=2015}$ is a dummy equal to in 2015, and a_b and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. Column 2 displays estimates from a specification:

$$NJobs_{b,\tau} = \exp\left(g_{end}(I_{HighVinex,i} \times I_{\tau=2015}) + g_{end,H}(I_{HighVinex,i} \times I_{HighInc} \times I_{\tau=2015}) + f_b + f_{muni,\tau} + v_{i,\tau}\right)$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

Table 8: Summary of Calibrated Model Parameters

Parameter	**Value**
Labor Share [1]	
Goods (α_G)	0.897
Services (α_S)	0.841
Preferences [2]	
G: ($\beta^G, \gamma^G, \bar{h}^G$)	(0.491, 0.342, 58.55)
S: ($\beta^S, \gamma^S, \bar{h}^S$)	(0.487, 0.340, 59.46)
Frechet Parameter (ϵ^g) [3]	G: 16.3772, S: 3.2416
Commuting Cost (ν^g) [3]	G: 0.1865, S: 0.2110
Commuting Sensitivity (κ^g) [4]	G: 0.0114, S: 0.0651
Shopping Sensitivity ($\kappa^{shop,g}$) [4]	G: 0.0114, S: 0.0651
Service Substitution (σ_S)	4.0
Housing Supply Elasticity (η_n) [5]	Varies by 'Vinexshare' (v)
Baseline (Post Shock):	$\eta_n = 0.6 + 0.15 \times v$
Counterfactual (Pre Shock):	$\eta_n = 0.6 - 0.55 \times v$ with $0 \leq v < 1$; $v = 1$ with fixed high rents ($q_n = 10^6$)

Notes: This table summarizes the key parameters used in the model simulation.

[1] *Factor Shares (α_G, α_S):* The labor shares are derived from estimated land shares ($1 - \alpha_s$). Land share is computed as: (leasing fees + imputed rent on owned real estate) / (leasing fees + imputed rent + total wages). Imputed rent is based on the book value of physical assets in land/real estate, assuming a 6% gross rental return. This yields a land share of 10.3% for tradables ($1 - \alpha_G$) and 15.9% for non-tradables ($1 - \alpha_S$), which are in line with, though slightly lower than, some literature benchmarks. (See Online Appendix C.1).

[2] *Preference Parameters:* Values are from Engel curve estimations based on an "annual user cost" definition of q_n (price per square meter). This user cost is an estimated annual financing cost for owner-occupied housing, calculated as $q_n \approx P_{sqm} \times 0.061535$. This financing factor ($k_{fin} \approx 0.0615$) is the sum of (i) the annualized mortgage payment (assuming 80% LTV, 30-year term, 5% interest) and (ii) the 5% annual opportunity cost of the 20% down payment. (See Online Appendix C.2).

[3] *Frechet & Commuting Cost (ϵ^g, ν^g):* These parameters are jointly estimated using a PPML gravity model of commuting flows (See Table C.15 in Online Appendix C.3).

[4] *Friction Sensitivities ($\kappa^g, \kappa^{shop,g}$): Commuting Sensitivity* (κ^g) is derived from the estimated parameters as $\kappa^g = \nu^g / \epsilon^g$. *Shopping Sensitivity* ($\kappa^{shop,g}$) is assumed to be equal to κ^g due to a lack of shopping flow data for separate estimation.

[5] *Housing Supply Elasticity (η_n):* The baseline elasticity for non-Vinex areas ($v = 0$) is set to $\eta_n = 0.6$. This reflects the highly inelastic housing supply of The Hague. This value is consistent with the lower bound of estimates for supply-constrained US cities, such as Miami (0.60), as documented in Saiz (2010). (See Online Appendix C.4). The elasticity for Vinex areas is specified as a function of land share.

Table 9: Welfare and population changes (pre vs. post) under three settings

Group	Pop. (Pre)	Pop. (Post)	Δ% Pop.	W (Pre)	W (Post)	Δ%W	$\bar{y}$ (Pre)	$\bar{y}$ (Post)	EV	CV
Panel A: CLOSED										
G	199,214	199,214	0.00%	701.47	724.15	3.23%	41,549	41,829	1,343	1,310
S	497,032	497,032	0.00%	5,004.47	5,953.41	18.96%	29,528	32,646	5,599	5,204
Panel B: SEMIOPEN										
G	168,566	199,214	18.18%	745.28	724.15	-2.83%	42,195	41,829	-1,196	-1,220
S	459,441	497,032	8.18%	4,967.40	5,953.41	19.85%	28,406	32,646	5,639	5,407
Panel C: OPEN										
G	144,886	199,214	37.50%	724.08	724.15	0.01%	42,685	41,829	4	4
S	373,184	497,032	33.19%	5,953.06	5,953.41	0.01%	35,445	32,646	2	2

Notes:

1. W_t^g is the expected maximum indirect utility index (i.e., mean utility welfare) for type g in period $t \in \{0, 1\}$, where $t = 0$ is pre-shock and $t = 1$ is post-shock.
2. $\Delta(\%W) \equiv 100 \times (W_1^g / W_0^g - 1)$ (level percent change). $\Delta \log W \equiv 100 \times [\ln(W_1^g) - \ln(W_0^g)]$.
3. $\bar{y}_t^g = \sum_{n,i} \lambda_{ni,t}^g \left[w_{i,t}^g - q_{n,t} \bar{h}^g \right]$ is the choice–probability–weighted average net disposable income (Stone–Geary).
4. EV^g and CV^g are per–capita money-metric welfare changes for type g: $\mathrm{EV}^g = \bar{y}_0^g \left[(\Phi_1^g / \Phi_0^g)^{1/\epsilon^g} - 1 \right]$, $\mathrm{CV}^g = \bar{y}_1^g \left[1 - (\Phi_0^g / \Phi_1^g)^{1/\epsilon^g} \right]$.
5. All quantities for $g \in \{G, S\}$ use two-period-consistent $\lambda_{ni,t}^g$ and service price index $P_{n,g,t}^{S,\mathrm{eff}}$.
6. EV and CV are in EUR units based on 2015 data.

Table 10: Aggregate indicators (Pre vs. Post) under three spatial openness settings

Metric	**Pre**	**Post**	**Δ%**
Panel A: CLOSED			
Output: Goods (Y_G)	10,987,840,429	10,935,628,413	-0.48%
Output: Services (Y_S^{nom})	22,024,749,542	23,562,762,358	6.98%
Output: Services (Y_S^{Real})	22,024,749,542	22,286,552,837	1.19%
Avg. Wage: Goods (w_G)	49,475	49,240	-0.48%
Avg. Wage: Services (w_S)	37,267	39,869	6.98%
Land Demand: Residential (D_R)	72,196,472	76,600,079	6.10%
Land Demand: Goods (D_G)	8,336,796	8,792,941	5.47%
Land Demand: Services (D_S)	26,190,278	30,171,790	15.20%
Land Demand: Total (D_{total})	106,723,546	115,564,810	8.28%
Avg. Land Rent (q_n)	131	122	-6.61%
Avg. Service Price (p_S)	1.0000	1.0573	5.73%
Panel B: SEMIOPEN			
Output: Goods (Y_G)	9,288,635,372	10,935,628,413	17.73%
Output: Services (Y_S^{nom})	19,347,130,617	23,562,762,358	21.79%
Output: Services (Y_S^{Real})	19,347,130,617	21,047,951,496	8.79%
Avg. Wage: Goods (w_G)	49,428	49,240	-0.38%
Avg. Wage: Services (w_S)	35,415	39,869	12.58%
Land Demand: Residential (D_R)	67,233,670	76,600,079	13.93%
Land Demand: Goods (D_G)	7,810,004	8,792,941	12.59%
Land Demand: Services (D_S)	25,431,524	30,171,790	18.64%
Land Demand: Total (D_{total})	100,475,197	115,564,810	15.02%
Avg. Land Rent (q_n)	119	122	3.14%
Avg. Service Price (p_S)	1.0000	1.1195	11.95%
Panel C: OPEN			
Output: Goods (Y_G)	7,975,177,074	10,935,628,413	37.12%
Output: Services (Y_S^{nom})	18,621,986,077	23,562,762,358	26.53%
Output: Services (Y_S^{Real})	18,621,986,077	24,124,562,398	29.55%
Avg. Wage: Goods (w_G)	49,375	49,240	-0.27%
Avg. Wage: Services (w_S)	41,966	39,869	-5.00%
Land Demand: Residential (D_R)	62,005,397	76,600,079	23.54%
Land Demand: Goods (D_G)	7,273,690	8,792,941	20.89%
Land Demand: Services (D_S)	26,466,732	30,171,790	14.00%

Continued on next page

Table 10: (Continued) Aggregate indicators (Pre vs. Post) under three spatial openness settings

Metric	**Pre**	**Post**	**Δ%**
Land Demand: Total (D_{total})	95,745,819	115,564,810	20.70%
Avg. Land Rent (q_n)	110	122	11.49%
Avg. Service Price (p_S)	1.0000	0.9765	-2.35%

Notes. All aggregates are constructed from equilibrium variables using the model's factor–market exhaustion and monopolistic competition structure.

1. **Goods sector output.** Since p^G is numéraire ($p^G = 1$), nominal and real output coincide:

$$Y_G = \sum_i w_i^G L_i^G + q_i D_i^G \text{ . Equivalently, } Y_G = \sum_i R_i^G$$

2. **Service sector output.** At location i, revenue is $R_i^S = w_i^S L_i^S/\alpha$, with variety mass

$$M_i = \tfrac{1}{\sigma_S f}(L_i^S)^{\alpha_S}(D_i^S)^{1-\alpha_S}, \quad y_i = a_i^S f(\sigma_S - 1), \quad Y_i^S = y_i M_i$$

   Hence total nominal output is $Y_S^{\text{nom}} = \sum_i R_i^S$. Real output (physical quantity) is $Y_S^{\text{Real}} = \sum_i Y_i^S = \sum_i M_i y_i$.

3. **Wages.** $\overline{w}_g = \dfrac{\sum_i w_i^g L_i^g}{\sum_i L_i^g}, \quad g \in \{G, S\}$.

4. **Land demands.** D_R is total residential land; D_G and D_S are land used in goods and services production.

5. **Average rent.** $\overline{q} = \dfrac{\sum_i q_i D_i^{\text{total}}}{\sum_i D_i^{\text{total}}}$.

6. **Service price index.** $p_i^S = \frac{\sigma_S}{\sigma_S - 1} \dfrac{\alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_i^S)^{\alpha_S} q_i^{1-\alpha_S}}{a_i^S}$, weighted to get $p^S = \dfrac{\sum_i p_i^S Y_i^S}{\sum_i Y_i^S}$.

7. **Price and Real Output Normalization.** Since the aggregate price p^S and real output Y_S^{Real} cannot be pinned down separately (only nominal output Y_S^{nom} is), we normalize the price and real output for each panel using that panel's pre-shock ($t = 0$) price, p_0^S. The reported values are: $p_t^S \leftarrow p_t^S / p_0^S$ and $Y_S^{\text{Real},t} \leftarrow Y_S^{\text{Real},t} \times p_0^S$.

8. Excluding the price, other variables are in EUR units based on 2015 data level.

Appendix:

How Housing Supply Expansions Reshape Cities

(intended for online publication)

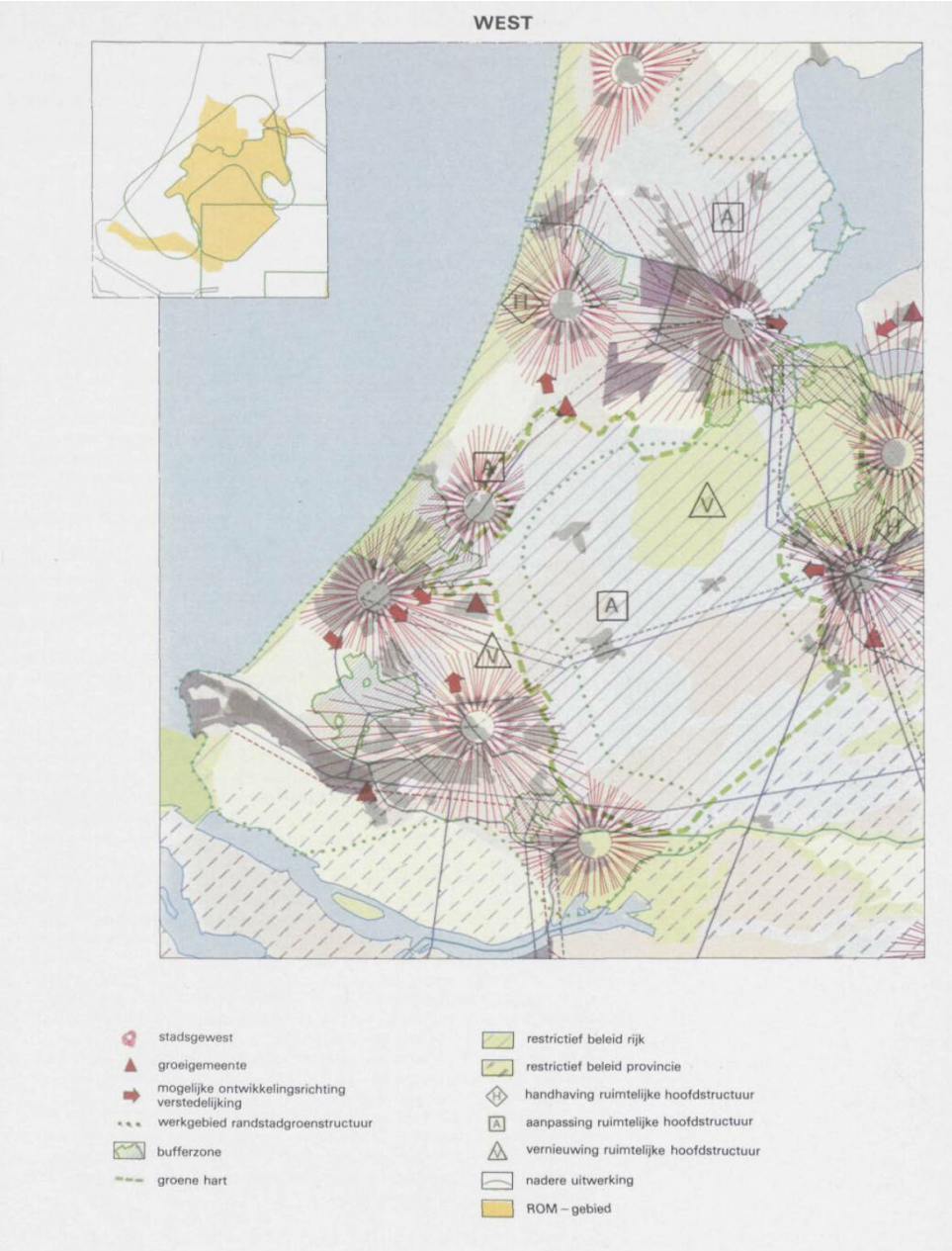
A. Additional Tables and Figures

B. Model Derivation Detail

C. Parameter Calibration

D. Calibration and Solving Algorithm

A Additional Figures and Tables



(a) Summary VINEX planning, Randstad areas

Figure A.1: The figure displays the overview map with the spatial plans for the Randstad area in the Vinex memorandum, which include Amsterdam (north), Utrecht (east), The Hague (west), and Rotterdam (south). The red radii show the 'urban regions' where development had to concentrate. The red arrows indicate the directions in which the central government wanted to expand these urban areas. Areas with shaded diagonal lines indicate areas where the national government restricts new development, and areas with dashed diagonals indicate areas where provinces restrict new development. The area within the dashed green line is the "Groene Hart" (green heart), a greenbelt area that the government sought to protect. Beyond this area, the government also designated buffer zones between cities that were to remain for nature, to prevent cities from developing into urban sprawl.

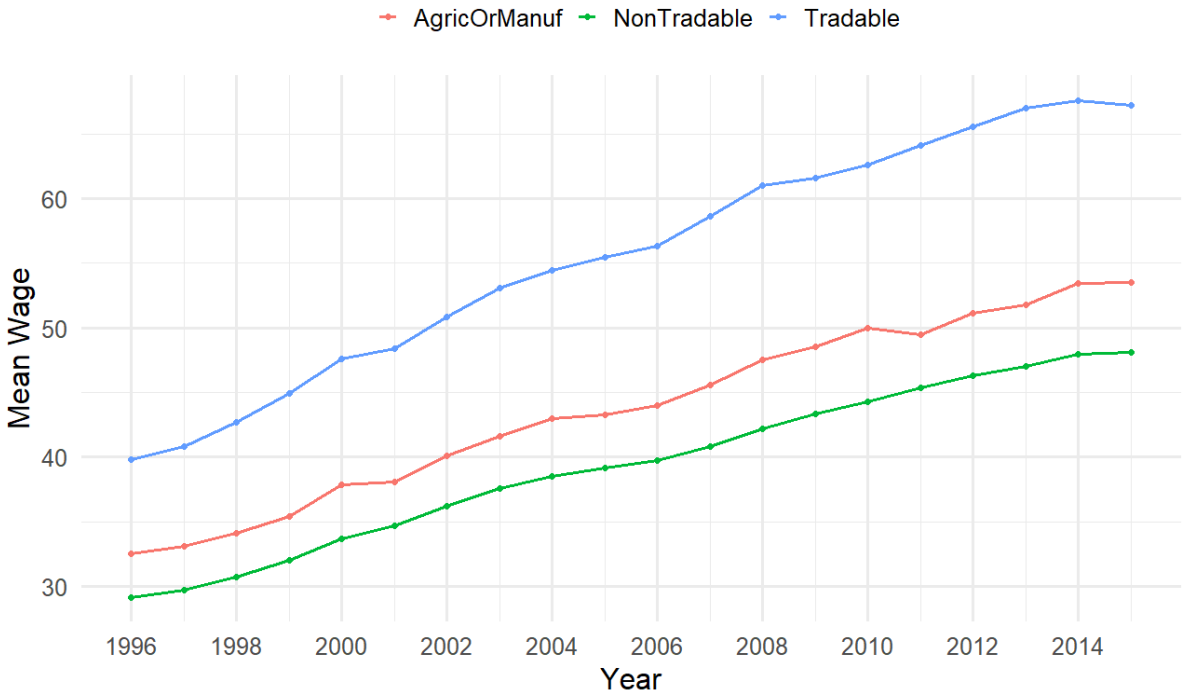
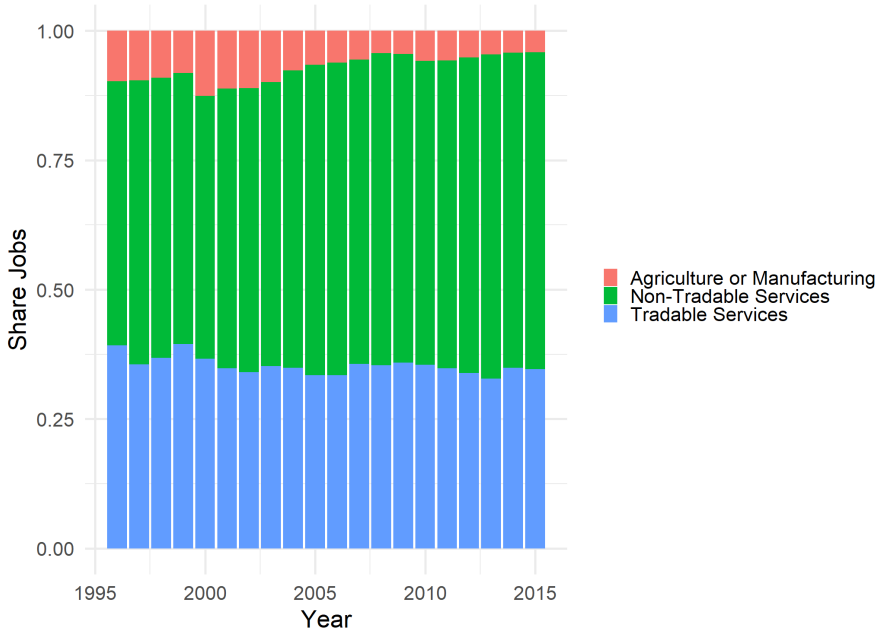
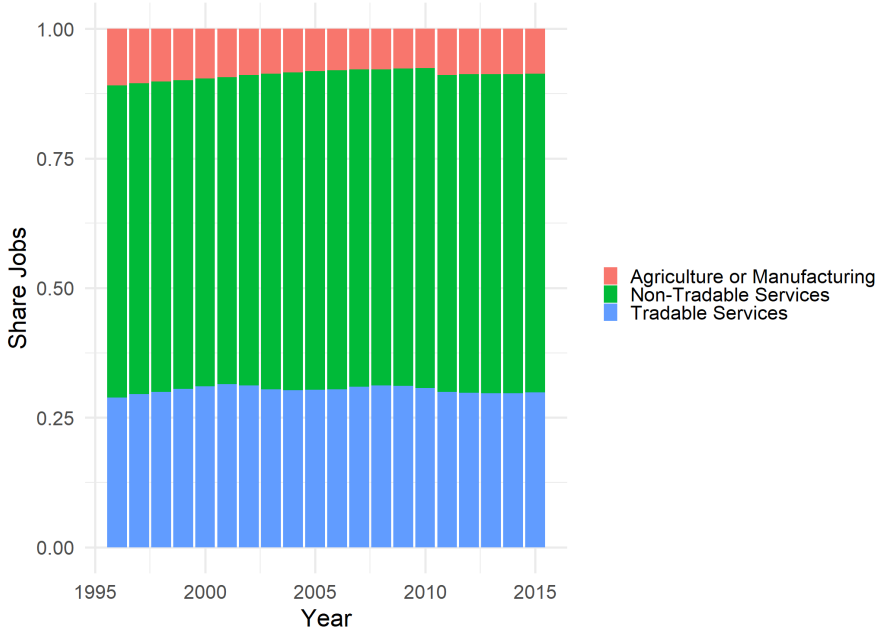


Figure A.2: The figure displays the time series of the mean monthly wages in Euros across jobs in sectors grouped by macro-category: Agriculture or Manufacturing, Non-Tradable Services, Tradable Services. Estimates are based on the LISA dataset.



(a) VINEX Residents Share of Jobs



(b) Non-VINEX Residents Share of Jobs

Figure A.3: The figure displays the composition of jobs for residents of VINEX and non-VINEX buurts, across sectors belonging to agriculture or manufacturing, non-tradable services, and tradable services, and for the years from 1996 to 2015. All estimates are based on the LISA dataset.

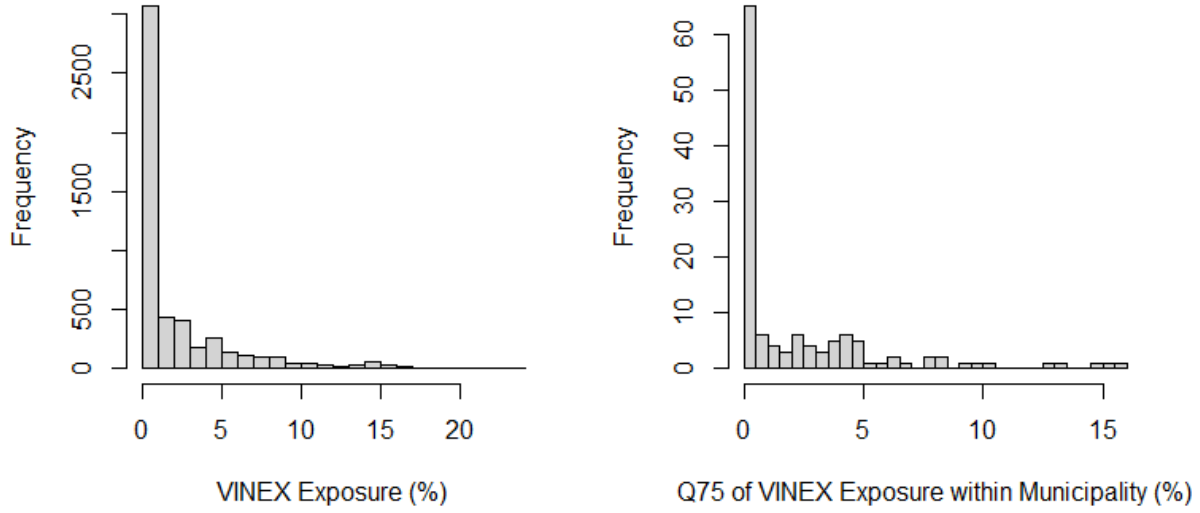


Figure A.4: Distribution of VINEX exposure, for non-VINEX buurts located in the Randstad. The panel on the left shows the distribution of the fraction of land covered by VINEX buurts within a 5-kilometer radius. The panel on the right shows the 75th percentile of exposure (share of land belonging to VINEX buurts within a 5-Km radius) across non-VINEX buurts located in the same municipality (gemeente). The latter is used to identify local "high-exposure" buurts within each municipality.

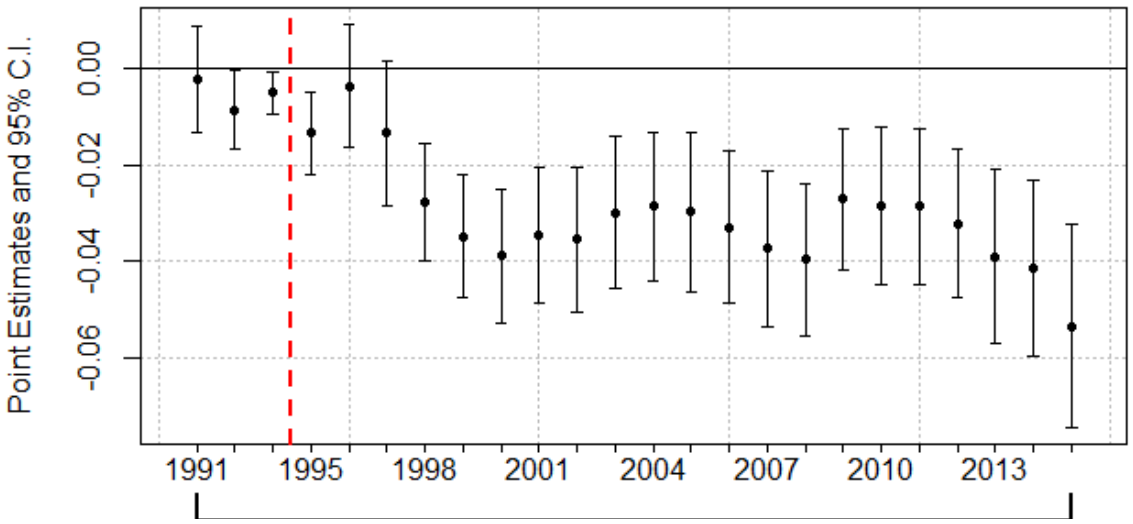
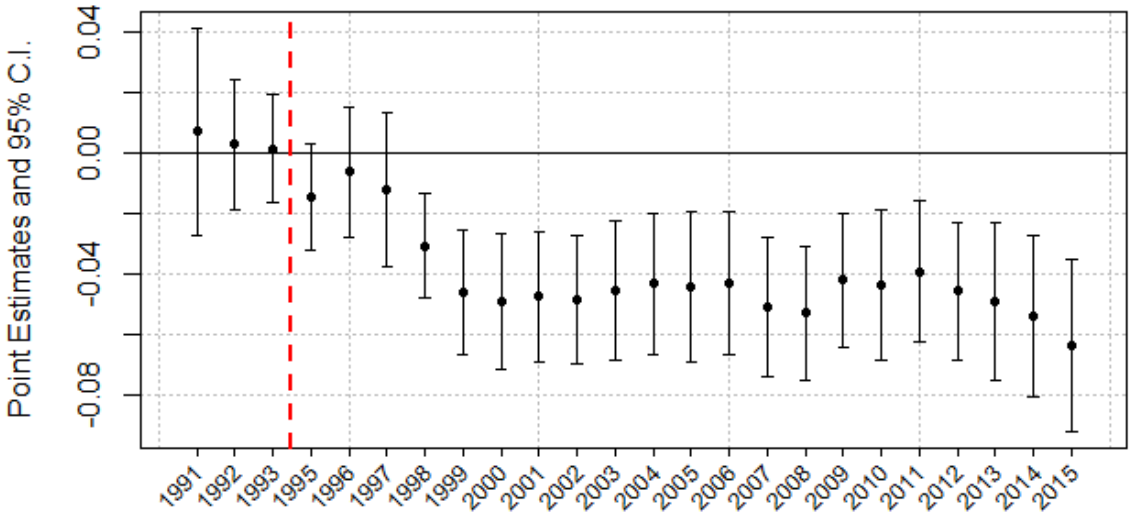


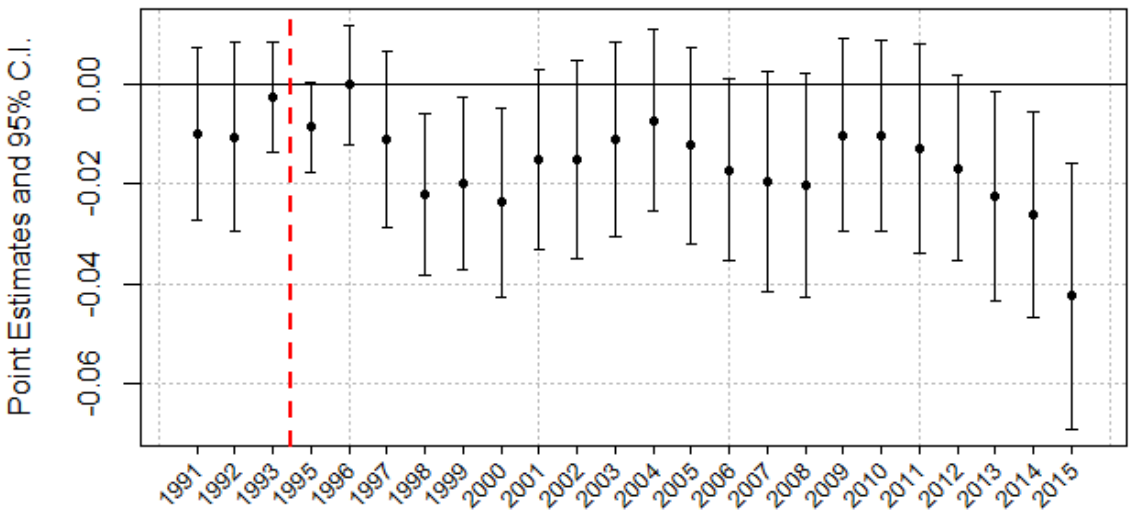
Figure A.5: The figure displays estimates from the following regression equation:

$$log(p_{i,\tau}) = \sum_{\tau=1991:2015} d_\tau(I_{HighVINEX,i} \times I_\tau) + BX_i + a_b + a_{muni,\tau} + \epsilon_{i,\tau},$$

where $log(p_{i,\tau})$ is the log sales price of property i in year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, I_τ is a dummy equal to one for sales in year τ, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for d_τ based on the full sample of sales in non-VINEX buurts. The omitted coefficient d_{1994} is equal to zero.



(a) Above Median Income Buurts



(b) Below Median Income Buurts

Figure A.6: The figure displays estimates from the following regression equation:

$$log(p_{i,\tau}) = \sum_{\tau=1991:2015} f_\tau(I_{HighVINEX,i} \times I_\tau \times I_{HighInc}) + \sum_{\tau=1991:2015} g_\tau(I_{HighVINEX,i} \times I_\tau \times I_{LowInc}) +$$
$$+BX_i + a_b + a_{muni,\tau,HighInc} + \epsilon_{i,\tau},$$

where $log(p_{i,\tau})$ is the log sales price of property i in year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, I_τ is a dummy equal to one for sales in year τ, $I_{HighInc}$ is a dummy equal to one for buurts with income above the median in their municipality, I_{LowInc} is a dummy for buurts that have income below median in their municipality, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Results are based on the full sample of sales in non-VINEX buurts. Panel (a) displays point estimates and 95% confidence intervals for f_τ, while panel (b) displays estimates of g_τ. The omitted coefficients f_{1995} and g_{1995} are equal to zero.

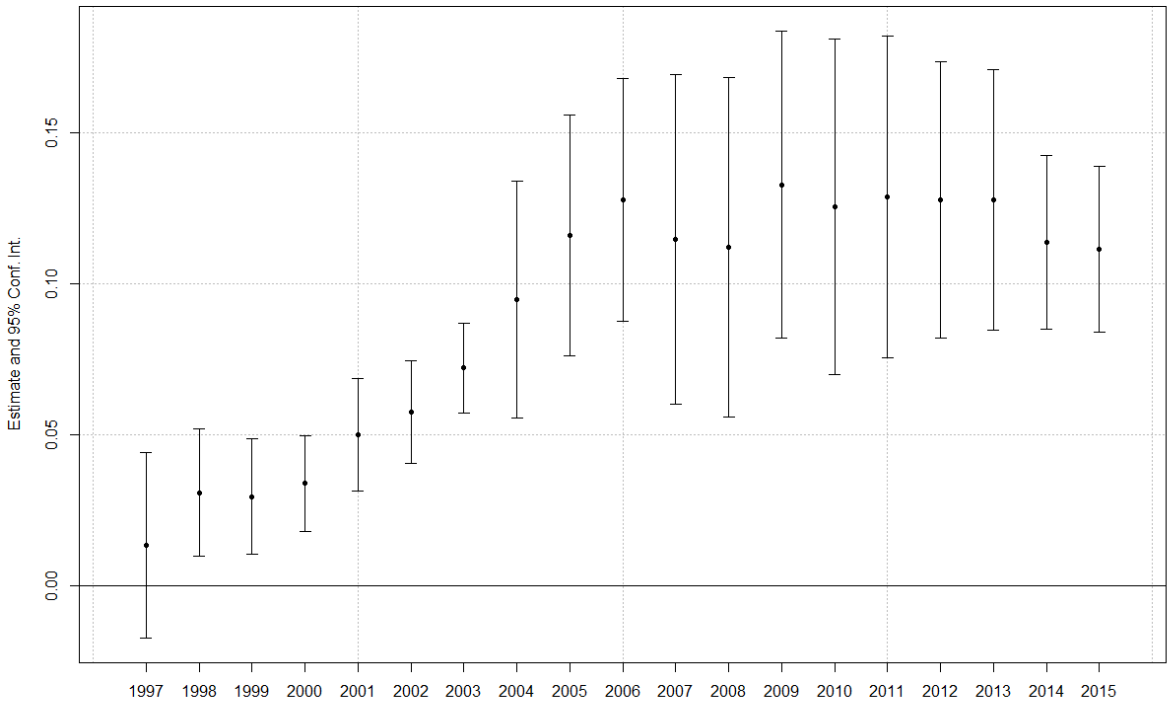


Figure A.7: The figure displays estimates from the following Poisson regression specification:

$$NJobs_{b,\tau} = \exp\left(\sum_{\tau=1997:2015} g_\tau(I_{HighVINEX,i} \times I_\tau) + a_b + a_{muni,\tau} + v_{i,\tau}\right),$$

where $NJobs_{b,\tau}$ is number of jobs located in non-VINEX buurt b in year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, I_τ is a dummy equal to one for sales in year τ, and a_b and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for g_τ based on the full sample of non-VINEX buurts. The regression is estimated over the years from 1996 to 2015, and the omitted coefficient g_{1996} is equal to zero.

Dependent Variables:	N-Units	Space	Space-per-Unit
	(1)	(2)	(3)
$I_{post} \times I_{VINEX}$	50.75***	4,252.0***	18.83***
	(2.841)	(380.3)	(6.560)
Fixed Effects			
Buurt	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes
Observations	157,920	157,920	43,329
R^2	0.14354	0.08622	0.39760

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.1: The table displays estimates from the following regression specification:

$$y_{b,t} = D_{VINEX} \left(I_{post} \times I_{VINEX} \right) + a_b + a_{muni,t} + e_{b,t},$$

where $y_{b,t}$ is either the number of new units, new space (in square meters), or the space-per-new unit (in square meters). I_{post} is a dummy equal to one for the year 1995 and following, and I_{VINEX} is a dummy equal to one for VINEX buurts; a_b are buurt fixed effects, and $a_{muni,t}$ are municipality by year fixed effects. The sample consists of all buurts in the Randstad region, over the period from 1984 to 2015. Standard errors are double-clustered by buurt and year and are reported in parentheses.

Dependent Variables:	m_{in} 1995-2015 (1)	m_{in-out} 1995-2015 (2)	m_{in} 1995-2005 (3)	m_{in-out} 1995-2005 (4)
I_{VINEX}	0.1009***	0.1003***	0.1939***	0.1754***
	(0.0183)	(0.0140)	(0.0206)	(0.0144)
Fixed-effects				
Municipality by Year	Yes	Yes	Yes	Yes
Observations	87,908	85,263	45,073	43,631
R^2	0.16305	0.11061	0.19896	0.16091

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.2: The table displays estimates from the following regression specification:

$$m_{x,b,t} = M_{VINEX} I_{VINEX} + a_{muni,t} + e_{b,t},$$

where $m_{x,b,t}$ is either the ratio of people moving into buurt b in year t over total population (m_{in}), or the ratio of people moving in minus people moving out the following year over total population; I_{VINEX} is a dummy equal to one for VINEX buurts; $a_{muni,t}$ are municipality by year fixed effects. The sample consists of all buurts in the Randstad region. Data is constructed using address registration data from Statistics Netherlands. We winsorize both variables at the top 0.5 percentile, since the distribution is highly skewed due to the presence of neighborhoods with low population experiencing new real estate development. The period is from 1995 to 2015 in columns 1 and 2, and from 1995 to 2005 in columns 3 and 4. Standard errors are double-clustered by buurt and year and are reported in parentheses.
Over the full time period, the estimated coefficient for the dummy is positive and statistically significant, and approximately equal to 0.1 for both m_{in} and m_{in-out}. This implies that the move-in flow, and the move-in flow net of following outflow are 10 percentage points higher in VINEX buurts compared to other buurts in the same municipality and year. This effect is quite large, considering that the mean of m_{in} is 11% and the mean of m_{in-out} is 0.9%. When the time period is restricted to the first decade of implementation of the program (from 1995 to 2005), the coefficient on the VINEX dummy is even larger, with point estimates of 19 percentage points for m_{in} and 17.5 percentage points for m_{in-out}. Thus, VINEX buurts have experienced substantial population growth, one order of magnitude larger than in the rest of the country, and especially pronounced in the first decade of the program.

	Full Sample (All non-VINEX Buurts) Dependent Variable: log($Price$)				
	(1)	(2)	(3) Above Med Income	(4) Below Med Income	(5)
$I_{HighVINEX} \times I_{post}$	-0.0603***	-0.0275***	-0.0449***	-0.0104	-0.0114
	(0.0115)	(0.0043)	(0.0086)	(0.0072)	(0.0071)
$I_{HighVINEX} \times I_{post} \times I_{HighInc}$					-0.0337**
					(0.0135)
log(volume)	0.6258***	0.3257***	0.3729***	0.2798***	0.3246***
	(0.0794)	(0.0763)	(0.0793)	(0.0762)	(0.0765)
Additional Controls	No	Yes	Yes	Yes	Yes
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes	No
Municipality by Year by $I_{HighIncome}$	No	No	No	No	Yes
Observations	1,049,255	1,049,255	510,543	527,552	1,038,095
R^2	0.80144	0.87624	0.88012	0.87376	0.87720

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.3: The table displays estimates of the spillovers of VINEX housing supply on house prices in non-VINEX buurts. Estimates are based on the full sample of non-VINEX buurts. Columns 1 to 4 display estimates from the specification:

$$log(p_{i,t}) = d_{VINEX} \left(I_{HighVINEX,i} \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t},$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Column 5 displays estimates from the specification:

$$log(p_{i,t}) = g_{VINEX,H} \left(I_{HighVINEX,i} \times I_{post,i,t} \times I_{HighInc}\right) + g_{VINEX} \left(I_{HighVINEX,i} \times I_{post,i,t}\right) +$$

$$+FX_i + f_b + f_{muni,t,HI} + v_{i,t},$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

	Full Sample (All non-VINEX Buurts) Dependent Variable: log($Price$)				
	(1)	(2)	(3) Above Med Income	(4) Below Med Income	(5)
$ShareVINEX \times I_{post}$	-0.0101***	-0.0051***	-0.0073***	-0.0024	-0.0023
	(0.0013)	(0.0006)	(0.0012)	(0.0025)	(0.0024)
$ShareVINEX \times I_{post} \times I_{HighInc}$					-0.0049
					(0.0031)
log(volume)	0.6258***	0.3257***	0.3729***	0.2798***	0.3246***
	(0.0794)	(0.0763)	(0.0793)	(0.0762)	(0.0765)
Additional Controls	No	Yes	Yes	Yes	Yes
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes	No
Municipality by Year by $I_{HighIncome}$	No	No	No	No	Yes
Observations	1,049,255	1,049,255	510,543	527,552	1,038,095
R^2	0.80145	0.87624	0.88013	0.87376	0.87720

Table A.4: The table displays estimates of the spillovers of VINEX housing supply on house prices in non-VINEX buurts. Panel A reports estimates based on the full sample of non-VINEX buurts, while Panel B reports estimates based on the subsample of buurts with high or zero exposure to VINEX. Columns 1 to 4 display estimates from the specification:

$$log(p_{i,t}) = d_{ShVINEX}\left(ShareVINEX_i \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t},$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $ShareVINEX$ is the share of VINEX land within a 5-Km radius of i's buurt centroid, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Column 5 displays estimates from the specification:

$$log(p_{i,t}) = g_{ShV,H}\left(ShareVINEX_i \times I_{post,i,t} \times I_{HighInc}\right) + g_{ShV}\left(ShareVINEX_i \times I_{post,i,t}\right)$$

$$+FX_i + f_b + f_{muni,t,HI} + v_{i,t},$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

	Full Sample (All non-VINEX Buurts)			
	Dependent Variable: log($Price$)			
	(1)	(2)	(3)	(4)
			Above Med Income	Below Med Income
	OLS	2SLS	2SLS	2SLS
$\Delta log(\widehat{S}) \times I_{post}$		-0.1096***	-0.1399***	-0.0438
		(0.0285)	(0.0260)	(0.0471)
$\Delta log(S) \times I_{post}$	-0.0328**			
	(0.0131)			
log(volume)	0.3556***	0.3556***	0.3818***	0.3251***
	(0.0677)	(0.0677)	(0.0735)	(0.0635)
Additional Controls	Yes	Yes	Yes	Yes
Fixed Effects				
Buurt	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes
Observations	783,978	783,978	391,398	389,664
R^2	0.88137	-	-	-

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.5: The table displays estimates of the inverse supply elasticity (elasticity of prices to new supply) in non-VINEX buurts. Estimates are based on the full sample of non-VINEX buurts. Column 1 displays OLS estimates from the specification:

$$log(p_{i,t}) = \delta_S \left(\Delta log(S_{b(i),k}) \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t}$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $\Delta log(S_{b(i),k}$ is the log change in new housing construction between before and after 1994 in the 5-Km radius surrounding buurt $b(i)$, in which property i is located, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Columns 2, 3, and 4 display 2SLS estimates, in which $\Delta log(S) \times I_{post}$ is instrumented using $I_{HighVINEX} \times I_{post}$ (see equations 7 and 6), where $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality.

	Full Sample (All non-VINEX Buurts)			
	Dependent Variable: log($Price$)			
	(1)	(2)	(3)	(4)
			Above Med Income	Below Med Income
	OLS	2SLS	2SLS	2SLS
$\Delta log(\widehat{S}) \times I_{post}$		-0.0730***	-0.0988***	-0.0279
		(0.0117)	(0.0191)	(0.0373)
$\Delta log(S) \times I_{post}$	-0.0328**			
	(0.0131)			
log(volume)	0.3556***	0.3556***	0.3818***	0.3251***
	(0.0677)	(0.0677)	(0.0735)	(0.0635)
Additional Controls	Yes	Yes	Yes	Yes
Fixed Effects				
Buurt	Yes	Yes	Yes	Yes
Municipality by Year	Yes	Yes	Yes	Yes
Observations	783,978	783,978	391,398	389,664
R^2	0.88137	-	-	-

Table A.6: The table displays estimates of the inverse supply elasticity (elasticity of prices to new supply) in non-VINEX buurts. Panel A reports estimates based on the full sample of non-VINEX buurts, while Panel B reports estimates based on the subsample of buurts with high or zero exposure to VINEX. Column 1 displays OLS estimates from the specification:

$$log(p_{i,t}) = \delta_S \left(\Delta log(S_{b(i),k}) \times I_{post,i,t}\right) + AX_i + a_b + a_{muni,t} + e_{i,t}$$

where $log(p_{i,t})$ is the log sales price of property i in year t, $\Delta log(S_{b(i),k}$ is the log change in new housing construction between before and after 1994 in the 5-Km radius surrounding buurt $b(i)$, in which property i is located, I_{post} is a dummy equal to one after 1994, and a_b and $a_{muni,t}$ are buurt and municipality by year fixed effects. Columns 2, 3, and 4 display 2SLS estimates, in which $\Delta log(S) \times I_{post}$ is instrumented using $ShareVINEX \times I_{post}$, where $ShareVINEX$ is the share of VINEX land within a 5-Km radius of i's buurt centroid.

Dependent Variables:	Panel A: Full Sample 1995-2005 (All non-VINEX Buurts)					
	m_{out}^{VINEX}		m_{in-out}		m_{in}	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{HighVINEX}$	0.0032***	0.0027***	0.0002	0.0014	-0.0014	0.0051
	(0.0005)	(0.0005)	(0.0021)	(0.0018)	(0.0025)	(0.0031)
$I_{HighVINEX} \times I_{HighInc}$		0.0009		-0.0002		-0.0143***
		(0.0009)		(0.0032)		(0.0039)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Fit statistics						
Observations	14,949	14,783	42,706	41,937	44,072	43,139
R^2	0.49628	0.52529	0.04905	0.08630	0.13603	0.17892

Dependent Variables:	Panel B: Full Sample 1995-2015 (All non-VINEX Buurts)					
	m_{out}^{VINEX}		m_{in-out}		m_{in}	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{HighVINEX}$	0.0022***	0.0020***	0.0006	0.0017	-0.0024	0.0043
	(0.0004)	(0.0004)	(0.0016)	(0.0016)	(0.0022)	(0.0031)
$I_{HighVINEX} \times I_{HighInc}$		0.0002		-0.0018		-0.0156**
		(0.0007)		(0.0013)		(0.0060)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Observations	46,857	46,133	82,348	80,683	84,861	82,870
R^2	0.41748	0.44773	0.04540	0.07961	0.14798	0.19007

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.7: The table displays estimates of the effects of VINEX housing supply on mobility in non-VINEX buurts. Estimates are based on the full sample of non-VINEX buurts. Panel A reports results for the years from 1995 to 2005, while Panel B reports results for the years from 1995 to 2015. Columns 1 and 3 to 5 display estimates from the following specification:

$$m_{x,b,\tau} = M_{VINEX} I_{HighVINEX,b} + n_{muni,\tau} + v_{b,\tau}$$

where $m_{x,b,\tau}$ is either the share of individuals moving to VINEX (m_{out}^{VINEX}), the difference between individuals moving in and out as a share of population (m_{in-out}), and the share of individuals moving in (m_{in}) in buurt b and year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, and $n_{muni,\tau}$ are municipality by year fixed effects. Columns 2, 4, and 6 display estimates from the specification:

$$m_{x,b,\tau} = M_{VINEX} I_{HighVINEX,i} + M_{VINEX} \left(I_{HighVINEX,b} \times I_{HighIncome,b}\right) + n_{muni,\tau} + v_{b,\tau}$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and $n_{muni,t,HighInc}$ are municipality by year by above median income ($I_{HighInc}$) fixed effects.

Dependent Variables:	High and Zero Exposure Buurts Only 1995-2015					
	m_{out}^{VINEX}		m_{in-out}		m_{in}	
	(1)	(2)	(3)	(4)	(5)	(6)
$I_{HighVINEX}$	0.0029***	0.0025***	0.0023	0.0029	-0.0003	0.0083
	(0.0005)	(0.0006)	(0.0023)	(0.0022)	(0.0033)	(0.0049)
$I_{HighVINEX} \times I_{HighInc}$		0.0010		0.0008		-0.0178
		(0.0009)		(0.0014)		(0.0113)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Observations	24,787	24,405	50,595	49,392	52,463	51,013
R^2	0.49341	0.53771	0.06463	0.11135	0.16166	0.21436

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.8: The table displays estimates of the effects of VINEX housing supply on mobility in non-VINEX buurts. The time period covers the years from 1995 to 2015. Estimates are based on the restricted sample of buurts with high or zero exposure to VINEX. Columns 1 and 3 to 5 display estimates from the specification, based on observations from 1996 and 2015 only:

$$m_{x,b,\tau} = M_{VINEX} I_{HighVINEX,b} + n_{muni,\tau} + v_{b,\tau}$$

where $m_{x,b,\tau}$ is either the share of individuals moving to VINEX (m_{out}^{VINEX}), the difference between individuals moving in and out as a share of population (m_{in-out}), and the share of individuals moving in (m_{in}) in buurt b and year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, and $a_{muni,\tau}$ are municipality by year fixed effects. Columns 2, 4, and 6 display estimates from the specification:

$$m_{x,b,\tau} = M_{VINEX} I_{HighVINEX,i} + M_{VINEX} \left(I_{HighVINEX,b} \times I_{HighIncome,b}\right) + n_{muni,\tau} + v_{b,\tau}$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and $n_{muni,t,HighInc}$ are municipality by year by above median income ($I_{HighInc}$) fixed effects.

	Panel A: Sample Period 1995-2005					
Dependent Variables:	m_{out}^{VINEX}		m_{in-out}		m_{in}	
Model:	(1)	(2)	(3)	(4)	(5)	(6)
$ShareVINEX$	0.0008***	0.0008**	-3.73×10^{-5}	0.0001	-0.0001	0.0010
	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0008)	(0.0007)
$ShareVINEX \times I_{HighInc}$		2.58×10^{-5}		0.0002		-0.0017*
		(0.0002)		(0.0004)		(0.0008)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Observations	14,949	14,783	42,706	41,937	44,072	43,139
R^2	0.51411	0.54210	0.04905	0.08631	0.13600	0.17838

	Panel B: Sample Period 1995-2015					
Dependent Variables:	m_{out}^{VINEX}		m_{in-out}		m_{in}	
	(1)	(2)	(3)	(4)	(5)	(6)
$ShareVINEX$	0.0006***	0.0006***	7.09×10^{-5}	0.0001	-0.0003	0.0008
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0007)	(0.0007)
$ShareVINEX \times I_{HighInc}$		-3.21×10^{-6}		0.0002		-0.0015
		(0.0001)		(0.0002)		(0.0009)
Fixed-effects						
Municipality by Year	Yes		Yes		Yes	
Municipality by Year by $I_{HighIncome}$		Yes		Yes		Yes
Observations	46,857	46,133	82,348	80,683	84,861	82,870
R^2	0.43350	0.46296	0.04540	0.07960	0.14793	0.18910

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.9: The table displays estimates of the effects of VINEX housing supply on mobility in non-VINEX buurts. Estimates are based on the full sample of non-VINEX buurts. Panel A reports results for the years from 1995 to 2005, while panel B reports results for the years from 1995 to 2015. Columns 1 and 3 to 5 display estimates from the following specification:

$$m_{x,b,\tau} = M_{VINEX} ShareVINEX_b + n_{muni,\tau} + v_{b,\tau}$$

where $m_{x,b,\tau}$ is either the share of individuals moving to VINEX (m_{out}^{VINEX}), the difference between individuals moving in and out as a share of population (m_{in-out}), and the share of individuals moving in (m_{in}) in buurt b and year τ, $ShareVinex$ the share of VINEX land within a 5-Km radius of the buurt b, and $n_{muni,\tau}$ are municipality by year fixed effects. Columns 2, 4, and 6 display estimates from the specification:

$$m_{x,b,\tau} = M_{VINEX} ShareVINEX_b + M_{VINEX} \left(ShareVINEX_b \times I_{HighIncome,b}\right) + n_{muni,\tau} + v_{b,\tau}$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and $n_{muni,t,HighInc}$ are municipality by year by above median income ($I_{HighInc}$) fixed effects.

	Panel Full Sample (All non-VINEX Buurts)				
	Dependent Variable: $NJobs$				
	(1)	(2)	(3)	(4)	(5)
	All		Agric./Manuf.	Non-Trad.	Trad.
$I_{HighVINEX} \times I_{\tau=2015}$	0.1125***	0.0791*	0.0625	0.0673**	0.2336***
	(0.0263)	(0.0435)	(0.0824)	(0.0267)	(0.0743)
$I_{HighVINEX} \times I_{HighInc} \times I_{\tau=2015}$		0.0507			
		(0.0632)			
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	No	Yes	Yes	Yes
Municipality by Year by $I_{HighIncome}$	No	Yes	No	No	No
Observations	10,614	9,906	9,650	10,517	10,357
Pseudo R^2	0.95600	0.95961	0.91831	0.95138	0.93393

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.10: The table displays estimates of the effects of VINEX housing supply on job growth in non-VINEX buurts. Estimates are based on the full sample of non-VINEX buurts. Columns 1 and 3 to 5 display estimates from the specification, based on observations from 1996 and 2015 only:

$$NJobs_{b,\tau} = \exp\left(g_{end}(I_{HighVINEX,i} \times I_{\tau=2015}) + a_b + a_{muni,\tau} + u_{i,\tau}\right)$$

where $NJobs_{b,\tau}$ is either the total number of jobs (column 1), the total number of jobs in Agriculture or Manufacturing (column 3), Non-Tradable Services (column 4), Tradable Services (column 5), Non-Specialized sectors (column 6), and Specialized sectors (column 7) in buurt b and year τ, $I_{HighVINEX}$ is a dummy equal to one for buurts in the top quartile of exposure to VINEX in their municipality, $I_{\tau=2015}$ is a dummy equal to in 2015, and a_b and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. Column 2 displays estimates from a specification:

$$NJobs_{b,\tau} = \exp\left(g_{end}(I_{HighVINEX,i} \times I_{\tau=2015}) + g_{end,H}(I_{HighVINEX,i} \times I_{HighInc} \times I_{\tau=2015}) + f_b + f_{muni,\tau} + v_{i,\tau}\right)$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

	Full Sample (All non-VINEX Buurts) Dependent Variable: $NJobs$				
	(1)	(2)	(3)	(4)	(5)
		All	Agric./Manuf.	Non-Trad.	Trad.
$ShareVINEX \times I_{\tau=2015}$	0.0098	-0.0003	-0.0070	0.0002	0.0335***
	(0.0070)	(0.0080)	(0.0191)	(0.0101)	(0.0080)
$ShareVINEX \times I_{HighInc} \times I_{\tau=2015}$		0.0214***			
		(0.0067)			
Fixed-effects					
Buurt	Yes	Yes	Yes	Yes	Yes
Municipality by Year	Yes	No	Yes	Yes	Yes
Municipality by Year by $I_{HighIncome}$	No	Yes	No	No	No
Observations	10,614	9,906	9,650	10,517	10,357
Pseudo R^2	0.95589	0.95958	0.91830	0.95131	0.93403

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.11: The table displays estimates of the effects of VINEX housing supply on job growth in non-VINEX buurts. Panel A reports estimates based on the full sample of non-VINEX buurts, while Panel B reports estimates based on the subsample of buurts with high or zero exposure to VINEX. Columns 1 and 3 to 7 display estimates from the specification, based on observations from 1996 and 2015 only:

$$NJobs_{b,\tau} = \exp\left(g_{end}(ShareVINEX_i \times I_{\tau=2015}) + a_b + a_{muni,\tau} + u_{i,\tau}\right)$$

where $NJobs_{b,\tau}$ is either the total number of jobs (column 1), the total number of jobs in Agriculture or Manufacturing (column 3), Non-Tradable Services (column 4), Tradable Services (column 5), Non-Specialized sectors (column 6), and Specialized sectors (column 7) in buurt b and year τ, $ShareVinex$ the share of VINEX land within a 5-Km radius of the buurt b, $I_{\tau=2015}$ is a dummy equal to in 2015, and a_b and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. Column 2 displays estimates from a specification:

$$NJobs_{b,\tau} = \exp\left(g_{end}(ShareVINEX_i \times I_{\tau=2015}) + g_{end,H}(ShareVINEX_i \times I_{HighInc} \times I_{\tau=2015}) + f_b + f_{muni,\tau} + v_{i,\tau}\right)$$

where $I_{HighInc}$ is a dummy equal to one in buurts that have average income per capita above the median in the municipality, and f_b and $f_{muni,t,HighInc}$ are buurt and municipality by year by above median income ($I_{HighInc}$) fixed effects.

SBI08 Level 2	Name (Dutch)	Name (English)	Sector (NACE)	Category
01	Landbouw	Agriculture	A	Agr. or Man.
02	Bosbouw	Forestry	A	Agr. or Man.
03	Visserij	Fishing	A	Agr. or Man.
06	B Delfstoffenwinning	Mining and quarrying	B	Agr. or Man.
08	B Delfstoffenwinning	Mining and quarrying	B	Agr. or Man.
09	B Delfstoffenwinning	Mining and quarrying	B	Agr. or Man.
10	Voedings-, genotmiddelenindustrie	Food and beverage industry	C	Agr. or Man.
11	Voedings-, genotmiddelenindustrie	Food and beverage industry	C	Agr. or Man.
12	Voedings-, genotmiddelenindustrie	Food and beverage industry	C	Agr. or Man.
13	Textiel-, kleding-, lederindustrie	Textile, clothing, and leather industry	C	Agr. or Man.
14	Textiel-, kleding-, lederindustrie	Textile, clothing, and leather industry	C	Agr. or Man.
15	Textiel-, kleding-, lederindustrie	Textile, clothing, and leather industry	C	Agr. or Man.
16	Houtindustrie	Wood industry	C	Agr. or Man.
17	Papierindustrie	Paper industry	C	Agr. or Man.
18	Grafische industrie	Graphic industry	C	Agr. or Man.
19	Aardolie-industrie	Petroleum industry	C	Agr. or Man.
20	Chemische industrie	Chemical industry	C	Agr. or Man.
21	Farmaceutische industrie	Pharmaceutical industry	C	Agr. or Man.
22	Rubber- en kunststofproductindustrie	Rubber and plastic products industry	C	Agr. or Man.
23	Bouwmaterialenindustrie	Building materials industry	C	Agr. or Man.
24	Basismetaalindustrie	Basic metal industry	C	Agr. or Man.
25	Metaalproductenindustrie	Metal products industry	C	Agr. or Man.
26	Elektrotechnische industrie	Electrical engineering industry	C	Agr. or Man.
27	Elektrische apparatenindustrie	Electrical appliances industry	C	Agr. or Man.
28	Machine-industrie	Machinery industry	C	Agr. or Man.
29	Auto- en aanhangwagenindustrie	Motor vehicle and trailer industry	C	Agr. or Man.
30	Overige transportmiddelenindustrie	Other transport equipment industry	C	Agr. or Man.
31	Meubel- en overige industrie	Furniture and other manufacturing	C	Agr. or Man.
32	Meubel- en overige industrie	Furniture and other manufacturing	C	Agr. or Man.
33	Reparatie en installatie van machines	Repair and installation of machinery	C	Agr. or Man.
35	Energiebedrijven	Energy companies	D	Agr. or Man.
36	Waterleidingbedrijven	Water supply companies	E	Non-Tr. Services
37	Riolering, afvalbeheer en sanering	Sewerage, waste, and remediation	E	Non-Tr. Services
38	Riolering, afvalbeheer en sanering	Sewerage, waste, and remediation	E	Non-Tr. Services
39	Riolering, afvalbeheer en sanering	Sewerage, waste, and remediation	E	Non-Tr. Services
41	Algemene bouw en projectontwikkeling	General construction and development	F	Tradable Services
42	Grond-, water- en wegenbouw	Civil eng. (ground, water, and roads)	F	Tr. Services
43	Gespecialiseerde bouw	Specialized construction	F	Tr. Services
45	Autohandel en -reparatie	Car trade and repair	G	Non-Tr. Services
46	Groothandel en handelsbemiddeling	Wholesale trade and brokerage	G	Non-Tr. Services
47	Detailhandel (niet in auto's)	Retail trade (excluding motor vehicles)	G	Non-Tr. Services
49	Vervoer over land	Land transport	H	Tr. Services
50	Vervoer over water	Water transport	H	Tr. Services
51	Vervoer door de lucht	Air transport	H	Tr. Services
52	Opslag, dienstverlening voor vervoer	Storage and transport services	H	Tr. Services
53	Post en koeriers	Postal and courier services	H	Tr. Services
55	I Horeca	Hospitality	I	Non-Tr. Services
56	I Horeca	Hospitality	I	Non-Tr. Services
58	Uitgeverijen	Publishing	J	Tr. Services
59	Film, TV en radio	Film, TV, and radio	J	Tr. Services
60	Film, TV en radio	Film, TV, and radio	J	Tr. Services
61	Telecommunicatie	Telecommunications	J	Tr. Services
62	IT- en informatiedienstverlening	IT and information services	J	Tr. Services
63	IT- en informatiedienstverlening	IT and information services	J	Tr. Services
64	Bankwezen	Banking	K	Tr. Services
65	Verzekeraars en pensioenfondsen	Insurance and pension funds	K	Tr. Services
66	Overige financiële dienstverlening	Other financial services	K	Tr. Services
68	Verhuur en handel van onroerend goed	Real estate rental and trade	L	Tr. Services
69	Juridisch en managementadvies	Legal and management consultancy	M	Tr. Services
70	Juridisch en managementadvies	Legal and management consultancy	M	Tr. Services
71	Architecten-, ingenieursbureaus e.d.	Architectural and engineering firms	M	Tr. Services
72	Research	Research	M	Tr. Services
73	Reclamewezen en marktonderzoek	Advertising and market research	M	Tr. Services
74	Overige professionele diensten	Other professional services	M	Tr. Services
75	Overige professionele diensten	Other professional services	M	Tr. Services
77	Verhuur van roerende goederen	Rental of movable property	N	Non-Tr. Services
78	Uitzendbureaus en arbeidsbemiddeling	Employment agencies and mediation	N	Non-Tr. Services
79	Reisbureaus, reisorganisatie en -info	Travel agencies, tour operators, and info	N	Non-Tr. Services
80	Overige zakelijke dienstverlening	Other business services	N	Non-Tr. Services
81	Overige zakelijke dienstverlening	Other business services	N	Non-Tr. Services
82	Overige zakelijke dienstverlening	Other business services	N	Non-Tr. Services
84	Openbaar bestuur en overheidsdiensten	Public administration and government	O	Non-Tr. Services
85	Onderwijs	Education	P	Non-Tr. Services
86	Gezondheidszorg	Health care	Q	Non-Tr. Services
87	Verzorging en welzijn	Care and welfare services	Q	Non-Tr. Services
88	Verzorging en welzijn	Care and welfare services	Q	Non-Tr. Services
90	Kunst, cultuur en kansspelen	Arts, culture, and gambling	R	Non-Tr. Services
91	Kunst, cultuur en kansspelen	Arts, culture, and gambling	R	Non-Tr. Services
92	Kunst, cultuur en kansspelen	Arts, culture, and gambling	R	Non-Tr. Services
93	Sport en recreatie	Sports and recreation	R	Non-Tr. Services
94	Ideele, belangen-, hobbyverenigingen	Non-profit, advocacy, and hobbies	S	Non-Tr. Services
95	Reparatie van consumentenartikelen	Repair of consumer goods	S	Non-Tr. Services
96	Overige persoonlijke dienstverlening	Other personal services	S	Non-Tr. Services

Table A.12: Mapping of SBI 2008 codes from the LISA data into sectors (based on the NACE Eurostat classification), and macro-categories (Agriculture or Manufacturing, Non-Tradable Services, Tradable Services).

B Model Derivation Detail

B.1 Housing Supply Micro-Foundation

In the main text, we posit an inverse housing supply function $q_n = \pi_n D_n^{1/\eta_n}$. This function can be derived from a production process for housing services, following Redding and Sturm (2024).

Assume housing services D_n at location n are produced using only land K_n with a Cobb-Douglas technology:

$$D_n = K_n^{\alpha_n} \tag{B.1}$$

where $\alpha_n \in (0, 1]$ captures the productivity of land in housing production. The cost of land is r_n per unit. The cost minimization problem for a housing producer is:

$$\min C_n = r_n K_n \quad \text{s.t.} \quad K_n^{\alpha_n} = D_n \tag{B.2}$$

Substituting the constraint, $K_n = D_n^{1/\alpha_n}$, the cost function is:

$$C_n = r_n D_n^{1/\alpha_n} \tag{B.3}$$

Under perfect competition, the price of housing q_n equals the marginal cost of production:

$$q_n = \frac{\partial C_n}{\partial D_n} = \frac{1}{\alpha_n} r_n D_n^{\frac{1-\alpha_n}{\alpha_n}} \tag{B.4}$$

This matches the inverse supply function $q_n = \pi_n D_n^{1/\eta_n}$ by setting:

$$\pi_n = \frac{r_n}{\alpha_n} \quad \text{and} \quad \frac{1}{\eta_n} = \frac{1-\alpha_n}{\alpha_n} \tag{B.5}$$

The parameter π_n captures location-specific land costs (r_n) and land productivity (α_n), while $\eta_n = \alpha_n/(1-\alpha_n)$ represents the price elasticity of housing supply.

We can verify this elasticity:

$$\begin{aligned} \frac{dD_n}{dq_n}\frac{q_n}{D_n} &= \frac{d}{dq_n}\left[\left(\frac{q_n}{\pi_n}\right)^{\eta_n}\right]\frac{q_n}{D_n} \\ &= \frac{\eta_n (q_n/\pi_n)^{\eta_n}}{D_n} = \frac{\eta_n D_n}{D_n} = \eta_n \end{aligned} \tag{B.6}$$

B.2 Worker's Problem and Optimal Demands

B.2.1 Service Aggregation and Price Index

A worker at residence n consumes service varieties from all locations $j \in \mathcal{N}$. The composite service good $C^S_{\omega ni}$ is a CES aggregator over all available varieties:

$$C^S_{\omega ni} = \left(\sum_{j=1}^{N} \int_0^{M_j} c_{nj}(\nu)^{\frac{\sigma_S - 1}{\sigma_S}} \, d\nu \right)^{\frac{\sigma_S}{\sigma_S - 1}}, \qquad \sigma_S > 1, \tag{B.7}$$

where $c_{nj}(\nu)$ is the consumption of variety ν from location j. Workers face an *effective* price $\tilde{p}_{nj}(\nu) = t^g_{nj} p_j(\nu)$ which includes the shopping friction $t^g_{nj} = \exp(\kappa^{\text{shop},g} \bar{\tau}_{nj})$.

The dual of this aggregation is the unit-expenditure function, or the effective service price index $P^{S,\text{eff}}_{n,g}$:

$$P^{S,\text{eff}}_{n,g} = \left(\sum_{j=1}^{N} \int_0^{M_j} \tilde{p}_{nj}(\nu)^{\,1-\sigma_S} \, d\nu \right)^{\frac{1}{1-\sigma_S}}. \tag{B.8}$$

Let $\mathcal{E}^S_{\omega ni}$ be the worker's total service expenditure. Standard CES demand results give the demand for a specific variety ν from location j:

$$c_{nj}(\nu) = \left(\frac{\tilde{p}_{nj}(\nu)}{P^{S,\text{eff}}_{n,g}} \right)^{-\sigma_S} \frac{\mathcal{E}^S_{\omega ni}}{P^{S,\text{eff}}_{n,g}}. \tag{B.9}$$

The total expenditure on all varieties from a specific *destination* j is:

$$\mathcal{E}^{S,(j)}_{\omega ni} = \int_0^{M_j} \tilde{p}_{nj}(\nu)\, c_{nj}(\nu)\, d\nu = \mathcal{E}^S_{\omega ni} \frac{\int_0^{M_j} \tilde{p}_{nj}(\nu)^{\,1-\sigma_S} d\nu}{\sum_k \int_0^{M_k} \tilde{p}_{nk}(\nu)^{\,1-\sigma_S} d\nu}. \tag{B.10}$$

This gives the expenditure share $\pi^S_{n \to j|g}$ (as seen in the main text, Eq. 29):

$$\pi^S_{n \to j|g} := \frac{\mathcal{E}^{S,(j)}_{\omega ni}}{\mathcal{E}^S_{\omega ni}} = \frac{\int_0^{M_j} \tilde{p}_{nj}(\nu)^{\,1-\sigma_S} d\nu}{\sum_k \int_0^{M_k} \tilde{p}_{nk}(\nu)^{\,1-\sigma_S} d\nu}. \tag{B.11}$$

Assuming all varieties ν within a location j are symmetric (with common price p_j and mass M_j), the integral simplifies:

$$\int_0^{M_j} \tilde{p}_{nj}(\nu)^{\,1-\sigma_S} d\nu = M_j \left(t^g_{nj} p_j \right)^{1-\sigma_S} \tag{B.12}$$

Substituting this back into Eq. (B.8) and (B.11) gives the specific forms used in the main text (Eq. 13 and Eq. 29):

$$P^{S,\text{eff}}_{n,g} = \left(\sum_{j=1}^{N} M_j \left(t^g_{nj} p_j \right)^{1-\sigma_S} \right)^{\frac{1}{1-\sigma_S}} \tag{B.13}$$

$$\pi^S_{n\to j|g} = \frac{M_j\left(t^g_{nj}p_j\right)^{1-\sigma_S}}{\sum_{k=1}^N M_k\left(t^g_{nk}p_k\right)^{1-\sigma_S}}. \tag{B.14}$$

B.2.2 Utility Maximization and Indirect Utility

The worker maximizes the Stone-Geary utility (Eq. 11) subject to the budget constraint (Eq. 14).

$$\max U^g_{\omega ni} = \frac{z_{\omega ni}B^g_n}{d^g_{ni}}\left(C^G_{\omega ni}\right)^{\beta^g}\left(C^S_{\omega ni}\right)^{\gamma^g}\left(H_{\omega ni}-\bar{h}^g\right)^{1-\beta^g-\gamma^g} \tag{B.15}$$

$$\text{s.t.}\quad p^G C^G_{\omega ni} + P^{S,\text{eff}}_{n,g}C^S_{\omega ni} + q_n(H_{\omega ni}-\bar{h}^g) = w^g_i - q_n\bar{h}^g \tag{B.16}$$

This is a standard Cobb-Douglas problem over the three goods C^G, C^S, and discretionary housing $(H-\bar{h}^g)$, using the discretionary income $y^g_{ni} = w^g_i - q_n\bar{h}^g$. The optimal demands are constant expenditure shares of this discretionary income (with $p^G=1$):

$$C^{G*}_{\omega ni} = \beta^g\,\frac{w^g_i - q_n\bar{h}^g}{p^G} = \beta^g(w^g_i - q_n\bar{h}^g) \tag{B.17}$$

$$C^{S*}_{\omega ni} = \gamma^g\,\frac{w^g_i - q_n\bar{h}^g}{P^{S,\text{eff}}_{n,g}} \tag{B.18}$$

$$\left(H_{\omega ni}-\bar{h}^g\right)^* = (1-\beta^g-\gamma^g)\,\frac{w^g_i - q_n\bar{h}^g}{q_n} \tag{B.19}$$

Total housing demand is $H^*_{\omega ni} = \bar{h}^g + (1-\beta^g-\gamma^g)(w^g_i - q_n\bar{h}^g)/q_n$. Total service expenditure is $\mathcal{E}^S_{\omega ni} = P^{S,\text{eff}}_{n,g}C^{S*}_{\omega ni} = \gamma^g(w^g_i - q_n\bar{h}^g)$.

Substituting these optimal demands back into the utility function yields the indirect utility $u^g_{\omega ni}$:

$$\begin{aligned}
u^g_{\omega ni} &= \frac{z_{\omega ni}\,B^g_n}{d^g_{ni}}\left(\beta^g\frac{y^g_{ni}}{p^G}\right)^{\beta^g}\left(\gamma^g\frac{y^g_{ni}}{P^{S,\text{eff}}_{n,g}}\right)^{\gamma^g}\left((1-\beta^g-\gamma^g)\frac{y^g_{ni}}{q_n}\right)^{1-\beta^g-\gamma^g}\\
&= \frac{z_{\omega ni}\,B^g_n}{d^g_{ni}}\,(y^g_{ni})^{\beta^g+\gamma^g+1-\beta^g-\gamma^g}\cdot(\beta^g)^{\beta^g}(\gamma^g)^{\gamma^g}(1-\beta^g-\gamma^g)^{1-\beta^g-\gamma^g}\\
&\quad\cdot(p^G)^{-\beta^g}(P^{S,\text{eff}}_{n,g})^{-\gamma^g}(q_n)^{-(1-\beta^g-\gamma^g)}\\
&= c^g\,\frac{z_{\omega ni}\,B^g_n}{d^g_{ni}}\left(w^g_i - q_n\bar{h}^g\right)(p^G)^{-\beta^g}\left(P^{S,\text{eff}}_{n,g}\right)^{-\gamma^g}(q_n)^{\beta^g+\gamma^g-1}
\end{aligned} \tag{B.20}$$

where $c^g = (\beta^g)^{\beta^g}(\gamma^g)^{\gamma^g}(1-\beta^g-\gamma^g)^{1-\beta^g-\gamma^g}$ is a constant.

B.3 Location Choice Probabilities

B.3.1 Joint Probability

The indirect utility can be written as $u^g_{\omega ni} = z_{\omega ni} \cdot V^g_{ni}$, where V^g_{ni} is the deterministic component:

$$V^g_{ni} = c^g \frac{B^g_n}{d^g_{ni}} (w^g_i - q_n \bar{h}^g)(p^G)^{-\beta g} (P^{S,\text{eff}}_{n,g})^{-\gamma^g} (q_n)^{\beta^g + \gamma^g - 1} \tag{B.21}$$

With the idiosyncratic taste shock $z_{\omega ni}$ following a Fréchet distribution $F(z) = \exp[-(T^g_n E^g_i) z^{-\epsilon^g}]$, the probability that a type-g worker chooses the (residence n, workplace i) pair is:

$$\lambda^g_{ni} = \frac{(T^g_n E^g_i)(V^g_{ni})^{\epsilon^g}}{\sum_{m=1}^N \sum_{j=1}^N (T^g_m E^g_j)(V^g_{mj})^{\epsilon^g}} = \frac{\Phi^g_{ni}}{\Phi^g} \tag{B.22}$$

where $\Phi^g = \sum_n \sum_i \Phi^g_{ni}$ and $\Phi^g_{ni} = (T^g_n E^g_i)(V^g_{ni})^{\epsilon^g}$. Substituting V^g_{ni}:

$$\Phi^g_{ni} = T^g_n E^g_i \left[\frac{c^g B^g_n (w^g_i - q_n \bar{h}^g)}{d^g_{ni} (p^G)^{\beta^g} (P^{S,\text{eff}}_{n,g})^{\gamma^g} (q_n)^{1-\beta^g-\gamma^g}} \right]^{\epsilon^g} \tag{B.23}$$

As noted in the main text, we normalize $p^G = 1$ (since it cancels) and $T^g_n = 1$ (as it's not separable from B^g_n). This leads to Eq. 16 in the main text.

B.3.2 Conditional Probabilities

From the joint probability λ^g_{ni}, we can derive conditional probabilities.

Probability of Working in i Given Residence in n:

$$\lambda^g(i \mid n) = \frac{\lambda^g_{ni}}{\sum_{j=1}^N \lambda^g_{nj}} = \frac{\Phi^g_{ni}/\Phi^g}{\sum_{j=1}^N (\Phi^g_{nj}/\Phi^g)} = \frac{\Phi^g_{ni}}{\sum_{j=1}^N \Phi^g_{nj}} \tag{B.24}$$

When we substitute the expression for Φ^g_{ni}, all terms that depend *only* on the residential location n (like T^g_n, B^g_n, q_n, $P^{S,\text{eff}}_{n,g}$) cancel out:

$$\lambda^g(i \mid n) = \frac{T^g_n E^g_i \left[\dots\right]^{-\epsilon^g} \left[c^g B^g_n (w^g_i - q_n \bar{h}^g)\right]^{\epsilon^g}}{\sum_{j=1}^N T^g_n E^g_j \left[\dots\right]^{-\epsilon^g} \left[c^g B^g_n (w^g_j - q_n \bar{h}^g)\right]^{\epsilon^g}} \tag{B.25}$$

$$\lambda^g(i \mid n) = \frac{E^g_i \left[d^g_{ni}\right]^{-\epsilon^g} (w^g_i - q_n \bar{h}^g)^{\epsilon^g}}{\sum_{j=1}^N E^g_j \left[d^g_{nj}\right]^{-\epsilon^g} (w^g_j - q_n \bar{h}^g)^{\epsilon^g}} \tag{B.26}$$

This conditional probability is used to calculate the expected wage for residents of n:

$$\mathbb{E}_n[w^g] = \sum_{i=1}^N w^g_i \lambda^g(i \mid n) = \frac{\sum_{i=1}^N E^g_i \left[d^g_{ni}\right]^{-\epsilon^g} w^g_i (w^g_i - q_n \bar{h}^g)^{\epsilon^g}}{\sum_{j=1}^N E^g_j \left[d^g_{nj}\right]^{-\epsilon^g} (w^g_j - q_n \bar{h}^g)^{\epsilon^g}} \tag{B.27}$$

Probability of Living in n Given Workplace i:

$$\lambda^g(n \mid i) = \frac{\lambda^g_{ni}}{\sum_{m=1}^N \lambda^g_{mi}} = \frac{\Phi^g_{ni}}{\sum_{m=1}^N \Phi^g_{mi}} \tag{B.28}$$

This time, terms that depend *only* on the workplace i (like E^g_i and w^g_i) cancel:

$$\lambda^g(n \mid i) = \frac{T^g_n E^g_i \left[d^g_{ni} \dots (w^g_i - q_n \bar{h}^g)\right]^{\epsilon^g}}{\sum_{m=1}^N T^g_m E^g_i \left[d^g_{mi} \dots (w^g_i - q_m \bar{h}^g)\right]^{\epsilon^g}} \tag{B.29}$$

$$\lambda^g(n \mid i) = \frac{T^g_n B^{g\,\epsilon^g}_n \left[d^g_{ni}\right]^{-\epsilon^g} (P^{S,\text{eff}}_{n,g})^{-\gamma^g \epsilon^g} (q_n)^{-(1-\beta^g-\gamma^g)\epsilon^g} (w^g_i - q_n \bar{h}^g)^{\epsilon^g}}{\sum_{m=1}^N T^g_m B^{g\,\epsilon^g}_m \left[d^g_{mi}\right]^{-\epsilon^g} (P^{S,\text{eff}}_{m,g})^{-\gamma^g \epsilon^g} (q_m)^{-(1-\beta^g-\gamma^g)\epsilon^g} (w^g_i - q_m \bar{h}^g)^{\epsilon^g}} \tag{B.30}$$

(Assuming normalization $T^g_n = 1$). This conditional probability is used to aggregate residential land demand.

B.4 Production, Firm Problems, and Factor Prices

B.4.1 Tradable Goods Sector (G)

Firms are in perfect competition, taking $p^G = 1$, w^G_i, and q_i as given. The profit function is:

$$\max_{L^G_{W,i}, D^G_i} \ \pi^G_i = p^G A^G_i (L^G_{W,i})^{\alpha_G} (D^G_i)^{1-\alpha_G} - w^G_i L^G_{W,i} - q_i D^G_i \tag{B.31}$$

First-order conditions are:

$$\frac{\partial \pi^G_i}{\partial L^G_{W,i}} = p^G A^G_i \alpha_G (L^G_{W,i})^{\alpha_G - 1} (D^G_i)^{1-\alpha_G} - w^G_i = 0 \quad \Rightarrow \quad w^G_i = p^G \alpha_G (Y^G_i / L^G_{W,i}) \tag{B.32}$$

$$\frac{\partial \pi^G_i}{\partial D^G_i} = p^G A^G_i (1-\alpha_G)(L^G_{W,i})^{\alpha_G} (D^G_i)^{-\alpha_G} - q_i = 0 \quad \Rightarrow \quad q_i = p^G (1-\alpha_G)(Y^G_i / D^G_i) \tag{B.33}$$

Taking the ratio of these two FOCs gives the optimal input ratio:

$$\frac{w^G_i}{q_i} = \frac{\alpha_G}{1-\alpha_G} \frac{D^G_i}{L^G_{W,i}} \quad \Rightarrow \quad \frac{D^G_i}{L^G_{W,i}} = \frac{(1-\alpha_G)\, w^G_i}{\alpha_G\, q_i} \tag{B.34}$$

Under CRS and perfect competition, profits are zero, so $p^G Y^G_i = w^G_i L^G_{W,i} + q_i D^G_i$. This implies the unit-cost condition:

$$p^G = \frac{\text{Cost}}{\text{Output}} = \frac{w^G_i L^G_{W,i} + q_i D^G_i}{A^G_i (L^G_{W,i})^{\alpha_G} (D^G_i)^{1-\alpha_G}} \tag{B.35}$$

Substituting the optimal input ratio $D_i^G = L_{W,i}^G[(1-\alpha_G)w_i^G/(\alpha_G q_i)]$:

$$p^G = \frac{w_i^G L_{W,i}^G + q_i L_{W,i}^G[\dots]}{A_i^G (L_{W,i}^G)^{\alpha_G}(L_{W,i}^G[\dots])^{1-\alpha_G}} = \frac{1}{A_i^G}\left(\frac{w_i^G}{\alpha_G}\right)^{\alpha_G}\left(\frac{q_i}{1-\alpha_G}\right)^{1-\alpha_G} \tag{B.36}$$

Setting $p^G = 1$ and solving for w_i^G gives the wage equation (Eq. 18):

$$(w_i^G)^{\alpha_G} = A_i^G \alpha_G^{\alpha_G}\left(\frac{1-\alpha_G}{q_i}\right)^{1-\alpha_G} \quad \Rightarrow \quad w_i^G = \alpha_G (A_i^G)^{1/\alpha_G}\left(\frac{1-\alpha_G}{q_i}\right)^{(1-\alpha_G)/\alpha_G} \tag{B.37}$$

B.4.2 Non-Tradable Services Sector (S)

This sector has monopolistic competition.

1. Unit Cost The firm-level technology is $y_i(\nu) = a_i^S \ell_{W,i}(\nu)^{\alpha_S} d_i(\nu)^{1-\alpha_S}$. The cost of one unit of the composite factor (labor and land) is:

$$r_i^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_i^S)^{\alpha_S} {q_i}^{1-\alpha_S} \tag{B.38}$$

The unit variable cost c_i is this factor cost divided by firm-level productivity a_i^S:

$$c_i = r_i^S / a_i^S \tag{B.39}$$

2. Pricing Firms face demand elasticity σ_S and set price p_i as a constant markup over marginal cost:

$$p_i = \frac{\sigma_S}{\sigma_S - 1}\, c_i = \frac{\sigma_S}{\sigma_S - 1}\, \frac{r_i^S}{a_i^S} \tag{B.40}$$

3. Free Entry Entry requires a fixed cost $F_i = r_i^S f$ (paid in the same factor bundle, with $f = 1$ normalized). The zero-profit condition is:

$$\text{Operating Profit} = \text{Fixed Cost} \quad \Rightarrow \quad (p_i - c_i) y_i = r_i^S f \tag{B.41}$$

From the pricing rule, $(p_i - c_i) = p_i/\sigma_S$. So:

$$\frac{1}{\sigma_S} p_i y_i = r_i^S f \quad \Rightarrow \quad R_i^{\text{firm}} = p_i y_i = \sigma_S r_i^S f \tag{B.42}$$

where R_i^{firm} is the revenue per firm. The total revenue in the sector R_i^S is $M_i R_i^{\text{firm}}$, so the mass of varieties M_i is:

$$M_i = \frac{R_i^S}{R_i^{\text{firm}}} = \frac{R_i^S}{\sigma_S r_i^S f} \tag{B.43}$$

4. Factor Exhaustion Because both variable and fixed costs are paid in the same factor bundle, total revenue R_i^S is fully exhausted by payments to labor and land:

$$R_i^S = w_i^S L_{W,i}^S + q_i D_i^S \tag{B.44}$$

where $L_{W,i}^S$ and D_i^S are *total* labor and land in the service sector at i. The cost shares imply:

$$w_i^S L_{W,i}^S = \alpha_S R_i^S \quad \text{and} \quad q_i D_i^S = (1-\alpha_S) R_i^S \tag{B.45}$$

5. Deriving M_i From factor exhaustion, we have $w_i^S = \alpha_S R_i^S / L_{W,i}^S$ and $q_i = (1-\alpha_S) R_i^S / D_i^S$. Substitute these into the composite factor price r_i^S:

$$\begin{aligned} r_i^S &= \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)} \left(\frac{\alpha_S R_i^S}{L_{W,i}^S}\right)^{\alpha_S} \left(\frac{(1-\alpha_S) R_i^S}{D_i^S}\right)^{1-\alpha_S} \\ &= R_i^S (L_{W,i}^S)^{-\alpha_S} (D_i^S)^{-(1-\alpha_S)} \end{aligned} \tag{B.46}$$

Now substitute this into the expression for M_i (with $f = 1$):

$$M_i = \frac{R_i^S}{\sigma_S r_i^S} = \frac{R_i^S}{\sigma_S \left[R_i^S (L_{W,i}^S)^{-\alpha_S} (D_i^S)^{-(1-\alpha_S)}\right]} = \frac{1}{\sigma_S} (L_{W,i}^S)^{\alpha_S} (D_i^S)^{1-\alpha_S} \tag{B.47}$$

This gives Eq. 20 in the main text.

6. Deriving w_i^S We start from the pricing rule:

$$p_i = \frac{\sigma_S}{\sigma_S - 1} \frac{\alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)} (w_i^S)^{\alpha_S} q_i^{1-\alpha_S}}{a_i^S} \tag{B.48}$$

Invert this to solve for w_i^S:

$$(w_i^S)^{\alpha_S} = p_i a_i^S \left(\frac{\sigma_S - 1}{\sigma_S}\right) \alpha_S^{\alpha_S} (1-\alpha_S)^{1-\alpha_S} q_i^{-(1-\alpha_S)} \tag{B.49}$$

$$w_i^S = \left[p_i a_i^S \left(\frac{\sigma_S - 1}{\sigma_S}\right) \alpha_S^{\alpha_S} (1-\alpha_S)^{1-\alpha_S} q_i^{-(1-\alpha_S)}\right]^{1/\alpha_S} \tag{B.50}$$

$$w_i^S = (p_i a_i^S)^{1/\alpha_S} \left(\frac{\sigma_S - 1}{\sigma_S}\right)^{1/\alpha_S} \alpha_S (1-\alpha_S)^{(1-\alpha_S)/\alpha_S} q_i^{-(1-\alpha_S)/\alpha_S} \tag{B.51}$$

$$w_i^S = \alpha_S \left(\frac{\sigma_S - 1}{\sigma_S}\right)^{1/\alpha_S} (a_i^S p_i)^{1/\alpha_S} \left(\frac{1-\alpha_S}{q_i}\right)^{(1-\alpha_S)/\alpha_S} \tag{B.52}$$

This gives Eq. 21 in the main text.

B.5 Market Equilibrium Conditions

B.5.1 Land Market Equilibrium

The market clearing condition at each location n is $D_n^{Total} = S_n$, where $D_n^{Total} = D_n^R + D_n^G + D_n^S$.

1. Residential Land Demand (D_n^R) This is the sum of housing demand from all workers residing at n.

$$\begin{aligned} D_n^R &= \sum_{g\in\{G,S\}} \sum_{i=1}^{N} H^*_{\omega ni} \lambda^g_{ni} \bar{L}^g \\ &= \sum_{g\in\{G,S\}} \sum_{i=1}^{N} \left[\bar{h}^g + (1-\beta^g-\gamma^g) \frac{w_i^g - q_n \bar{h}^g}{q_n} \right] \lambda^g_{ni} \bar{L}^g \\ &= \sum_{g\in\{G,S\}} \left(\sum_{i=1}^{N} \lambda^g_{ni} \bar{L}^g \right) \bar{h}^g + \sum_{g\in\{G,S\}} \frac{1-\beta^g-\gamma^g}{q_n} \sum_{i=1}^{N} (w_i^g - q_n \bar{h}^g) \lambda^g_{ni} \bar{L}^g \end{aligned} \tag{B.53}$$

Using $L^g_{Rn} = \sum_{i=1}^N \lambda^g_{ni} \bar{L}^g$ (total type-g residents at n) and $\lambda^g(i|n) = \lambda^g_{ni} \bar{L}^g / L^g_{Rn}$:

$$\begin{aligned} D_n^R &= \sum_{g\in\{G,S\}} L^g_{Rn} \bar{h}^g + \sum_{g\in\{G,S\}} \frac{1-\beta^g-\gamma^g}{q_n} L^g_{Rn} \sum_{i=1}^{N} (w_i^g - q_n \bar{h}^g) \lambda^g(i|n) \\ &= \sum_{g\in\{G,S\}} L^g_{Rn} \left[\bar{h}^g + \frac{1-\beta^g-\gamma^g}{q_n} \left(\left(\sum_{i=1}^{N} w_i^g \lambda^g(i|n) \right) - q_n \bar{h}^g \right) \right] \\ &= \sum_{g\in\{G,S\}} L^g_{Rn} \left[\bar{h}^g + (1-\beta^g-\gamma^g) \frac{\mathbb{E}_n[w^g] - q_n \bar{h}^g}{q_n} \right] \end{aligned} \tag{B.54}$$

This gives Eq. 24 from the main text.

2. Production Land Demand (D_n^G, D_n^S) From firm optimization:

$$D_n^G = L^G_{W,n} \left[\frac{(1-\alpha_G)\, w_n^G}{\alpha_G\, q_n} \right] = \frac{(1-\alpha_G) w_n^G L^G_{W,n}}{\alpha_G q_n} \tag{B.55}$$

$$D_n^S = \frac{(1-\alpha_S) R_n^S}{q_n} \tag{B.56}$$

3. Land Supply (S_n) From the housing supply function, $q_n = \pi_n D_n^{1/\eta_n}$, which inverts to:

$$D_n = \left(\frac{q_n}{\pi_n} \right)^{\eta_n} \tag{B.57}$$

4. Clearing Condition Setting $D_n^R + D_n^G + D_n^S = D_n$ gives the full equilibrium condition:

$$\sum_{g\in\{G,S\}} L_{Rn}^g \left[\bar{h}^g + (1-\beta^g-\gamma^g)\frac{\mathbb{E}_n[w^g] - q_n\bar{h}^g}{q_n}\right] + \frac{(1-\alpha_G)w_n^G L_{W,n}^G}{\alpha_G q_n} + \frac{(1-\alpha_S)R_n^S}{q_n} = \left(\frac{q_n}{\pi_n}\right)^{\eta_n} \tag{B.58}$$

B.5.2 Local Services Market Equilibrium

1. Service Demand ($\mathcal{E}_j^S$) Total expenditure at service destination j ($\mathcal{E}_j^S$) is the sum of spending from all residents n of all types g. The total service budget for a type-g worker at n with workplace i is $\mathcal{E}_{\omega ni}^S = \gamma^g(w_i^g - q_n\bar{h}^g)$. The *average* service budget for a type-g resident at n is $\gamma^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g)$. Total service budget for all type-g residents at n is $L_{R,n}^g \cdot \gamma^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g)$. This budget is allocated across all service destinations j according to the share $\pi_{n\to j|g}^S$. Therefore, the total expenditure flowing from n to j from type-g workers is $\pi_{n\to j|g}^S \cdot L_{R,n}^g \gamma^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g)$. Summing over all origins n and types g gives the total expenditure received by destination j (Eq. 28):

$$\mathcal{E}_j^S = \sum_{g\in\{G,S\}} \sum_{n=1}^{N} \pi_{n\to j|g}^S \, \gamma^g \, L_{Rn}^g \left(\mathbb{E}_n[w^g] - q_n\bar{h}^g\right) \tag{B.59}$$

2. Calibration of Coverage Factor ζ The model only observes expenditure from workers L^G and L^S. To account for total economic activity, we scale this observed expenditure $\mathcal{E}_j^S$ by ζ to match total firm revenue R_j^S.

$$R_j^S = \zeta \mathcal{E}_j^S \tag{B.60}$$

The factor ζ is calibrated to ensure that total service revenue in the city equals total service expenditure. Aggregate Revenue (from firms): $R_{tot}^S = \sum_j R_j^S$. From factor exhaustion, $w_j^S L_{W,j}^S = \alpha_S R_j^S$, so $R_j^S = (w_j^S L_{W,j}^S)/\alpha_S$.

$$R_{tot}^S = \sum_{j=1}^{N} \frac{w_j^S L_{W,j}^S}{\alpha_S} = \frac{1}{\alpha_S} \cdot \text{wageBill}_S \tag{B.61}$$

Aggregate Expenditure (from residents): This is the total service budget B from all workers.

$$B = \sum_{n=1}^{N} \sum_{g\in\{G,S\}} L_{R,n}^g \gamma^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g) \tag{B.62}$$

The clearing condition $R_{tot}^S = \zeta B$ defines the coverage factor:

$$\zeta = \frac{R_{tot}^S}{B} = \frac{(\text{wageBill}_S)/\alpha_S}{\sum_n \sum_g L_{R,n}^g \gamma^g(\mathbb{E}_n[w^g] - q_n\bar{h}^g)} \tag{B.63}$$

B.6 Welfare Analysis Derivations

B.6.1 Expected Utility

As derived earlier, the indirect utility for worker ω is $u^g_{\omega ni} = c^g z_{\omega ni} \Theta^g_{ni}(w^g_i - q_n \bar{h}^g)$, where

$$\Theta^g_{ni} := \frac{B^g_n}{d^g_{ni}} (p^G)^{-\beta g} \left(P^{S,\text{eff}}_{n,g}\right)^{-\gamma^g} (q_n)^{\beta g + \gamma g - 1} \tag{B.64}$$

The worker chooses the (n, i) pair that maximizes this utility. Given the Fréchet assumption on $z_{\omega ni}$, the expected maximum utility is:

$$\begin{aligned} W^g = \mathbb{E}\left[\max_{(n,i)} u^g_{\omega ni}\right] &= \Gamma\left(1 - \tfrac{1}{\epsilon^g}\right) \left(\sum_{(n,i)} T^g_n E^g_i \left[c^g \Theta^g_{ni} \left(w^g_i - q_n \bar{h}^g\right)\right]^{\epsilon^g}\right)^{1/\epsilon^g} \\ &= \Gamma\left(1 - \tfrac{1}{\epsilon^g}\right) c^g \left(\sum_{n,i} T^g_n E^g_i \left[\Theta^g_{ni} \left(w^g_i - q_n \bar{h}^g\right)\right]^{\epsilon^g}\right)^{1/\epsilon^g} \end{aligned} \tag{B.65}$$

We define the *option value sum* Φ^g (the inclusive value to the power ϵ^g) as:

$$\Phi^g := \sum_{n=1}^{N} \sum_{i=1}^{N} T^g_n E^g_i \left[\Theta^g_{ni} \left(w^g_i - q_n \bar{h}^g\right)\right]^{\epsilon^g} \tag{B.66}$$

This gives the expected utility (welfare) for a type-g worker (Eq. 31):

$$W^g = \Gamma\left(1 - \tfrac{1}{\epsilon^g}\right) c^g (\Phi^g)^{1/\epsilon^g} \tag{B.67}$$

Since $\Gamma(\cdot)$ and c^g are constants, welfare changes are driven entirely by changes in $(\Phi^g)^{1/\epsilon^g}$.

B.6.2 Money-Metric Welfare (EV and CV)

The key property is that the indirect utility $u^g_{\omega ni}$ is homogeneous of degree one in net disposable income $y^g_{ni} = w^g_i - q_n \bar{h}^g$. This implies the expected utility W^g is also homogeneous of degree one in income.

Let $W^g(Y^g; \Theta^g_t)$ be the expected utility given an income vector Y^g and a vector of prices/amenities Θ^g_t at time t. Homogeneity means $W^g(k \cdot Y^g; \Theta^g_t) = k \cdot W^g(Y^g; \Theta^g_t)$. Let $y^g_t = \sum_{n,i} \lambda^g_{ni,t}(w^g_{i,t} - q_{n,t}\bar{h}^g)$ be the average net disposable income in period t. We can write $W^g_t = W^g(y^g_t; \Theta^g_t)$.

Equivalent Variation (EV) EV is the income transfer at *pre-shock (t=0)* prices that makes the worker indifferent between the two equilibria.

$$W^g(y^g_0 + \text{EV}^g; \Theta^g_0) = W^g(y^g_1; \Theta^g_1) \tag{B.68}$$

By homogeneity, $W^g(y_0^g + \text{EV}^g; \Theta_0^g) = \frac{y_0^g + \text{EV}^g}{y_0^g} W^g(y_0^g; \Theta_0^g)$.

$$\frac{y_0^g + \text{EV}^g}{y_0^g} W_0^g = W_1^g \quad \Rightarrow \quad 1 + \frac{\text{EV}^g}{y_0^g} = \frac{W_1^g}{W_0^g} \tag{B.69}$$

$$\text{EV}^g = y_0^g \left[\frac{W_1^g}{W_0^g} - 1 \right] \tag{B.70}$$

Substituting $W_t^g = (\text{const}) \cdot (\Phi_t^g)^{1/\epsilon^g}$:

$$\text{EV}^g = y_0^g \left[\frac{(\Phi_1^g)^{1/\epsilon^g}}{(\Phi_0^g)^{1/\epsilon^g}} - 1 \right] = y_0^g \left[\left(\frac{\Phi_1^g}{\Phi_0^g} \right)^{1/\epsilon^g} - 1 \right] \tag{B.71}$$

This gives Eq. 33.

Compensating Variation (CV) CV is the income transfer at *post-shock (t=1)* prices that restores the worker to their *pre-shock (t=0)* utility.

$$W^g(y_1^g - \text{CV}^g; \Theta_1^g) = W^g(y_0^g; \Theta_0^g) \tag{B.72}$$

By homogeneity:

$$\frac{y_1^g - \text{CV}^g}{y_1^g} W_1^g = W_0^g \quad \Rightarrow \quad 1 - \frac{\text{CV}^g}{y_1^g} = \frac{W_0^g}{W_1^g} \tag{B.73}$$

$$\text{CV}^g = y_1^g \left[1 - \frac{W_0^g}{W_1^g} \right] \tag{B.74}$$

Substituting the expression for W^g:

$$\text{CV}^g = y_1^g \left[1 - \left(\frac{\Phi_0^g}{\Phi_1^g} \right)^{1/\epsilon^g} \right] \tag{B.75}$$

This gives Eq. 34.

C Parameter Calibration

C.1 Estimation of Factor Shares α_G and α_S

We estimate factor shares for labor and land (commercial floor space) under a two-factor Cobb–Douglas production framework with constant returns to scale:

$$Y = A\, L^{\alpha_s} D^{\,1-\alpha_s}, \quad s \in \{G, S\},$$

where L denotes labor input, D denotes the quantity of commercial floor space, and s indexes the tradable goods sector (G) and non-tradable services sector (S).

Computation of land shares. Instead of directly inferring the labor share from observed payments, we derive it indirectly from the estimated land (floor space) share $1 - \alpha_s$. For each sector s, the land share is computed as:

$$1 - \alpha_s = \frac{\text{Leasing fees} + \text{Imputed rent on owned real estate}}{\text{Leasing fees} + \text{Imputed rent on owned real estate} + \text{Total wages}}. \tag{C.76}$$

The imputed rent component is based on the book value of firms' physical assets in land and real estate, assuming a gross rental return of 6% per year. This adjustment ensures that both tenant-occupied and owner-occupied business premises are treated symmetrically in the cost base.

Estimated values. Applying this method yields sectoral land shares of

$$1 - \hat{\alpha}_G = 0.103 \quad \text{and} \quad 1 - \hat{\alpha}_S = 0.159,$$

corresponding to labor shares of

$$\hat{\alpha}_G = 0.897 \quad \text{and} \quad \hat{\alpha}_S = 0.841.$$

These results imply that the non-tradable service sector is relatively more land-intensive, consistent with its higher demand for local space and lower exposure to tradeability constraints.

Relation to the literature. The estimated land shares fall within the range reported in recent quantitative urban models, albeit slightly below some benchmark values. Our estimates thus represent relatively land-efficient production structures, particularly in tradable sectors.

Table C.13: Floor Space Expenditure Shares in Urban Quantitative Models

$1-\alpha$ (Floor share)	Background city	Source
0.20	Berlin	Ahlfeldt et al. (2015)
0.15	Copenhagen	Ahlfeldt et al. (2025)
0.3125	London	Heblich, Redding, and Sturm (2020)
0.156	Bogotá	Tsivanidis (2018)

C.2 Preference Parameters

Minimum Housing Requirement: $\bar{h}^g$ and Housing Share $(1-\beta^g-\gamma^g)$ To calibrate the minimum housing requirement $\bar{h}^g$ and the discretionary expenditure shares, we derive an estimable Engel curve from the model's optimal housing demand function.

The optimal demand for housing (from the main text) is:

$$H^{g*}_{\omega ni} = \bar{h}^g + (1-\beta^g-\gamma^g)\frac{w^g_i - q_n\bar{h}^g}{q_n} \tag{C.77}$$

By multiplying by q_n and dividing by total income w^g_i, we rearrange this equation to express the housing expenditure share as a linear function of the rent-to-income ratio:

$$\frac{q_n H^{g*}_{\omega ni}}{w^g_i} = (1-\beta^g-\gamma^g) + (\beta^g+\gamma^g)\bar{h}^g \cdot \frac{q_n}{w^g_i} \tag{C.78}$$

This theoretical relationship maps directly to the following linear regression model:

$$\frac{\text{Housing Expenditure}^g}{\text{Total Expenditure}^g} = \beta_0 + \beta_1 \cdot \frac{q_n(\text{rent})}{\text{Total Expenditure}^g} \tag{C.79}$$

We estimate Equation (C.79) using OLS, where Housing Expenditure^g corresponds to $q_n H^{g*}_{\omega ni}$ and Total Expenditure^g corresponds to w^g_i. The resulting coefficients identify our structural parameters:

- The intercept $\hat{\beta}_0$ directly identifies the discretionary housing share: $(1-\beta^g-\gamma^g) = \hat{\beta}_0$.
- The minimum housing requirement $\bar{h}^g$ is subsequently recovered using both coefficients, as $\bar{h}^g = \hat{\beta}_1/(1-\hat{\beta}_0)$.

Expenditure Shares: β^g, γ^g With the discretionary housing share $(1-\beta^g-\gamma^g)$ and $\bar{h}^g$ identified from the regression, the remaining shares for tradable goods (β^g) and local services (γ^g) are defined as shares of *discretionary income* $(w^g - q\bar{h}^g)$. These parameters are calibrated to match external data on consumption patterns, consistent with their

definitions:

$$\beta^g = \frac{\text{Expenditure on tradable goods}}{\text{Discretionary income}} = \frac{p^G C^{Gg}}{w^g - q\bar{h}^g} \tag{C.80}$$

$$\gamma^g = \frac{\text{Expenditure on local services}}{\text{Discretionary income}} = \frac{p^S C^{Sg}}{w^g - q\bar{h}^g} \tag{C.81}$$

Table C.14: Calibration for Work's Preference

Value	**Source**
$\beta^G = 0.474; \gamma^G = 0.330; (1 - \beta^G - \gamma^G) = 0.196;\ \bar{h}^G = 51.72$	using rent
$\beta^S = 0.476; \gamma^S = 0.333; (1 - \beta^S - \gamma^S) = 0.191;\ \bar{h}^S = 55.02$	using rent
$\beta^G = 0.491; \gamma^G = 0.342; (1 - \beta^G - \gamma^G) = 0.167;\ \bar{h}^G = 58.55$	using annual user cost
$\beta^S = 0.487; \gamma^S = 0.340; (1 - \beta^S - \gamma^S) = 0.173;\ \bar{h}^S = 59.46$	using annual user cost

Notes on the calculation of q_n (price per square meter) for Engel curve estimations:

a) For calibrations based on "rent": q_n represents the annual rent per square meter.

b) For calibrations based on "annual user cost": q_n is an estimated annual financing-related cost per square meter, primarily for owner-occupied housing. It is calculated using the formula:

$$q_n \approx P_{sqm} \times k_{fin}$$

where P_{sqm} is the property value per square meter (approximated as valproperties/avgsqm), and the financing cost factor $k_{fin} \approx 0.061535$. This factor is derived from two main components:

(i) The annualized mortgage payment for the loaned portion of P_{sqm}. This assumes an 80% Loan-to-Value (LTV) ratio, a 30-year loan term, and a 5% annual interest rate. The calculation is:

$$\text{Cost}_{\text{loan}} = (P_{sqm} \times 0.8_{\text{LTV}}) \times 0.0644186_{\text{annuity factor}} \approx P_{sqm} \times 0.051535$$

(ii) The annual opportunity cost of the down payment (20% of P_{sqm}). This assumes a 5% annual return on the equity portion:

$$\text{Cost}_{\text{opportunity}} = (P_{sqm} \times 0.2_{\text{down payment}}) \times 0.05_{\text{return rate}} = P_{sqm} \times 0.01$$

Thus, $k_{fin} \approx 0.051535 + 0.01 = 0.061535$. This definition of "annual user cost" focuses on financing components.

C.3 Spatial Mobility Parameter: $\nu^g = \kappa^g \epsilon^g$; Frechet Parameter ϵ^g and Workplace Amenities E_i^g

To estimate the key preference parameters ϵ^g (Fréchet dispersion) and ν^g (spatial mobility), we derive a log-linear regression equation from the joint choice probability λ_{ni}^g.

We begin with the log of the joint probability:

$$\ln \lambda_{ni}^g = \ln \Phi_{ni}^g - \ln \Phi^g \tag{C.82}$$

where $\Phi^g = \sum_{m,j} \Phi_{mj}^g$ is the inclusive value (or option value sum), which is a constant for a given worker type g.

We expand the log of the choice-specific value, $\ln \Phi_{ni}^g$:

$$\ln \Phi_{ni}^g = \ln \left(T_n^g E_i^g \Big[d_{ni}^g \, (p^G)^{\beta^g} \, (P_{n,g}^{S,\text{eff}})^{\gamma^g} \, (q_n)^{1-\beta^g-\gamma^g} \Big]^{-\epsilon^g} \Big[c^g B_n^g \, (w_i^g - q_n \bar{h}^g) \Big]^{\epsilon^g} \right)$$

Further we have:

$$\begin{aligned} \ln \Phi_{ni}^g = & \ln T_n^g + \ln E_i^g \\ & - \epsilon^g \ln \Big[d_{ni}^g \, (p^G)^{\beta^g} \, (P_{n,g}^{S,\text{eff}})^{\gamma^g} \, (q_n)^{1-\beta^g-\gamma^g} \Big] \\ & + \epsilon^g \ln \Big[c^g B_n^g \, (w_i^g - q_n \bar{h}^g) \Big] \end{aligned}$$

Expanding the log terms and substituting the definitions $s_{ni}^g \equiv \max\{w_i^g - q_n \bar{h}^g, \underline{s}\}$ and $d_{ni}^g = \exp(\kappa^g \tau_{ni})$, which implies $\ln d_{ni}^g = \kappa^g \tau_{ni}$:

$$\begin{aligned} \ln \Phi_{ni}^g = & \ln T_n^g + \ln E_i^g \\ & - \epsilon^g \Big[\kappa^g \tau_{ni} + \beta^g \ln p^G + \gamma^g \ln P_{n,g}^{S,\text{eff}} + (1 - \beta^g - \gamma^g) \ln q_n \Big] \\ & + \epsilon^g \Big[\ln c^g + \ln B_n^g + \ln s_{ni}^g \Big] \end{aligned}$$

Substituting this back into the expression for $\ln \lambda_{ni}^g$:

$$\begin{aligned} \ln \lambda_{ni}^g = & (\epsilon^g \ln c^g - \ln \Phi^g) \\ & + \Big(\ln T_n^g + \epsilon^g \ln B_n^g - \epsilon^g \gamma^g \ln P_{n,g}^{S,\text{eff}} - \epsilon^g (1 - \beta^g - \gamma^g) \ln q_n \Big) \\ & + \Big(\ln E_i^g - \epsilon^g \beta^g \ln p^G \Big) \\ & + \epsilon^g \ln s_{ni}^g - (\epsilon^g \kappa^g) \tau_{ni} \end{aligned} \tag{C.83}$$

We define the composite spatial mobility parameter as $\nu^g \equiv \epsilon^g \kappa^g$. By collecting terms that are constant, vary only with residence n, or vary only with workplace i, we can specify a log-linear regression model with fixed effects:

$$\ln \lambda_{ni}^g = \underbrace{k_0^g}_{\text{constant}} + \underbrace{\alpha_n^g}_{\text{residence FE}} + \underbrace{\delta_i^g}_{\text{workplace FE}} + \epsilon^g \ln s_{ni}^g - \nu^g \tau_{ni} + e_{ni} \tag{C.84}$$

where e_{ni} is an econometric error term. The fixed effects absorb all location-specific unobservables:

$$\begin{aligned} k_0^g &\equiv \epsilon^g \ln c^g - \ln \Phi^g, \\ \alpha_n^g &\equiv \ln T_n^g + \epsilon^g \ln B_n^g - \epsilon^g \left[\gamma^g \ln P_{n,g}^{S,\text{eff}} + (1 - \beta^g - \gamma^g) \ln q_n \right], \\ \delta_i^g &\equiv \ln E_i^g - \epsilon^g \beta^g \ln p^G \end{aligned}$$

This specification (Eq. C.84) allows for the joint estimation of the Fréchet parameter ϵ^g (as the coefficient on log surplus income) and the composite mobility parameter ν^g (as the coefficient on travel impedance τ_{ni}). The workplace fixed effects δ_i^g are used to back out the workplace amenities $E_i^g = \exp(\delta_i^g + \epsilon^g \beta^g \ln p^G)$, which are identified up to a normalization (e.g., $\text{mean}(E_i^g) = 1$).

Table C.15: Estimation of Mobility and Friction Parameters from Gravity Equation

Method	**Sector**	$\boldsymbol{\epsilon^g}$	$\boldsymbol{\nu^g}$ $(= \boldsymbol{\epsilon^g} \times \boldsymbol{\kappa^g})$	$\boldsymbol{\kappa^g}$ $(= \boldsymbol{\nu^g}/\boldsymbol{\epsilon^g})$
PPML	TG	16.3772 ± 22.7018	0.1865 ± 0.0056	0.0114
PPML	NTS	3.2416 ± 1.5004	0.2110 ± 0.0041	0.0651
OLS	TG	13.6260 ± 1.7034	0.1464 ± 0.0038	0.0107
OLS	NTS	7.7607 ± 1.1180	0.1677 ± 0.0028	0.0216

Notes: This table reports the jointly estimated parameters from the commuting gravity model. ϵ^g is the Fréchet shape parameter and ν^g is the commuting cost sensitivity. Standard errors are reported following the ± symbol. TG = Tradable Goods; NTS = Non-Tradable Services. The PPML estimates (top two rows) are used as the baseline for the main model calibration, as reported in Table 8.

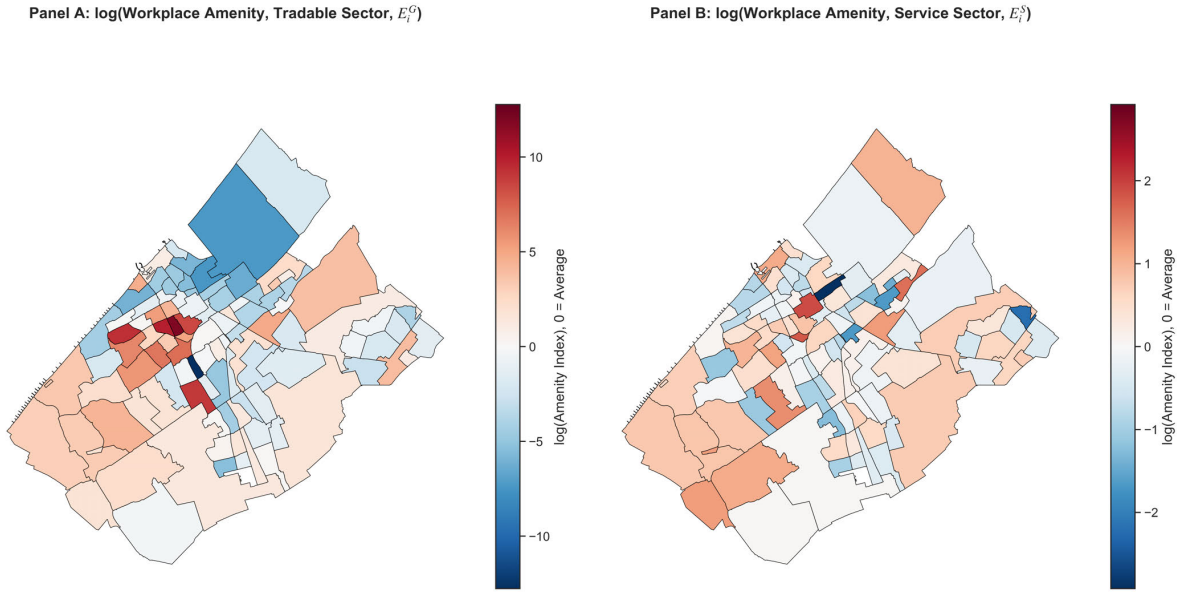


Figure C.8: Spatial Distribution of Calibrated Workplace Amenities (Log Scale)

Notes: This figure maps the log-transformed workplace amenity for each neighborhood. Amenities are first normalized by their geometric mean (so the average amenity equals 1), and then log-transformed. On this log scale, 0 (white) represents the geometric average amenity level. Red values (> 0) indicate higher-than-average amenities. Blue values (< 0) indicate lower-than-average amenities. **Panel A** shows the amenity for Tradable Goods workers ($\log(E_i^G)$). **Panel B** shows the amenity for Non-Tradable Service workers ($\log(E_i^S)$).

C.4 Housing Supply Elasticity η_n

Following the micro-foundation, the parameter α_n (and thus η_n) could be identified directly if data on land rents r_n and physical land quantity K_n were available. As noted by Ahlfeldt et al. (2015), the ratio of total housing revenue to total land cost would reveal the parameter:

$$\frac{q_n D_n}{r_n K_n} = \frac{\pi_n D_n^{1/\alpha_n}}{r_n D_n^{1/\alpha_n}} = 1/\alpha_n \tag{C.85}$$

In the absence of such detailed land use data, an alternative is to econometrically estimate the elasticity from the inverse supply function itself:

$$q_n = \pi_n D_n^{\frac{1}{\eta_n}} \tag{C.86}$$

Taking the log on both sides gives the log-linear relationship:

$$\ln(q_n) = \ln(\pi_n) + \frac{1}{\eta_n} \ln(D_n) \tag{C.87}$$

However, estimating this equation directly (e.g., by regressing $\ln(D_n)$ on $\ln(q_n)$) leads to inconsistent estimates. The land price q_n and quantity D_n are endogenous equilibrium outcomes, simultaneously determined by both supply and demand. The supply shifter $\ln(\pi_n)$ captures unobserved local costs and regulatory constraints, and any unobserved local demand shock would shift both q_n and D_n, biasing the OLS coefficient.

As shown by Baum-Snow and Han (2023) and Su (2022), identifying $\frac{1}{\eta_n}$ requires a valid instrument for $\ln(D_n)$ (such as a predicted population shock) that shifts demand without directly affecting the supply schedule. As we do not have a readily available instrument for our study area, we turn to calibration.

Table C.16 summarizes benchmark elasticities from the literature. Given the significant identification challenges, we calibrate η_n for all locations. We adopt a conservative value of $\eta_{\mathbf{n}} = \mathbf{0.60}$. This value corresponds to the most inelastic supply (minimum value) estimated by Saiz (2010), which was for Miami, a city famously constrained by geography. We choose this lower-bound value because The Hague is one of the most densely populated cities in the Netherlands, a country with significant land constraints and stringent zoning regulations. This inelastic assumption provides a conservative benchmark for our counterfactual analysis.

Table C.16: Calibration for Housing Supply Elasticities η_n

Value	**Location**	**Source**
0.60	**(This study, Calibrated)**	**Based on Saiz (2010) minimum**
0.60 (min)	Miami	Saiz (2010), 30-year horizon
5.45 (max)	Wichita	Saiz (2010), 30-year horizon
4.76	U.S. (1980)	Diamond (2016)
0.70	Bogotá	Tsivanidis (2018)
1.08	U.S. (ACS)	Su (2022)

D Calibration and Solving Algorithm

This section details the numerical algorithms used to calibrate the model's exogenous variables and solve for its general equilibrium. The calibration process is structured to first back out unobserved fundamentals (such as productivity and amenities) from the observed baseline data. Then, a general equilibrium solver finds the model's fixed point, which is used for counterfactual analysis.

D.1 Model Implied Wage Solving

A fundamental property of the model is that the absolute scale of the surplus term, y^g_{ni}, is not identified from choice data alone. The model's choice probabilities, $\lambda^g(i|n)$, are invariant to a positive scaling of the surplus income term. This scale invariance implies that nominal wages, w^g_i, are not uniquely identified without an external anchor.

Our two-step iterative algorithm (Algorithm 1) is designed to solve this identification problem. The first step is a tâtonnement process that adjusts **relative wages** to clear all local labor markets. This step finds a structurally correct wage vector, but at an arbitrary absolute level. The second step serves as the necessary **external anchor**: it imposes the macroeconomic constraint that the total wage bill must match the data, thereby re-scaling the entire wage vector to its correct, economically meaningful **absolute level**.

Algorithm 1: Wage Calibration via Observed Labor Allocation

Data: Initial wage guess $w_i^g = w_0$ for all i

Result: Equilibrium wages w_i^g matching workplace labor demand

while *not converged* **do**

  foreach *residence* n *and workplace* i **do**

    Compute surplus:;

      $y_{ni}^g = \max(w_i^g - q_n \bar{h}^g, 1)$;

      Compute conditional choice value:;

      $V_{ni}^g = E_i^g \left[d_{ni}^g\right]^{-\epsilon^g} \left(y_{ni}^g\right)^{\epsilon^g}$;

  foreach *residence* n **do**

    Compute conditional probability of working in i given n:;

      $\lambda^g(i|n) = \frac{V_{ni}^g}{\sum_j V_{nj}^g}$;

  Predict workplace labor:;

  $\hat{L}_{Wi}^g = \sum_n \lambda^g(i|n) L_{Rn}^g$;

  Update wage:;

    Step 1: Update relative wages based on the labor supply gap $w_{\text{next},i}^g \leftarrow w_i^g \cdot \frac{L_{Wi}^g}{\hat{L}_{Wi}^g}$;

    Step 2: Rescale the entire wage vector to match the observed aggregate wage bill $w_i^g \leftarrow w_{\text{next},i}^g \cdot \frac{\sum_j w_{\text{data},j}^g L_{Wj}^g}{\sum_j w_{\text{next},j}^g L_{Wj}^g}$;

D.2 Productivity Solving

Given equilibrium wages and land rents (from data or the wage-solving algorithm), we calibrate location-specific productivities A_i^G and a_i^S by inverting the firms' zero-profit conditions.

D.2.1 Tradable Goods Sector Productivity

For the perfectly competitive tradable goods sector, productivity A_i^G is calculated directly from the unit-cost condition, assuming $p^G = 1$.

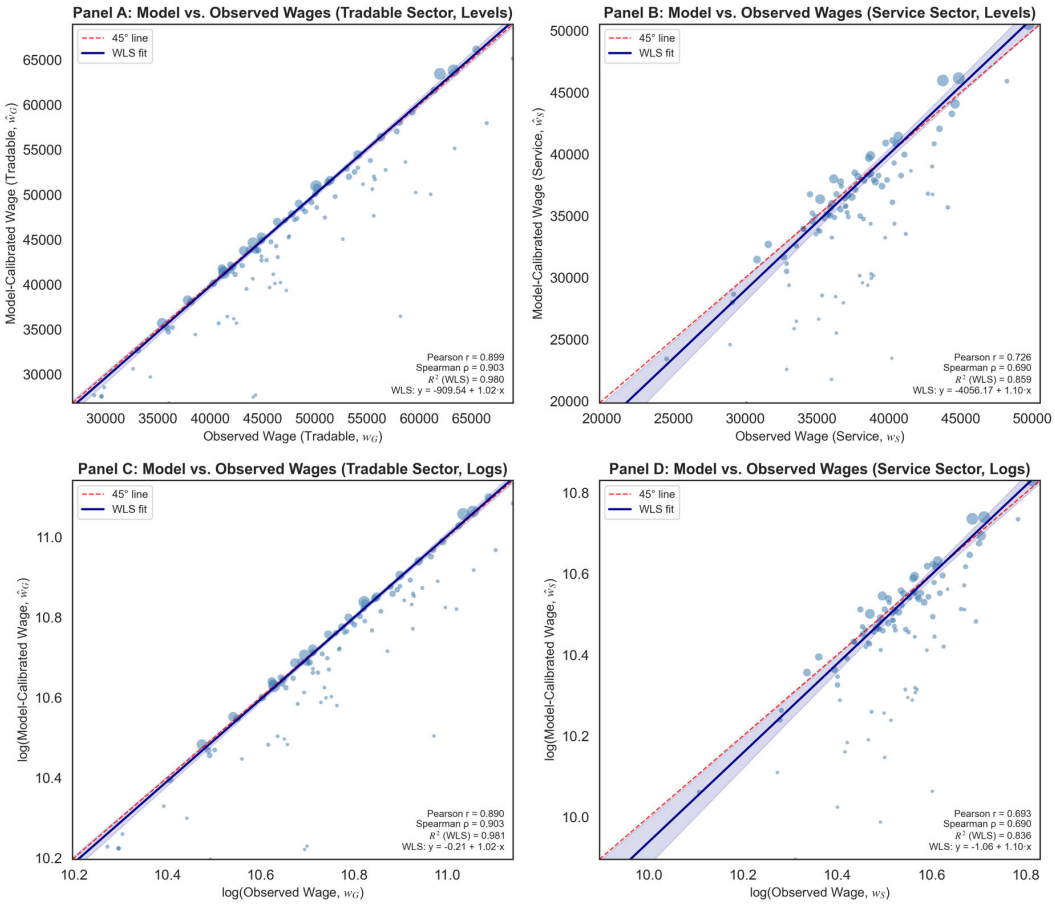


Figure D.9: Comparison of Model-Calibrated and Observed Wages

Notes: This figure plots the model-calibrated wage (y-axis) against the observed wage (x-axis) for each location. Panel A and C show the Tradable Goods sector (G), while Panel B and D show the Non-Tradable Service sector (S). The top row (A, B) displays values in levels, and the bottom row (C, D) uses log-transformed values. The size of each bubble corresponds to the employment in that sector and location. The solid blue line represents the weighted least squares (WLS) fit, and the dashed red line is the 45-degree line, which indicates a perfect fit.

Algorithm 2: Goods-Sector Productivity Calibration from Wages and Rents

Data: Observed goods wages $\{w_i^G\}$, land rents $\{q_i\}$, labor share $\alpha_G \in (0,1)$; (optional) goods price $\{p_i^G\}$ with default $p_i^G \equiv 1$

Result: Calibrated goods-sector productivity $\{A_i^G\}$ for all i

foreach *location* i **do**

$$A_i^G \leftarrow \left(\frac{w_i^G}{\alpha_G}\right)^{\alpha_G} \left(\frac{q_i}{1-\alpha_G}\right)^{1-\alpha_G}$$

D.2.2 Service Sector Productivity

For the monopolistically competitive service sector, productivity a_i^S is not directly observable. It is embedded within the service price p_n, which itself depends on local demand. We solve for $\{a_n^S\}$ using an iterative algorithm (Algorithm 3) that adjusts $\{a_n^S\}$ until the model-implied service expenditure at each destination $\mathcal{E}_n^{S,\text{imp}}$ matches the "true" expenditure $\mathcal{E}_n^{S,\text{true}}$ derived from the observed service-sector wage bill.

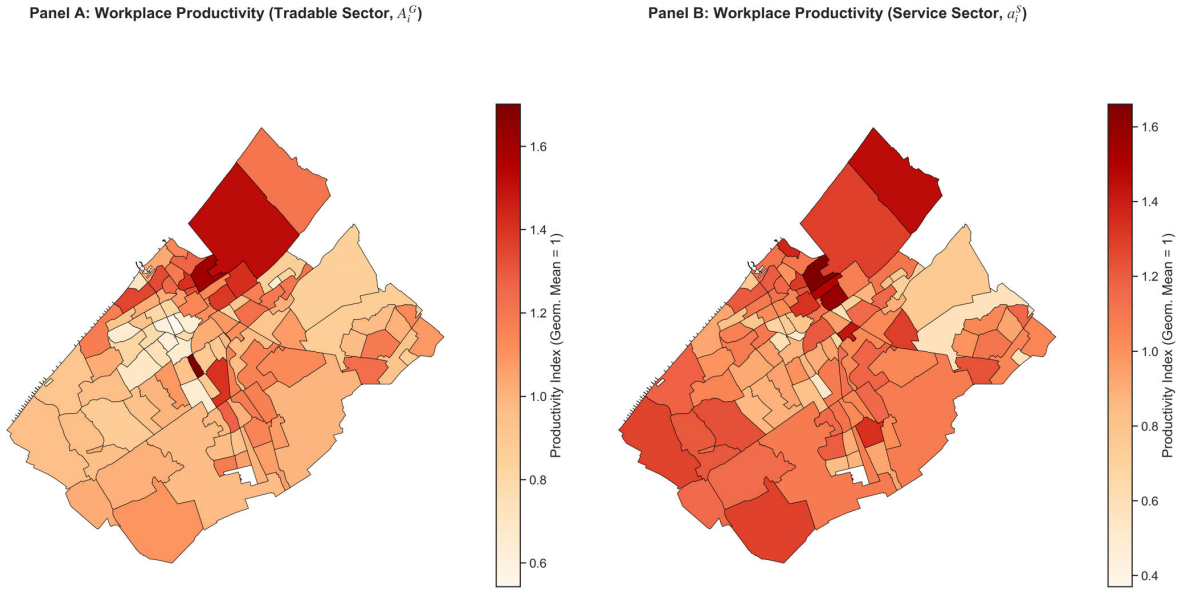


Figure D.10: Spatial Distribution of Calibrated Workplace Productivity

Notes: This figure maps the calibrated workplace productivity for each neighborhood, normalized by the geometric mean (so that the mean equals 1). **Panel A** shows the productivity for the Tradable Goods sector (A_i^G). **Panel B** shows the productivity for the Non-Tradable Service sector (a_i^S). Darker shades of red indicate higher productivity levels relative to the mean.

Algorithm 3: NTS Productivity via Destination-Expenditure Matching

Require: Data: $\{w_n^S, L_{Wn}^S, q_n, L_{Rm}^g, \lambda^g(i \mid m), \bar{\tau}_{mn}\}$ for $g \in \{G, S\}$.

Require: Params: $\alpha_S \in (0,1)$, $\{\gamma^g, \bar{h}^g, \kappa_{\text{shop}}^g\}$, $\sigma_S > 1$, $\mu_S = \frac{\sigma_S}{\sigma_S - 1}$, $f > 0$ (default $f = 1$), coverage ζ (or ζ_n).

Require: Normalization: fix $a_{n_0}^S \equiv 1$ (or $\frac{1}{N}\sum_n \ln a_n^S = 0$).

Ensure: Relative $\{a_n^S\}$, prices $\{p_n^S\}$, varieties $\{M_n\}$, shares $\{\pi_{m\to n|g}^S\}$.

1: **Budgets (by residence m).**

$$\mathbb{E}_m[w^g] = \sum_i w_i^g \, \lambda^g(i \mid m), \qquad B_{mg} = \gamma^g L_{Rm}^g \Big(\mathbb{E}_m[w^g] - q_m \bar{h}^g \Big).$$

2: **"True" destination expenditure and supply objects (by n).**

$$R_n^S = \frac{w_n^S L_{Wn}^S}{\alpha_S}, \qquad \mathcal{E}_n^{S,\text{true}} = \frac{R_n^S}{\zeta}, \qquad r_n^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_n^S)^{\alpha_S} q_n^{1-\alpha_S},$$

$$M_n = \frac{R_n^S}{\sigma_S r_n^S f}.$$

3: **Iterate on productivity $\{a_n^S\}$.** Initialize $a_n^{S,(0)} \equiv 1$; choose damping $\rho \in (0,1]$ and tolerance `tol`.

4: **while** not converged **do**

5: Prices and weights: $p_n^{(t)} = \mu_S \frac{r_n^S}{a_n^{S,(t)}}, \quad W_n^{(t)} = M_n \, (p_n^{(t)})^{1-\sigma_S}$.

6: Travel term: $t_{mn}^g = \exp(\kappa_{\text{shop}}^g \bar{\tau}_{mn})$.

7: Destination shares:

$$\pi_{m\to n|g,(t)}^S = \frac{W_n^{(t)} \, (t_{mn}^g)^{1-\sigma_S}}{\sum_k W_k^{(t)} \, (t_{mk}^g)^{1-\sigma_S}}.$$

8: Implied expenditure: $\mathcal{E}_n^{S,\text{imp},(t)} = \sum_g \sum_m B_{mg} \, \pi_{m\to n|g,(t)}^S$.

9: Multiplicative update and normalization:

$$\tilde{a}_n^{S,(t+1)} = a_n^{S,(t)} \left(\frac{\mathcal{E}_n^{S,\text{true}}}{\max\{\mathcal{E}_n^{S,\text{imp},(t)}, \varepsilon\}} \right)^{1/\sigma_S}, \qquad \tilde{a}_{n_0}^{S,(t+1)} \equiv 1,$$

$$a_n^{S,(t+1)} = (1-\rho) a_n^{S,(t)} + \rho \, \tilde{a}_n^{S,(t+1)}.$$

10: Stop if $\max_n \left| \frac{a_n^{S,(t+1)} - a_n^{S,(t)}}{a_n^{S,(t)}} \right| < \texttt{tol}$.

11: **end while**

12: **Outputs:** a_n^S, $p_n^S = \mu_S r_n^S / a_n^S$, $M_n = R_n^S / (\sigma_S r_n^S f)$, $\pi_{m\to n|g}^S$. *Identification:* only relative $\{a_n^S, p_n^S, M_n\}$ are identified; the demand system depends on $M_n (p_n^S)^{1-\sigma_S}$. A normalization fixes the common scale.

D.3 Residence Amenity and Housing Parameter Calibration

With productivities and wages set, the final unobserved fundamentals are the residential amenities B_n^g and the housing supply shifters π_n.

D.3.1 Residence Amenity Calibration

We use an iterative procedure (Algorithm 4) to find the vector of type-specific residential amenities B_n^g that ensures the model's predicted residential population $\hat{L}_{Rn}^g$ matches the observed population L_{Rn}^g in every location.

Algorithm 4: Amenity Calibration via Residence Matching

Data: Initial amenity guess $B_n^g = 1$ for all n

Result: Calibrated B_n^g matching observed L_{Rn}^g

while *not converged* **do**

  foreach *residence-workplace pair* (n, i) **do**

    Compute attractiveness:;

    $$\Phi_{ni}^g \leftarrow T_n^g E_i^g \left[d_{ni}^g (p^G)^{\beta^g} (P_{n,g}^{S,\text{eff}})^{\gamma^g} (q_n)^{1-\beta^g-\gamma^g}\right]^{-\epsilon^g} \left[c^g B_n^g (w_i^g - q_n \bar{h}^g)\right]^{\epsilon^g}$$

    where $p_G = 1$ and :;

    $$P_{n,g}^{S,\text{eff}} = \left(\sum_{j=1}^N M_j \left(t_{nj}^g p_j\right)^{1-\sigma_S}\right)^{\frac{1}{1-\sigma_S}}, \qquad t_{nj}^g = \exp\left(\kappa^{\text{shop},g}\, \bar{\tau}_{nj}\right).$$

  foreach *residence location* n **do**

    Compute share of residents:;

    $$\lambda_n^g \leftarrow \frac{\sum_i \Phi_{ni}^g}{\sum_{m,i} \Phi_{mi}^g}$$

    Predict residence population:;

    $$\hat{L}_{Rn}^g \leftarrow \lambda_n^g \cdot \bar{P}^g$$

    Update amenity:;

    $$B_n^g \leftarrow B_n^g \cdot \frac{L_{Rn}^g}{\hat{L}_{Rn}^g}$$

With all components for the choice function now assembled (i.e., calibrated B_n^g, E_i^g; observed q_n; and all implied prices and wages), we can compute the model-predicted joint choice probabilities, $\hat{\lambda}_{ni}^g$, for all pairs (n, i) and types g. To validate the model's internal consistency and goodness-of-fit, we then compare these predicted $\hat{\lambda}_{ni}^g$ values directly against their empirical counterparts, the observed commuting shares from the data.

D.3.2 Housing Parameter Calibration

The housing supply elasticity η_n is estimated externally (as discussed in Section C.4). Given η_n and the baseline equilibrium values for all land demands (D_n^R, D_n^G, D_n^S) and the

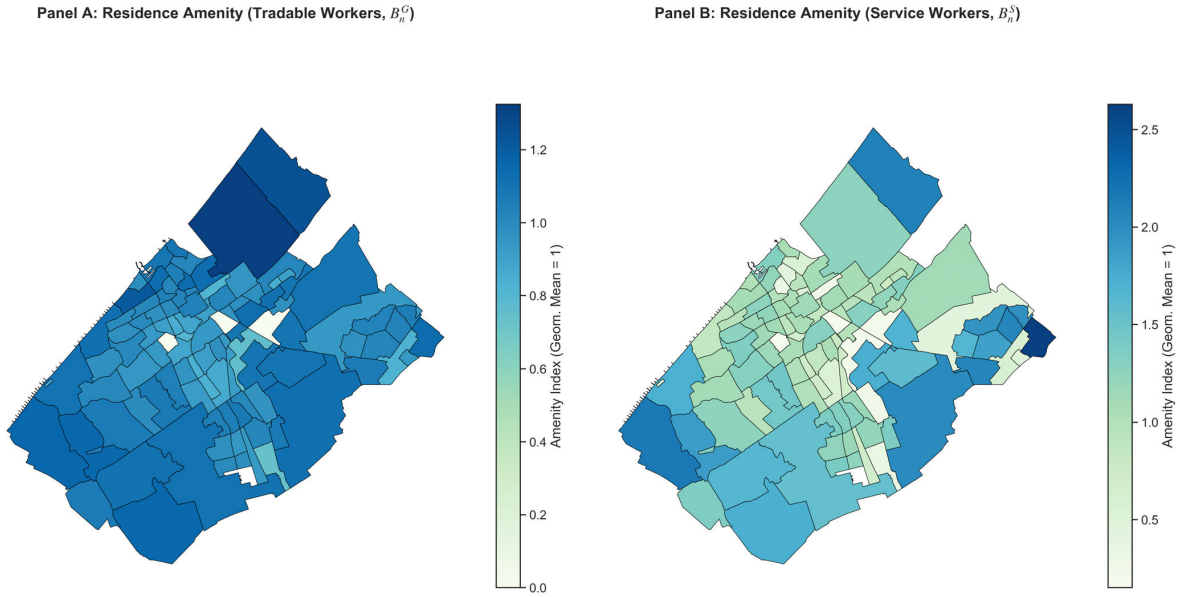


Figure D.11: Spatial Distribution of Calibrated Residence Amenities

Notes: This figure maps the calibrated residential amenity for each neighborhood, normalized by the geometric mean (so that the mean equals 1). **Panel A** shows the amenity for Tradable Goods workers (B_n^G). **Panel B** shows the amenity for Non-Tradable Service workers (B_n^S). Darker shades indicate higher residential amenity levels relative to the mean.

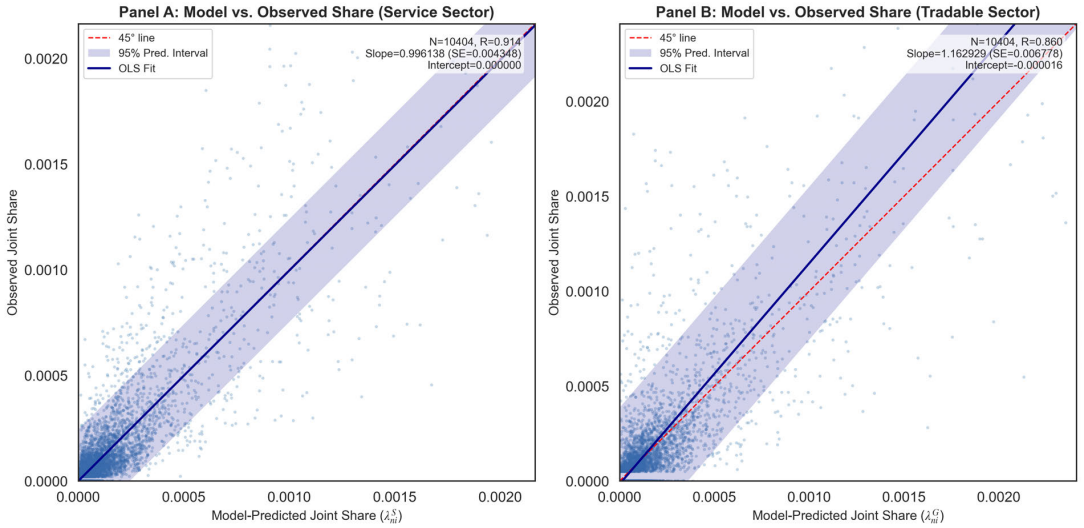


Figure D.12: Model Fit for Joint Commuting Probabilities

Notes: This figure compares the model-predicted joint commuting probability (x-axis) against the observed probability (y-axis) for each residence–workplace pair. **Panel A** shows the fit for the Non-Tradable Service (NTS) sector. **Panel B** shows the fit for the Tradable Goods (TG) sector. The dashed red line is the 45-degree line of perfect fit. The solid blue line is the OLS regression fit, with the shaded region representing the 95% prediction interval.

land rent q_n, the housing supply shifter π_n is calibrated by directly inverting the land market clearing condition (Eq. 27 in the main text), as shown in Algorithm 5.

Algorithm 5: Housing Supply Shifter (π_n)

Input: Parameters $\{\bar{h}^g, \beta^g, \gamma^g, \alpha_G, \alpha_S, \eta_n, \pi_n\}$;
Observed variables $\{L^g_{R,n}, w^g, w^G_n, L^G_{W,n}, \mathcal{E}^S_n, q_n\}$

Output: Land market clearing check for location n

1 **Step 1:** Compute total residential demand for land:
$D^R_n = \sum_{g\in\{G,S\}} L^g_{R,n}\left[\bar{h}^g + (1-\beta^g-\gamma^g)\frac{\mathbb{E}_n[w^g]-q_n\bar{h}^g}{q_n}\right]$.

2 **Step 2:** Compute goods sector land demand:

$$D^G_n = \frac{(1-\alpha_G)w^G_n L^G_{W,n}}{\alpha_G q_n}.$$

3 **Step 3:** Compute services sector land demand:

$$D^S_n = \frac{(1-\alpha_S)\mathcal{E}^S_n}{q_n}.$$

4 **Step 4:** Aggregate total land demand:

$$D^{Total}_n = D^R_n + D^G_n + D^S_n.$$

5 **Step 5:** Impose market clearing condition:

$$D^{Total}_n = S_n = \left(\frac{q_n}{\pi_n}\right)^{\eta_n}.$$

6 **Step 6:** Solve for π_n: $\pi_n = \frac{q_n}{\left(D^{Total}_n\right)^{1/\eta_n}}$.

D.4 General Equilibrium Algorithm for Counterfactuals

To solve for the new equilibrium after a shock (e.g., a change in housing supply π_n or population $\bar{L}^g$), we employ a nested fixed-point algorithm (Algorithm 6). The "outer loop" iterates on the land rent vector $\{q_n\}$ and the population distribution $\{\lambda_{ni}^g\}$. For each guess of q_n and λ_{ni}^g, an "inner loop" (Algorithm 7) must be solved to find the equilibrium in the non-tradable service sector.

Algorithm 6: General Equilibrium Solution: Nested Fixed-Point Algorithm

Require: Initial population distribution $\{\lambda_{ni}^g(0)\}$, parameters $\{\alpha_G, \alpha_S, \beta^g, \gamma^g, \bar{h}^g, \eta_n, \pi_n, \sigma_S, f, \kappa^{\text{work},g}, \kappa^{\text{shop},g}\}$

Ensure: Equilibrium solution $\{\lambda_{ni}^{g*}, q_n^*, w_i^{g*}, p_n^*, M_n^*, \mathcal{E}_n^{S*}\}$

Initialize: Set initial values $\lambda_{ni}^g \leftarrow \lambda_{ni}^g(0)$, $q_n \leftarrow q_n(0)$

Set convergence tolerances $\text{tol}_{\text{out}}, \text{tol}_{\text{in}}$ and damping parameters $\rho_{\text{out}}, \rho_{\text{in}}$

while outer loop not converged **do**

  Step 1: Compute base variables from population distribution

    Compute labor supply: $L_i^g = \sum_n \lambda_{ni}^g \bar{L}^g$

    Compute residential population: $L_{Rn}^g = \sum_i \lambda_{ni}^g \bar{L}^g$

    Compute conditional probabilities: $\lambda^g(i|n) = \lambda_{ni}^g \bar{L}^g / L_{Rn}^g$

  Step 2: Compute tradable goods wages (perfect competition, zero profit)

    $w_i^G = \alpha_G [A_i^G (\frac{1-\alpha_G}{q_i})^{1-\alpha_G}]^{1/\alpha_G}$

  Step 3: Solve service sector equilibrium (inner loop)

    Call Algorithm 7: $\{\mathcal{E}_n^S, w_n^S, p_n, M_n, \pi_{m\to n|g}^S\} \leftarrow \texttt{SolveServiceBlock}(\lambda, q, w^G, L^S)$

  Step 4: Compute land demand

    Residential demand: $D_n^R = \sum_g L_{Rn}^g [\bar{h}^g + (1-\beta^g-\gamma^g)\frac{\mathbb{E}_n[w^g] - q_n \bar{h}^g}{q_n}]$

    Tradable production demand: $D_n^G = \frac{(1-\alpha_G) w_n^G L_{W,n}^G}{\alpha_G q_n}$

    Service production demand: $D_n^S = \frac{(1-\alpha_S)\mathcal{E}_n^S}{q_n}$

  Step 5: Update land rents (market clearing)

    $q_n^{\text{new}} = \pi_n (D_n^R + D_n^G + D_n^S)^{1/\eta_n}$

  Step 6: Update population distribution

    Compute effective service price: $P_{n,g}^{S,\text{eff}} = [\sum_k M_k (t_{nk}^g p_k)^{1-\sigma_S}]^{\frac{1}{1-\sigma_S}}$

    Compute location choice value:

    $\Phi_{ni}^g = T_n^g E_i^g [d_{ni}^g (p^G)^{\beta^g} (P_{n,g}^{S,\text{eff}})^{\gamma^g} (q_n)^{1-\beta^g-\gamma^g}]^{-\epsilon^g} [c^g B_n^g (w_i^g - q_n \bar{h}^g)]^{\epsilon^g}$

    Update distribution: $\lambda_{ni}^{g,\text{new}} = \frac{\Phi_{ni}^g}{\sum_{m,j} \Phi_{mj}^g}$

  Step 7: Damped update

    $\lambda_{ni}^g \leftarrow \rho_{\text{out}} \lambda_{ni}^{g,\text{new}} + (1-\rho_{\text{out}}) \lambda_{ni}^g$

    $q_n \leftarrow \rho_{\text{out}} q_n^{\text{new}} + (1-\rho_{\text{out}}) q_n$

  Step 8: Check convergence

    If $\max\{|\lambda^{\text{new}} - \lambda|/|\lambda|, |q^{\text{new}} - q|/|q|\} < \text{tol}_{\text{out}}$, stop

end while

return $\{\lambda_{ni}^g, q_n, w_i^g, p_n, M_n, \mathcal{E}_n^S\}$

Algorithm 7: Service Sector Equilibrium Solution (Inner Loop)

Require: Population distribution $\{\lambda_{ni}^g\}$, land rents $\{q_n\}$, tradable wages $\{w_i^G\}$, service labor $\{L_{W,i}^S\}$

Ensure: Service equilibrium $\{\mathcal{E}_n^S, w_n^S, p_n, M_n, \pi_{m\to n|g}^S\}$

Initialize: $\mathcal{E}_n^S \leftarrow \mathcal{E}_n^{S,(0)}$ (can use value from previous outer iteration)

while inner loop not converged **do**

  Step 1: Compute service wages and factor prices from expenditure

    Service wage: $w_n^S = \zeta \frac{\alpha_S \mathcal{E}_n^S}{L_{W,n}^S}$

    Composite factor price: $r_n^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_n^S)^{\alpha_S} q_n^{1-\alpha_S}$

  Step 2: Compute service land demand

    $D_n^S = \zeta \frac{(1-\alpha_S)\mathcal{E}_n^S}{q_n}$

  Step 3: Compute variety mass and prices

    Variety mass: $M_n = \zeta \frac{\mathcal{E}_n^S}{\sigma_S r_n^S f}$

    Service price: $p_n = \frac{\sigma_S}{\sigma_S - 1} \frac{r_n^S}{a_n^S}$

  Step 4: Compute consumption destination shares (based on current M_n, p_n)

    $\pi_{m\to n|g}^S = \frac{M_n (t_{mn}^g p_n)^{1-\sigma_S}}{\sum_k M_k (t_{mk}^g p_k)^{1-\sigma_S}}$

    where $t_{mn}^g = \exp(\kappa^{\text{shop},g} \bar{\tau}_{mn})$

  Step 5: Compute resident budgets

    Expected wage: $\mathbb{E}_m[w^g] = \sum_i w_i^g \lambda^g(i|m)$

    Service expenditure budget: $B_{mg} = \gamma^g L_{Rm}^g (\mathbb{E}_m[w^g] - q_m \bar{h}^g)$

  Step 6: Update service expenditure (demand = supply)

    $\mathcal{E}_n^{S,\text{new}} = \sum_{g\in\{G,S\}} \sum_{m=1}^N B_{mg} \cdot \pi_{m\to n|g}^S$

  Step 7: Damped update

    $\mathcal{E}_n^S \leftarrow \rho_{\text{in}} \mathcal{E}_n^{S,\text{new}} + (1-\rho_{\text{in}}) \mathcal{E}_n^S$

  Step 8: Check convergence

    If $\max_n |\mathcal{E}_n^{S,\text{new}} - \mathcal{E}_n^S| / \mathcal{E}_n^S < \text{tol}_{\text{in}}$, stop

end while

Final update of all service variables

  Recompute $w_n^S, r_n^S, D_n^S, M_n, p_n$ using converged $\mathcal{E}_n^S$

return $\{\mathcal{E}_n^S, w_n^S, p_n, M_n, \pi_{m\to n|g}^S\}$

D.5 Open City Equilibrium Algorithm

For the "Open City" counterfactual, the total population of each worker type (L_G, L_S) is endogenous. We assume workers migrate until the expected utility U_g within the city equals a baseline (or "outside option") utility U_g^{baseline}. This requires an additional "outermost" loop (Algorithm 8) that adjusts $(\bar{L}_G, \bar{L}_S)$ and calls the entire General Equilibrium solver (Algorithm 6) at each step until the utility gap is closed.

Algorithm 8: Open City Spatial Equilibrium with Endogenous Population

Input: Calibrated data, parameters $\{\alpha_g, \epsilon^g, \nu^g, \ldots\}$, distance matrix d_{ni}

Output: Equilibrium populations $(\bar{L}_G^*, \bar{L}_S^*)$, allocations $(\lambda_G^*, \lambda_S^*, q^*)$, utilities (U_G^*, U_S^*)

`// Step 1: Baseline Equilibrium (Closed City, CF=false)`

Set $CF \leftarrow$ false;

$(U_G^{\text{baseline}}, U_S^{\text{baseline}}, \bar{L}_G^0, \bar{L}_S^0) \leftarrow$ SpatialEquilibrium$(\cdot)$;

`// Step 2: Counterfactual with Endogenous Population (CF=true)`

Set $CF \leftarrow$ true, $\bar{L}_G \leftarrow \bar{L}_G^0$, $\bar{L}_S \leftarrow \bar{L}_S^0$;

for $k = 1, 2, \ldots, K_{\max}^{pop}$ **do**

  `// Layer 1: Solve Spatial Equilibrium Given Populations`

  $(U_G, U_S, \lambda_G, \lambda_S, q, \ldots) \leftarrow$ SpatialEquilibrium$(\bar{L}_G, \bar{L}_S, CF)$;

  `// Compute utility gaps`

  $\text{gap}_G \leftarrow \frac{U_G - U_G^{\text{baseline}}}{U_G^{\text{baseline}}}, \quad \text{gap}_S \leftarrow \frac{U_S - U_S^{\text{baseline}}}{U_S^{\text{baseline}}}$;

  `// Check convergence`

  if $|gap_G| < \tau^{pop}$ ***and*** $|gap_S| < \tau^{pop}$ **then**

    break;

  `// Adjust populations to equalize utilities`

  $\bar{L}_G \leftarrow \bar{L}_G \cdot \exp\left(\alpha^{\text{pop}} \cdot \ln\left(\frac{U_G}{U_G^{\text{baseline}}}\right)\right)$;

  $\bar{L}_S \leftarrow \bar{L}_S \cdot \exp\left(\alpha^{\text{pop}} \cdot \ln\left(\frac{U_S}{U_S^{\text{baseline}}}\right)\right)$;

return $(\bar{L}_G, \bar{L}_S, \lambda_G, \lambda_S, q, w_G, w_S, \ldots)$

D.6 General Equilibrium Algorithm Correctness Validation

To validate the correctness and accuracy of our numerical algorithm, we conduct a replication exercise. We have calibrated the model's exogenous parameters and variables (e.g., sectoral productivity A_i, regional amenities B_n) to perfectly match the baseline equilibrium data in the before sections. Holding this calibrated set of parameters and variables fixed, we then employ our solver to compute the general equilibrium of the model

from the ground up. This "forward-solved" equilibrium is then compared against the original baseline data.

The results of this exercise are presented in the figure below. The figure plots the forward-solved values for key endogenous variables—including land rents (q_n), tradable wages (w_G), service wages (w_S), service revenue ($\mathcal{E}_S$), and the spatial distribution of residents and workers—against their observed counterparts. As depicted, the forward-solved outcomes align perfectly with the observed data. All data points lie precisely on the 45-degree line, with a correlation coefficient of unity (R=1.0000) for each variable. This perfect replication confirms that our algorithm correctly and reliably solves the system of equations and identifies the model's fixed-point equilibrium. This successful validation provides a solid foundation for the counterfactual analyses that follow.

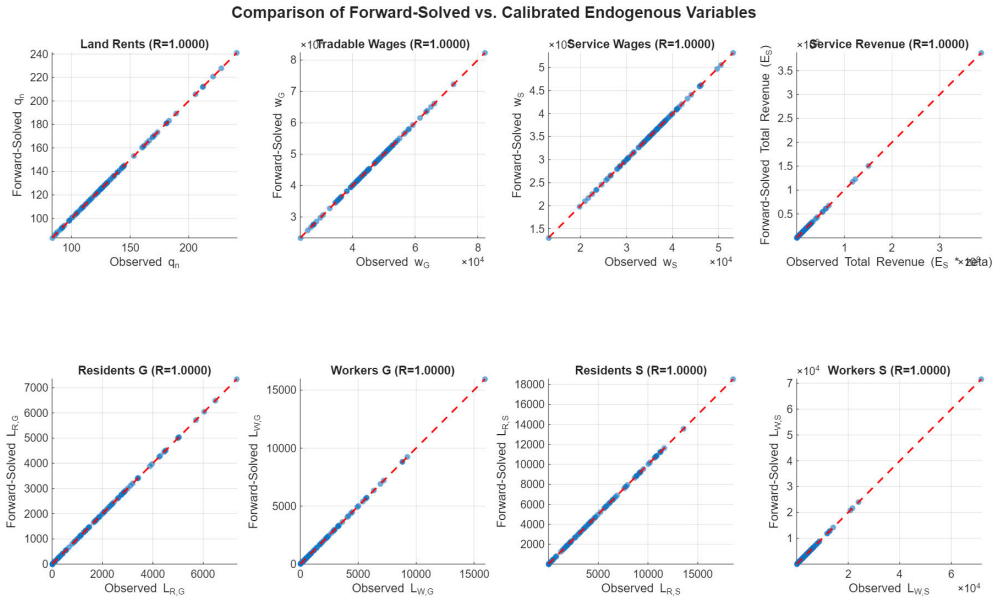


Figure D.13: Forward Equilibrium For Baseline (No Parameter Changed)