# How Housing Supply Expansions Reshape Cities*

Marco Giacoletti† University of Notre Dame
Matthijs Korevaar‡ Erasmus University
Franklin Qian§ UNC-Chapel Hill

April 17, 2026

**Abstract**

We study the Vinex program, a large-scale relaxation of residential land supply constraints near major Dutch cities. Using administrative microdata, we show that house prices in highly exposed neighborhoods declined by 2–3%, with effects concentrated in high-income areas and no differential response in lower-income areas. New construction attracted high-income households from nearby neighborhoods and stimulated 14% stronger local employment growth, concentrated in tradable services. A two-sector quantitative spatial model with non-homothetic preferences replicates these patterns through sector-specific residential re-sorting, endogenous employment concentration via agglomeration externalities and Armington trade, and a unified land market. In a closed city, per-worker welfare gains are roughly €3,200 for tradable-sector and €3,800 for service-sector workers; service workers benefit more because housing absorbs a larger share of their income. When accounting for observed in-migration, per-worker gains are attenuated but remain positive for both groups.

*For this project, Korevaar has benefited from funding of the Netherlands Organization for Scientific Research (grant number VI.Veni.231E.026). This paper includes our own calculations based on non-public microdata from Statistics Netherlands (project 9817). We thank Chandler Lutz, Isaac Hacamo, S. Lakshmi Naaraayanan, Stephen Ross, Frank van Oort for helpful comments. We thank Jeroen van Haaren, Maarten Nefs, Michiel Gerritse, and Bart Knijff (Brainbay) for providing access to employment and house price data.

†University of Notre Dame, Mendoza College of Business. Email: mgiacole@nd.edu

‡Erasmus School of Economics. Email: korevaar@ese.eur.nl

§University of North Carolina Kenan-Flagler Business School. Email: franklin_qian@kenan-flagler.unc.edu

# 1 Introduction

What happens when supply constraints in major cities are loosened at scale? Housing supply in many developed countries has failed to keep pace with demand, putting 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, residential sorting, and economic activity, remain poorly understood. In particular, existing work cannot tell us whether localized price effects aggregate into citywide welfare gains, how housing and labor markets jointly adjust, or whether the benefits of new supply reach workers across the income distribution.

We exploit the Vinex program, a nationally planned urban expansion in the Netherlands.[1] This setting offers three advantages for studying large-scale supply expansions. First, scale: in the mid-1990s, after decades of restricting construction near major cities, the Dutch government allocated large tracts of suburban land for residential development. The program produced roughly half a million mostly owner-occupied homes and triggered moving chains that ultimately relocated about 10% of the Dutch population. Few housing supply shocks rival this scale. Second, exogeneity: 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; balance tests confirm that highly exposed and unexposed neighborhoods are well matched on pre-program building stock characteristics and price trends. Third, data: rich administrative microdata on all properties, residents, and jobs allow us to trace housing, migration, and employment adjustments at the neighborhood level, linking housing and labor market responses in a way that existing studies of individual building projects cannot.

We show that large-scale housing supply expansions reshape urban structure well beyond the neighborhoods where construction occurs. Relative to less exposed neighborhoods in the same municipality, areas near Vinex developments experienced persistent house price declines of 2–3%, with effects concentrated in high-income neighborhoods that competed most directly with the new housing; prices in lower-income areas showed no differential response. This heterogeneity reflects the re-sorting of residents and jobs: Vinex drew higher-income movers from nearby affluent areas, and highly exposed neighborhoods saw 14% stronger employment growth driven almost entirely by tradable services, with finance and IT accounting for the bulk of the increase. To interpret and quantify these patterns, we develop a quantitative spatial equilibrium model (QSM) that shows how welfare implications vary depending on whether the city absorbs the shock through internal

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

re-sorting or through in-migration. In a closed city, both tradable-sector and service-sector workers gain, with service-sector workers benefiting proportionally more because housing absorbs a larger share of their income. In a semi-open city that accounts for Vinex-induced in-migration, per-worker welfare gains are smaller but remain positive for both groups even as aggregate output rises.

We first establish that Vinex generated a large, discrete shock to housing construction on suburban land that was previously mostly undeveloped. Construction in Vinex and non-Vinex areas followed parallel trends before the program, diverging sharply after 1995. Because construction consisted mostly of owner-occupied single-family homes, Vinex disproportionately attracted residents working in higher-wage tradable services, consistent with evidence on the sorting of high-income households into newer housing (Hanson and Moretti, 2025). Using administrative microdata on all Dutch residents, we trace the resulting moving chains: roughly 600,000 residents moved directly into Vinex homes, freeing up lower-value housing for lower-income households and setting off a chain that relocated at least 900,000 additional residents. These chains are consistent with recent evidence from the U.S. and Finland (Mast, 2022; Bratu, Harjunen, and Saarimaa, 2022), but at a substantially larger scale; unlike those studies, we also trace the substantial local employment growth that accompanied the new construction.

To identify causal effects on surrounding neighborhoods, we exploit planner-assigned land allocations rather than realized construction and compare highly exposed to unexposed neighborhoods within the same municipality.[2] Pre-program price trends are parallel, and exposed areas are balanced on pre-1994 building stock characteristics, including service, commercial, and residential building stocks and their recent development rates. House prices in high-exposure neighborhoods declined persistently by 2–3%, with effects about 50% larger in above-median-income areas and insignificant in below-median-income areas; these results survive a broad range of robustness checks, including placebo randomization tests that reject the null at the 0.1% level. Outflows to Vinex developments doubled in exposed areas, yet net population remained stable, consistent with offsetting in-migration. Using Vinex land assignments as an instrument, we estimate an inverse supply elasticity of approximately $-0.05$. Exposed areas also experienced 14% stronger employment growth, concentrated in tradable services, where employment increased by 32%, driven primarily by finance and IT; a leave-one-out analysis confirms that no single industry drives this result. Yet reduced-form estimates alone cannot determine whether these gains reflect net job creation or displacement from other locations, nor can they quantify the welfare implications of the resulting spatial reallocation. To interpret these patterns and assess their broader consequences, we turn to a quantitative spatial equilibrium model.

Our model builds on the quantitative spatial framework surveyed by Redding and Rossi-Hansberg (2017) and developed in Ahlfeldt et al. (2015), Monte, Redding, and Rossi-Hansberg (2018), and Heblich, Redding, and Sturm (2020), but introduces several features tailored to studying large-scale

[2]We measure exposure as the share of land within 5 km designated for Vinex and define highly exposed neighborhoods as those in the top quartile within their municipality. We choose the 5 km radius because it captures both direct migration to Vinex and competition for new residents between Vinex and the surrounding non-Vinex neighborhoods.

housing supply policy. The model features heterogeneous workers, exogenously assigned to one of two production sectors (tradable goods and non-tradable services), and an integrated neighborhood-level land market in which residential and commercial uses compete for space. We adopt Stone-Geary preferences with a minimum housing consumption level, which generate non-homothetic housing demand: high-income workers, whose discretionary budget is large relative to the subsistence housing requirement, have more elastic housing demand and respond more strongly to differences in housing costs and quality across locations; low-income workers, constrained closer to the minimum, spend a larger share of income on housing and thus benefit more from rent declines. This mechanism simultaneously drives the sector-specific sorting we document empirically and the differential welfare incidence in the counterfactual analysis. We model tradable goods as Armington varieties, where each location produces a distinct good, and non-tradable services under monopolistic competition with free entry, where the mass of local service varieties responds endogenously to local demand. The Armington structure dampens the pass-through from local cost changes to tradable wages, while endogenous service variety creates a love-of-variety channel through which residential inflows raise the quality of local consumption. The two worker types are allowed to differ flexibly in their sensitivity to local net income and to commuting distance, estimated separately for each sector from commuting flows: tradable-sector workers are more responsive to local net income and less sensitive to commuting distance than service-sector workers, reinforcing the income-driven sorting generated by non-homothetic preferences. The housing policy enters the model as a shift in the location-specific land supply elasticity.

The model quantifies how the incidence of these effects varies with the degree of population adjustment. We compare equilibria in a "No Vinex" counterfactual world and in the observed post-policy city under two main scenarios: a closed city with fixed sectoral populations and a semi-open city with partially adjusted populations. The counterfactual analysis replicates the empirical patterns and explains them through three general-equilibrium mechanisms. First, high-income tradable workers sort disproportionately into Vinex, while lower-income service workers partially backfill vacated neighborhoods, generating heterogeneous demand shifts that explain the concentration of price declines in affluent nearby areas. Second, employment growth near Vinex arises endogenously, without direct policy intervention in labor markets. For tradable-sector jobs, agglomeration externalities raise local productivity as employment density increases, and the Armington trade structure absorbs much of the resulting cost reduction through lower output prices rather than higher wages, producing moderate employment growth with relatively stable wages. For service-sector jobs, the inflow of high-income residents raises local demand, attracting new service establishments through the free-entry channel. Together, these mechanisms rationalize the strong employment growth concentrated in tradable services documented in the reduced-form analysis. Third, in a unified land market, the observed rent decline understates the true residential demand shift because increased commercial demand from new service and tradable-sector establishments partially offsets the residential decline. In both scenarios, welfare operates primarily through the cost-of-living channel (lower rents, goods prices, and service prices) rather than through rising wages.

We also report an open-city benchmark in the appendix, in which population adjusts endogenously; in that case, in-migration competes away the welfare gains, but the implied population adjustment is far larger than observed.

Together, these results show that the effects of large-scale housing supply expansions extend well beyond local price reductions documented in existing work, reshaping the spatial distribution of residents, jobs, and economic activity across the income distribution. In the short run (the closed-city scenario), incumbents benefit from lower rents and prices, with per-worker welfare gains of roughly €3,200 for tradable-sector and €3,800 for service-sector workers. In the empirically relevant semi-open scenario, which captures medium-run population adjustment, in-migration attenuates per-worker gains by 25–30%, but the policy simultaneously achieves a 4% reduction in average land rents, substantial growth in both goods and services output, and positive welfare gains for both worker types. The Vinex expansion thus delivers moderate housing cost relief alongside strong agglomeration in jobs and aggregate output, a combination that reduced-form estimates of localized price effects cannot capture on their own.

**Related literature.** Our paper contributes to three strands of the literature. *Local housing supply effects.* A growing literature estimates the effects of new housing construction on nearby prices and mobility. Mast (2022) traces moving chains from new market-rate buildings in U.S. cities, Pennington (2022) identifies price reductions within 100 meters in San Francisco, Asquith, Mast, and Reed (2023) studies new apartments in low-income U.S. neighborhoods, and Bratu, Harjunen, and Saarimaa (2022) documents filtering in Helsinki using administrative data. These studies provide compelling micro-level evidence but are limited to individual buildings or small developments, reach effects within at most a few kilometers, and do not observe labor market adjustments.[3] We study a supply shock that is orders of magnitude larger (roughly 450,000 units versus individual buildings), use planner-assigned land allocations for identification, and trace both housing and employment responses simultaneously using universe-level administrative data. The Vinex setting bridges the gap between micro-level filtering studies and the macro literature on housing constraints and spatial misallocation (Hsieh and Moretti, 2019), providing causal evidence on the citywide consequences of relaxing supply constraints at scale.

*Quantitative spatial models.* Our model builds on the canonical quantitative spatial equilibrium (QSM) framework surveyed by Redding and Rossi-Hansberg (2017), developed in Ahlfeldt et al. (2015), and applied to commuting and migration in Monte, Redding, and Rossi-Hansberg (2018), urban transit in Heblich, Redding, and Sturm (2020), Tsivanidis (2018), and Severen (2023), and regional shocks in Caliendo et al. (2018) and Owens, Rossi-Hansberg, and Sarte (2020). We contribute to this literature by combining several features that have not previously appeared together in a within-city spatial equilibrium model. Standard QSMs typically adopt Cobb-Douglas preferences with a fixed housing expenditure share; following Couture et al. (2019), we adopt

[3]See also Baum-Snow and Han (2023) on the microgeography of housing supply, and related work on urban migration (Boustan, 2010; Derenoncourt, 2022), agglomeration spillovers (Baum-Snow, Gendron-Carrier, and Pavan, 2024), and the welfare effects of urban infrastructure (Severen, 2023; Zárate, 2022).

a Stone-Geary specification that generates income-dependent housing demand elasticities. This non-homotheticity plays a dual role: it drives the sector-specific spatial sorting documented in our data (high-income workers with more elastic housing demand respond more to new supply) and generates the differential welfare incidence across income groups (low-income workers with higher housing expenditure shares gain more from rent declines). We embed two-sector production at the neighborhood level within a single metropolitan area: an Armington tradable goods sector and a monopolistically competitive non-tradable services sector with endogenous firm entry. Multi-sector spatial models exist at the regional or state level (Caliendo et al., 2018; Caliendo, Dvorkin, and Parro, 2019), and Armington trade structures appear in cross-regional settings (Allen and Arkolakis, 2014), but embedding both sectors with endogenous service variety at the neighborhood scale is, to our knowledge, new. The two worker types are allowed to differ in their sensitivity to net income and commuting distance, estimated separately for each sector, enabling the model to capture the distinct mobility patterns of tradable and service workers.[4] Together, this combination of rich worker heterogeneity, two-sector production, and non-homothetic preferences enables the model to rationalize the simultaneous price declines, heterogeneous employment growth, and income-specific sorting patterns that we observe around large-scale supply expansions.

*Housing finance and house price dynamics.* Our findings also contribute to the financial economics literature on the determinants of house prices, which has focused primarily on demand-side drivers such as credit conditions (Favilukis and Van Nieuwerburgh, 2021) and speculative dynamics (Nathanson and Zwick, 2018).[5] We provide evidence on a large supply-side shock, documenting how new construction propagates through house prices across the income distribution and across space. Louie, Mondragon, and Wieland (2025) argue that cross-city variation in measured supply elasticities does not explain differences in house price growth; our within-city analysis shows that relaxing supply constraints does reduce nearby prices, but heterogeneously, concentrated in neighborhoods that compete most directly with the new housing.[6]

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 program. Section 8 concludes.

[4] We separately identify Fréchet preference dispersion ($\epsilon^g$) and commuting friction ($\kappa_g$) for each worker type via PPML gravity estimation on commuting flows, a distinction that most QSMs collapse into a single composite parameter (see Section 6).

[5] See also Kaplan, Mitman, and Violante (2020) on credit and housing booms, Bayer, Magnum, and Roberts (2021) on investor behavior, and Chorodow-Reich, Guren, and McQuade (2024) on house price dynamics.

[6] Our work also connects to the literatures on spatial sorting and inequality (Diamond, 2016; Diamond and Suárez Serrato, 2025; Couture et al., 2019; Fajgelbaum and Gaubert, 2020) and the welfare effects of place-based investments (Tsivanidis, 2018; Heblich, Redding, and Sturm, 2020; Schubert, 2022).

# 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, encompassing all major Dutch urban regions (van der Krabben and Jacobs, 2013).[7]

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 expansion near major cities in favor of new towns. Vinex developments were expected to have strong "spatial quality," which in the Dutch planning tradition meant coordinated investment in roads, public transit, and cycling infrastructure connecting new neighborhoods to existing urban centers (Pojani and Stead, 2018; van Wee and Maat, 2003). These transport investments were a standard feature of Dutch urban development, not a Vinex-specific policy aimed at stimulating commercial activity.

At the same time, prospective sites had to comply with preexisting national planning constraints. Earlier policies had imposed strict residential 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.[8] 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

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

[8] Municipalities retained zoning authority, and local residents could appeal zoning changes (Ruimtelijk Planbureau, 2006), but these agreements were binding, and appeals could not block the construction of Vinex neighborhoods.

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.[9] 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.

Finally, an important institutional feature is the asymmetry in Dutch planning between residential and commercial land. While the national government tightly restricted where new housing could be built, the regulation of commercial and industrial land was far more permissive. Dutch municipalities competed to attract firms by developing commercial zones at low cost, producing a persistent oversupply of commercial land (van der Krabben and van Dinteren, 2010). Levkovich, Rouwendal, and Brugman (2018) show that this differential regulation segmented the Dutch land market, with residential land trading at a large premium over commercial or agricultural land. While the Vinex program also led to job creation, permissive zoning for commercial land implied that this is better viewed as a market response to the arrival of new residents and not a coordinated supply-side policy to attract firms.

In sum, the Vinex program relaxed the residential supply constraint near major cities through a top-down process guided by planning principles rather than profitability or nearby neighborhood characteristics. Feasibility was ensured through restricting developments elsewhere and subsidization when needed. The program was accompanied by transport infrastructure but did not specifically target commercial zoning, making it a predominantly residential supply shock. These institutional features are central to our empirical strategy.

## 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.[10] 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

[9] 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)

[10] 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.

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.[11]

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.[12] 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 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.[13] For all movers between 1995 and 2015, we compute the straight-line distance between their current and previous residences.

While these data are exceptionally rich, some sources are available only from the mid-1990s onward (moves, employment and wage data), limiting our ability to construct pre-trend tests for demographic and employment outcomes.

[11] 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.

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

[13] As with BAG, properties demolished between 1995 and 2014 are not included in the Woonbase.

# 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 program 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:

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

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.

The development of Vinex sites also coincides with an expansion in non-residential construction. However, this expansion lags residential development by several years. Appendix Figure A.2 applies the same test as in equation (1) to service and commercial real estate buildings. We find no pre-trend in non-residential development: service construction takes off only around 1998 and commercial real estate peaks in the mid-2000s, consistent with these buildings following the arrival of new residents rather than preceding it.

### 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.[14] 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.13).

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

[14] 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.

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.4 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 to 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 residential construction accelerates from 1995 onward and non-residential development follows several years later (see Figure 2 and Appendix Figure A.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.13). As shown in Appendix Figure A.3, 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 and fewer jobs in industry and manufacturing, consistent with their suburban, newly developed character. However, they also have a notably higher share of jobs in tradable services, a pattern more commonly associated with urban cores than with suburban areas.

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 program: 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. While Vinex construction was staggered over the late 1990s and 2000s, the pace of development was likely endogenous to local demand, making construction timing a poor source of identifying variation. Instead, our exposure measure is based on the land allocations formalized in the covenants of 1994–1995, which were determined simultaneously for all sites and reflect the planner's intent rather than market-driven construction dynamics.

**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.[15] We define

$$I_{HighVinex,i} = 1 \quad \text{if } ShareVinex_{5km,i} \text{ lies in the top quartile within the municipality.}$$

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.

A related concern is that Vinex exposure may correlate with pre-existing non-residential infrastructure or development trends. Table 3 tests this by regressing the 1994 stock and pre-program (1985–1994) development ratios of service, commercial, and residential buildings on our exposure measures. With municipality fixed effects, all coefficients for $I_{HighVinex,i}$ are statistically insignificant

[15] Appendix Figure A.5 shows the distribution of exposure by neighborhood

and economically negligible. The only borderline-significant coefficient, the residential development ratio on $ShareVinex_{5km,i}$, implies just a 0.35% higher annual development rate, a trivially small magnitude. As noted in Section 2.2, we cannot conduct analogous pre-trend tests on population composition, as demographic microdata are available only from the mid-1990s onward.

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 $\tau$; $I_{\tau,i}$ 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-differences estimates have a straightforward interpretation, showing the difference over time between two sets of neighborhoods. This measure captures effects arising from *relative* differences in exposure. Because our identification exploits within-municipality variation, the estimates are biased toward zero if Vinex also affects zero-exposure neighborhoods through general equilibrium channels, for example by absorbing residents who would otherwise have moved there. The reduced-form results should therefore be interpreted as conservative lower bounds on the absolute effect of new supply on nearby prices and employment. We quantify the magnitude of these general equilibrium adjustments in Section 7.

A related concern is that Vinex developments were accompanied by transport infrastructure investments. However, any new residential development requires basic road and transit connections to be accessible, so infrastructure investment is an inherent component of housing construction rather than a separate treatment. The infrastructure accompanying Vinex was not exceptional: it followed the same standards applied to all Dutch residential development (Pojani and Stead, 2018). Moreover, our within-municipality comparison absorbs any city-wide infrastructure improvements.

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

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

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 program'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 $ShareVinex_{5km,i}$.

Table A.4 complements these tests with a detailed balance analysis of non-residential and residential building characteristics as of 1994. Controlling for municipality fixed effects, high-exposure and non-exposed buurts are well balanced along nearly all dimensions of property composition, size, age, and use, providing further support for the validity of our identification strategy.[16]

## 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 $\tau$ 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

[16]The only notable differences are that service buildings in high-exposure buurts tend to be newer and that office space constitutes a smaller share of commercial real estate. We do not include demographic variables because they are available only after the start of Vinex development.

Vinex effect to differ between buurts above and below the median municipal income:

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

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 $f_\tau$ and $g_\tau$, 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.6 and Figure A.7.

Table 4 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 municipality-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.5).

Appendix Figure A.8 reports a placebo test. We re-estimate equation (3) 1,000 times, randomly reassigning high-exposure status across non-Vinex buurts. The distribution of placebo estimates is centered at zero, confirming that our results are not driven by spurious spatial correlation. The empirical estimate lies far in the tail of the placebo distribution, rejecting the null of no effect with a p-value of 0.1%.

#### 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 $\gamma$ captures how much more construction occurred around buurts with greater Vinex exposure.

Table 5 shows that $\gamma$ is large and statistically significant across specifications. With municipality fixed effects, a 1 p.p. increase in Vinex land share is associated with a 7.0 p.p. larger increase in nearby construction. Buurts in the top-quartile exposure group ($I_{HighVinex} = 1$) experienced, on average, a 22.8 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 $\delta_S$ is the inverse supply elasticity: the causal effect of a Vinex-driven increase in nearby supply on local prices.

Table 6 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 local 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.[17]

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 7 provides the main results for the 1995-2005 period.

**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

[17] Appendix Table A.6 repeats the same exercise on the full sample of non-Vinex buurts, finding very similar results. Appendix Table A.7 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 6.

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 the difference between the two 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 significant 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.8 provides analogous results, including all buurts as baseline, instead of only zero-exposure buurts. Appendix Table A.9 provides results for the entire 1995-2015 period. Finally, Appendix Table A.10 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 $\tau$, $I_{HighVinex,b}$ 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.9).

**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 8 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.

Appendix Figure A.10 implements a leave-one-out analysis, re-estimating the specification in Column 1 of Table 8 while excluding one NACE sector at a time (see Appendix Table A.13 for definitions). If a particular sector drives our results, excluding it should substantially reduce the estimated coefficient. Removing *Media & IT* or *Banking and Insurance* produces the largest drops, while removing *Retail* increases the estimate. These patterns confirm that the job spillovers are concentrated in higher-wage tradable service industries.

A possible explanation of our findings is that, through agglomeration effects, Vinex neighborhoods are creating new clusters of jobs far away from city centers. An alternative explanation is that Vinex is creating job agglomeration mainly in neighborhoods that are exposed to new development but are located closer to central business districts. We find that this second explanation better aligns with the data. Figure 8 visualized the spatial patterns of workplace spillovers. We re-estimate equation (10), sequentially excluding from the sample neighborhoods that are located within 2.5 kilometers and 5 kilometers of a central business district.[18] The figure reports the corresponding estimates of the coefficient $g_{end}$, both when the dependent variable is the total number of jobs in a buurt (panel a), and when it is the total number of jobs in tradable services (panel b). We can see that the coefficient estimates weaken once we exclude buurts within 5 km of a central business district, suggesting that exposed non-Vinex buurts closer to urban cores provide an important contribution to our results.

**Robustness.** Appendix Table A.11 reports estimates using the full set of non-Vinex buurts as the comparison group, with results very similar to the baseline. Appendix Table A.12 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.

Appendix Figure A.11 applies the same randomization strategy as in Figure A.8 to the employment estimates, again strongly rejecting the null with a p-value of 0.1%.

[18]We identify central business districts using the coordinates of the city centers of the major cities in the Randstad, excluding Almere, which was mainly developed through the Vinex program. We have a total of 19 central business districts.

# 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 distinction between heterogeneous workers by production sector, combined with a unified land market where residential housing, 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. The tradable goods sector follows an Armington structure in which each production location supplies a distinct variety, so that residents face location-specific effective goods prices. The non-tradable service sector features monopolistic competition with free entry, so that the mass of local service varieties expands with the scale of the local economy, generating an agglomeration externality that amplifies the effect of population inflows on local service provision. This structure allows us to trace how a local housing supply shock, like the Vinex program, attracts specific types of workers and thereby alters local demand, land prices, and employment, generating the spatial spillovers observed in the data.

## 5.1 Environment

The city comprises $N$ discrete spatial locations indexed by $n$ or $i$, where $n, i \in \mathcal{N} = \{1, 2, ..., N\}$. We apply the model to The Hague metropolitan area, with $N = 102$ neighborhoods. 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.

Economic activity is organized into two production sectors: a tradable goods sector (denoted $G$) and a non-tradable services sector (denoted $S$).[19] We adopt an Armington structure in which each workplace location $i$ produces a distinct tradable goods variety with factory-gate price $p_i^G$, and residents can purchase goods from any location subject to iceberg transport frictions. Non-tradable services are produced at a specific location $j$, but residents from any location $n$ can consume them, subject to analogous shopping frictions. Each service location $j$ has a local service price $p_j^S$ that reflects both production costs and local demand conditions.

The city's labor force consists of workers categorized into two types, indexed by $g \in \{G, S\}$, based on their employment sector. Each worker's sectoral assignment is exogenous: workers cannot switch sectors in response to the policy, so the model rules out occupational reallocation between tradable and service employment.[20] The total population of type-$g$ workers, $\overline{L}^g$, is fixed: workers can relocate within the city but cannot migrate to other cities. We relax this assumption in counterfactual exercises. Let $\lambda_{ni}^g$ denote the probability that a randomly selected type-$g$ worker chooses to reside

[19] Empirically, the non-tradable sector $S$ corresponds to the Non-Tradable Services identified in our data, while the tradable sector $G$ groups the remaining sectors: Tradable Services and Agriculture-Manufacturing.

[20] This assumption is standard in multi-sector QSMs (Monte, Redding, and Rossi-Hansberg, 2018; Caliendo et al., 2018) and is motivated by the substantial sector-specific human capital that limits short- to medium-run occupational switching.

in location $n$ and work in location $i$, so that the residential population of type-$g$ workers at location $n$ is $L^g_{R,n} = \sum_{i=1}^N \lambda^g_{ni} \overline{L}^g$ and the workplace population at location $i$ is $L^g_{W,i} = \sum_{n=1}^N \lambda^g_{ni} \overline{L}^g$.

### 5.2 Worker Preferences and Behavior

**Utility Function.** Consider a worker $\omega$ of type $g$ who resides in location $n$ and commutes to workplace $i$. This worker derives utility from consuming 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 $\bar{h}^g \geq 0$:

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

where $z_{\omega ni}$ 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 $n$, and $d^g_{ni} = \exp(\kappa_g \bar{\tau}_{ni}) \geq 1$ represents an iceberg commuting cost, with $\kappa_g$ denoting the commuting friction and $\bar{\tau}_{ni}$ the travel distance between $n$ and $i$. 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, $T^g_n > 0$ is the residential scale parameter, and $\epsilon^g > 1$ governs the dispersion of preferences. Since $T^g_n$ and $B^g_n$ enter the choice probability multiplicatively, they are not separately identified; in practice, we normalize $T^g_n = 1$ and let $B^g_n$ absorb all residential fundamentals.

**Consumption of Local Services and Goods.** Workers can access services from any location $j$ and tradable goods from any production location $k$, but face iceberg shopping frictions in both cases. To consume one unit of a service variety from location $j$ while residing at $n$, a worker must purchase $t^S_{nj} = \exp(\kappa^{\text{shop},S} \bar{\tau}_{nj}) \geq 1$ units, and analogously $t^G_{nk} = \exp(\kappa^{\text{shop},G} \bar{\tau}_{nk})$ for goods.

At each service location $j$, a mass $M_j > 0$ of differentiated service varieties is available at a common within-location price $p^S_j$. Workers aggregate these varieties via a CES function with elasticity of substitution $\sigma_S > 1$. The resulting effective service price index for a resident of location $n$ is:

$$P^{S,\text{eff}}_n = \left(\sum_{j=1}^N M_j (t^S_{nj} p^S_j)^{1-\sigma_S}\right)^{\frac{1}{1-\sigma_S}}. \tag{13}$$

Each production location $k$ supplies a distinct tradable goods variety at factory-gate price $p^G_k$. The corresponding effective goods price index follows an analogous Armington CES structure with

elasticity $\sigma_G > 1$:

$$P_n^{G,\text{eff}} = \left( \sum_{k=1}^{N} (t_{nk}^G p_k^G)^{1-\sigma_G} \right)^{\frac{1}{1-\sigma_G}}. \tag{14}$$

The share of service expenditure flowing from residence $n$ to service destination $j$ follows the CES gravity form:

$$\pi_{n\to j}^S = \frac{M_j (t_{nj}^S p_j^S)^{1-\sigma_S}}{\sum_{k=1}^{N} M_k (t_{nk}^S p_k^S)^{1-\sigma_S}}. \tag{15}$$

Expenditure flows increase with the variety mass at destination $j$ and decrease with the friction-adjusted price $t_{nj}^S p_j^S$. The analogous goods expenditure share is:

$$\pi_{n\to k}^G = \frac{(t_{nk}^G p_k^G)^{1-\sigma_G}}{\sum_{m=1}^{N} (t_{nm}^G p_m^G)^{1-\sigma_G}}. \tag{16}$$

Both price indices vary across residential locations, so that location-specific variation in the cost of living becomes a key channel through which housing supply shocks propagate across the city.

**Budget Constraint and Optimal Choices.** A type-$g$ worker residing in $n$ and working in $i$ earns wage $w_i^g$. After purchasing the minimum housing requirement $\bar{h}^g$ at local price $q_n$, the worker allocates the remaining discretionary income $w_i^g - q_n \bar{h}^g$ across goods, services, and additional housing:

$$P_n^{G,\text{eff}} C_{\omega ni}^G + P_n^{S,\text{eff}} C_{\omega ni}^S + q_n (H_{\omega ni} - \bar{h}^g) = w_i^g - q_n \bar{h}^g. \tag{17}$$

Given the Cobb-Douglas structure, optimal demands are constant expenditure shares $\beta^g$, $\gamma^g$, and $1 - \beta^g - \gamma^g$ of discretionary income on goods, services, and housing, respectively. Total housing demand is $H_{\omega ni}^* = \bar{h}^g + (1 - \beta^g - \gamma^g)(w_i^g - q_n \bar{h}^g)/q_n$. An important implication of the Stone-Geary structure is that the elasticity of housing demand with respect to rent varies with income. For high-income workers, discretionary income $w_i^g - q_n \bar{h}^g$ is large relative to the subsistence requirement, so housing demand is elastic and responds substantially to rent differences across locations. For low-income workers, most income is absorbed by the minimum housing requirement, leaving housing demand close to $\bar{h}^g$ and largely insensitive to rent variation. Conversely, housing expenditure as a share of total income is higher for low-income workers, so a given rent decline generates proportionally larger welfare gains for them. Substituting optimal demands into the utility function yields an indirect utility proportional to

$$u_{\omega ni}^g \propto \frac{z_{\omega ni} B_n^g}{d_{ni}^g} \left( w_i^g - q_n \bar{h}^g \right) \left( P_n^{G,\text{eff}} \right)^{-\beta^g} \left( P_n^{S,\text{eff}} \right)^{-\gamma^g} (q_n)^{\beta^g + \gamma^g - 1}.$$

**Location Choice Probabilities.** Given the Fréchet preference shocks, the probability that a type-$g$ worker selects residence $n$ and workplace $i$ takes the familiar gravity form:

$$\lambda_{ni}^g = \frac{\Phi_{ni}^g}{\sum_{m=1}^{N} \sum_{j=1}^{N} \Phi_{mj}^g}, \tag{18}$$

where the attractiveness of pair $(n, i)$ is

$$\Phi_{ni}^{g} = E_i^g \left[ \frac{B_n^g (w_i^g - q_n \bar{h}^g)}{d_{ni}^g (P_n^{G,\text{eff}})^{\beta^g} (P_n^{S,\text{eff}})^{\gamma^g} (q_n)^{1-\beta^g-\gamma^g}} \right]^{\epsilon^g}.$$

Intuitively, workers are drawn to location pairs that offer high amenities, high net income, and low living costs. The conditional commuting probability is $\lambda^g(i|n) = \lambda_{ni}^g / \sum_j \lambda_{nj}^g$, and the expected wage of a type-$g$ resident at $n$ is $\mathbb{E}_n[w^g] = \sum_i w_i^g \lambda^g(i|n)$.

### 5.3 Production Technologies and Factor Prices

**Endogenous Productivity (Agglomeration).** We incorporate agglomeration externalities, where productivity in both sectors depends on the total density of economic activity rather than sector-specific density. Let $L_{W,i}^{\text{Tot}} = L_{W,i}^G + L_{W,i}^S$ denote total employment at location $i$. Effective productivity in each sector combines a location-specific fundamental with a spatial agglomeration spillover:

$$A_i^{G,\text{eff}} = \bar{A}_i^G \left( \sum_{k=1}^{N} e^{-\delta_G \tau_{ik}} L_{W,k}^{\text{Tot}} \right)^{\psi_G}, \qquad a_i^{S,\text{eff}} = \bar{a}_i^S \left( \sum_{k=1}^{N} e^{-\delta_S \tau_{ik}} L_{W,k}^{\text{Tot}} \right)^{\psi_S},$$

where $\bar{A}_i^G$ and $\bar{a}_i^S$ are fundamental productivities, $\delta_G$ and $\delta_S$ govern the spatial decay of spillovers, and $\psi_G$ and $\psi_S$ are agglomeration elasticities. This specification implies that a location surrounded by dense employment benefits from higher productivity in both sectors, creating a feedback loop between employment density and output.

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

$$Y_i^G = A_i^{G,\text{eff}} (L_{W,i}^G)^{\alpha_G} (D_i^G)^{1-\alpha_G}, \tag{19}$$

where $\alpha_G \in (0, 1)$ is the labor share. Under perfect competition, the zero-profit condition pins the local goods price $p_i^G$ to unit cost. Inverting this condition yields the wage equation:

$$w_i^G = \alpha_G \left( A_i^{G,\text{eff}} \, p_i^G \right)^{1/\alpha_G} \left( \frac{1-\alpha_G}{q_i} \right)^{(1-\alpha_G)/\alpha_G}. \tag{20}$$

Because $p_i^G$ is endogenous and location-specific under the Armington structure, goods-sector wages reflect not only local supply conditions but also the location's attractiveness as a goods supplier to the rest of the city. The cost-minimizing input ratio is $D_i^G / L_{W,i}^G = [(1-\alpha_G)/\alpha_G] \cdot (w_i^G / q_i)$.

**Non-Tradable Services Sector.** The service sector features monopolistic competition with free entry. Each service location $i$ hosts a continuum of differentiated varieties $\nu \in [0, M_i]$. Firm-level

production combines labor $\ell_i(\nu)$ and land $d_i(\nu)$ with effective productivity $a_i^{S,\text{eff}}$:

$$y_i(\nu) = a_i^{S,\text{eff}} \left(\ell_i(\nu)\right)^{\alpha_S} \left(d_i(\nu)\right)^{1-\alpha_S}. \tag{21}$$

Each firm faces a constant elasticity of demand $\sigma_S > 1$ and sets price as a markup over marginal cost: $p_i^S = [\sigma_S/(\sigma_S - 1)] \cdot c_i$, where the unit variable cost $c_i$ is determined by the firm-level productivity and the composite factor price. Entry is free but requires a fixed cost $F_i = r_i^S f$ paid in the same factor bundle; we normalize $f = 1$, as it is not separately identified from $a_i^S$. Under the zero-profit condition from free entry, the mass of active varieties at location $i$ is:

$$M_i = \frac{1}{\sigma_S} (L_{W,i}^S)^{\alpha_S} (D_i^S)^{1-\alpha_S}, \tag{22}$$

so that variety proliferation increases with the scale of the local service sector. The implied wage equation is:

$$w_i^S = \alpha_S \left(\frac{\sigma_S - 1}{\sigma_S}\right)^{1/\alpha_S} (a_i^{S,\text{eff}} p_i^S)^{1/\alpha_S} \left(\frac{1-\alpha_S}{q_i}\right)^{(1-\alpha_S)/\alpha_S}. \tag{23}$$

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

### 5.4 Land Market

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

$$q_n = \pi_n D_n^{1/\eta_n}, \tag{24}$$

where $q_n$ denotes the equilibrium housing price (or rent per unit of housing), $D_n$ is total land demand from residential and commercial uses, $\pi_n > 0$ is a location-specific supply shifter, and $\eta_n > 0$ is the price elasticity of housing supply.

### 5.5 Market Equilibrium

**Labor Market Clearing.** For each worker type $g \in \{G, S\}$, workplace labor $L_{W,i}^g = \sum_n \lambda_{ni}^g \overline{L}^g$ and residential population $L_{R,n}^g = \sum_i \lambda_{ni}^g \overline{L}^g$ are determined by the choice probabilities defined above.

**Land Market Clearing.** A key feature of the model is that land serves three distinct uses at each location: residential housing, goods production, and service production. Residential land demand aggregates housing consumption across all workers residing at location $n$:

$$D_n^R = \sum_{g \in \{G,S\}} L_{R,n}^g \left[\bar{h}^g + (1 - \beta^g - \gamma^g) \frac{\mathbb{E}_n[w^g] - q_n \bar{h}^g}{q_n}\right]. \tag{25}$$

Commercial land demand in each sector follows from cost minimization: $D_n^G = (1-\alpha_G) w_n^G L_{W,n}^G / (\alpha_G q_n)$ and $D_n^S = (1-\alpha_S) w_n^S L_{W,n}^S / (\alpha_S q_n)$. The land market clears when total demand equals supply:

$$D_n^R + D_n^G + D_n^S = \left( \frac{q_n}{\pi_n} \right)^{\eta_n}. \tag{26}$$

This unified land market creates a general equilibrium linkage: an increase in employment at a location raises commercial land demand, pushing up $q_n$ and thereby raising housing costs for residents. Conversely, a housing supply expansion such as the Vinex program lowers $q_n$, reducing costs for both residents and firms.

**Service Market Clearing.** Services are produced at location $j$ and consumed by residents from all locations, subject to shopping frictions. Total service expenditure flowing to destination $j$ aggregates the spending of all residents, weighted by the shopping shares $\pi_{n\to j}^S$ defined in equation (15):

$$\mathcal{E}_j^S = \sum_{g \in \{G,S\}} \sum_{n=1}^{N} \pi_{n\to j}^S \, \gamma^g L_{R,n}^g (\mathbb{E}_n[w^g] - q_n \bar{h}^g), \tag{27}$$

where $\gamma^g L_{R,n}^g (\mathbb{E}_n[w^g] - q_n \bar{h}^g)$ is the total service budget of type-$g$ workers residing at $n$. In practice, we only observe expenditure by employed workers in the labor force. Because services are non-tradable, unobserved consumers such as tourists, retirees, and students also patronize local service firms. We introduce a coverage factor $\zeta_S > 0$ that scales modeled worker expenditure up to match total service revenue; in practice, $\zeta_S > 1$ because non-workers also consume local services. The service market clears when

$$R_j^S = \zeta_S \, \mathcal{E}_j^S, \qquad \forall \, j \in \{1, \ldots, N\}. \tag{28}$$

**Tradable Goods Market Clearing.** The Armington structure requires an additional market-clearing condition. Each location $i$ produces a distinct goods variety, and total expenditure flowing to $i$ aggregates the goods spending of all residents, weighted by the shopping shares $\pi_{n\to i}^G$ defined in equation (16):

$$\mathcal{E}_i^G = \sum_{n=1}^{N} \sum_{g \in \{G,S\}} \pi_{n\to i}^G \, \beta^g L_{R,n}^g (\mathbb{E}_n[w^g] - q_n \bar{h}^g). \tag{29}$$

We similarly introduce a coverage factor $\zeta_G > 0$. Unlike the service sector, $\zeta_G$ may be below one: if the city's goods sector is small relative to residents' goods demand, local goods revenue falls short of local goods expenditure, reflecting the city's role as a net importer of tradable goods. Market-clearing requires that goods-sector revenue, equal to payroll scaled by the labor share, matches total expenditure:

$$\frac{w_i^G L_{W,i}^G}{\alpha_G} = \zeta_G \, \mathcal{E}_i^G, \qquad \forall \, i \in \{1, \ldots, N\}. \tag{30}$$

This condition endogenously determines the local goods price $p_i^G$, which feeds back into workers' cost of living and location choices through the goods price index $P_n^{G,\text{eff}}$.

### 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 $\Phi^g = \sum_{n,i} \Phi_{ni}^g$ is the inclusive value that aggregates the attractiveness of all residence-workplace pairs, as defined in equation (18). Because the constant $\Gamma(1 - 1/\epsilon^g)$ is common across equilibria, welfare comparisons reduce to changes in $\Phi^g$. The inclusive value $\Phi^g$ reflects three price channels: land rents $q_n$, effective service prices $P_n^{S,\text{eff}}$, and effective goods prices $P_n^{G,\text{eff}}$. In particular, because goods prices are location-specific under the Armington structure, a policy that shifts the location or productivity of goods production alters the effective goods prices faced by residents, creating a welfare channel absent from models with a common goods numeraire.

**Money-Metric Measures.** To express welfare changes in monetary terms, we use two standard measures. Let $t = 0$ denote the pre-shock (no-Vinex counterfactual) equilibrium and $t = 1$ the post-shock (observed post-policy) equilibrium. The equivalent variation (EV) is the income transfer, evaluated at pre-shock prices, that would make workers indifferent between the two equilibria:

$$\text{EV}^g = \bar{y}_0^g \left[\left(\frac{\Phi_1^g}{\Phi_0^g}\right)^{1/\epsilon^g} - 1\right], \tag{32}$$

where $\bar{y}_t^g = \sum_{n,i} \lambda_{ni,t}^g (w_{i,t}^g - q_{n,t}\bar{h}^g)$ is the choice-probability-weighted average net disposable income in equilibrium $t$. The compensating variation (CV) is the corresponding measure evaluated at post-shock prices:

$$\text{CV}^g = \bar{y}_1^g \left[1 - \left(\frac{\Phi_0^g}{\Phi_1^g}\right)^{1/\epsilon^g}\right]. \tag{33}$$

## 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.[21]

Our calibration strategy proceeds in two main stages. First, we set or estimate key preferences and technological parameters. Production factor shares $(\alpha_G, \alpha_S)$ are estimated from the assessed value of non-residential real estate in The Hague metropolitan area (Appendix C.1). Stone-Geary preference parameters $(\beta^g, \gamma^g, \bar{h}^g)$ are identified from an Engel curve regression on microdata (Appendix C.2). The Fréchet elasticity of location choice $(\epsilon^g)$ and commuting friction $(\kappa_g)$ are jointly estimated from a PPML gravity model of bilateral commuting flows (Appendix C.3). Shopping frictions $(\kappa^{\text{shop},g})$ are calibrated to match empirical benchmarks on the spatial decay of consumer expenditure (Appendix C.5). Taking logs of the choice probability in equation (18) yields the estimating equation:

$$\ln \lambda_{ni}^g = \alpha_n^g + \delta_i^g + \epsilon^g \ln y_{ni}^g - \nu^g \tau_{ni} + e_{ni}, \tag{34}$$

where $\alpha_n^g$ and $\delta_i^g$ are residence and workplace fixed effects, $y_{ni}^g = w_i^g - q_n \bar{h}^g$ is the discretionary income, and $\tau_{ni}$ is the travel impedance. The workplace fixed effects directly identify workplace amenities: $E_i^g = \exp(\delta_i^g)$. For the remaining parameters, we set the elasticity of substitution to $\sigma_G = \sigma_S = 4$ following Monte, Redding, and Rossi-Hansberg (2018), and adopt agglomeration elasticities $\psi_G = \psi_S = 0.07$ and spatial decay parameters $\delta_G = \delta_S = 0.36$ from Ahlfeldt et al. (2015). Housing supply elasticities are set to $\eta_n = 1.0$ for Vinex neighborhoods and $\eta_n = 0.6$ for all other neighborhoods, corresponding to the most inelastic city in Saiz (2010). Table 9 reports the complete set of calibrated parameters, which remain fixed in our baseline equilibrium and counterfactual exercises.

We then calibrate the model's remaining unobserved fundamentals through an inverse calibration exercise. With workplace amenities $E_i^g$ already identified from the gravity fixed effects, we find the set of fundamentals $\{w_i^g, \bar{A}_i^G, \bar{a}_i^S, B_n^g, \pi_n, \zeta_G, \zeta_S\}$ that ensures the model's equilibrium simultaneously matches the observed data on workplace populations $(L_{W,i}^g)$, residential populations $(L_{R,n}^g)$, wages $(w_i^g)$, and rents $(q_n)$. The productivity calibration proceeds in two stages: we first solve for the effective productivities $A_i^{G,\text{eff}}$ and $a_i^{S,\text{eff}}$ that rationalize the observed post-policy equilibrium, then decompose them into fundamental productivities $\bar{A}_i^G$ and $\bar{a}_i^S$ by stripping out the agglomeration spillover. The fundamentals are held fixed across equilibria; in the counterfactual, effective productivities change because the agglomeration externality responds to the new spatial distribution of employment. The coverage factors $\zeta_G$ and $\zeta_S$ are calibrated as the ratio of aggregate sectoral revenue to aggregate modeled expenditure. The algorithms for this inverse calibration are detailed in Online Appendix D. The resulting spatial distributions of calibrated fundamentals are visualized in Online Appendix Figures C.12 (workplace amenities), D.14 (productivity), and D.15 (residential amenities).

[21] This strategy of calibrating to a post-shock equilibrium to evaluate a counterfactual (i.e., what would the spatial equilibrium look like if the policy had *not* occurred?) is long adopted in the literature (e.g., Caliendo, Dvorkin, and Parro, 2019; Galle, Rodríguez-Clare, and Yi, 2022).

### 6.2 Model Fit

By construction, the calibration ensures that the model exactly matches the observed spatial distributions of workplace employment ($L^g_{W,i}$), residential population ($L^g_{R,n}$), 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.13 plots the model-calibrated wages ($\hat{w}^g_i$) against observed wages, demonstrating a tight fit around the 45-degree line. Figure D.16 further validates the model's commuting predictions by comparing model-predicted joint commuting probabilities against observed shares.

## 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 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 are set to $\eta_n = 1.0$ for Vinex neighborhoods and $\eta_n = 0.6$ for all other neighborhoods, reflecting the substantially more elastic supply on newly released greenfield land relative to established areas.

The counterfactual equilibrium removes the Vinex expansion. We introduce two changes. First, we exclude Vinex neighborhoods, which were undeveloped farmland before the policy, from the feasible choice set by assigning them a prohibitively high rent ($q_n = 10^6$), which drives their equilibrium population and land demand to zero. Second, we set the housing supply elasticity of all remaining neighborhoods to $\eta_n = 0.6$, reflecting the tighter pre-policy regulatory environment in which newly released Vinex land was not yet available.

We solve this counterfactual under two openness scenarios, with algorithms detailed in Online Appendix D:

1. **Closed City:** Total population of both sectors is held fixed at the observed 2015 levels, isolating the pure reallocation effect of the policy.
2. **Semi-Open City:** Counterfactual populations are set below the 2015 baseline to reflect the hypothesis that, without Vinex, the region's population would have grown only at the national rate rather than at the faster rates observed in the Randstad. Specifically, we deflate 2015 populations by the ratio of national to regional employment growth: $s^G = \rho^{\text{nat}}/\rho^G \approx 0.846$ and $s^S = \rho^{\text{nat}}/\rho^S \approx 0.924$, where $\rho^{\text{nat}} = 1.1$ is national population growth and $\rho^G = 1.3$, $\rho^S = 1.19$ are observed regional sectoral growth factors over 1995–2015. The differential scaling reflects the fact that the goods sector experienced stronger Vinex-induced employment growth than the services sector.

We also compute an open-city benchmark in which both $\bar{L}^G$ and $\bar{L}^S$ adjust endogenously until expected utility equals the baseline level. Because the implied population changes are unrealistically large, we report these results in Online Appendix E and focus the main text on the closed and semi-open cases.

### 7.2 Redistribution Effect

**Residential Re-Sorting and the Local Demand Channel** The model decomposes the aggregate price and employment effects documented in Section 4 into the underlying spatial reallocation of residents, workers, and production inputs across neighborhoods. In the closed and semi-open scenarios, the dominant residential response is a substantial reduction in G-Sector residents and residential land demand in neighborhoods adjacent to the new Vinex developments (Figure 9, Rows 1–2; Figure 10, Row 1). This is the model counterpart to the "first-mover" pattern in the data: high-income tradable workers disproportionately sort into the new Vinex housing stock, leaving incumbent nearby neighborhoods with lower residential demand. This sorting is driven by the non-homothetic housing demand structure: G-Sector workers have higher discretionary income and more elastic housing demand, making them the natural buyers of the larger, newly built Vinex homes. S-Sector workers, whose income is closer to the subsistence housing threshold, are less responsive.

S-Sector workers partially backfill these neighborhoods, attracted by the lower rents, but their inflow is quantitatively smaller than the G-Sector outflow (Figure 10, Row 2). In the semi-open case, net in-migration attenuates the decline in G-Sector residents in some locations and amplifies the S-Sector backfilling effect (Figure 9, Rows 1–2, Column 2). As a result, total land demand (residential plus commercial) remains negative in many Vinex-adjacent neighborhoods in the closed and semi-open scenarios (Figure 10, Row 5), even after accounting for the increase in commercial land demand discussed below. This net negative demand shift is the model's main explanation for the nearby price declines documented in the reduced-form evidence. It is important to note, however, that the model predicts average rents decline substantially in both the closed and semi-open scenarios (Figure 11, Row 3), not only in high-income neighborhoods near Vinex. S-Sector residential land demand also declines broadly across the city (Figure 10, Row 2), as some service workers relocate to Vinex or to neighborhoods vacated by G-Sector first-movers. The reduced-form design, which compares high-exposure to zero-exposure neighborhoods within the same municipality, captures only the *differential* price effect above this common decline. The near-zero reduced-form coefficient in low-income areas is therefore consistent with the model: neighborhoods where service workers reside experience lower rents on average through the general equilibrium cost-of-living channel, but they do not lose residents differentially to Vinex (because the new housing stock targets a different market segment), so there is no additional local demand shock to generate a differential price decline detectable by the DiD design.

**Workplace Employment Spillovers** Rows 3–4 of Figure 9 display the spatial distribution of workplace employment by sector. The model predicts that G-Sector employment rises in neighborhoods near Vinex developments. Two model features interact to produce this concentration. First, agglomeration externalities create a positive feedback loop: as G-Sector workers sort into Vinex and nearby residential locations, they raise employment density at nearby workplaces, which increases effective productivity $A_i^{G,\text{eff}}$ through the spatial spillover, attracting further employment. Second, the Armington trade structure accommodates this feedback by allowing the local goods price $p_i^G$ to absorb cost reductions rather than transmitting them entirely into higher wages. Without the Armington structure, productivity gains at a location would raise wages sharply, bidding up local rents and choking off the agglomeration feedback. With location-specific goods prices, the cost reduction is instead partially passed through to consumers city-wide via lower $p_i^G$, keeping local factor costs moderate and sustaining the employment concentration. S-Sector employment grows in the Vinex areas themselves and their immediate surroundings through a distinct channel: the inflow of high-income residents raises local service demand, inducing entry of new service varieties under free entry (equation 22), which in turn lowers the effective service price index $P_n^{S,\text{eff}}$ through a love-of-variety effect and attracts further residents, reinforcing the initial demand shift. This feedback is strongly localized because the high shopping friction for services ($\kappa_S = 0.065$) concentrates expenditure flows near residences. These predictions align with the reduced-form evidence in Section 4, where highly exposed non-Vinex neighborhoods experienced employment growth of over 10%, concentrated in Tradable Services. Importantly, both employment channels arise endogenously from residential sorting and local demand linkages, rather than requiring direct policy incentives for firms.

**Production Reallocation and Land Use** On the production side, the model generates meaningful reallocation even though workplace shifts are more muted than residential shifts. Goods-sector land demand rises in many locations in the closed and semi-open scenarios (Figure 10, Row 3), reflecting factor substitution: when Vinex relaxes land scarcity and lowers rents, land becomes relatively cheaper, and firms optimally substitute toward land. Service-sector commercial land demand also expands near Vinex areas (Figure 10, Row 4), driven by the local demand channel described above.

A key insight from the unified land market is that the observed rent decline is the net effect of reduced residential demand and increased commercial demand. The equilibrium rent $q_n$ (Figure 11, Row 3) declines less than residential demand alone would imply, because rising commercial land demand partially offsets the residential decline. This means that the underlying residential demand shift is larger than what rent changes alone suggest, a decomposition that reduced-form evidence cannot provide.

The model captures firm entry in the service sector through the free-entry condition: as local demand rises near Vinex, new service varieties enter ($M_i$ increases), amplifying the reallocation through the love-of-variety channel. In the goods sector, however, the model features a single

representative firm at each location and does not allow for firm entry or relocation. The observed suburban agglomeration of tradable-services jobs documented in Section 4 likely also reflects establishment-level entry and relocation decisions in the goods sector that lie outside our framework. To the extent that these responses amplify the intensive-margin reallocation captured by the model, our estimates provide a lower bound on the goods-sector employment response.

**Prices, Wages, and the Cost-of-Living Channel** The price adjustments in Figure 11 reveal the primary channel through which Vinex improves welfare. Figure 12 shows the corresponding changes in effective productivity, which rise modestly through the agglomeration channel as employment density increases near Vinex areas. In both the closed and semi-open scenarios, land rents decline on average across neighborhoods (Figure 11, Row 3), by about 12% in the closed city and 4% in the semi-open city (Table 11). These rent declines propagate into output prices, but the transmission differs sharply across sectors.

In the goods sector, the industry supply curve is effectively flat: perfect competition and constant returns to scale mean that firms supply any quantity at unit cost, so demand shifts from residential re-sorting or in-migration move quantities along this flat curve without affecting $p_i^G$. Only the downward shift of the supply curve itself, driven by lower rents entering the unit-cost condition, moves $p_i^G$. Because land accounts for only 7% of production costs ($1-\alpha_G = 0.07$), this shift is small, and average goods prices fall modestly (Figure 11, Row 6). Moreover, the Armington structure means that the effective goods price index $P_n^{G,\text{eff}}$ faced by any resident aggregates prices from all production locations, so even this small local cost change is diluted across many substitutes. In the service sector, the industry supply curve slopes upward: under monopolistic competition with free entry, scaling up the local service sector bids up local factor prices, raising the markup-over-cost price $p_i^S$. When Vinex lowers rents, the supply curve shifts down, and because service demand is locally captive (the high shopping friction $\kappa_S = 0.065$ concentrates expenditure near residences), the price decline is transmitted directly rather than buffered by city-wide substitution. As a result, in the semi-open city, average service prices fall by roughly four times as much as goods prices (Figure 11, Row 4; Table 11).[22] In some locations, the reallocation of S-Sector workers reduces the local mass of service varieties $M_i$ (Row 5), which pushes up the effective service price index through the CES love-of-variety channel, partially offsetting the decline in per-variety prices.

Because both sectors share the same wage equation structure, $d\ln w^g \approx (1/\alpha_g)\, d\ln p^g$, the asymmetry in price declines translates directly into wage differences.[23] G-Sector wages are relatively insensitive to the policy, while S-Sector wages decline more on average but are spatially heterogeneous:

[22] Importantly, the direct cost channel is identical for both sectors; both sectors share the same land share, so a rent decline produces the same first-order cost reduction. The asymmetry arises entirely from general equilibrium amplification in the service sector.

[23] The full log-linearized wage equation is $d\ln w^g \approx (1/\alpha_g)\, d\ln p^g - [(1-\alpha_g)/\alpha_g]\, d\ln q + (1/\alpha_g)\, d\ln A_i^{g,\text{eff}}$. The dominant term is the output price channel ($1/\alpha_g \approx 1.075$); the rent channel (0.075) and agglomeration term are small. Because $\Delta\bar{p}^S \approx 4 \times \Delta\bar{p}^G$, the price asymmetry drives the wage asymmetry. The exact 2.7× wage ratio in Table 11 is a full GE outcome aggregating over 102 heterogeneous locations; this approximation illustrates the dominant channel using city-wide averages.

they rise near Vinex areas where the inflow of high-income G-Sector residents raises local service demand and the local service price $p_i^S$ (Figure 11, Row 2). In both cases, wage declines are more than offset by the fall in rents and consumption prices, so that welfare rises for both worker types.

The welfare gains in the closed and semi-open scenarios therefore operate primarily through the cost-of-living channel (lower rents, goods prices, and service prices) rather than through rising income. Taken together, the model replicates the empirical patterns and explains them through three general equilibrium mechanisms that reduced-form evidence alone cannot identify. First, sector-specific residential re-sorting generates the heterogeneous demand shifts that concentrate price declines in high-income neighborhoods. Second, employment growth near Vinex arises endogenously from this sorting: agglomeration and Armington accommodation concentrate tradable-sector jobs, while the free-entry channel attracts new service establishments. Third, the unified land market implies that observed rent declines understate the true residential demand shift, because increased commercial land demand from both sectors partially offsets the residential decline.

### 7.3 Aggregate Economic Impact and Welfare Analysis

We now turn from spatial redistribution to city-wide outcomes. Tables 10 and 11 summarize the results for the closed and semi-open scenarios. The key finding is that both worker groups benefit from the Vinex expansion, but the magnitude of these gains depends on the degree of population adjustment.

**The "Closed" City.** The closed city isolates the short-run reallocation effect on a fixed incumbent population. Both worker groups gain, with equivalent variations of approximately 3,200 EUR for G-Sector workers and 3,800 EUR for S-Sector workers. The larger gains for S-Sector workers reflect the greater housing cost burden on lower incomes. The gains operate primarily through the cost-of-living channel: average land rents fall by about 12%, which in turn lowers goods prices (through reduced production costs) and service prices. Wages decline by about 1.5% for the G-Sector and 4% for the S-Sector; this asymmetry mirrors the roughly fourfold difference in output price declines between the two sectors, driven by the flat-versus-upward-sloping supply curve distinction discussed above. These wage declines are more than offset by the fall in rents and consumption prices. On the production side, goods-sector revenue declines by about 1.6% as workers re-sort across locations, while real service output remains roughly unchanged. Vinex thus entails a modest reallocation cost on the production side, but the cost-of-living gains dominate, yielding positive net welfare for both worker types.

**The "Semi-Open" City.** The semi-open city captures the medium-run adjustment observed over the 1995–2015 sample period. The post-policy city has roughly 18% more G-Sector workers and 8% more S-Sector workers than the no-Vinex counterfactual. Despite this in-migration, welfare gains remain positive for both groups (EV of approximately 2,200 EUR for G and 2,900 EUR for S). The

per-worker gains are attenuated relative to the closed city by about 25–30%, because in-migration competes for the same land and services that the policy made cheaper, partially bidding up the prices that Vinex lowered. Aggregate welfare gains, however, are larger in the semi-open city because the benefits extend to a substantially bigger population. Crucially, however, prices and wages still fall in both sectors: because the goods supply curve is flat, the demand shift from in-migration raises output quantities but does not push goods prices back up, and the rent-driven cost reduction continues to dominate. In the service sector, although in-migration raises local demand, part of this increase is absorbed by new firm entry rather than by higher per-variety prices, so the rent-driven cost reduction dominates there as well. Average rents nonetheless remain about 4% lower than in the no-Vinex counterfactual. This scenario captures the empirically relevant middle ground: Vinex both improves affordability for incumbents and supports a moderately larger city with higher aggregate output in both sectors.

# 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 a 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 showed no differential price change. At the same time, Vinex stimulated sizable local employment growth, especially in Tradable Services. Although employment data do not permit pre-trend validation, placebo tests and the sectoral concentration of effects support a causal interpretation. These findings show that major supply expansions influence not only housing markets but also the geography of economic activity.

A quantitative spatial equilibrium model replicates these patterns and explains them through three general equilibrium mechanisms that reduced-form evidence alone cannot identify: sector-specific residential re-sorting that concentrates price declines in affluent areas, endogenous employment growth driven by agglomeration and free entry rather than direct policy intervention, and a unified land market in which commercial demand partially offsets residential declines. The same non-homothetic preference structure that drives sorting (high-income workers respond more to new supply) also generates the distributional welfare pattern: service-sector workers gain proportionally more because housing costs absorb a greater share of their lower incomes. In both the short-run closed-city and empirically relevant semi-open scenarios, welfare gains are positive for both worker types, operating primarily through lower rents and local prices rather than higher incomes. In the semi-open case, in-migration attenuates per-worker gains but the policy still delivers lower rents, higher output, and positive welfare for all workers. An open-city benchmark in the appendix shows that full population adjustment would compete away the affordability improvements.

For policymakers, the key insight is that reduced-form price comparisons may substantially

understate the benefits of supply expansions for low-income households. The model shows that average rents decline broadly in both scenarios, but the reduced-form design cannot detect this common decline because it is shared by treated and control areas alike. Service-sector workers gain proportionally more in the welfare analysis, precisely because the cost-of-living decline benefits those for whom housing absorbs a larger share of income. More broadly, large-scale housing programs should be evaluated not only by the number of units delivered but also by how they reshape the broader urban equilibrium.

Our findings derive from a centrally planned program in a compact, well-connected urban system. The mechanisms we identify are likely to operate in other settings where new supply targets similar market segments, though the magnitudes will depend on local planning institutions, housing market structure, and the degree of city openness to migration.

## References


Agarwal, S., J. B. Jensen, and F. Monte. 2020. Consumer mobility and the local structure of consumption industries. Working Paper.

Ahlfeldt, G. M., S. J. Redding, D. M. Sturm, and N. Wolf. 2015. The economics of density: Evidence from the berlin wall. *Econometrica* 83:2127–89.

Ahlfeldt, G., I. Mulalic, C. Soto Vieira, and D. M. Sturm. 2025. The geography of life: Evidence from Copenhagen.

Allen, T., and C. Arkolakis. 2014. Trade and the topography of the spatial economy. *Quarterly Journal of Economics* 129:1085–140.

Asquith, B. J., E. Mast, and D. Reed. 2023. Local effects of large new apartment buildings in low-income areas. *Review of Economics Statistics* 1–17.

Baum-Snow, N., N. Gendron-Carrier, and R. Pavan. 2024. Local productivity spillovers. *American Economic Review* 114:1030–69.

Baum-Snow, N., and L. Han. 2023. The microgeography of housing supply. *Journal of Political Economy* Forthcoming.

Bayer, P., K. Magnum, and J. W. Roberts. 2021. Speculative fever: Investor contagion in the housing bubble. *American Economic Review* 111:609–51.

Boeijenga, J., and J. Mensink. 2008. *Vinex atlas*. 010.

Boustan, L. P. 2010. Was postwar suburbanization "white flight"? evidence from the black migration. *Quarterly Journal of Economics* 125:417–43.

Bratu, C., O. Harjunen, and T. Saarimaa. 2022. City-wide effects of new housing supply: Evidence from moving chains.

Caliendo, L., M. Dvorkin, and F. Parro. 2019. Trade and labor market dynamics: General equilibrium analysis of the china trade shock. *Econometrica* 87:741–835.

Caliendo, L., F. Parro, E. Rossi-Hansberg, and P.-D. Sarte. 2018. The impact of regional and sectoral productivity changes on the U.S. economy. *Review of Economic Studies* 85:2042–96.

Chorodow-Reich, G., A. Guren, and T. J. McQuade. 2024. The 2000s housing cycle with 2020 hindsight: A neo-kindlebergerian view. *Review of Economic Studies* 91:785–816.

Couture, V., C. Gaubert, J. Handbury, and E. Hurst. 2019. Income growth and the distributional effects of urban spatial sorting. Tech. rep., National Bureau of Economic Research.

Derenoncourt, E. 2022. Can you move to opportunity? evidence from the great migration. *American Economic Review* 112(2):369–408.

Diamond, R. 2016. The determinants and welfare implications of us workers' diverging location choices by skill: 1980–2000. *American Economic Review* 106:479–524.

Diamond, R., and J. C. Suárez Serrato. 2025. Spatial sorting and inequality. In *Handbook of Regional and Urban Economics*. NBER Working Paper No. 33609.

Fajgelbaum, P. D., and C. Gaubert. 2020. Optimal spatial policies, geography, and sorting. *Quarterly Journal of Economics* 135:959–1036.

Faludi, A., and A. J. Van der Valk. 1994. *Rule and order dutch planning doctrine in the twentieth century*, vol. 28. Springer Science & Business Media.

Favilukis, J., and S. Van Nieuwerburgh. 2021. Out-of-town home buyers and city welfare. *Journal of Finance* 76:2577-2638–.

Galle, S., A. Rodríguez-Clare, and M. Yi. 2022. Slicing the pie: Quantifying the aggregate and distributional effects of trade. *The Review of Economic Studies* 90:331–75.

Gyourko, J., A. Saiz, and A. Summers. 2008. A new measure of the local regulatory environment for housing markets: The wharton residential land use regulatory index. *Urban Studies* 45(3).

Hanson, G. H., and E. Moretti. 2025. Where have all the good jobs gone? changes in the geography of work in the us, 1980-2021.

Heblich, S., S. J. Redding, and D. M. Sturm. 2020. The making of the modern metropolis: Evidence from london. *Quarterly Journal of Economics* 135:2059–133.

Hsieh, C.-T., and E. Moretti. 2019. Housing constraints and spatial misallocation. *American Economic Journal: Macroeconomics* 11:1–39.

Kaplan, G., K. Mitman, and G. Violante. 2020. The housing boom and bust: Model meets evidence. *Journal of Political Economy* 128:3285–345.

Levkovich, O., J. Rouwendal, and L. Brugman. 2018. Spatial planning and segmentation of the land market: The case of the netherlands. *Land Economics* 94:137–54. doi:10.3368/le.94.1.137.

Louie, S., J. A. Mondragon, and J. Wieland. 2025. Supply constraints do not explain house price and quantity growth across us cities. Tech. rep., National Bureau of Economic Research.

Mast, E. 2022. The effect of new market-rate housing construction on the low-income housing market.

Ministerie van VROM. 1991. Vierde nota over de ruimtelijke ordening extra (vinex). Tech. Rep. 21 879, nrs. 1–2, Tweede Kamer der Staten-Generaal, Den Haag. Kamerstukken Tweede Kamer, vergaderjaar 1990–1991.

Miyauchi, Y., K. Nakajima, and S. J. Redding. 2025. Consumption access and the spatial concentration of economic activity: Evidence from smartphone data. *Quarterly Journal of Economics* 140:407–61.

Monte, F., S. J. Redding, and E. Rossi-Hansberg. 2018. Commuting, migration, and local employment elasticities. *American Economic Review* 108:3855–90.

Nathanson, C., and E. Zwick. 2018. Arrested development: Theory and evidence of supply-side speculation in the housing market. *Journal of Finance* 73(6):2587–633.

Owens, R., E. Rossi-Hansberg, and P.-D. Sarte. 2020. Rethinking Detroit. *American Economic Journal: Economic Policy* 12:258–305.

Pennington, K. 2022. The spatial impact of new housing on rents, displacement, and gentrification: Evidence from san francisco.

Pojani, D., and D. Stead. 2018. Past, present and future of transit-oriented development in three european capital city-regions. In *Advances in Transport Policy and Planning*, vol. 1, 93–118. Elsevier. doi:10.1016/bs.atpp.2018.07.003.

Redding, S. J., and E. Rossi-Hansberg. 2017. Quantitative spatial economics. *Annual Review of Economics* 9:21–58. doi:10.1146/annurev-economics-063016-103713.

Ruimtelijk Planbureau. 2006. *Woningproductie ten tijde van vinex: een verkenning.* NAi Uitgevers.

Saiz, A. 2010. The geographic determinants of housing supply. *Quarterly Journal of Economics* 125(3):1253–96.

Schubert, G. 2022. House price contagion and u.s. city migration networks.

Severen, C. 2023. Commuting, labor, and housing market effects of mass transportation: Welfare and identification. Review of Economics and Statistics, forthcoming.

Su, Y. 2022. The rising value of time and the origin of urban gentrification. *American Economic Journal: Economic Policy* 14:402–39.

Tsivanidis, J. N. 2018. The aggregate and distributional effects of urban transit infrastructure: Evidence from bogotá's transmilenio. *Unpublished manuscript* .

Valentinyi, Á., and B. Herrendorf. 2008. Measuring factor income shares at the sectoral level. *Review of Economic Dynamics* 11:820–35.

van der Krabben, E., and H. M. Jacobs. 2013. Public land development as a strategic tool for redevelopment: Reflections on the dutch experience. *Land Use Policy* 30:774–83.

van der Krabben, E., and J. van Dinteren. 2010. Public development of industrial estates in the netherlands: Undesired market outcomes and policy interventions. *Tijdschrift voor Economische en Sociale Geografie* 101:91–9. doi:10.1111/j.1467-9663.2009.00589.x.

Van der Wouden, H. C. 2015. *De ruimtelijke metamorfose van nederland 1988-2015: het tijdperk van de vierde nota*. Nai010 uitgevers/publishers.

van Wee, B., and K. Maat. 2003. Land-use and transport: A review and discussion of dutch research. *European Journal of Transport and Infrastructure Research* 3:199–218. doi:10.18757/ejtir.2003.3.2.3687.

Zárate, R. D. 2022. Spatial misallocation, informality, and transit improvements: Evidence from Mexico City. Working Paper.

## Figures and Tables

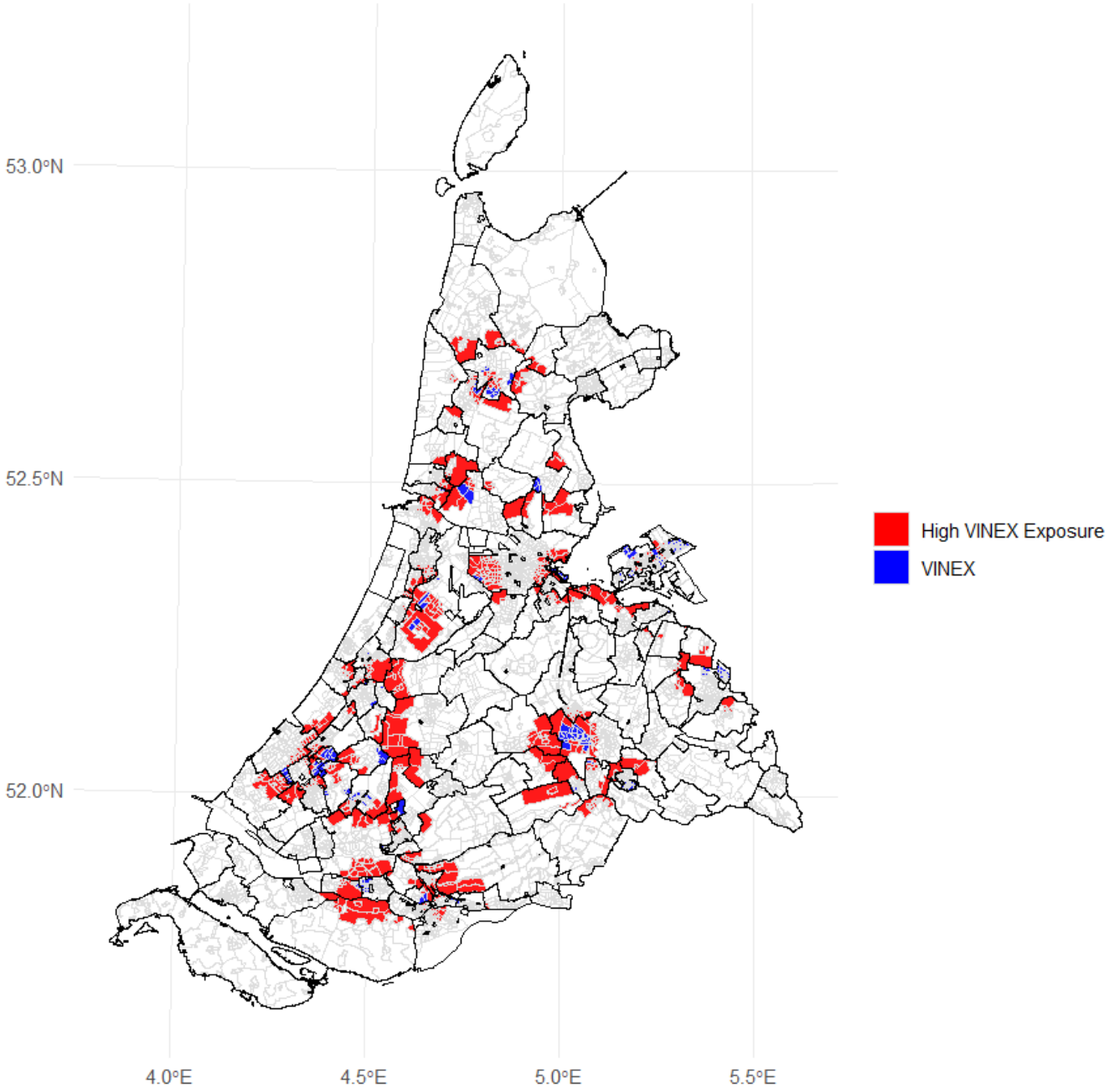
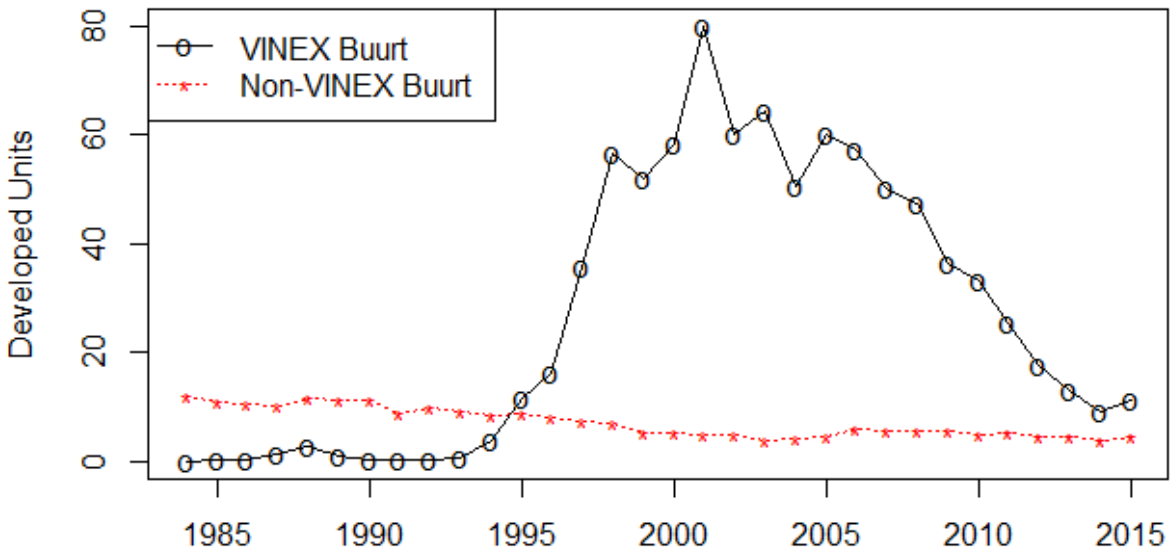
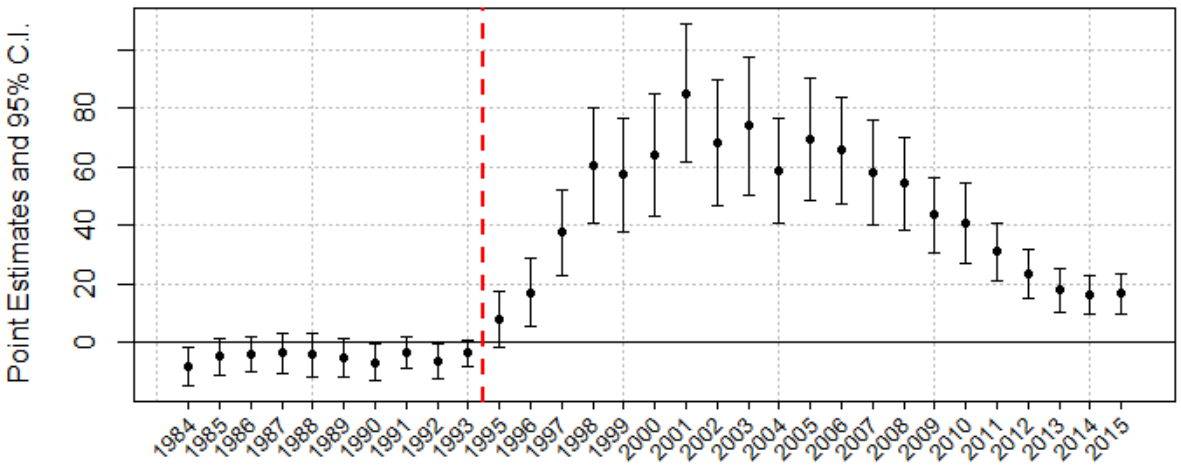



Figure 1: **Spatial Distribution of Vinex and Vinex-Exposed Neighborhoods.** The figure shows the locations of Vinex buurts and highly-exposed neighborhoods within municipalities, which are defined in Section 4.1. Vinex buurts are highlighted in blue, while buurts with high Vinex exposure (top quartile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

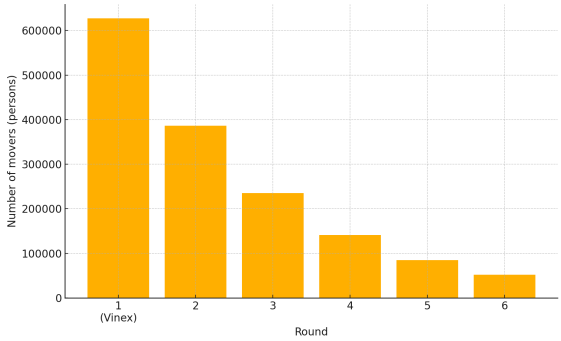



(a) Raw Averages: Developed Units

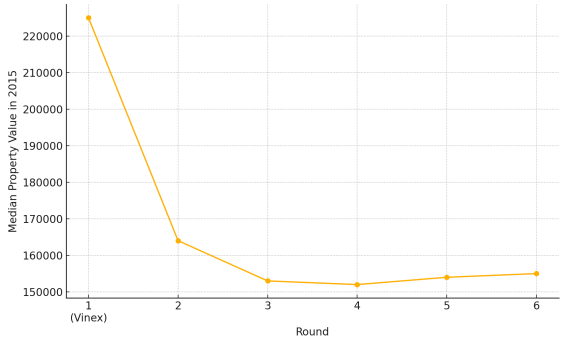



(b) Difference-in-Differences Vinex Developed Units

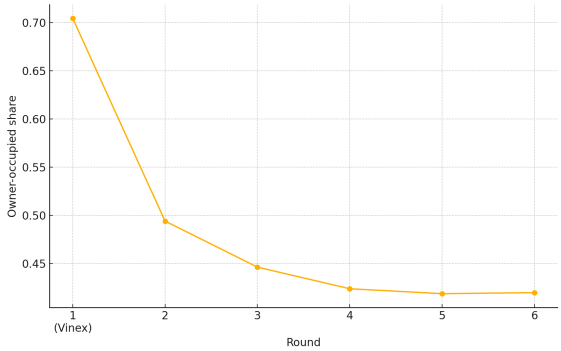
Figure 2: **The Vinex Supply Shock.** The figure displays the gap in the number of developed units between Vinex and non-Vinex buurts between 1984 and 2015. Panel (a) displays the average number of new housing units developed across buurts. Panel (b) shows the excess number of units developed on average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



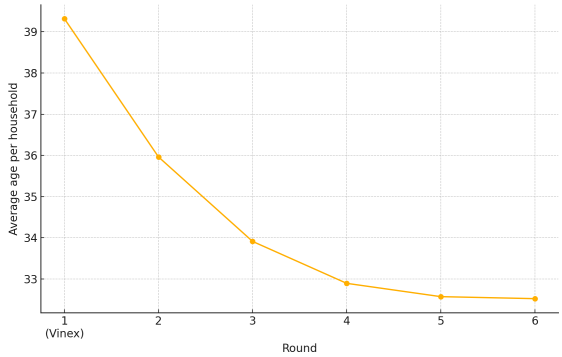

(a) Number of movers per round



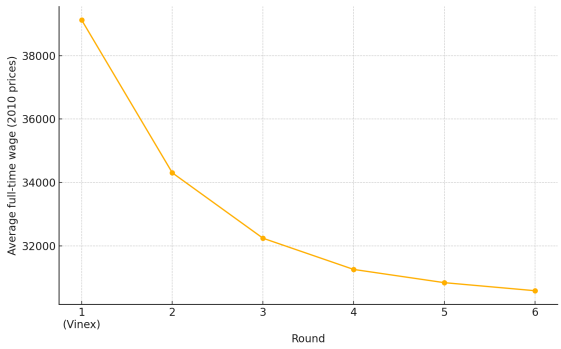

(b) Median property value per round (2015)



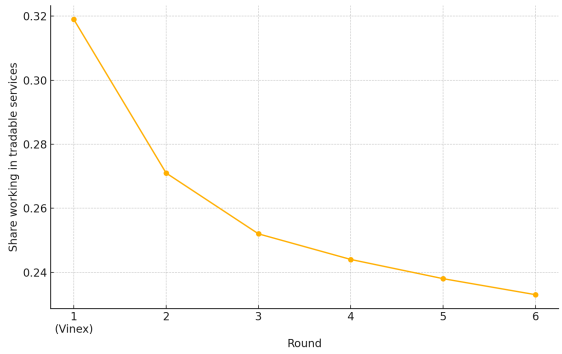

(c) Owner-occupied share per round




(d) Average age per household per round

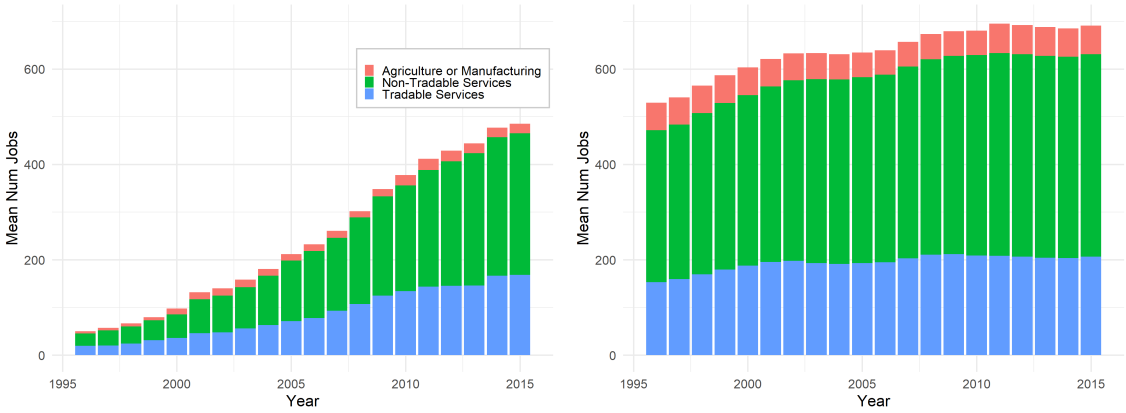



(e) Average full-time wage (2010 prices)




(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.

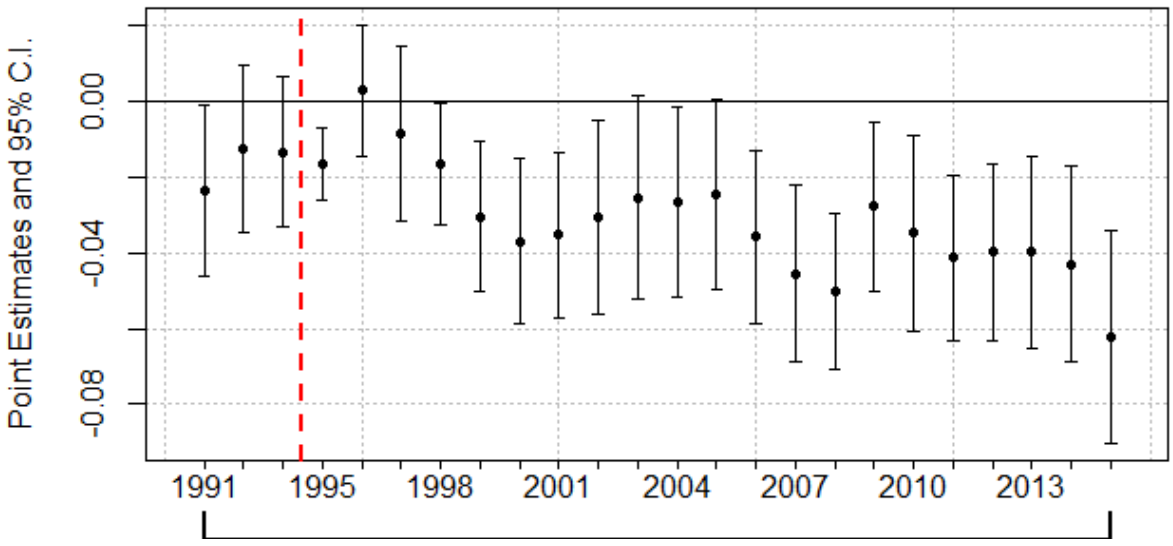
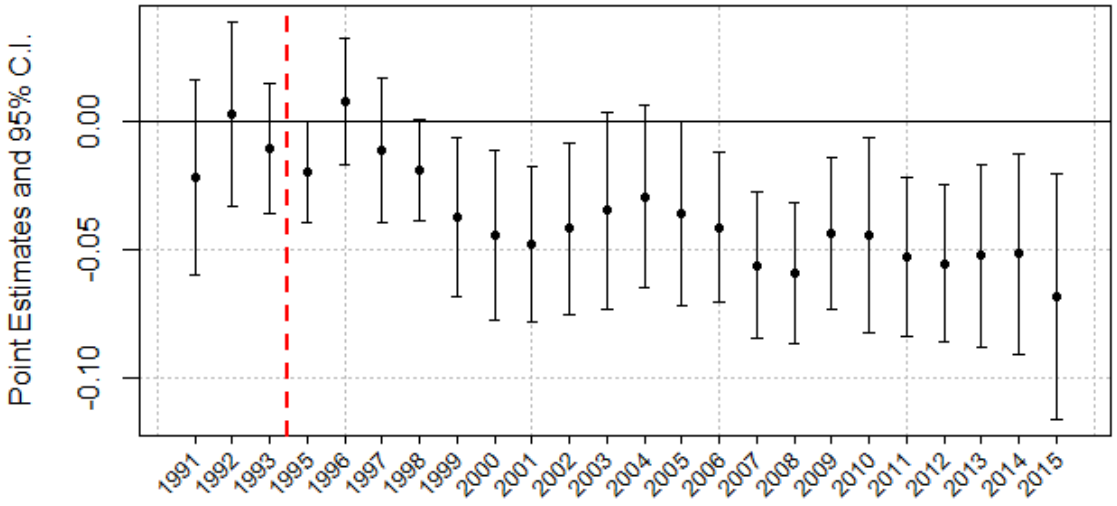



Figure 5: Effects on Prices in Non-Vinex Neighborhoods.

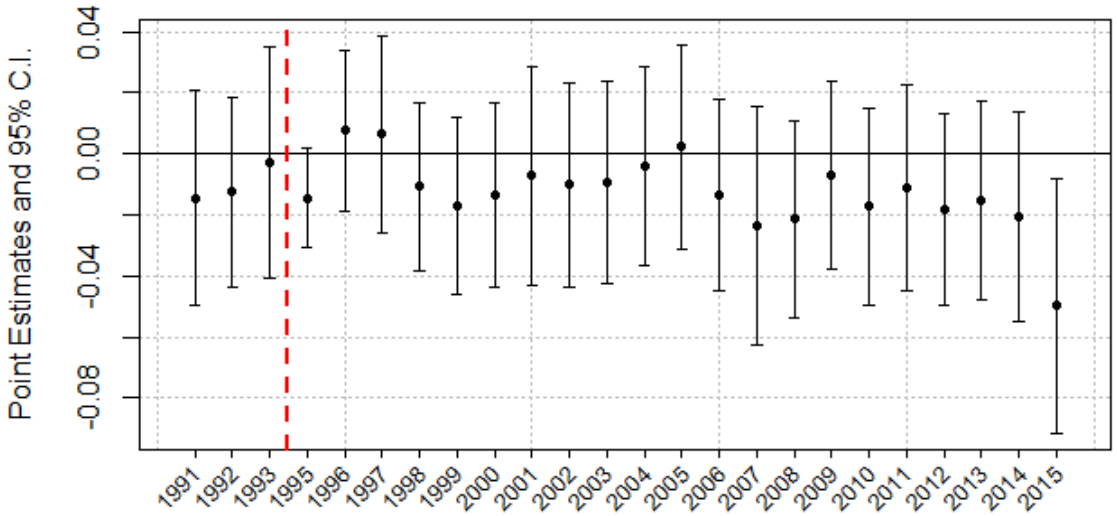
The figure displays estimates from the following regression equation:

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

where $\log(p_{i,\tau})$ is the log sales price of property $i$ in year $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one in year $\tau$, and $a_b$ and $a_{muni,t}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for $d_\tau$ based on the restricted sample of buurts 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 $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one in year $\tau$, $I_{HighInc}$ 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 $a_{muni,\tau}$ 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 $f_\tau$, while panel (b) displays estimates of $g_\tau$. The omitted coefficients $f_{1995}$ and $g_{1995}$ are equal to zero.

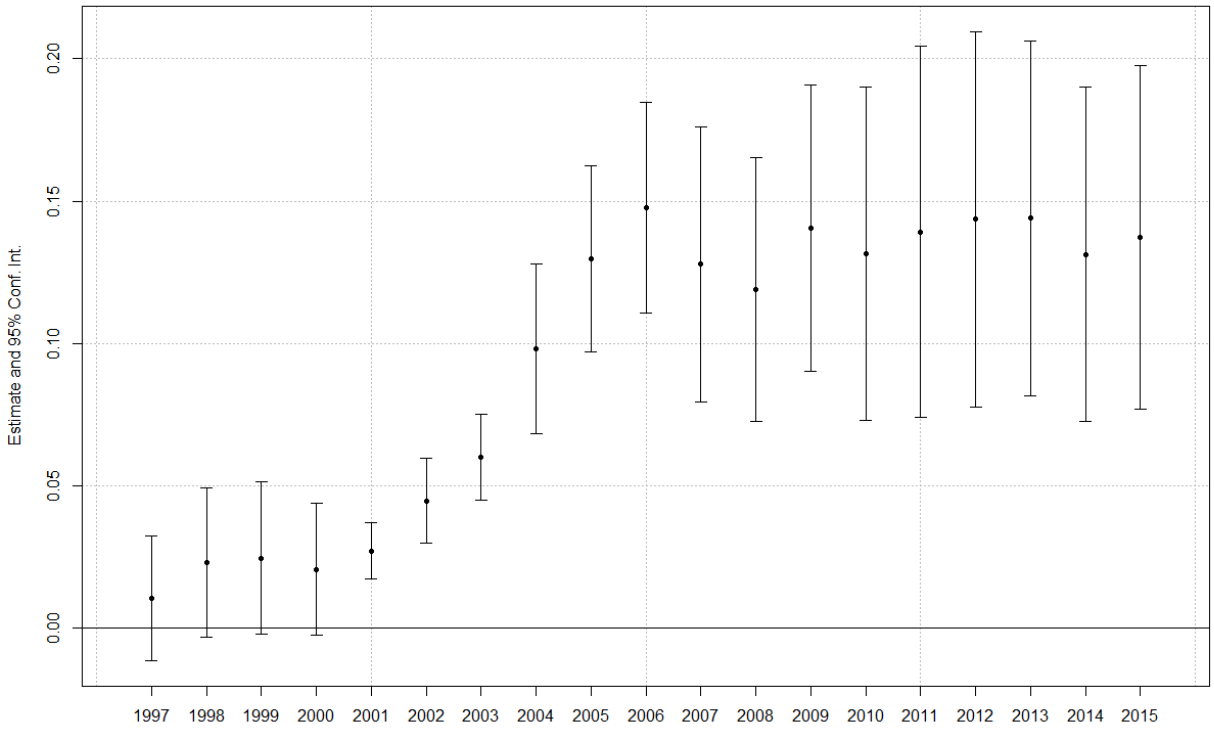
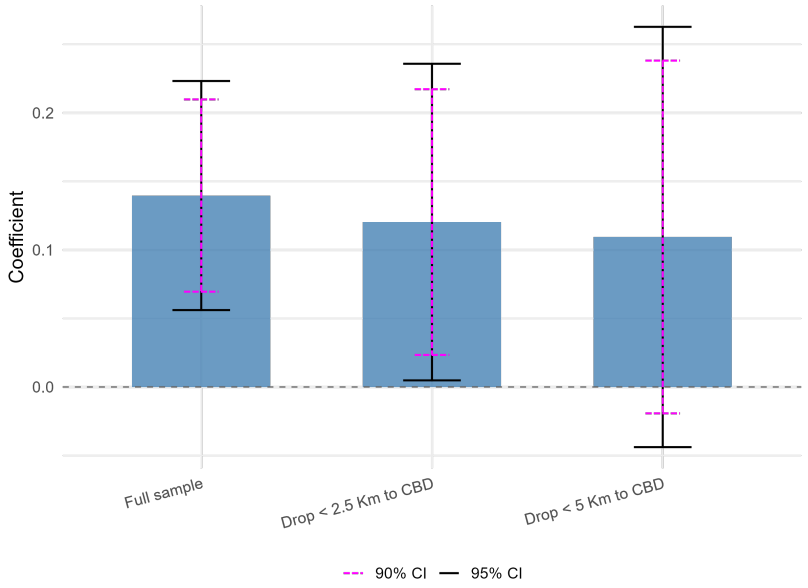



Figure 7: Effects on Jobs in Non-Vinex Neighborhoods.

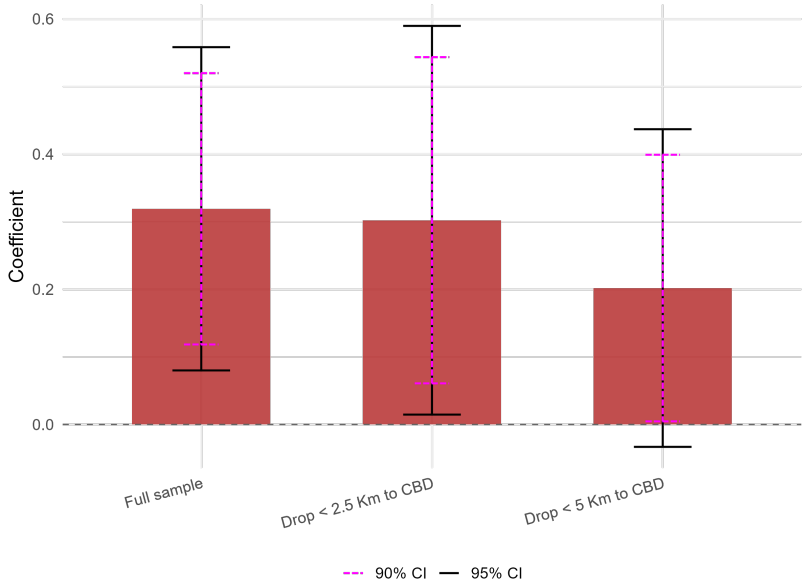
The figure displays estimates from the following Poisson regression specification:

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

where $NJobs_{b,\tau}$ is number of jobs located in non-Vinex buurt $b$ in year $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one in year $\tau$, and $a_b$ and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for $g_\tau$ 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.




(a) All Jobs




(b) Tradable Services Jobs

Figure 8: Effects on Jobs in Non-Vinex Neighborhoods by CBD Distance.

The figure displays estimates of the coefficient $g_{end}$ from the following Poisson regression specification:

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

where $NJobs_{b,\tau}$ is either the total number of jobs (panel a) or the total number of jobs Tradable Services (panel b) in buurt $b$ and year $\tau$, $I_{HighVinex}$ 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 one in 2015, and $a_b$ and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. Estimates are based on observations from 1996 and 2015 only. From left to right, the sample first includes all buurts with high or zero exposure to Vinex, then excludes buurts within 2.5 km of a central business district, and buurts within 5 km of a central business district.

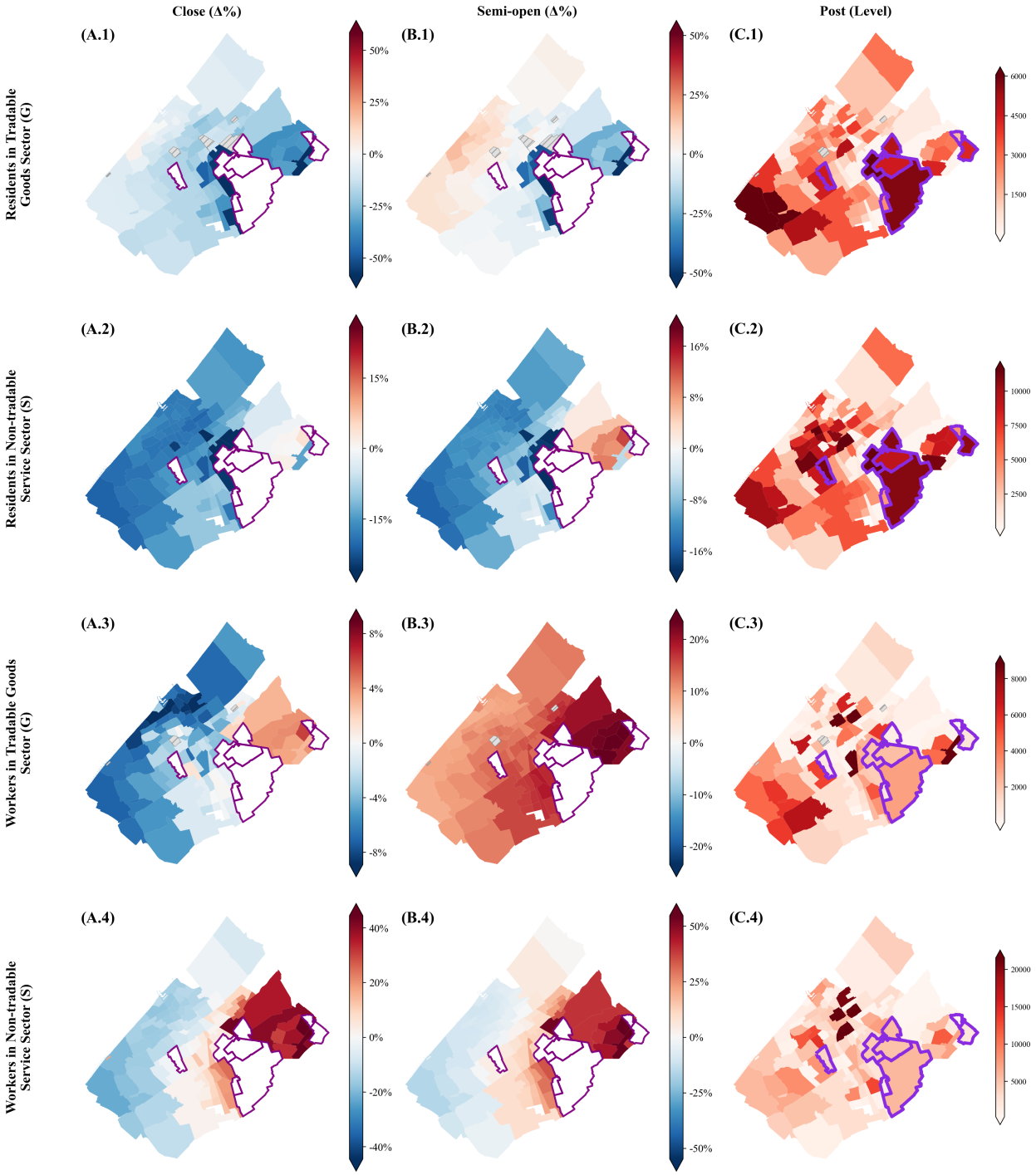



Figure 9: **Spatial Re-sorting of Residents and Workers.** The first two columns report the percentage change in the post-shock equilibrium relative to the no-Vinex (pre-shock) counterfactual under the closed-city and semi-open-city scenarios. The third column reports post-shock equilibrium levels. Rows 1–2 show the residential population of G-Sector and S-Sector workers ($L^G_{R,n}$, $L^S_{R,n}$), while Rows 3–4 show workplace employment by sector ($L^G_{W,i}$, $L^S_{W,i}$). Vinex neighborhoods are outlined in magenta. Neighborhoods with fewer than 50 sector-specific workers are masked (gray hatching).

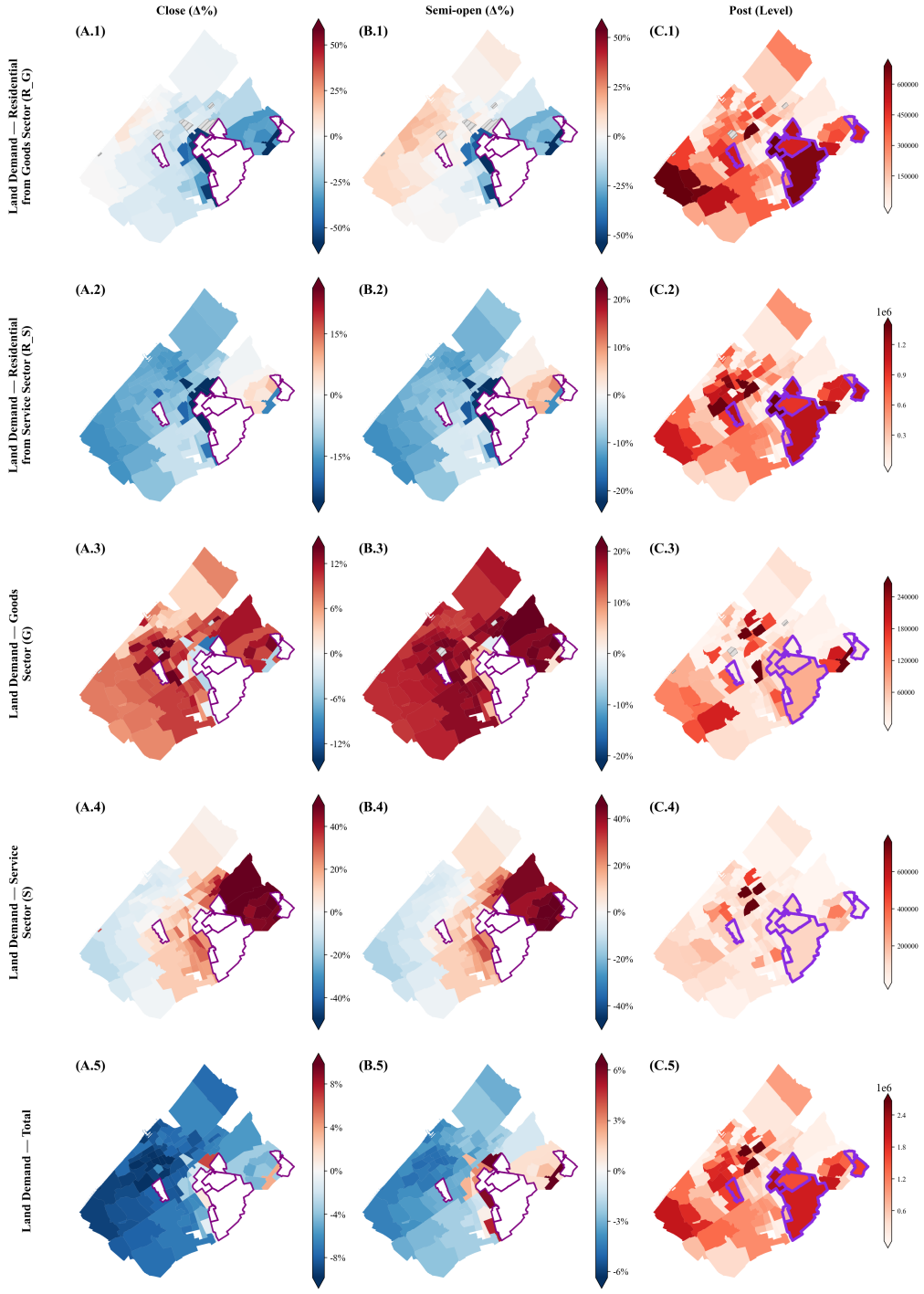



Figure 10: **Residential and Production Land Demand.** The first two columns report the percentage change in the post-shock equilibrium relative to the no-Vinex (pre-shock) counterfactual under the closed-city and semi-open-city scenarios. The third column reports post-shock equilibrium levels. Rows 1–2 show residential land demand by G-Sector and S-Sector residents, Rows 3–4 show commercial land demand in the tradable-goods ($D_n^G$) and non-tradable service ($D_n^S$) sectors, and Row 5 shows total land demand ($D_n^{\text{total}}$). Vinex neighborhoods are outlined in magenta.

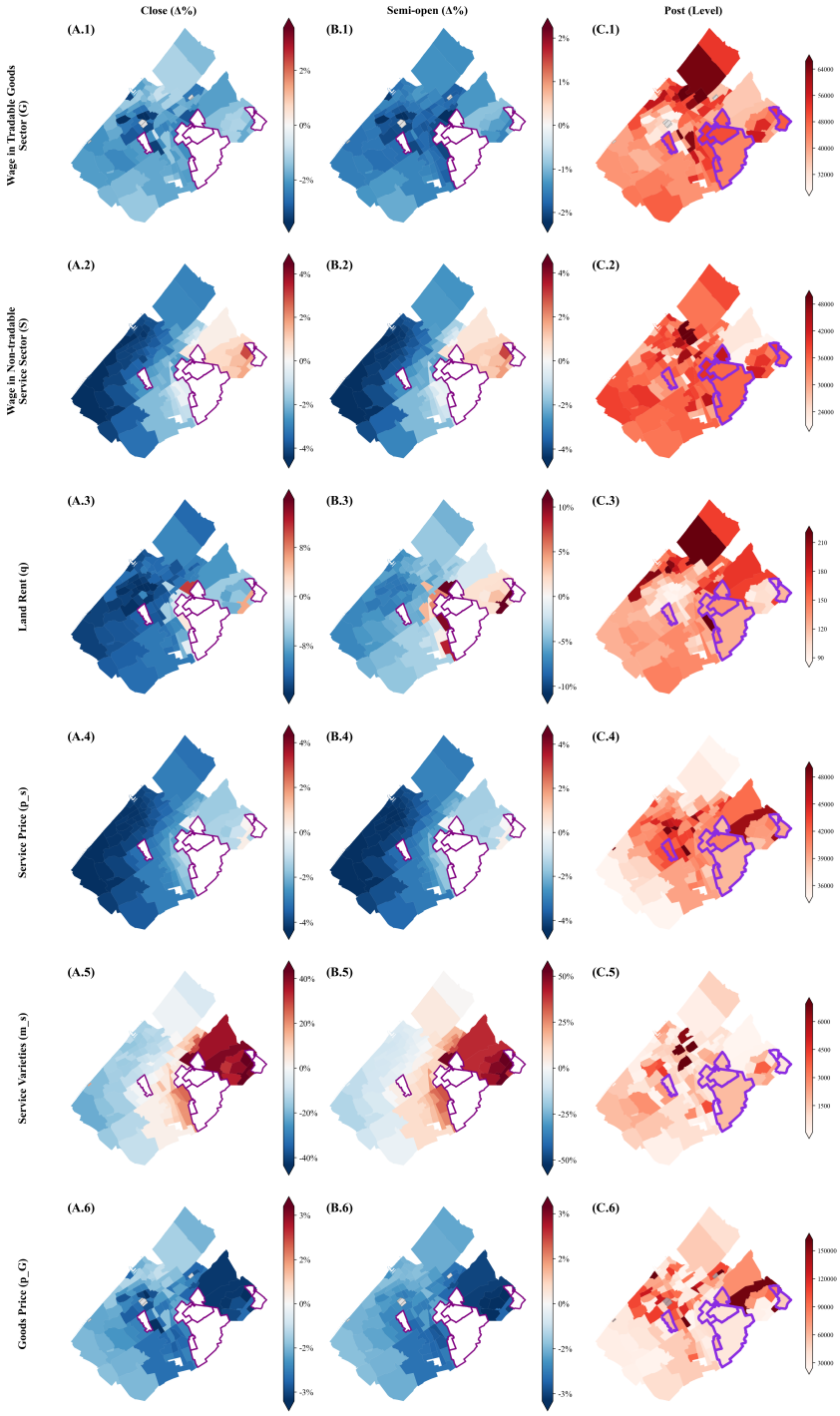



Figure 11: **Equilibrium Wages, Rents, Prices, and Variety.** The first two columns report the percentage change in the post-shock equilibrium relative to the no-Vinex (pre-shock) counterfactual under the closed-city and semi-open-city scenarios. The third column reports post-shock equilibrium levels. Row 1: G-Sector wages ($w_i^G$). Row 2: S-Sector wages ($w_i^S$). Row 3: land rent ($q_n$). Row 4: service prices ($p_i^S$). Row 5: mass of service varieties ($M_i$). Row 6: goods prices ($p_i^G$). Vinex neighborhoods are outlined in magenta.

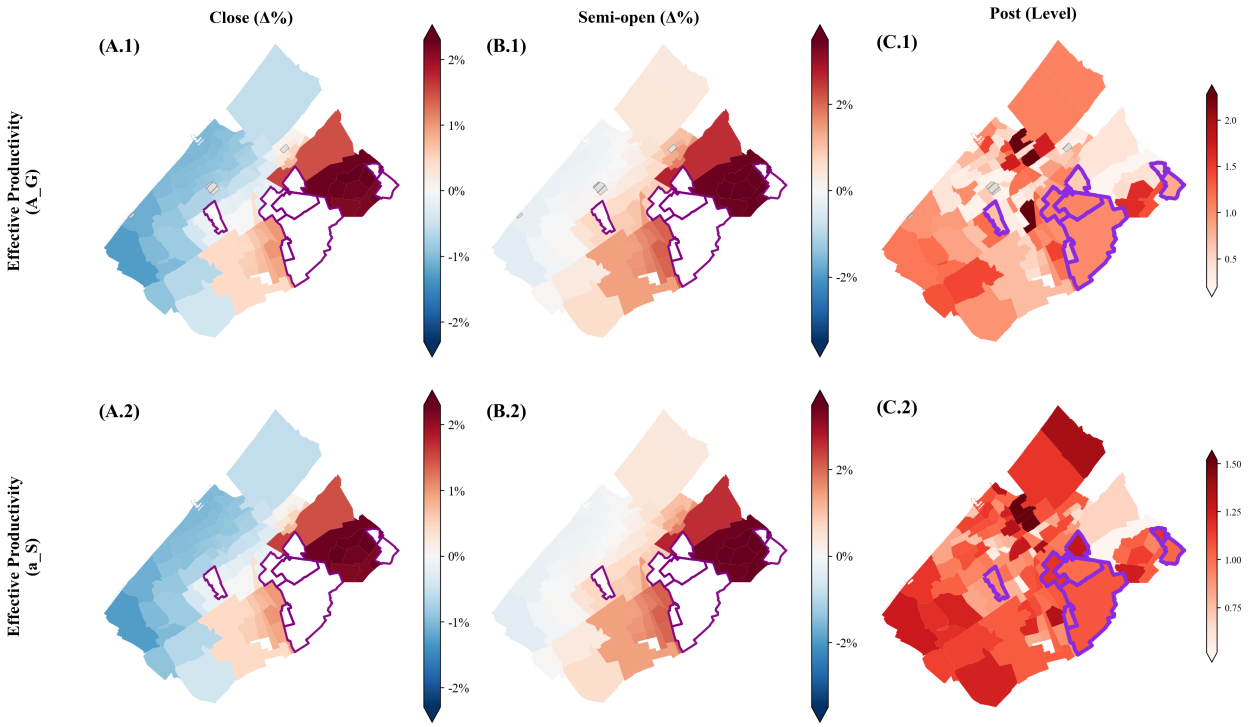



Figure 12: **Effective Productivity Across Sectors.** The first two columns report the percentage change in the post-shock equilibrium relative to the no-Vinex (pre-shock) counterfactual under the closed-city and semi-open-city scenarios. The third column reports post-shock equilibrium levels. Row 1 shows effective productivity in the tradable-goods sector ($A_i^{G,\text{eff}}$), and Row 2 shows effective productivity in the non-tradable service sector ($a_i^{S,\text{eff}}$). Effective productivity combines fundamental productivity with the urbanization externality. Vinex neighborhoods are outlined in magenta.

Table 1: Summary Statistics

| | Panel A: New Construction By Buurt and Year | | | | |
|---|---|---|---|---|---|
| | Q1 | Median | Mean | Q3 | Observations |
| 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 | | | | |
| | Q1 | Median | Mean | Q3 | Observations |
| 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 | | | | |
| | Q1 | Median | Mean | Q3 | Observations |
| 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 | | | | |
| | Q1 | Median | Mean | Q3 | Observations |
| 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. The table displays the relationship between buurt-level mean price growth between 1991 and 1995, and post-1994 exposure to Vinex development for non-Vinex buurts, 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 buurts that are in the top 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: Pre-Vinex Real Estate Stock and Vinex Locations

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Panel A: Service Area | | | | | | | |
| Dependent Variable: | Log(Stock 1994) | | | | Ratio (Constr. 1985-1994/Stock 1994) | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $ShareVinex_{5km}$ | 0.9162 | | -0.3916 | | 1.324*** | | 0.7684 | |
| | (0.7295) | | (2.216) | | (0.1630) | | (0.5005) | |
| $I_{HighVinex}$ | | -0.0009 | | -0.0770 | | 0.0175 | | 0.0199 |
| | | (0.0707) | | (0.0894) | | (0.0159) | | (0.0208) |
| *Fixed-effects* | | | | | | | | |
| Municipality | | | Yes | Yes | | | Yes | Yes |
| Observations | 4,003 | 4,003 | 4,003 | 4,003 | 3,781 | 3,781 | 3,781 | 3,781 |
| $R^2$ | 0.00039 | $3.7 \times 10^{-8}$ | 0.20131 | 0.20155 | 0.01715 | 0.00032 | 0.10101 | 0.09964 |
| | Panel B: Commercial Real Estate Area | | | | | | | |
| Dependent Variable: | Log(Stock 1994) | | | | Ratio (Constr. 1985-1994/Stock 1994) | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $ShareVinex_{5km}$ | 0.1627 | | -1.369 | | 1.115*** | | 0.5961 | |
| | (0.9131) | | (2.090) | | (0.1508) | | (0.5697) | |
| $I_{HighVinex}$ | | 0.0672 | | -0.0217 | | 0.0072 | | 0.0086 |
| | | (0.0874) | | (0.1357) | | (0.0146) | | (0.0156) |
| Municipality | | | Yes | Yes | | | Yes | Yes |
| Observations | 4,811 | 4,811 | 4,811 | 4,811 | 4,452 | 4,452 | 4,452 | 4,452 |
| $R^2$ | $6.6 \times 10^{-6}$ | 0.00012 | 0.18371 | 0.18358 | 0.01212 | $5.45 \times 10^{-5}$ | 0.09327 | 0.09229 |
| | Panel C: Residential Real Estate Area | | | | | | | |
| Dependent Variable: | Log(Stock 1994) | | | | Ratio (Constr. 1985-1994/Stock 1994) | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $ShareVinex_{5km}$ | 2.068*** | | 1.006 | | 1.345*** | | 0.9800* | |
| | (0.6893) | | (2.028) | | (0.1115) | | (0.5519) | |
| $I_{HighVinex}$ | | -0.0489 | | -0.1057 | | 0.0095 | | 0.0077 |
| | | (0.0661) | | (0.1141) | | (0.0108) | | (0.0122) |
| *Fixed-effects* | | | | | | | | |
| Municipality | | | Yes | Yes | | | Yes | Yes |
| Observations | 4,966 | 4,966 | 4,966 | 4,966 | 4,966 | 4,966 | 4,966 | 4,966 |
| $R^2$ | 0.00181 | 0.00011 | 0.12286 | 0.12319 | 0.02849 | 0.00015 | 0.11544 | 0.11080 |

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

*Notes:* Standard errors, double-clustered by municipality and year, are reported in parentheses. The table displays the relationship between buurt-level measure of pre-1994 non-residential and residential stock and development of buildings, and post-1994 exposure to Vinex development for non-Vinex buurts, based on the following regression specification:

$$B_b = \delta ExposureVinex_b + a_{muni} + e_b,$$

where $B_b$ is either the log of service (panel A), commercial (panel B), or residential area measured in sqm as of 1994, or the ratio of new square meters added between 1985 and 1994, and the stock in 1994. 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 buurts that are in the top 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 4: 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. 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 5: 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. The table displays estimates from the following regression specification:

$$\log(S_{b,5Km,1995:2015}/S_{b,5Km,1984:1994}) = \gamma ExposureVinex_{b,5km} + g_{muni} + v_b$$

where $S_{b,5Km,1996:2015}$ ($S_{b,5Km,1984:1995}$) is the number of new units built between 1995 and 2015 (1984 and 1994) within a 5Km radius of non-Vinex buurt $b$, and $g_{muni}$ is a municipality fixed effect.

Table 6: 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. 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 7: 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. 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, 3, and 5 display estimates from the 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 $\tau$, $I_{HighVinex}$ 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:

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

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 8: 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:* Standard errors, double-clustered by municipality and year, are reported in parentheses. 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 following 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 (columns 1 and 2), the total number of jobs in Agriculture or Manufacturing (column 3), Non-Tradable Services (column 4), Tradable Services (column 5) in buurt $b$ and year $\tau$, $I_{HighVinex}$ 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 9: Parameter Values

| Parameter | Description | Internal | Value | Source / target |
|---|---|---|---|---|
| **Production** | | | | |
| $\alpha_G,\ \alpha_S$ | Labor share | Y | 0.93 | $1-\alpha = 7\%$ land share; Appendix C.1 |
| $\sigma_G,\ \sigma_S$ | Elasticity of substitution | N | 4 | Monte, Redding, and Rossi-Hansberg (2018); Appendix C.4 |
| $f$ | Fixed cost, service entry | N | 1 | Normalization |
| **Preferences** | | | | |
| $\beta^G, \gamma^G, \bar{h}^G$ | G-worker expenditure shares & min. housing | Y | 0.491, 0.342, 58.55 | Engel curve regression; Appendix C.2 |
| $\beta^S, \gamma^S, \bar{h}^S$ | S-worker expenditure shares & min. housing | Y | 0.487, 0.340, 59.46 | Engel curve regression; Appendix C.2 |
| **Spatial mobility** | | | | |
| $\epsilon^G,\ \epsilon^S$ | Fréchet dispersion | Y | 16.38, 3.24 | PPML commuting gravity; Appendix C.3 |
| $\nu^G,\ \nu^S$ | Commuting-cost coefficient | Y | 0.187, 0.211 | PPML commuting gravity; Appendix C.3 |
| $\kappa_G,\ \kappa_S$ | Commuting sensitivity | Y | 0.011, 0.065 | Derived: $\kappa_g = \nu^g/\epsilon^g$ |
| $\kappa^{\text{shop},G},\ \kappa^{\text{shop},S}$ | Shopping friction | N | 0.011, 0.065 | Ex post validation: Appendix C.5 |
| **Agglomeration** | | | | |
| $\delta_G,\ \delta_S$ | Spillover spatial decay | N | 0.36 | Ahlfeldt et al. (2015); Appendix C.4 |
| $\psi_G,\ \psi_S$ | Agglomeration elasticity | N | 0.07 | Ahlfeldt et al. (2015); Appendix C.4 |
| **Housing supply** | | | | |
| $\eta_n$ | Supply elasticity | N | 0.6 or 1.0 | Non-Vinex: 0.6 (Saiz, 2010); Vinex: 1.0; Appendix C.6 |
| $\zeta_G,\ \zeta_S$ | Coverage factor | Y | 0.879, 2.547 | Calibrated: $R_g/\sum_m \text{budget}_m^g$; Appendix D |
| **Calibrated fundamentals ($N = 102$ locations)** | | | | |
| $\bar{A}_i^G,\ \bar{a}_i^S$ | Sector productivity | Y | $N$ locations | Market clearing inversion; Appendix D.2, Algorithms 2–3 |
| $B_n^G,\ B_n^S$ | Residential amenity | Y | $2 \times N$ locations | Residence matching; Appendix D.3, Algorithm 4 |
| $E_i^G,\ E_i^S$ | Workplace amenity | Y | $2 \times N$ locations | PPML workplace fixed effects; Appendix C.3 |
| $\pi_n$ | Land supply shifter | Y | $N$ locations | Land market clearing; Appendix D.3, Algorithm 5 |

*Notes:* This table reports all parameters used in the quantitative spatial model. "Internal" indicates whether the parameter is calibrated or estimated within the model (Y) or set externally from the literature or by normalization (N). $N = 102$ denotes the number of neighborhoods in The Hague metropolitan area. All monetary values are in 2015 euros. See Appendix C for calibration details and Appendix D for the solution algorithms.

Table 10: Welfare and Population Changes (Pre vs. Post) Under Closed and Semi-Open Settings

| | Closed | | | Semi-Open | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Metric** | **Pre** | **Post** | **Δ%** | **Pre** | **Post** | **Δ%** |
| **Panel A. Population & Net Income** | | | | | | |
| Population: G ($L^G$) | 199,214 | 199,214 | 0.00% | 168,566 | 199,214 | 18.18% |
| Population: S ($L^S$) | 497,032 | 497,032 | 0.00% | 459,441 | 497,032 | 8.18% |
| Avg. net income: G ($\bar{y}^G$) | 41,651 | 41,830 | 0.43% | 42,199 | 41,830 | −0.87% |
| Avg. net income: S ($\bar{y}^S$) | 33,269 | 32,646 | −1.87% | 33,846 | 32,646 | −3.54% |

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **G** | **S** | **G** | **S** |
| **Panel B. Welfare** | | | | |
| $\Delta\%W$ | 7.59% | 11.41% | 5.29% | 8.44% |
| EV (EUR) | 3,160 | 3,795 | 2,234 | 2,857 |
| CV (EUR) | 2,950 | 3,342 | 2,103 | 2,541 |

*Notes:* G = tradable-goods sector; S = non-tradable service sector. "Pre" denotes the no-Vinex counterfactual equilibrium ($t = 0$); "Post" denotes the observed 2015 post-policy equilibrium ($t = 1$). Panel A: $\Delta\% = 100 \times (\text{Post}/\text{Pre} - 1)$. Average net income is choice-probability-weighted: $\bar{y}_t^g = \sum_{n,i} \lambda_{ni,t}^g (w_{i,t}^g - q_{n,t}\bar{h}^g)$. Panel B: $\Delta\%W = 100 \times (W_1^g/W_0^g - 1)$, where $W_t^g$ is the expected maximum indirect utility (equation 31). EV and CV are per-capita money-metric welfare measures (equations 32–33). All monetary values are in 2015 euros. See Online Appendix E for the open-city benchmark.

Table 11: Aggregate economic outcomes (pre vs. post) under closed and semi-open settings

| | Closed | | | Semi-Open | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Metric** | **Pre** | **Post** | **Δ%** | **Pre** | **Post** | **Δ%** |
| **Panel A. Output** | | | | | | |
| Goods, nominal ($Y_G^{\text{nom}}$) | 10.72B | 10.55B | −1.58% | 9.05B | 10.55B | 16.55% |
| Goods, real ($Y_G^{\text{real}}$) | 349.0K | 345.2K | −1.08% | 293.8K | 345.2K | 17.49% |
| Services, nominal ($Y_S^{\text{nom}}$) | 22.19B | 21.31B | −3.96% | 20.46B | 21.31B | 4.12% |
| Services, real ($Y_S^{\text{real}}$) | 245.7K | 246.1K | 0.13% | 227.9K | 246.1K | 7.98% |
| **Panel B. Wages and Prices** | | | | | | |
| Avg. wage: goods ($\bar{w}_G$) | 50,029 | 49,241 | −1.58% | 49,930 | 49,241 | −1.38% |
| Avg. wage: services ($\bar{w}_S$) | 41,514 | 39,869 | −3.96% | 41,423 | 39,869 | −3.75% |
| Avg. land rent ($\bar{q}$) | 139 | 122 | −12.06% | 127 | 122 | −4.19% |
| Avg. goods price ($\bar{p}_G$) | 30,707 | 30,553 | −0.50% | 30,801 | 30,553 | −0.80% |
| Avg. service price ($\bar{p}_S$) | 40,435 | 39,164 | −3.15% | 40,517 | 39,164 | −3.34% |
| **Panel C. Land Demand** | | | | | | |
| Residential ($D_R$) | 72.80M | 76.60M | 5.23% | 68.61M | 76.60M | 11.64% |
| Goods ($D_G$) | 5.21M | 5.76M | 10.70% | 4.80M | 5.76M | 20.13% |
| Services ($D_S$) | 10.92M | 12.01M | 9.97% | 10.98M | 12.01M | 9.40% |
| Total ($D_{\text{total}}$) | 88.92M | 94.38M | 6.13% | 84.39M | 94.38M | 11.84% |

*Notes:* "Pre" denotes the no-Vinex counterfactual equilibrium ($t = 0$); "Post" denotes the observed 2015 post-policy equilibrium ($t = 1$). $\Delta\% = 100 \times (\text{Post}/\text{Pre} - 1)$. Nominal output ($Y_g^{\text{nom}}$) is total sectoral revenue; real output ($Y_g^{\text{real}}$) sums physical output across locations. Average wages are employment-weighted: $\bar{w}_g = \sum_i w_i^g L_{W,i}^g / \sum_i L_{W,i}^g$. Average rent is land-demand-weighted: $\bar{q} = \sum_i q_i D_i^{\text{total}} / \sum_i D_i^{\text{total}}$. Average goods price is output-weighted: $\bar{p}_G = \sum_i p_i^G Y_i^G / \sum_i Y_i^G$, where $p_i^G$ is the unit cost at location $i$ (Section 5). Average service price is output-weighted: $\bar{p}_S = \sum_i p_i^S Y_i^S / \sum_i Y_i^S$, where $p_i^S$ is the markup-over-cost price and $Y_i^S = M_i y_i$ is real service output (Section 5). $D_R$, $D_G$, $D_S$ denote total land demand by residential, goods-production, and service-production use. B = billions, M = millions, K = thousands. Land demand is in square meters. All monetary values are in 2015 euros. See Online Appendix E for the open-city benchmark.

Appendix:

# How Housing Supply Expansions Reshape Cities

(intended for online publication)

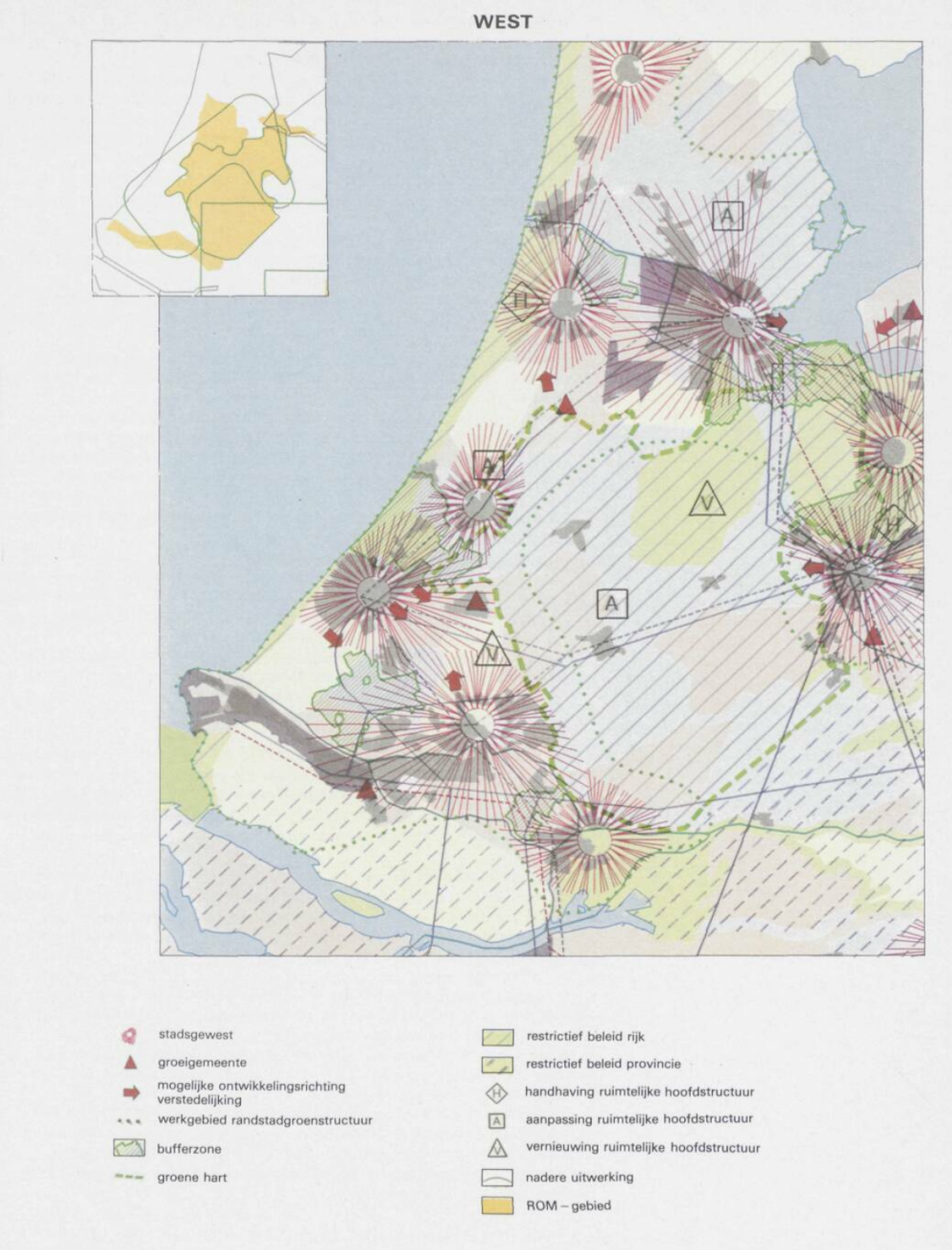
## A. Additional Figures and Tables

## B. Model Derivation Detail

## C. Parameter Calibration

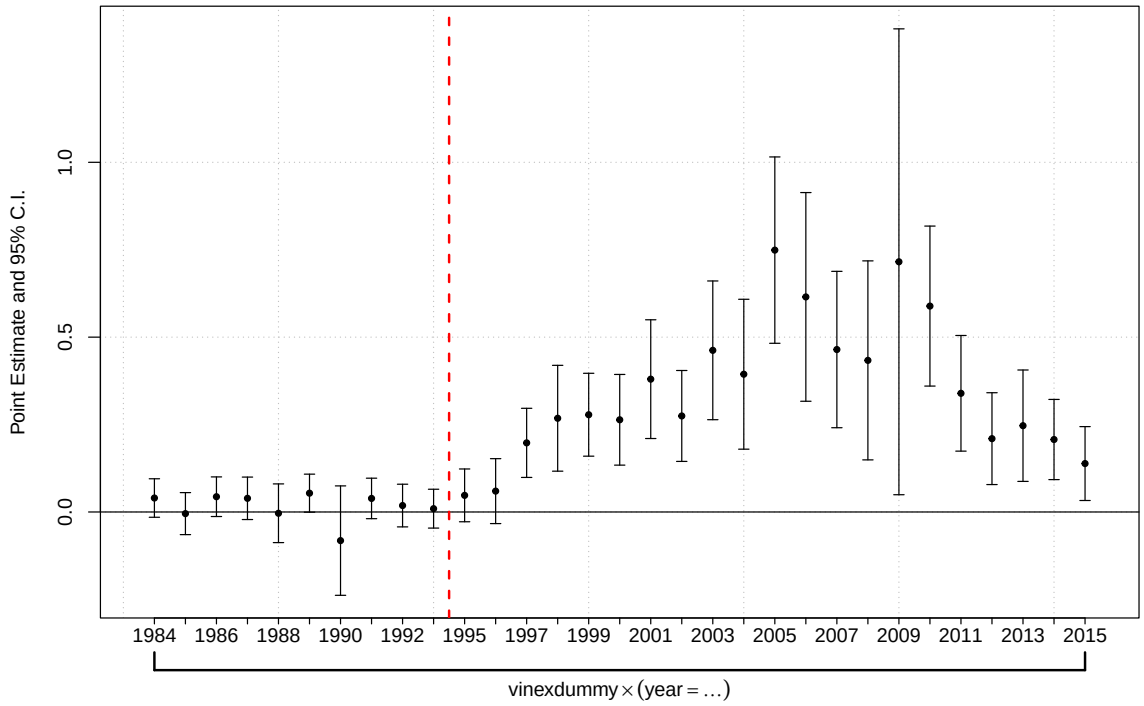
## D. Calibration and Solving Algorithm

# A Additional Figures and Tables

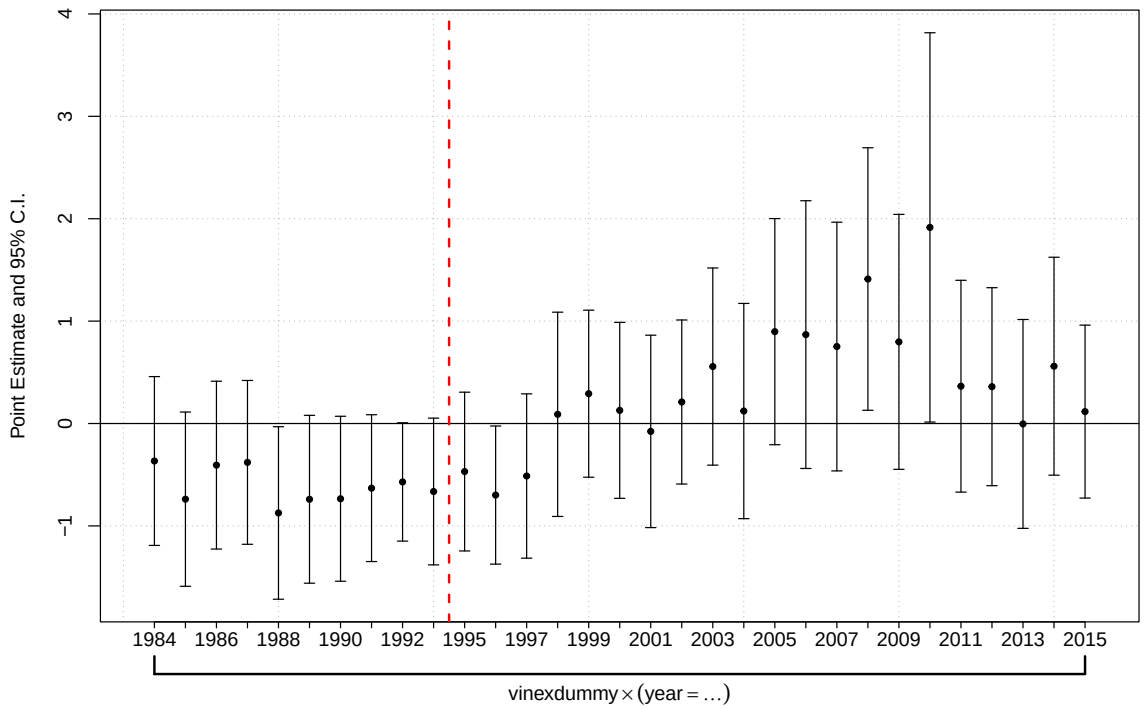



(a) Summary Vinex planning, Randstad areas

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.




(a) Difference-in-Differences Vinex Developed Service Buildings




(b) Difference-in-Differences Vinex Developed Commercial Real Estate Buildings

Figure A.2: The figure displays the gap in the number of developed non-residential units between Vinex and non-Vinex buurts between 1984 and 2015. Panel (a) shows the excess number of service buildings (public assembly, detention, education, healthcare, and sports) developed on average across Vinex buurts, measured by coefficients $\gamma_{t,Vinex}$ from equation (1). Panel (b) repeats the same exercise for commercial real estate buildings (industrial, office, lodging, retail, and other functions). The coefficient for the omitted category in 1994 is set to zero.

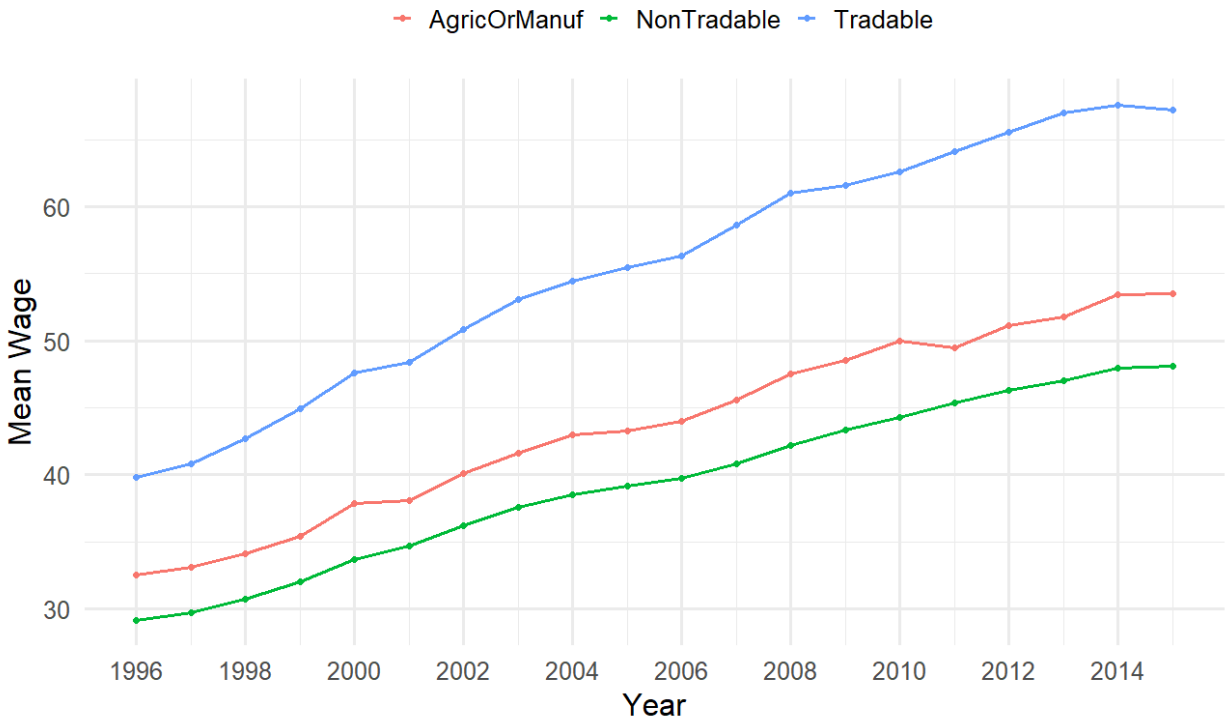
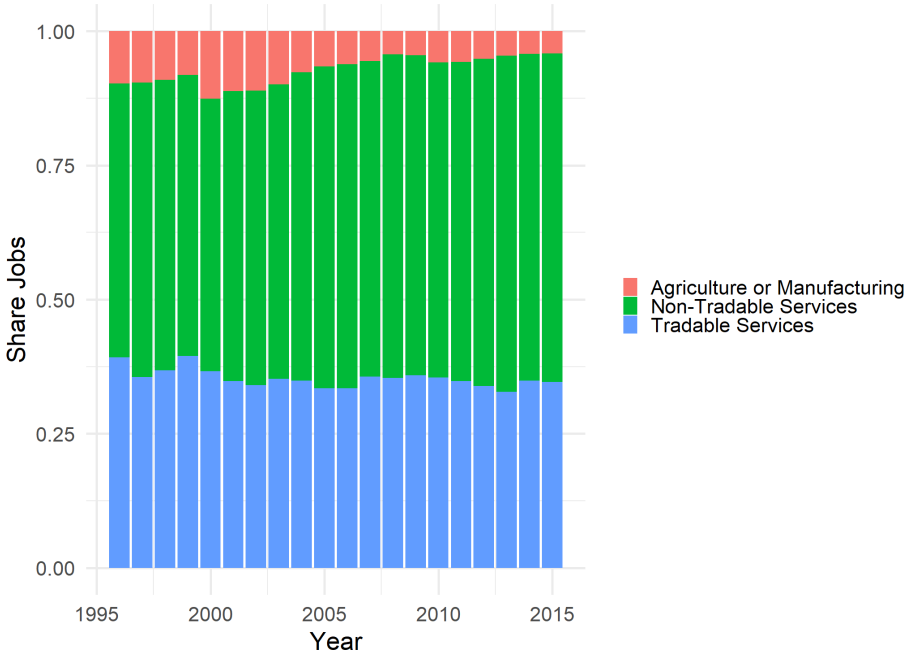
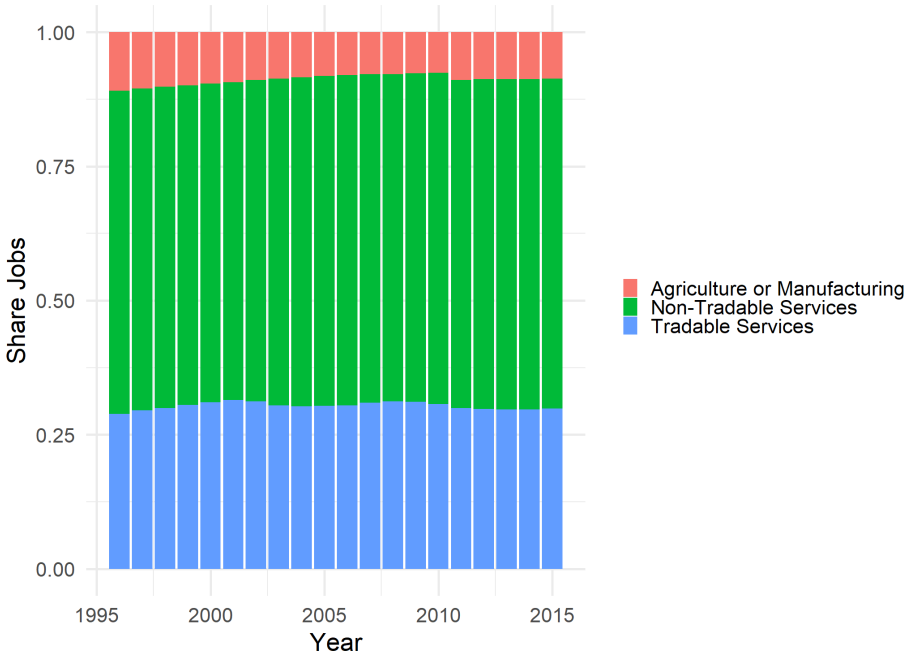



Figure A.3: The figure displays the time series of the mean monthly wages in Euros across jobs in sectors grouped by macro-category: Agriculture or Manufacturing, Non-Tradable Services, Tradable Services. Estimates are based on the LISA dataset.




(a) Vinex Residents Share of Jobs




(b) Non-Vinex Residents Share of Jobs

Figure A.4: 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 administrative data from Statistics Netherlands.

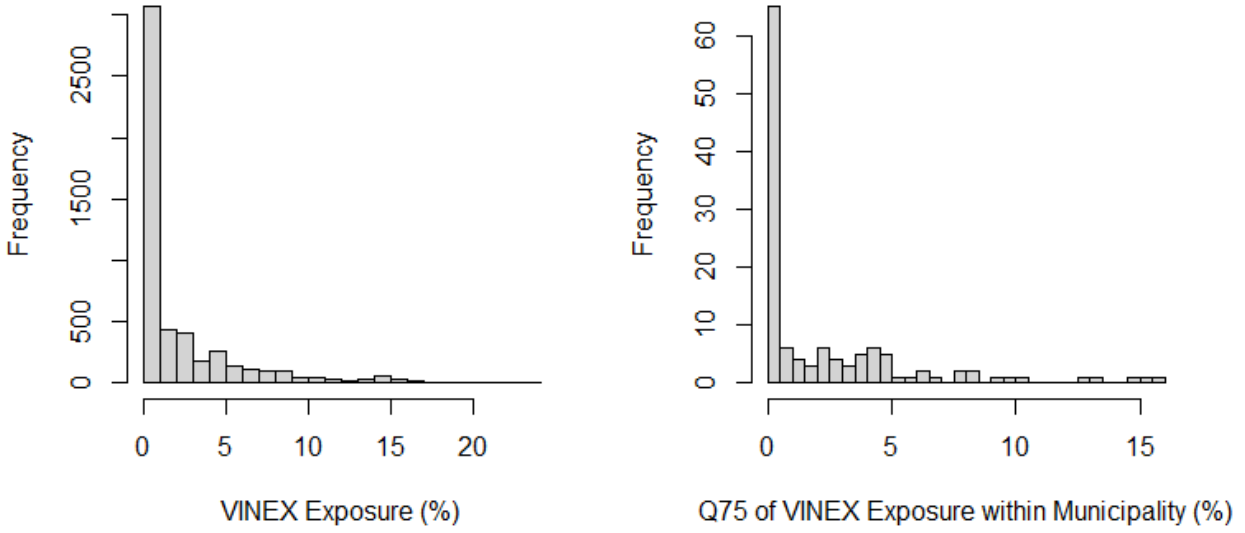



Figure A.5: Distribution of Vinex exposure, for non-Vinex buurts located in the Randstad. The panel on the left shows the distribution of the fraction of land covered by Vinex buurts within a 5-kilometer radius. The panel on the right shows the 75th percentile of exposure (share of land belonging to 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.

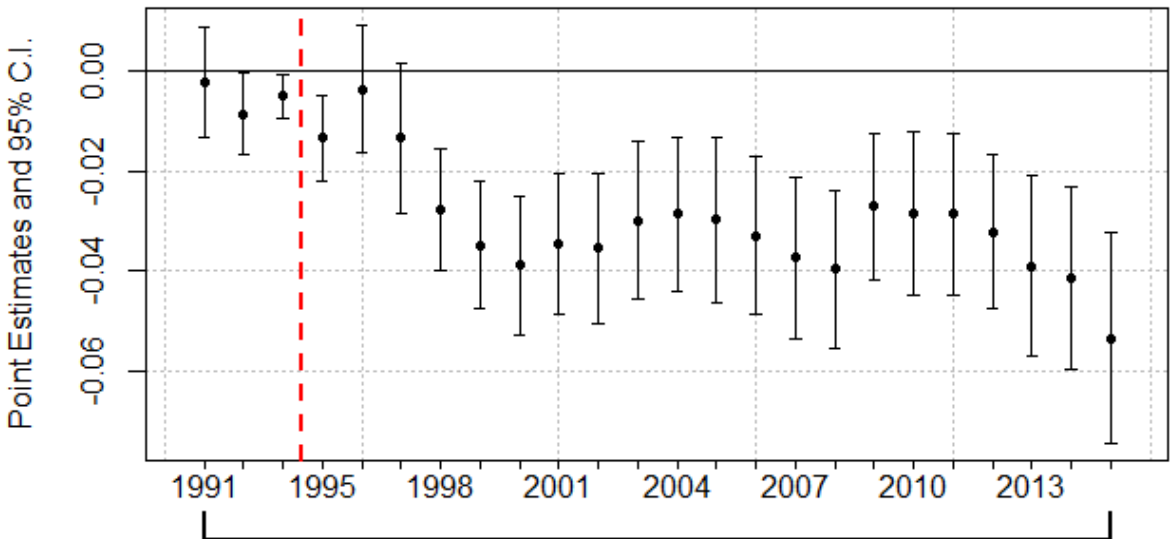
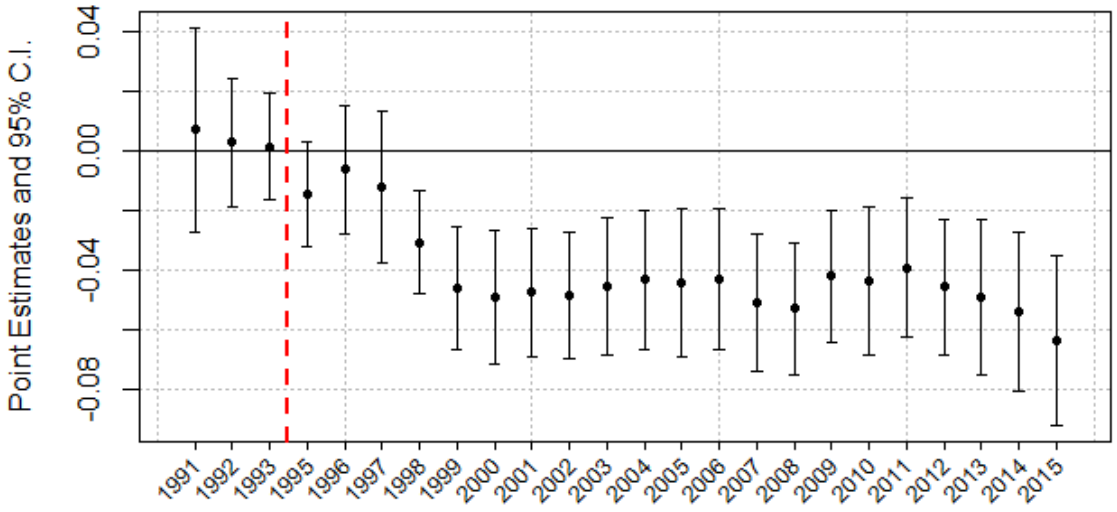



Figure A.6: Effects on Prices in Non-Vinex Neighborhoods (Full Sample).

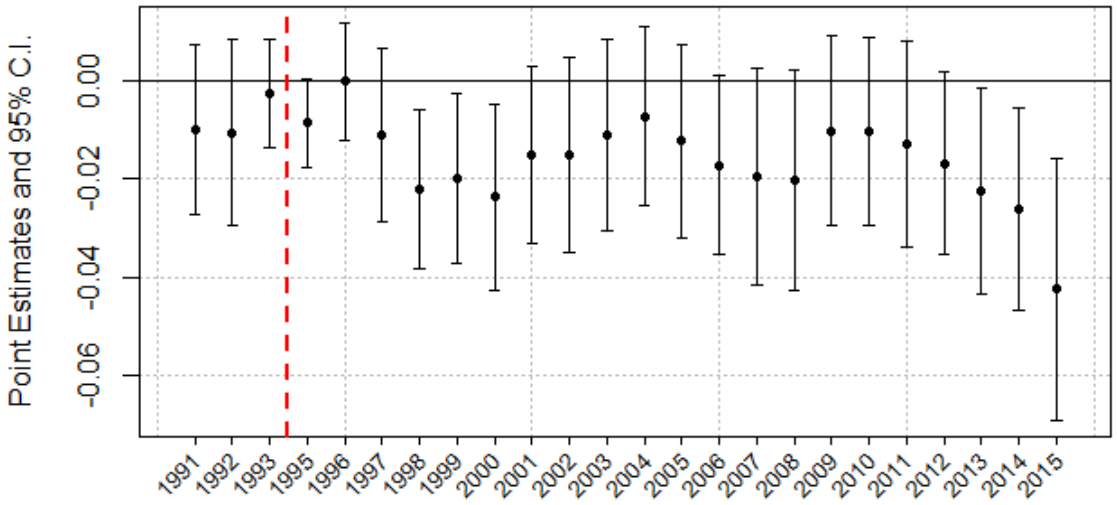
The figure displays estimates from the following regression equation:

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

where $\log(p_{i,\tau})$ is the log sales price of property $i$ in year $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one for sales in year $\tau$, and $a_b$ and $a_{muni,t}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for $d_\tau$ 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.7: Effects on Prices in Non-Vinex Neighborhoods, by Income (Full Sample).

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 $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one for sales in year $\tau$, $I_{HighInc}$ 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 $f_\tau$, while panel (b) displays estimates of $g_\tau$. The omitted coefficients $f_{1995}$ and $g_{1995}$ are equal to zero.

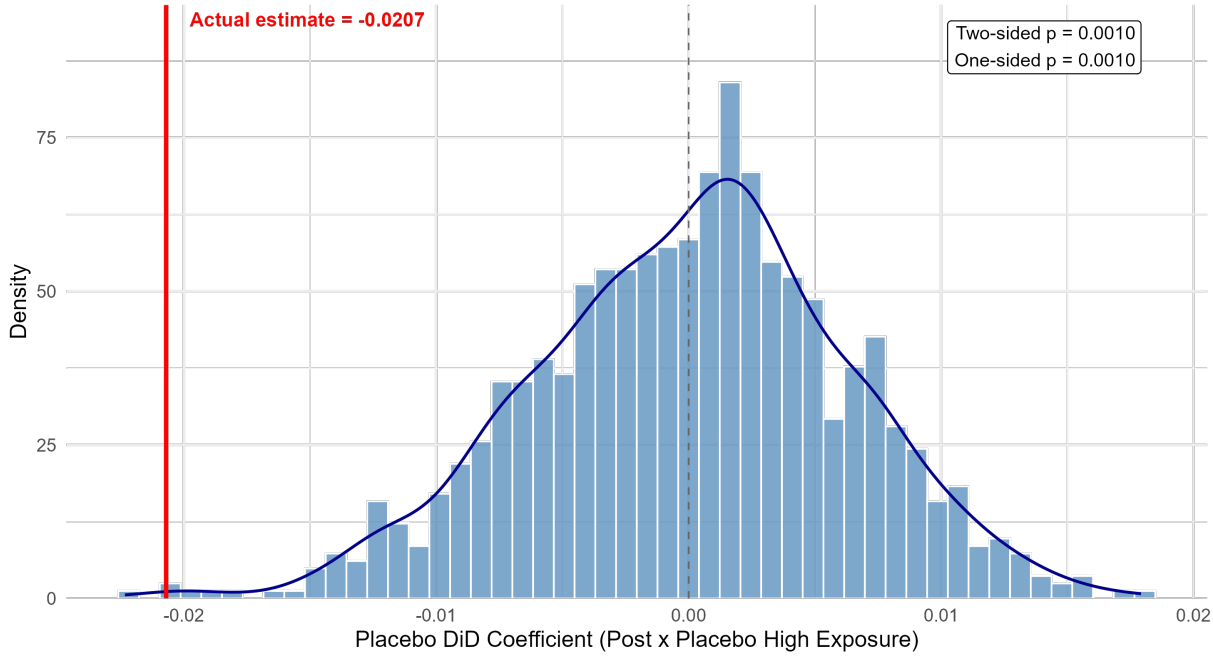



Figure A.8: This figure displays the results from a placebo test for estimates of high-Vinex exposure on house prices, based on equation (3). The solid red line displays the estimated treatment effect in the data, while the histogram displays the distribution of estimates from 1,000 simulations in which we randomly assign the high-Vinex esposure dummy to buurts. We use the simualted distribution (which is drawn under the null of no treatment) to calculate the p-value of our empirical estimate.

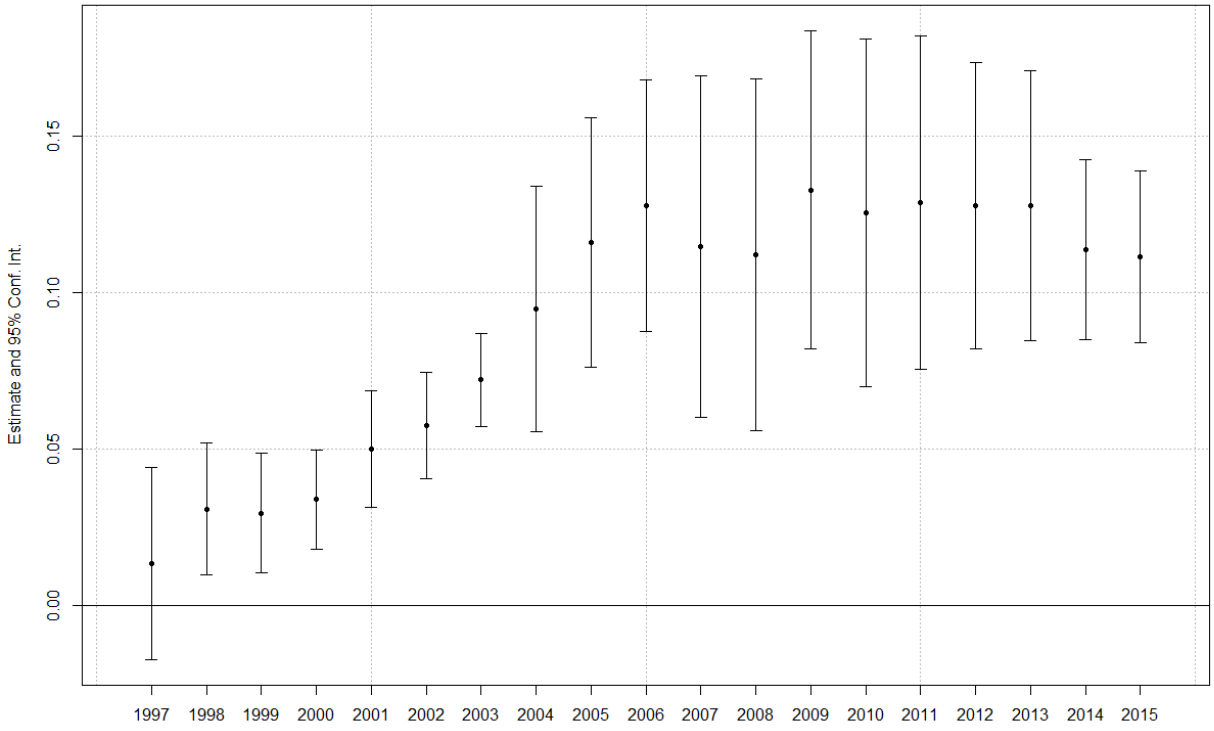



Figure A.9: Effects on Jobs in Non-Vinex Neighborhoods (Full Sample).

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 $\tau$, $I_{HighVinex}$ is a dummy equal to one for buurts in the top quartile of exposure to Vinex in their municipality, $I_\tau$ is a dummy equal to one for sales in year $\tau$, and $a_b$ and $a_{muni,\tau}$ are buurt and municipality by year fixed effects. We display point estimates and 95% confidence intervals for $g_\tau$ 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.

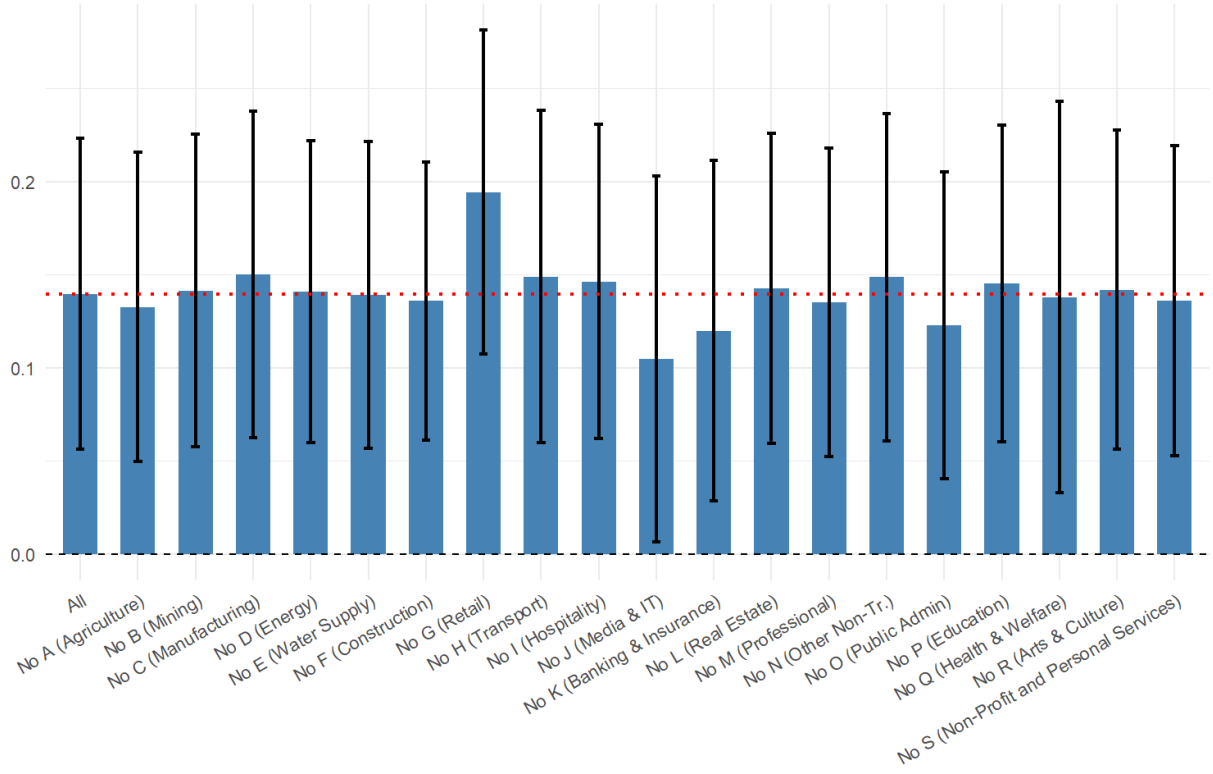



Figure A.10: Effects on Jobs by Sector (Leave-One-Out).

The figure displays estimates of $g_{end}$ from the following Poisson regression specification, and are based on the restricted sample of buurts with high or zero exposure to Vinex, and years 1996 and 2015 only:

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

where $NJobs_{b,\tau}^{-s}$ is number of jobs located in non-Vinex buurt $b$ in year $\tau$, excluding industry sector $s$ (belonging to one of the letter coded NACE sectors listed in Table A.13). $I_{HighVinex}$ 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. The first bar to the left and the corresponding red-dashed line correspond to the estimates based on the full sample of jobs, also displayed in column 1 of Table 8.

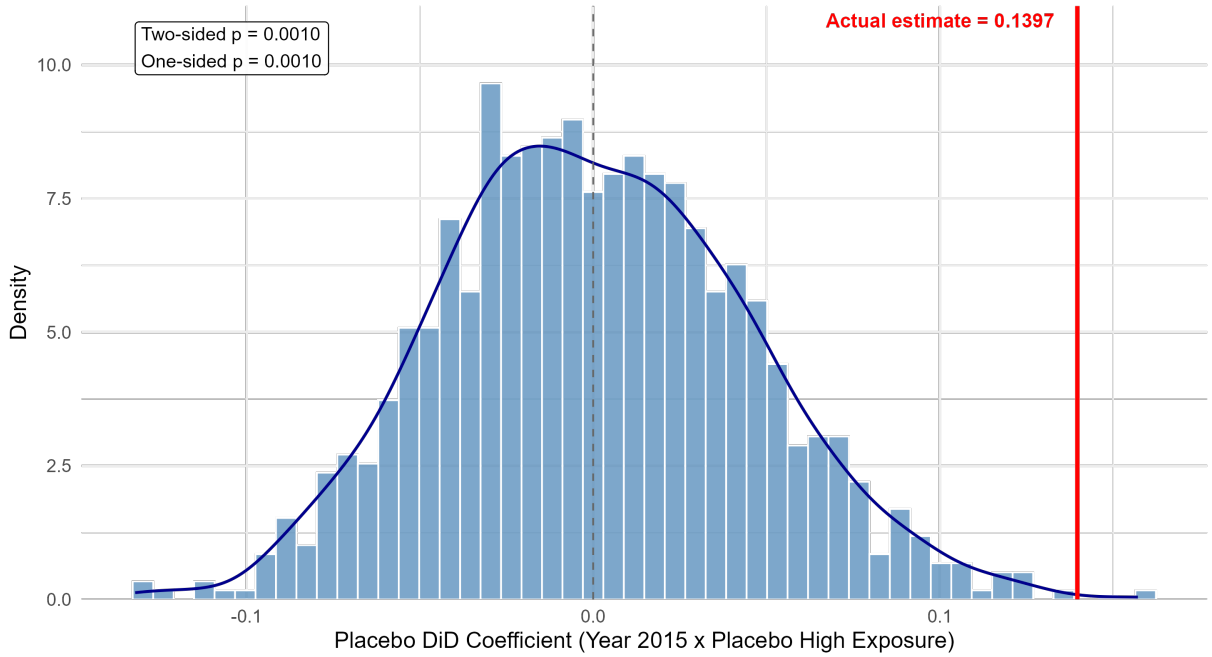



Figure A.11: This figure displays the results from a placebo test for estimates of high-Vinex exposure on jobs, based on equation (10). The solid red line displays the estimated treatment effect in the data, while the histogram displays the distribution of estimates from 1,000 simulations in which we randomly assign the high-Vinex esposure dummy to buurts. We use the simualted distribution (which is drawn under the null of no treatment) to calculate the p-value of our empirical estimate.

| 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: Vinex Construction: Units, Space, and Unit Size

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: Population Inflows to Vinex Neighborhoods

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 Above Med | (4) Below Below Med | (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: Price Effects in Non-Vinex Neighborhoods (Full Sample)

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.

| | (1) Mean $HighVinex = 1$ | (2) Mean $ShareVinex = 0$ | (3) Mean $HighVinex = 0$ | (4) $\Delta_{HighZero}$ Mun. FE | (5) $\Delta_{HighOther}$ Mun. FE |
|---|---|---|---|---|---|
| Has Service Buildings (dummy) | 0.8 | 0.8 | 0.8 | -0.0 | -0.0 |
| | | | | (0.0) | (0.0) |
| Has CRE Buildings (dummy) | 1.0 | 1.0 | 1.0 | -0.0 | 0.0 |
| | | | | (0.0) | (0.0) |
| Median Age, Service (yrs) | 34.8 | 41.7 | 41.7 | -12.5 | -9.7* |
| | | | | (10.9) | (5.7) |
| Median Age, CRE (yrs) | 28.1 | 31.1 | 31.5 | -10.1 | -6.1 |
| | | | | (7.6) | (4.2) |
| Has Education (dummy) | 0.4 | 0.4 | 0.4 | -0.0 | -0.0 |
| | | | | (0.0) | (0.0) |
| Share Education (of Service) | 0.250 | 0.219 | 0.238 | 0.009 | -0.000 |
| | | | | (0.024) | (0.017) |
| Has Healthcare (dummy) | 0.4 | 0.4 | 0.4 | -0.0 | -0.0 |
| | | | | (0.0) | (0.0) |
| Share Healthcare (of Service) | 0.115 | 0.114 | 0.121 | 0.008 | -0.000 |
| | | | | (0.017) | (0.012) |
| Has Office (dummy) | 0.7 | 0.6 | 0.6 | -0.0 | -0.0 |
| | | | | (0.0) | (0.0) |
| Share Office (of CRE) | 0.206 | 0.192 | 0.207 | -0.029** | -0.019* |
| | | | | (0.014) | (0.010) |
| Has Retail (dummy) | 0.6 | 0.6 | 0.6 | 0.0 | -0.0 |
| | | | | (0.1) | (0.0) |
| Share Retail (of CRE) | 0.182 | 0.167 | 0.183 | 0.017 | -0.005 |
| | | | | (0.016) | (0.013) |
| N Residential Buildings | 677.0 | 491.6 | 559.1 | 34.0 | 37.1 |
| | | | | (86.7) | (68.7) |
| Median Area Residential ($m^2$) | 118.1 | 138.3 | 127.8 | -24.0 | -7.6 |
| | | | | (16.4) | (6.9) |
| Median Age (yrs) | 37.2 | 41.3 | 39.8 | -10.9 | -5.0 |
| | | | | (6.8) | (4.0) |

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

Table A.4: Pre-Vinex Building Stock Balance Test

The table compares sample means of characteristics of the non-residential and residential stock of buildings completed as by 1994 across three groups of non-Vinex buurts: buurts with high Vinex exposure, buurts with no Vinex exposure, and buurts that do not have high exposure. The first three columns report sample means, while columns (4) and (5) report coefficients $\Delta$ from the following regression specification:

$$C_b = \Delta I_{HighVinex,b} + \kappa_{muni} + e_b$$

where $C_b$ is one of the characteristics of interest, and $\kappa_{muni}$ are municipality fixed effects. In column (4), $\Delta_{HighZero}$ is estimated over the sample of high and zero exposure buurts, and $\Delta_{HighOther}$ is estimate over the entire sample of non-Vinex buurts, include high exposure and all non-high exposure buurts.

| | Full Sample (All non-Vinex Buurts) Dependent Variable: log($Price$) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) Above Above Med | (4) Below Below Med | (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.5: Price Effects Using Continuous Vinex Exposure

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 | Below |
| | | | Above Med | Below Med |
| | 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.6: Inverse Supply Elasticities (Full Sample)

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 Above Med | Below Below Med |
| | 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.7: Inverse Supply Elasticities Using Continuous Instrument

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.8: Mobility Effects in Non-Vinex Neighborhoods (Full Sample)

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 $\tau$, $I_{HighVinex}$ 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.9: Mobility Effects, 1995–2015

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 $\tau$, $I_{HighVinex}$ 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** | $-3.73 \times 10^{-5}$ | 0.0001 | -0.0001 | 0.0010 |
| | (0.0002) | (0.0002) | (0.0003) | (0.0003) | (0.0008) | (0.0007) |
| $ShareVinex \times I_{HighInc}$ | | $2.58 \times 10^{-5}$ | | 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*** | $7.09 \times 10^{-5}$ | 0.0001 | -0.0003 | 0.0008 |
| | (0.0001) | (0.0002) | (0.0002) | (0.0002) | (0.0007) | (0.0007) |
| $ShareVinex \times I_{HighInc}$ | | $-3.21 \times 10^{-6}$ | | 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.10: Mobility Effects Using Continuous Vinex Exposure

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 $\tau$, $ShareVinex$ 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.11: Effects on Jobs in Non-Vinex Neighborhoods (Full Sample)

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 following 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) in buurt $b$ and year $\tau$, $I_{HighVinex}$ 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.12: Effects on Jobs Using Continuous Vinex Exposure

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 5 display estimates from the following 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) in buurt $b$ and year $\tau$, $ShareVinex$ 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 | Tr. 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.13: 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.

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

## 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:

$$C^S_{\omega ni} = \left( \sum_{j=1}^{N} \int_0^{M_j} c_{nj}(\nu)^{\frac{\sigma_S - 1}{\sigma_S}} \, d\nu \right)^{\frac{\sigma_S}{\sigma_S - 1}}, \qquad \sigma_S > 1, \tag{B.6}$$

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

assumption that all varieties at location $j$ are produced symmetrically at a common price $p_j^S$, cost minimization over the CES bundle yields the effective service price index $P_n^{S,\text{eff}}$:

$$P_n^{S,\text{eff}} = \left( \sum_{j=1}^{N} M_j \left( t_{nj}^S p_j^S \right)^{1-\sigma_S} \right)^{\frac{1}{1-\sigma_S}}. \tag{B.7}$$

The corresponding shopping expenditure share, which gives the fraction of a resident's service spending directed to varieties at location $j$, is:

$$\pi_{n\to j}^S = \frac{M_j \left( t_{nj}^S p_j^S \right)^{1-\sigma_S}}{\sum_{k=1}^{N} M_k \left( t_{nk}^S p_k^S \right)^{1-\sigma_S}}. \tag{B.8}$$

### B.2.2 Goods Aggregation and Price Index (Armington across production locations)

A worker at residence $n$ also consumes tradable goods produced at each location $i \in \mathcal{N}$. Unlike the service sector, where each location hosts a continuum of $M_j$ differentiated varieties, each goods production location supplies a single distinct variety. This Armington structure implies that the composite goods consumption $C_{\omega ni}^G$ is a CES aggregate over *locations* rather than over a continuum of firms.

Each location produces a distinct goods variety with factory-gate price $p_i^G$, and consumers face an effective delivered price $\tilde{p}_{ni}^G = t_{ni}^G p_i^G$ that includes a transport friction analogous to the service shopping friction, $t_{ni}^G = \exp(\kappa^{\text{shop},G} \bar{\tau}_{ni})$. Let $c_{nk}^G$ denote the quantity of the goods variety from production location $k$ consumed by a worker residing at $n$. The composite goods consumption is:

$$C_{\omega ni}^G = \left( \sum_{k=1}^{N} \left( c_{nk}^G \right)^{\frac{\sigma_G - 1}{\sigma_G}} \right)^{\frac{\sigma_G}{\sigma_G - 1}}, \qquad \sigma_G > 1. \tag{B.9}$$

Cost minimization over this bundle yields the effective goods price index $P_n^{G,\text{eff}}$:

$$P_n^{G,\text{eff}} = \left( \sum_{k=1}^{N} \left( t_{nk}^G p_k^G \right)^{1-\sigma_G} \right)^{\frac{1}{1-\sigma_G}}. \tag{B.10}$$

The corresponding goods expenditure share, which gives the fraction of a resident's goods spending directed to production location $k$, is:

$$\pi_{n\to k}^G = \frac{\left( t_{nk}^G p_k^G \right)^{1-\sigma_G}}{\sum_{j=1}^{N} \left( t_{nj}^G p_j^G \right)^{1-\sigma_G}}. \tag{B.11}$$

Note that, unlike the service expenditure share (Eq. B.8), the goods share does not feature a variety mass $M_k$ because each location produces exactly one variety.

### B.2.3 Utility Maximization and Indirect Utility

The worker maximizes the Stone-Geary utility subject to the budget constraint. In the Armington specification, the relevant goods price is the residence-specific effective price index $P_n^{G,\text{eff}}$ derived above. The optimization problem is:

$$\max_{C^G, C^S, H} \quad U_{\omega ni}^g = \frac{z_{\omega ni} B_n^g}{d_{ni}^g} \left(C_{\omega ni}^G\right)^{\beta^g} \left(C_{\omega ni}^S\right)^{\gamma^g} \left(H_{\omega ni} - \bar{h}^g\right)^{1-\beta^g-\gamma^g} \tag{B.12}$$

subject to

$$P_n^{G,\text{eff}} C_{\omega ni}^G + P_n^{S,\text{eff}} C_{\omega ni}^S + q_n (H_{\omega ni} - \bar{h}^g) = w_i^g - q_n \bar{h}^g \equiv y_{ni}^g, \tag{B.13}$$

where the right-hand side $y_{ni}^g = w_i^g - q_n \bar{h}^g$ is the worker's discretionary income after paying for the minimum housing requirement $\bar{h}^g$ at local price $q_n$. Given the Cobb-Douglas structure of above-subsistence consumption, optimal demands are constant expenditure shares of this discretionary income:

$$C_{\omega ni}^{G*} = \beta^g \frac{y_{ni}^g}{P_n^{G,\text{eff}}}, \tag{B.14}$$

$$C_{\omega ni}^{S*} = \gamma^g \frac{y_{ni}^g}{P_n^{S,\text{eff}}}, \tag{B.15}$$

$$\left(H_{\omega ni} - \bar{h}^g\right)^* = \left(1 - \beta^g - \gamma^g\right) \frac{y_{ni}^g}{q_n}. \tag{B.16}$$

Total housing demand is therefore $H_{\omega ni}^* = \bar{h}^g + \left(1 - \beta^g - \gamma^g\right) y_{ni}^g / q_n$.

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

$$\begin{aligned} u_{\omega ni}^g &= \frac{z_{\omega ni}\, B_n^g}{d_{ni}^g} \left(\beta^g \frac{y_{ni}^g}{P_n^{G,\text{eff}}}\right)^{\beta^g} \left(\gamma^g \frac{y_{ni}^g}{P_n^{S,\text{eff}}}\right)^{\gamma^g} \left((1 - \beta^g - \gamma^g) \frac{y_{ni}^g}{q_n}\right)^{1-\beta^g-\gamma^g} \\ &= c^g \, \frac{z_{\omega ni}\, B_n^g}{d_{ni}^g} \, y_{ni}^g \, \left(P_n^{G,\text{eff}}\right)^{-\beta^g} \left(P_n^{S,\text{eff}}\right)^{-\gamma^g} \left(q_n\right)^{\beta^g+\gamma^g-1}, \end{aligned} \tag{B.17}$$

where $c^g = (\beta^g)^{\beta^g} (\gamma^g)^{\gamma^g} (1 - \beta^g - \gamma^g)^{1-\beta^g-\gamma^g}$ is a constant determined by preference shares. The second line collects all preference-share constants into $c^g$ and uses $y_{ni}^g = w_i^g - q_n \bar{h}^g$ for compactness. Note that the term $\left(P_n^{G,\text{eff}}\right)^{-\beta^g}$ captures the cost-of-living effect of the tradable goods price index faced by residents at $n$. This term is absent from specifications that normalize the tradable goods price to unity.

## B.3 Location Choice Probabilities

### B.3.1 Joint Probability

The indirect utility derived in the previous section can be written as $u^g_{\omega ni} = z_{\omega ni} \cdot V^g_{ni}$, where

$$V^g_{ni} = c^g \frac{B^g_n}{d^g_{ni}} (w^g_i - q_n \bar{h}^g)(P^{G,\text{eff}}_n)^{-\beta^g} (P^{S,\text{eff}}_n)^{-\gamma^g} (q_n)^{\beta^g+\gamma^g-1} \tag{B.18}$$

is the deterministic component of utility for the residence-workplace pair $(n, i)$. Given the Fréchet distribution of the idiosyncratic shocks $z_{\omega ni}$ with scale parameters $T^g_n E^g_i$ and shape parameter $\epsilon^g$, the probability that a type-$g$ worker chooses this pair is:

$$\lambda^g_{ni} = \frac{\Phi^g_{ni}}{\sum_{m=1}^N \sum_{j=1}^N \Phi^g_{mj}}, \qquad \text{where} \quad \Phi^g_{ni} = T^g_n E^g_i \left[ \frac{B^g_n (w^g_i - q_n \bar{h}^g)}{d^g_{ni} (P^{G,\text{eff}}_n)^{\beta^g} (P^{S,\text{eff}}_n)^{\gamma^g} (q_n)^{1-\beta^g-\gamma^g}} \right]^{\epsilon^g}. \tag{B.19}$$

The object $\Phi^g_{ni} = T^g_n E^g_i (V^g_{ni})^{\epsilon^g}$ is the "attractiveness" of pair $(n, i)$, as referred to in the main text. Unlike a specification with a common tradable goods price, the Armington goods price index $(P^{G,\text{eff}}_n)^{-\beta^g \epsilon^g}$ depends on residence $n$ and therefore does not cancel from the joint probability. As a result, the spatial allocation of workers depends on the goods cost of living faced at their residence location, creating an additional channel through which housing supply shocks propagate: by changing the spatial distribution of goods production and hence local goods prices, the Vinex policy alters the relative attractiveness of different residential locations.

### B.3.2 Conditional Probabilities

The joint probability $\lambda^g_{ni}$ can be decomposed into conditional probabilities by marginalizing over one dimension.

**Probability of working at $i$ given residence $n$.** Conditioning on $n$, all residence-specific terms ($B^g_n$, $P^{G,\text{eff}}_n$, $P^{S,\text{eff}}_n$, $q_n$) appear in both the numerator and denominator and cancel. The conditional commuting probability therefore depends only on workplace attractiveness, commuting costs, and the surplus income:

$$\lambda^g(i \mid n) = \frac{E^g_i (d^g_{ni})^{-\epsilon^g} (w^g_i - q_n \bar{h}^g)^{\epsilon^g}}{\sum_{j=1}^N E^g_j (d^g_{nj})^{-\epsilon^g} (w^g_j - q_n \bar{h}^g)^{\epsilon^g}}. \tag{B.20}$$

This is the object used in the wage calibration algorithm (Algorithm 1 in Section D).

**Probability of residing at $n$ given workplace $i$.** Conditioning on $i$, the workplace amenity $E^g_i$ cancels, but the residence-specific price indices remain:

$$\lambda^g(n \mid i) \propto T^g_n (B^g_n)^{\epsilon^g} (d^g_{ni})^{-\epsilon^g} (P^{G,\text{eff}}_n)^{-\beta^g \epsilon^g} (P^{S,\text{eff}}_n)^{-\gamma^g \epsilon^g} (q_n)^{-(1-\beta^g-\gamma^g)\epsilon^g} (w^g_i - q_n \bar{h}^g)^{\epsilon^g}. \tag{B.21}$$

A notable feature of this expression is that the surplus term $(w_i^g - q_n \bar{h}^g)$ depends on *both* workplace $i$ (through the wage) and residence $n$ (through the housing price). This is a direct consequence of the Stone-Geary minimum housing requirement $\bar{h}^g > 0$: with $\bar{h}^g = 0$, the surplus reduces to $w_i^g$, which would cancel from the conditional probability $\lambda^g(n|i)$. With $\bar{h}^g > 0$, however, the residential housing cost enters the surplus and creates an additional interaction between workplace and residence choices.

## B.4 Endogenous Productivity (Agglomeration)

We incorporate urbanization agglomeration economies, where productivity in both sectors depends on the total density of economic activity rather than sector-specific density. Let $L_{W,i}^{\text{Tot}} = L_{W,i}^G + L_{W,i}^S$ denote total employment at location $i$. Effective productivity in each sector combines a location-specific fundamental with a spatial agglomeration spillover:

$$A_i^{G,\text{eff}} = \bar{A}_i^G \cdot \left( \sum_{k=1}^{N} e^{-\delta_G \tau_{ik}} L_{W,k}^{\text{Tot}} \right)^{\psi_G}, \tag{B.22}$$

$$a_i^{S,\text{eff}} = \bar{a}_i^S \cdot \left( \sum_{k=1}^{N} e^{-\delta_S \tau_{ik}} L_{W,k}^{\text{Tot}} \right)^{\psi_S}, \tag{B.23}$$

where $\bar{A}_i^G$ and $\bar{a}_i^S$ are exogenous fundamental productivities, $\delta_G$ and $\delta_S$ govern the spatial decay of spillovers, and $\psi_G$ and $\psi_S$ are the agglomeration elasticities. The spillover term $\sum_k e^{-\delta_g \tau_{ik}} L_{W,k}^{\text{Tot}}$ ($g \in \{G, S\}$) is a distance-weighted measure of employment density surrounding location $i$: nearby workers contribute more than distant ones, with the rate of decay governed by $\delta_g$. This specification implies that a location surrounded by dense employment benefits from higher productivity in both sectors, creating a feedback loop between residential sorting, employment density, and output that is central to the model's counterfactual results.

## B.5 Production, Firm Problems, and Factor Prices

### B.5.1 Tradable Goods Sector ($G$)

Firms in the tradable goods sector operate under perfect competition with free entry, using the effective productivity $A_i^{G,\text{eff}}$ from the agglomeration specification. Each location $i$ produces a distinct goods variety with local price $p_i^G$, selling to residents in all locations subject to the transport frictions defined in Section B. The firm's problem is:

$$\max_{L_{W,i}^G, D_i^G} \pi_i^G = p_i^G A_i^{G,\text{eff}} (L_{W,i}^G)^{\alpha_G} (D_i^G)^{1-\alpha_G} - w_i^G L_{W,i}^G - q_i D_i^G. \tag{B.24}$$

The first-order conditions for labor and land imply that each factor is paid its marginal revenue product:

$$w_i^G = \alpha_G \frac{p_i^G Y_i^G}{L_{W,i}^G}, \qquad q_i = (1-\alpha_G)\frac{p_i^G Y_i^G}{D_i^G}, \tag{B.25}$$

where $Y_i^G = A_i^{G,\text{eff}}(L_{W,i}^G)^{\alpha_G}(D_i^G)^{1-\alpha_G}$ is output. Under free entry, profits are driven to zero, so $p_i^G Y_i^G = w_i^G L_{W,i}^G + q_i D_i^G$. Substituting the optimal factor ratio $D_i^G/L_{W,i}^G = [(1-\alpha_G)/\alpha_G](w_i^G/q_i)$ into the production function yields the unit-cost pricing condition:

$$p_i^G = \frac{1}{A_i^{G,\text{eff}}}\left(\frac{w_i^G}{\alpha_G}\right)^{\alpha_G}\left(\frac{q_i}{1-\alpha_G}\right)^{1-\alpha_G}. \tag{B.26}$$

Inverting this expression for $w_i^G$ gives the wage equation used in the main text:

$$w_i^G = \alpha_G\left(A_i^{G,\text{eff}} p_i^G\right)^{1/\alpha_G}\left(\frac{1-\alpha_G}{q_i}\right)^{(1-\alpha_G)/\alpha_G}. \tag{B.27}$$

### B.5.2 Non-Tradable Services Sector ($S$)

The service sector features monopolistic competition with CES demand and free entry. Each service firm at location $i$ uses the effective productivity $a_i^{S,\text{eff}}$ from the agglomeration specification. Firm-level production combines labor $\ell_i(\nu)$ and land $d_i(\nu)$ according to $y_i(\nu) = a_i^{S,\text{eff}}\ell_i(\nu)^{\alpha_S} d_i(\nu)^{1-\alpha_S}$.

**Pricing.** Each firm faces a constant elasticity of demand $\sigma_S > 1$ from the CES aggregator (Eq. B.6) and sets price as a constant markup over marginal cost:

$$p_i^S = \frac{\sigma_S}{\sigma_S - 1}\cdot\frac{r_i^S}{a_i^{S,\text{eff}}} = \frac{\sigma_S}{\sigma_S-1}\cdot\frac{1}{a_i^{S,\text{eff}}}\left(\frac{w_i^S}{\alpha_S}\right)^{\alpha_S}\left(\frac{q_i}{1-\alpha_S}\right)^{1-\alpha_S}, \tag{B.28}$$

where $r_i^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_i^S)^{\alpha_S} q_i^{1-\alpha_S}$ is the unit composite input cost. The expanded form parallels the G-sector unit-cost condition (Eq. B.26), with the addition of the monopolistic competition markup $\sigma_S/(\sigma_S-1)$.

**Entry and variety mass.** Entry requires a fixed cost $F_i = r_i^S f$ paid in the same composite input bundle, with $f$ normalized to unity. Under free entry, each firm earns revenue equal to $\sigma_S$ times its fixed cost, so $R_i^S(\nu) = \sigma_S r_i^S f$ per firm. The mass of active varieties at location $i$ is therefore:

$$M_i = \frac{R_i^S}{\sigma_S r_i^S f} = \frac{1}{\sigma_S f}(L_{W,i}^S)^{\alpha_S}(D_i^S)^{1-\alpha_S}, \tag{B.29}$$

where $R_i^S = w_i^S L_{W,i}^S/\alpha_S$ is total service revenue at location $i$ (from factor exhaustion), and the second equality uses the Cobb-Douglas factor demands. Variety proliferation thus increases with the scale of the local service sector.

**Wage equation.** Inverting the pricing condition for $w_i^S$ yields:

$$w_i^S = \alpha_S \left(\frac{\sigma_S - 1}{\sigma_S}\right)^{1/\alpha_S} (a_i^{S,\text{eff}} p_i^S)^{1/\alpha_S} \left(\frac{1-\alpha_S}{q_i}\right)^{(1-\alpha_S)/\alpha_S}. \tag{B.30}$$

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

## B.6 Market Equilibrium Conditions

### B.6.1 Land Market Equilibrium

At each location $n$, total land demand from residents and firms must equal the quantity supplied. Using the residential demand from the worker's problem and the commercial land demands from the production sector, the clearing condition is:

$$\underbrace{\sum_{g\in\{G,S\}} L_{Rn}^g \left[\bar{h}^g + (1-\beta^g-\gamma^g)\frac{\mathbb{E}_n[w^g] - q_n\bar{h}^g}{q_n}\right]}_{D_n^R \text{ (residential)}} + \underbrace{\frac{(1-\alpha_G) w_n^G L_{W,n}^G}{\alpha_G q_n}}_{D_n^G \text{ (goods)}} + \underbrace{\frac{(1-\alpha_S) w_n^S L_{W,n}^S}{\alpha_S q_n}}_{D_n^S \text{ (services)}} = \underbrace{\left(\frac{q_n}{\pi_n}\right)^{\eta_n}}_{S_n \text{ (supply)}} \tag{B.31}$$

where $\mathbb{E}_n[w^g] = \sum_i w_i^g \lambda^g(i|n)$ is the expected wage for type-$g$ residents at $n$. This unified land market creates a key general equilibrium linkage: changes in employment at a location alter commercial land demand, which feeds back into housing costs and residential sorting.

### B.6.2 Local Services Market Equilibrium

Total service expenditure flowing to location $j$, denoted by $\mathcal{E}_j^S$, equates to total revenue at $j$ scaled by the service sector coverage factor $\zeta_S \geq 1$. In practice, we only observe expenditures by employed workers in the labor force; unobserved consumers (retirees, students, and other non-participants) also patronize local services. The coverage factor scales up the observed worker expenditure to match the full revenue generated by service firms, and is calibrated as $\zeta_S = \sum_j R_j^S / \sum_j \mathcal{E}_j^S$.

$$R_j^S = \zeta_S \mathcal{E}_j^S = \zeta_S \sum_{g\in\{G,S\}} \sum_{n=1}^{N} \pi_{n\to j}^S \gamma^g L_{Rn}^g \left(\mathbb{E}_n[w^g] - q_n\bar{h}^g\right) \tag{B.32}$$

### B.6.3 Tradable Goods Market Equilibrium (Armington across production locations)

In the Armington specification, each location $i$ produces a distinct goods variety with price $p_i^G$. Total revenue in the local goods sector equals the total expenditure by all residents on that location's goods variety, scaled by the goods sector coverage factor $\zeta_G > 0$. Unlike the service sector, $\zeta_G$ may be below one if the city is a net importer of tradable goods, so that local goods-sector revenue falls short of residents' goods expenditure.

**Supply Side (Revenue at production location $i$):** Under perfect competition with Cobb–Douglas production, goods-sector revenue equals payroll scaled by the labor share:

$$R_i^G = p_i^G Y_i^G = \frac{w_i^G L_{W,i}^G}{\alpha_G}. \tag{B.33}$$

**Demand Side (Expenditure flowing to $i$):** Residents at $n$ of type $g$ spend a share $\beta^g$ of discretionary income on the composite goods bundle, and allocate that spending across production locations using the goods shopping share $\pi_{n\to i}^G$ (from Eq. (B.11)):

$$\mathcal{E}_i^G = \sum_{n=1}^{N} \sum_{g\in\{G,S\}} \pi_{n\to i}^G \, \beta^g \, L_{R,n}^g \, (\mathbb{E}_n[w^g] - q_n \bar{h}^g). \tag{B.34}$$

**Clearing Condition (for each production location $i$):** The equilibrium adjusts such that:

$$R_i^G = \frac{w_i^G L_{W,i}^G}{\alpha_G} = \zeta_G \, \mathcal{E}_i^G, \qquad \forall i \in \{1, \ldots, N\}. \tag{B.35}$$

### B.6.4 Nominal Anchor and Equilibrium Determination

The demand side of the model (location choice, product markets, land demand) involves only ratios of nominal variables. This raises the question of what pins down the absolute price level. The following proposition shows that the land *supply* function provides the unique nominal anchor.

**Proposition 1** (Land Market as Nominal Anchor)**.** *Let $(\mathbf{w}^*, \mathbf{q}^*, \mathbf{p}^*)$ be an equilibrium clearing all labor, goods, services, and land markets, with equilibrium land demand $D_n^*$ at each location. Consider a proportional rescaling of wages and rents, $(\mathbf{w}, \mathbf{q}) \to (\theta\mathbf{w}^*, \theta\mathbf{q}^*)$ for $\theta > 0$, with output prices $\mathbf{p}$ adjusting via zero-profit conditions.*

*(i)* ***Prices follow.*** *Zero-profit conditions imply $p_i^G \propto (w_i^G)^{\alpha_G} q_i^{1-\alpha_G}$ and $p_i^S \propto (w_i^S)^{\alpha_S} q_i^{1-\alpha_S}$, so $\mathbf{p} \to \theta\mathbf{p}^*$. All nominal variables scale together.*

*(ii)* ***Demand-side homogeneity.*** *Under this joint scaling, all real allocations (location choice probabilities $\lambda_{ni}^g$, employment $L_{W,i}^g$ and $L_{R,n}^g$, shopping shares $\pi_{n\to j}^g$, firm mass $M_j$, and total land demand $D_n$) are invariant. That is, $D_n(\theta\mathbf{w}^*, \theta\mathbf{q}^*) = D_n^*$ for all $\theta > 0$.*

*(iii)* ***Supply-side breaks the invariance.*** *The land supply function $S_n = (q_n/\pi_n)^{\eta_n}$ is homogeneous of degree $\eta_n > 0$ in $q_n$:*

$$S_n(\theta q_n^*) = \theta^{\eta_n} S_n(q_n^*) \neq S_n(q_n^*) \quad \text{for } \theta \neq 1.$$

*(iv)* ***Unique nominal level.*** *Since land market clearing requires $D_n = S_n$ at every location, and $D_n$ is unchanged while $S_n$ is not, only $\theta = 1$ satisfies all markets simultaneously.*

*Proof sketch.* For notational brevity, we suppress the type superscript $g$ throughout this proof.

Part (i) is immediate from the Cobb-Douglas unit cost functions.

For part (ii), we verify invariance of each demand-side object under the joint scaling $(\mathbf{w}, \mathbf{q}, \mathbf{p}) \to \theta(\mathbf{w}, \mathbf{q}, \mathbf{p})$.

*Location choice.* The kernel of the joint probability is

$$\Phi_{ni} \;\propto\; \left(P_n^{G,\text{eff}}\right)^{-\epsilon\beta} \left(P_n^{S,\text{eff}}\right)^{-\epsilon\gamma} q_n^{-\epsilon(1-\beta-\gamma)} \left(w_i - q_n \bar{h}\right)^{\epsilon}.$$

The price indices $P_n^{G,\text{eff}}$ and $P_n^{S,\text{eff}}$ are CES aggregates of prices, hence homogeneous of degree one in $\mathbf{p}$. (For services, this uses the fact that $M_j$ is invariant; see below.) Under joint scaling, each factor picks up a power of $\theta$:

$$\Phi_{ni} \;\to\; \theta^{-\epsilon\beta}\, \theta^{-\epsilon\gamma}\, \theta^{-\epsilon(1-\beta-\gamma)}\, \theta^{\epsilon}\, \Phi_{ni} \;=\; \theta^{0}\, \Phi_{ni},$$

since the exponents sum to $-\epsilon(\beta + \gamma + 1 - \beta - \gamma) + \epsilon = 0$. Since $\lambda_{ni} = \Phi_{ni} / \sum_{m,j} \Phi_{mj}$, the common factor cancels, and all $\lambda_{ni}$ are unchanged.

*Employment.* Since $\lambda_{ni}$ is invariant and total populations $\bar{L}$ are exogenous, $L_{W,i} = \bar{L} \sum_n \lambda_{ni}$ and $L_{R,n} = \bar{L} \sum_i \lambda_{ni}$ are also invariant.

*Shopping shares.* $\pi^G_{n\to k} \propto (t^G_{nk}\, p^G_k)^{1-\sigma_G}$; under $\mathbf{p} \to \theta\mathbf{p}$, the factor $\theta^{1-\sigma_G}$ appears in both numerator and denominator, hence cancels. Similarly for $\pi^S_{n\to j}$.

*Firm mass.* $M_j = R^S_j / (\sigma_S\, r_j\, f)$, where revenue $R^S_j \propto w^S_j L^S_{W,j} \to \theta R^S_j$ and unit input cost $r_j \propto (w^S_j)^{\alpha_S} q_j^{1-\alpha_S} \to \theta\, r_j$. Hence $M_j \to \theta R^S_j / (\sigma_S \cdot \theta\, r_j \cdot f) = M_j$. This confirms $P_n^{S,\text{eff}}$ is degree one in $\mathbf{p}$.

*Residential land demand.* Per-capita demand is $\bar{h} + (1 - \beta - \gamma)(w - q\bar{h})/q$. Under $w \to \theta w$, $q \to \theta q$: the ratio $(w - q\bar{h})/q = w/q - \bar{h}$ is invariant. Hence $D^R_n$ is unchanged.

*Commercial land demand.* $D^G_i = (1 - \alpha_G)\, w^G_i L^G_{W,i} / (\alpha_G\, q_i)$. Since $L^G_{W,i}$ is invariant and $w/q \to \theta w/(\theta q) = w/q$, we have $D^G_i$ invariant. Similarly for $D^S_i$.

Parts (iii)–(iv): at the original equilibrium, $D^*_n = S^*_n = (q^*_n/\pi_n)^{\eta_n}$. At the scaled prices, demand remains $D^*_n$ but supply becomes $\theta^{\eta_n}(q^*_n/\pi_n)^{\eta_n} = \theta^{\eta_n} D^*_n$. Equating gives $\theta^{\eta_n} = 1$, hence $\theta = 1$. □

**Remark 1.** *The Stone-Geary minimum housing requirement $\bar{h}^g > 0$ does not affect the nominal anchor. As shown above, residential demand depends on the ratio $w/q$, which is invariant under joint scaling regardless of $\bar{h}^g$. However, $\bar{h}^g > 0$ plays a distinct and important role in the* computational *stability of the model: it creates an aggregate instability in the inner wage-iteration loop that necessitates the wage-bill rescaling technique (see Remark 2 in Section D).*

# C Parameter Calibration

## C.1 Estimation of Factor Shares $\alpha_G$ and $\alpha_S$

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

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

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

**Computation of land shares.** We estimate a uniform land share directly from the assessed value of non-residential real estate in the study area. We take the total WOZ value (tax-assessed market value) of all non-residential properties in The Hague metropolitan area and convert it to an annual rental flow using a gross capitalization rate of 6%. The land share is then computed as the ratio of imputed land rent to total factor costs:

$$1-\alpha = \frac{\text{Non-residential RE value} \times r_{\text{cap}}}{\text{Non-residential RE value} \times r_{\text{cap}} + \text{Total wages}} = \frac{26{,}903 \times 0.06}{26{,}903 \times 0.06 + 23{,}593} \approx 0.064, \quad \text{(C.36)}$$

where the WOZ values and wage data are from 2015. We round this estimate to 7% in the baseline calibration, yielding $\alpha_G = \alpha_S = 0.93$.

**Calibrated values.** A production-side floor-space cost share of approximately 7% is below the values used in some recent quantitative urban models (see Table C.14, which range from 15% to 31%). Valentinyi and Herrendorf (2008) report pure land income shares of 4% for manufactured consumption and 6% for services in the U.S. economy; including structures raises these to 15–21%, within the range of the urban models.

**Robustness to alternative estimation.** An alternative approach based on firm balance-sheet data (computing the ratio of leasing fees plus imputed rent on owned real estate to total factor costs) yields sector-specific land shares of $1-\hat{\alpha}_G = 0.103$ (tradable goods) and $1-\hat{\alpha}_S = 0.159$ (non-tradable services). These estimates are higher than 7%, which is expected: our two-factor Cobb–Douglas framework attributes all non-labor costs to commercial floor space, whereas in practice firms also pay for intermediate inputs and equipment capital.

## 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.

Table C.14: 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) |

The optimal demand for housing is:

$$H_{\omega ni}^{g*} = \bar{h}^g + (1-\beta^g-\gamma^g)\frac{w_i^g - q_n\bar{h}^g}{q_n} \tag{C.37}$$

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

$$\frac{q_n H_{\omega ni}^{g*}}{w_i^g} = (1-\beta^g-\gamma^g) + (\beta^g+\gamma^g)\bar{h}^g \cdot \frac{q_n}{w_i^g} \tag{C.38}$$

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

$$\frac{\text{Housing Expenditure}^g}{\text{Total Expenditure}^g} = b_0 + b_1 \cdot \frac{q_n(\text{rent})}{\text{Total Expenditure}^g} \tag{C.39}$$

We estimate Equation (C.39) using OLS, where Housing Expenditure$^g$ corresponds to $q_n H_{\omega ni}^{g*}$ and Total Expenditure$^g$ corresponds to $w_i^g$. The resulting coefficients identify our structural parameters:

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

**Expenditure Shares:** $\beta^g, \gamma^g$ With the discretionary housing share $(1-\beta^g-\gamma^g)$ and $\bar{h}^g$ identified from the regression, the remaining shares for tradable goods ($\beta^g$) and local services ($\gamma^g$) are defined as shares of *discretionary income* ($w_i^g - q_n\bar{h}^g$). In the Armington version of the model, the relevant expenditure objects use the residence-specific effective price indices $P_n^{G,\text{eff}}$ and $P_n^{S,\text{eff}}$. Thus,

$$\beta^g = \frac{\text{Expenditure on tradable goods}}{\text{Discretionary income}} = \frac{P_n^{G,\text{eff}} C_{\omega ni}^{G*}}{w_i^g - q_n\bar{h}^g} \tag{C.40}$$

$$\gamma^g = \frac{\text{Expenditure on local services}}{\text{Discretionary income}} = \frac{P_n^{S,\text{eff}} C_{\omega ni}^{S*}}{w_i^g - q_n\bar{h}^g} \tag{C.41}$$

In practice, we compute these shares from Dutch national accounts data on household consumption expenditure, allocating aggregate spending into tradable goods ($\beta^g$) and non-tradable local services ($\gamma^g$) using the sectoral classification in Table A.13. Thus, the Engel curve regression identifies the

housing share $(1-\beta^g-\gamma^g)$ and minimum housing $\bar{h}^g$, while national accounts data pin down $\beta^g$ and $\gamma^g$ individually.

Table C.15: Calibration of Worker Preference Parameters

| **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 **(baseline)** |
| $\beta^S = 0.487; \gamma^S = 0.340; (1-\beta^S-\gamma^S) = 0.173;\ \bar{h}^S = 59.46$ | using annual user cost **(baseline)** |

*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 $\epsilon^g$ and Workplace Amenities $E_i^g$

To estimate the key preference parameters $\epsilon^g$ (Fréchet dispersion) and $\nu^g$ (spatial mobility), we derive a log-linear regression equation from the joint choice probability $\lambda_{ni}^g$ in the Armington version of the model.

We begin with the log of the joint probability:

$$\ln \lambda_{ni}^g = \ln \Phi_{ni}^g - \ln \Phi^g \tag{C.42}$$

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, $\ln \Phi_{ni}^g$:

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

Expanding the logarithm:

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

Expanding the log terms and substituting $d_{ni}^g = \exp(\kappa_g \tau_{ni})$, so that $\ln d_{ni}^g = \kappa_g \tau_{ni}$. For the surplus term, we use the discretionary income $y_{ni}^g = w_i^g - q_n \bar{h}^g$ defined in Section B, floored at a small positive value to ensure the logarithm is well-defined:

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

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

$$\begin{aligned} \ln \lambda_{ni}^g = & (\epsilon^g \ln c^g - \ln \Phi^g) \\ & + \Big( \ln T_n^g + \epsilon^g \ln B_n^g - \epsilon^g \beta^g \ln P_n^{G,\text{eff}} - \epsilon^g \gamma^g \ln P_n^{S,\text{eff}} - \epsilon^g (1 - \beta^g - \gamma^g) \ln q_n \Big) \\ & + \ln E_i^g \\ & + \epsilon^g \ln y_{ni}^g - (\epsilon^g \kappa_g) \tau_{ni} \end{aligned} \tag{C.43}$$

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:

$$\ln \lambda_{ni}^g = \underbrace{k_0^g}_{\text{constant}} + \underbrace{\alpha_n^g}_{\text{residence FE}} + \underbrace{\delta_i^g}_{\text{workplace FE}} + \epsilon^g \ln y_{ni}^g - \nu^g \tau_{ni} + e_{ni} \tag{C.44}$$

where $e_{ni}$ is an econometric error term.[24] The fixed effects absorb all location-specific unobservables:

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

This specification (Eq. C.44) allows for the joint estimation of the Fréchet parameter $\epsilon^g$ (as the coefficient on log surplus income) and the composite mobility parameter $\nu^g$ (as the coefficient on travel impedance $\tau_{ni}$). Under the Armington specification, the residence-specific price indices $(P_n^{G,\text{eff}}, P_n^{S,\text{eff}})$ are absorbed by the residence fixed effect $\alpha_n^g$; they do not load into the workplace fixed effect. Therefore, the workplace fixed effects $\delta_i^g$ are used to back out the workplace amenities as

$$E_i^g = \exp(\delta_i^g),$$

which are identified up to a normalization (e.g., $\text{mean}(E_i^g) = 1$).

Table C.16: 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. $\epsilon^g$ is the Fréchet shape parameter and $\nu^g$ 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 9. The standard error on $\epsilon^G$ is large relative to the point estimate, reflecting the difficulty of separately identifying the surplus income elasticity from the commuting cost coefficient in the goods sector, where commuting distances are longer and surplus income varies less across pairs. The commuting cost parameter $\nu^G$ is precisely estimated in both specifications.

[24] In this regression, $\alpha_n^g$ and $\delta_i^g$ denote fixed effect coefficients, not the production factor shares $\alpha_G, \alpha_S$ or the agglomeration spatial decay parameters $\delta_G, \delta_S$ used elsewhere in the model.

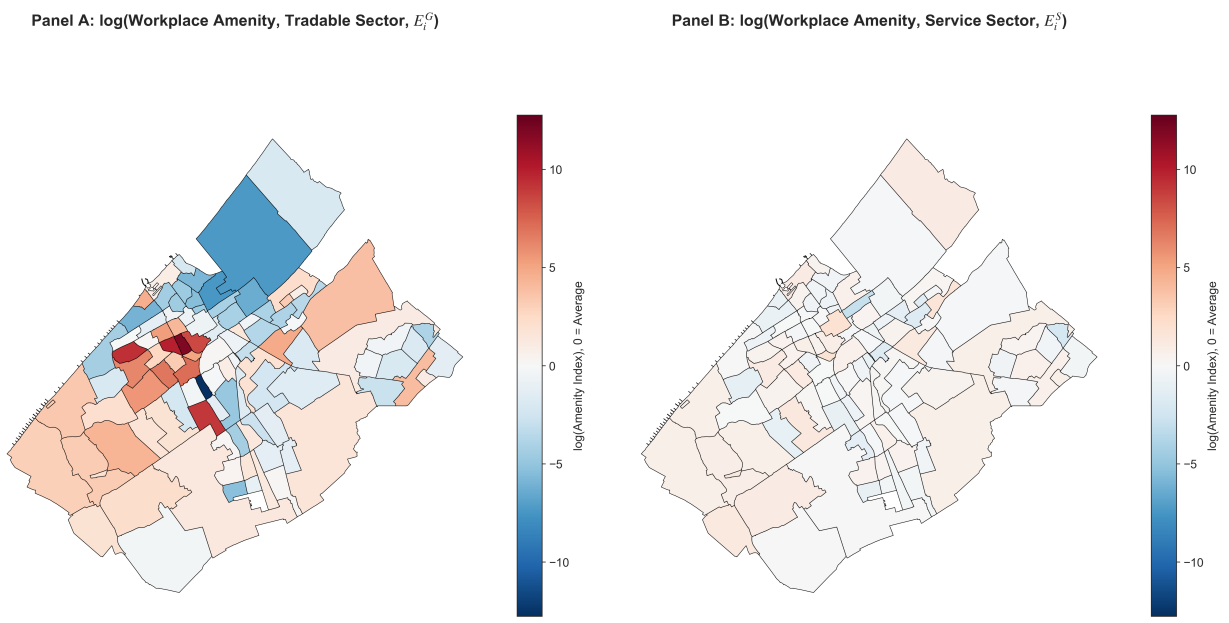



Figure C.12: Spatial Distribution of Calibrated Workplace Amenities (Log Scale)

*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 Elasticity of Substitution and Agglomeration Parameters

The elasticity of substitution is set to $\sigma_G = \sigma_S = 4$, following Monte, Redding, and Rossi-Hansberg (2018), who estimate a trade elasticity of 4 for goods flows across U.S. commuting zones in a quantitative spatial equilibrium framework closely related to ours. This value implies a moderate degree of substitutability across location-specific varieties in both the Armington goods market and the Dixit-Stiglitz service market.

The agglomeration parameters are taken from Ahlfeldt et al. (2015), who exploit the reunification of Berlin as a natural experiment to estimate the production externality specification. We adopt their point estimates: the spatial decay of spillovers $\delta_G = \delta_S = 0.36$ and the agglomeration elasticity $\psi_G = \psi_S = 0.07$. The symmetric specification across sectors reflects the urbanization (rather than localization) interpretation of agglomeration economies adopted in our model.

## C.5 Shopping Friction Calibration

We set shopping frictions equal to commuting frictions for each sector: $\kappa^{\text{shop},G} = \kappa_G = 0.011$ and $\kappa^{\text{shop},S} = \kappa_S = 0.065$. Because shopping frictions are not separately identified from observed data in our model, we justify this calibration ex post by comparing the implied semi-elasticities of shopping flows with respect to distance against empirical benchmarks from the recent literature.

The semi-elasticity of shopping expenditure with respect to distance is $(\sigma_g - 1) \cdot \kappa^{\text{shop},g}$ for each sector. The analogous object for commuting is $\nu^g = \epsilon^g \cdot \kappa_g$. Let $\bar{\nu}$ denote the population-weighted average commuting semi-elasticity:

$$\bar{\nu} = \frac{L^G \nu^G + L^S \nu^S}{L^G + L^S} = \frac{199{,}214 \times 0.187 + 497{,}032 \times 0.211}{696{,}246} = 0.204.$$

Two empirical benchmarks discipline the ratio of shopping to commuting distance decay. First, Miyauchi, Nakajima, and Redding (2025) estimate that consumption trips to non-traded services decay with distance at roughly 1.0–1.3 times the rate of commuting trips, based on smartphone GPS data in Japan. This is a within-study comparison, so functional form differences cancel in the ratio. Second, Agarwal, Jensen, and Monte (2020) document substantial heterogeneity in the spatial reach of consumer expenditure across goods categories using transaction-level credit card data from Singapore. They find that median shopping distances are roughly 4 km for food stores, 12 km for eating and drinking establishments, and 20 km for durable goods, implying that tradable goods expenditure decays 3–5 times more slowly with distance than local service expenditure.

Our calibrated values align well with both benchmarks:

| **Sector** | $(\sigma_g - 1) \cdot \kappa^{\text{shop},g}$ | **Value** | **Ratio to $\bar{\nu}$** | **Literature target** |
|---|---|---|---|---|
| S-sector | $3 \times 0.065$ | 0.195 | 0.96× | $\approx 1.0\times$ (Miyauchi, Nakajima, and Redding, 2025) |
| G-sector | $3 \times 0.011$ | 0.034 | 0.17× | $\approx 0.2\times$ (Agarwal, Jensen, and Monte, 2020) |

The ratio $\kappa^{\text{shop},S}/\kappa^{\text{shop},G} = 5.9$ is consistent with Agarwal, Jensen, and Monte's finding that service expenditure decays roughly five times faster with distance than tradable goods expenditure. The key economic intuition is that services (restaurants, personal care, retail) require physical proximity, while tradable goods can be sourced across the metropolitan area.

The numerical coincidence that $\kappa^{\text{shop},g} = \kappa_g$ arises because $(\sigma_g - 1) = 3$ and the Fréchet elasticities $\epsilon^G$ and $\epsilon^S$ happen to scale the commuting frictions such that $\nu^g$ falls in the empirically relevant range for shopping semi-elasticities.

## C.6 Housing Supply Elasticity $\eta_n$

Following the micro-foundation, the parameter $\alpha_n$ (and thus $\eta_n$) 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:

$$\frac{q_n D_n}{r_n K_n} = \frac{\pi_n D_n^{1/\alpha_n}}{r_n D_n^{1/\alpha_n}} = 1/\alpha_n \tag{C.45}$$

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

$$q_n = \pi_n D_n^{\frac{1}{\eta_n}} \tag{C.46}$$

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

$$\ln(q_n) = \ln(\pi_n) + \frac{1}{\eta_n} \ln(D_n) \tag{C.47}$$

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.17 summarizes benchmark elasticities from the literature. Given the significant identification challenges, we calibrate $\eta_n$ 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.17: Calibration for Housing Supply Elasticities $\eta_n$

| **Value** | **Location** | **Source** |
|---|---|---|
| **0.60** | **(This study, Calibrated)** | **Based on Saiz (2010) minimum** |
| 0.60 (min) | Miami | Saiz (2010), 30-year horizon |
| 1.75 (pop-wtd. avg.) | U.S. MSAs | Saiz (2010), 30-year horizon |
| 1.25–2.45 (IQR) | U.S. MSAs | 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) |

**Vinex areas.** In the post-policy baseline (CF = false), housing supply elasticities are set to $\eta_n = 1.0$ for Vinex neighborhoods and $\eta_n = 0.6$ for all other neighborhoods, reflecting the substantially more elastic supply on newly released greenfield land. In the counterfactual (CF = true), all non-wasteland neighborhoods revert to the common elasticity of $\eta_n = 0.6$, reflecting the pre-policy regulatory environment. Vinex locations, which were undeveloped farmland before the policy, are excluded from the choice set by assigning a prohibitively high rent ($q_n = 10^6$).

# 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, $y_{ni}^g$, 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, $w_i^g$, 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 $i$; observed land rents $q_n^{\text{data}}$

**Result:** Equilibrium wages $w_i^g$ matching workplace labor demand

**while** *not converged* **do**

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

    Compute surplus:;

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

    Compute conditional choice value:;

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

  **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 $w_i^g \leftarrow w_{\text{next},i}^g \cdot \frac{\sum_j w_{\text{data},j}^g L_{Wj}^g}{\sum_j w_{\text{next},j}^g L_{Wj}^g}$;

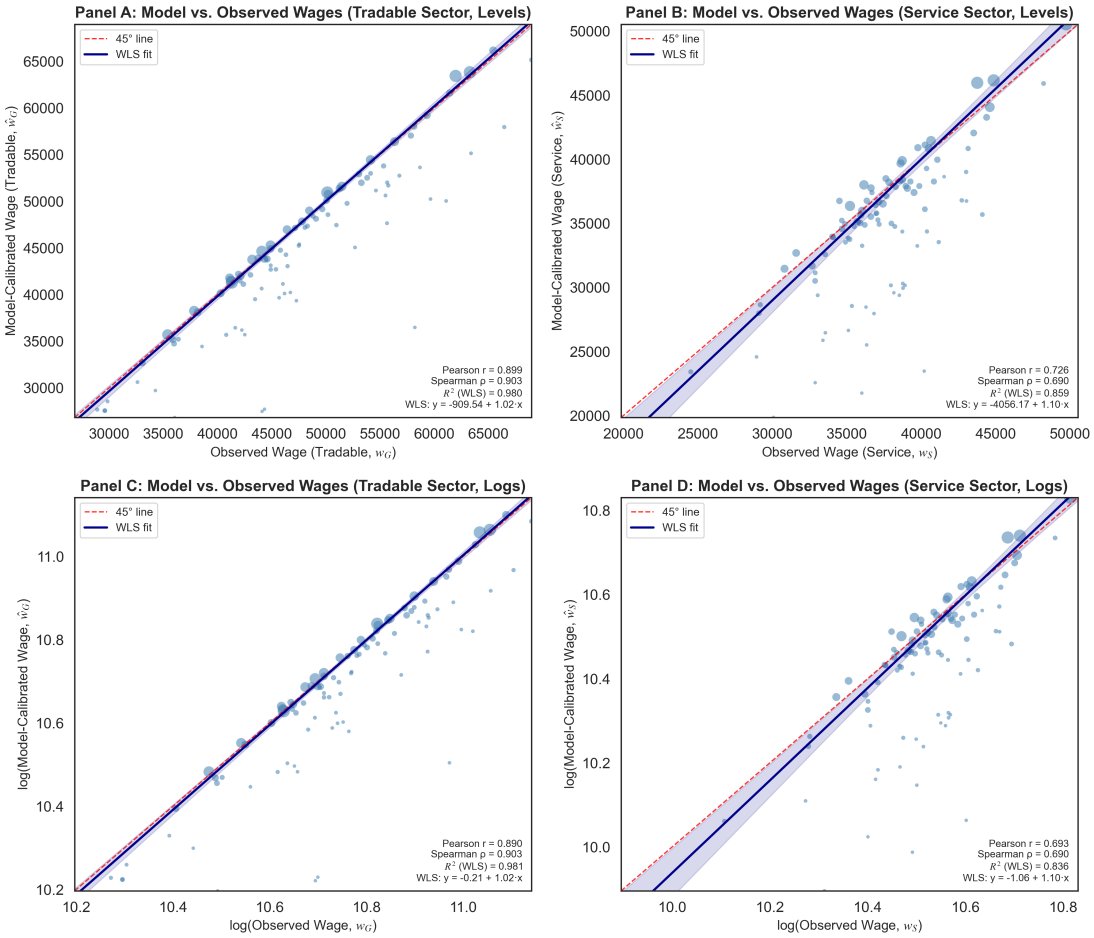



Figure D.13: Comparison of Model-Calibrated and Observed Wages

*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.

## D.2 Productivity Solving

Given equilibrium wages and land rents (derived from the wage-solving step) and the observed labor allocation, we calibrate the location-specific productivities.

According to the model's agglomeration specification in Section B, the realized *effective* productivity $(A_n^{G,\text{eff}}, a_n^{S,\text{eff}})$ is composed of an exogenous *fundamental* productivity $(\bar{A}_n^G, \bar{a}_n^S)$ and an endogenous agglomeration spillover depending on total employment density.

The calibration proceeds in two stages:

1. **Market Clearing Inversion:** We iterate to find the *effective* productivities that rationalize the observed revenues (supply) with model-implied global demand under the Armington/Monopolistic assumptions.
2. **Agglomeration Decomposition:** We strip out the spatial spillover effects from the effective productivities to recover the structural fundamentals.

### D.2.1 Tradable Goods Sector Productivity

In the G-sector, firms operate under perfect competition with Armington differentiation. The price $p_n^G$ is determined by the unit cost and effective productivity (Eq. B.27). We employ Algorithm 2 to recover the fundamental productivity $\bar{A}_n^G$.

### D.2.2 Service Sector Productivity

In the S-sector, wages are determined by monopolistic competition pricing (Eq. B.30). We employ Algorithm 3 to recover the fundamental productivity $\bar{a}_n^S$.

**Algorithm 2:** Goods Productivity Calibration (Effective & Fundamental)

**Require:** Data: $\{w_n^G, L_{Wn}^G, L_{Wn}^S, q_n, L_{Rm}^g, \bar{\tau}_{mn}\}$.
**Require:** Params: $\alpha_G, \beta^g, \sigma_G, \zeta_G, \psi_G, \delta_G$.
**Require:** Normalization: fix $\bar{A}_{n_0}^G \equiv 1$.
**Ensure:** Fundamental $\bar{A}_n^G$, Effective $A_n^{G,\text{eff}}$, Prices $p_n^G$.

**Stage 1: Recover Effective Productivity $A_n^{G,\textbf{eff}}$.**

*Resident Demand Potential:* $E_m^G = \sum_g \beta^g L_{Rm}^g (\mathbb{E}_m[w^g] - q_m \bar{h}^g)$.

*Observed Supply (Target Revenue):* $R_n^{G,\text{true}} = \frac{w_n^G L_{Wn}^G}{\alpha_G}$.

*Unit Cost Kernel:* $c_n^G = \left(\frac{w_n^G}{\alpha_G}\right)^{\alpha_G} \left(\frac{q_n}{1-\alpha_G}\right)^{1-\alpha_G}$.

Iterate on $A_n^{G,\text{eff}}$ (init $A^{(0)} = 1$):

**while** not converged **do**

Price: $p_n^{G,(t)} = c_n^G / A_n^{G,\text{eff},(t)}$.

Trade Shares: $\pi_{m\to n}^{G,(t)} = \frac{(t_{mn}^G p_n^{G,(t)})^{1-\sigma_G}}{\sum_k (t_{mk}^G p_k^{G,(t)})^{1-\sigma_G}}$.

Implied Revenue: $R_n^{G,\text{imp},(t)} = \zeta_G \sum_m E_m^G \pi_{m\to n}^{G,(t)}$.

Update (Revenue $\propto p^{1-\sigma_G} \propto (A^{\text{eff}})^{\sigma_G - 1}$):

$$A_n^{G,\text{eff},(t+1)} = A_n^{G,\text{eff},(t)} \left(\frac{R_n^{G,\text{true}}}{R_n^{G,\text{imp},(t)}}\right)^{\frac{1}{\sigma_G - 1}}.$$

**end while**

**Stage 2: Recover Fundamental Productivity $\bar{A}_n^G$.**

Calculate Agglomeration Spillover:

$$\Omega_n^G = \left(\sum_{k=1}^{N} e^{-\delta_G \tau_{nk}} (L_{W,k}^G + L_{W,k}^S)\right)^{\psi_G}$$

Back out Fundamental:

$$\bar{A}_n^G = \frac{A_n^{G,\text{eff}}}{\Omega_n^G}$$

**Algorithm 3:** Service Productivity Calibration (Effective & Fundamental)

**Require:** Data: $\{w_n^S, L_{Wn}^S, L_{Wn}^G, q_n, L_{Rm}^g, \bar{\tau}_{mn}\}$.
**Require:** Params: $\alpha_S, \gamma^g, \sigma_S, \zeta_S, \psi_S, \delta_S, f$ (default $f = 1$).
**Require:** Normalization: fix $\bar{a}_{n_0}^S \equiv 1$.
**Ensure:** Fundamental $\bar{a}_n^S$, Effective $a_n^{S,\text{eff}}$, Prices $p_n^S$.

**Stage 1: Recover Effective Productivity $a_n^{S,\textbf{eff}}$.**

*Resident Demand Potential:* $E_m^S = \sum_g \gamma^g L_{Rm}^g (\mathbb{E}_m[w^g] - q_m \bar{h}^g)$.

*Observed Supply:* $R_n^{S,\text{true}} = \frac{w_n^S L_{Wn}^S}{\alpha_S}$ and Target Exp $\mathcal{E}_n^{\text{true}} = R_n^{S,\text{true}}/\zeta_S$.

*Marginal Cost Kernel:*

$$r_n^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_n^S)^{\alpha_S} q_n^{1-\alpha_S}.$$

*Mass of Varieties (Zero Profit Condition):*

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

Iterate on $a_n^{S,\text{eff}}$ (init $a^{(0)} = 1$):

**while** not converged **do**

**Price:** With markup $\mu_S = \frac{\sigma_S}{\sigma_S - 1}$:

$$p_n^{S,(t)} = \mu_S \frac{r_n^S}{a_n^{S,\text{eff},(t)}}.$$

**Market Access (Price Index Component):**

$$W_n^{(t)} = M_n (p_n^{S,(t)})^{1-\sigma_S}.$$

**Shopping Shares:**

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

**Implied Expenditure:**

$$\mathcal{E}_n^{S,\text{imp},(t)} = \sum_m E_m^S \, \pi_{m\to n}^{S,(t)}.$$

**Update** (Expenditure $\propto p^{1-\sigma_S} \propto (a^{\text{eff}})^{\sigma_S - 1}$):

$$a_n^{S,\text{eff},(t+1)} = a_n^{S,\text{eff},(t)} \left( \frac{\mathcal{E}_n^{S,\text{true}}}{\mathcal{E}_n^{S,\text{imp},(t)}} \right)^{\frac{1}{\sigma_S - 1}}.$$

**end while**

**Stage 2: Recover Fundamental Productivity $\bar{a}_n^S$.**

Calculate Agglomeration Spillover:

$$\Omega_n^S = \left( \sum_{k=1}^N e^{-\delta_S \tau_{nk}} (L_{W,k}^G + L_{W,k}^S) \right)^{\psi_S}$$

Back out Fundamental:

$$\bar{a}_n^S = \frac{a_n^{S,\text{eff}}}{\Omega_n^S}$$

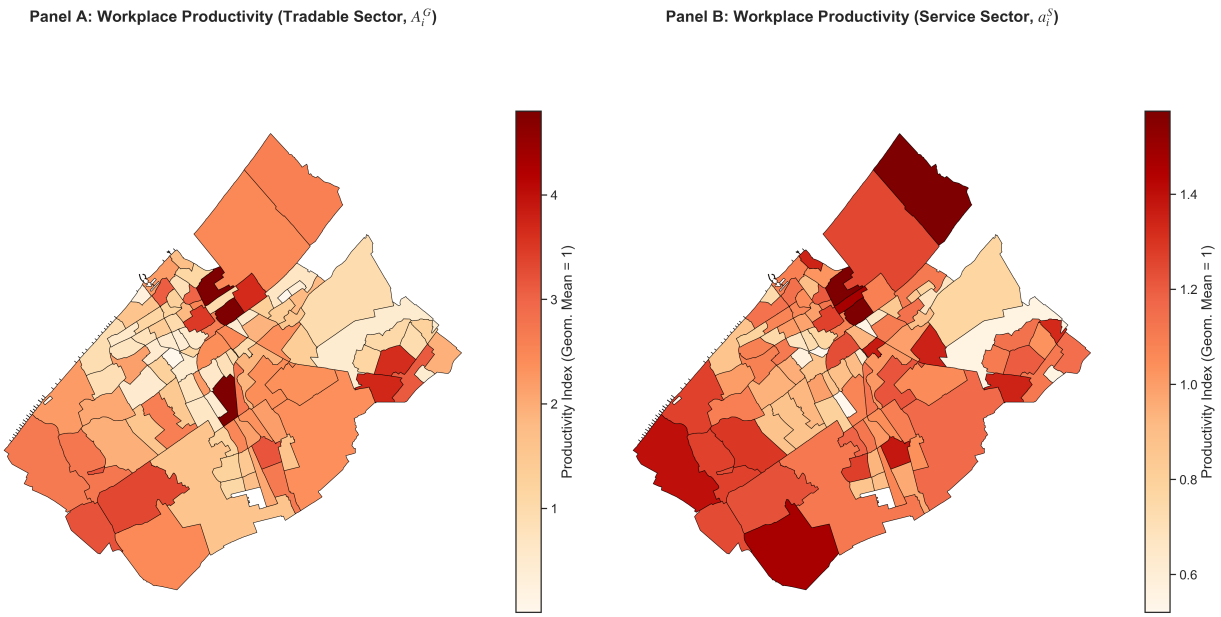



Figure D.14: Spatial Distribution of Calibrated Workplace Productivity

*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.

## 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 $\pi_n$.

### 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.

Unlike the simplified case with a unified goods price, the Armington specification implies that residents in different locations face different effective price indices for tradable goods, $P_n^{G,\text{eff}}$, depending on their access to productive locations. This variation in the cost of living must be accounted for in the amenity inversion.

**Algorithm 4:** Amenity Calibration via Residence Matching

**Data:** Initial amenity guess $B_n^g = 1$ for all $n$; calibrated prices $\{p_n^G, p_n^S\}$ and varieties $\{M_n\}$

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

**Step 1: Pre-compute Price Indices (Cost of Living)**;

**foreach** *residence* $n$ **do**

  Goods Price Index (Armington):;

  $P_n^{G,\text{eff}} = \left(\sum_{k=1}^N (t_{nk}^G p_k^G)^{1-\sigma_G}\right)^{\frac{1}{1-\sigma_G}}$;

  Services Price Index (Monopolistic Competition):;

  $P_n^{S,\text{eff}} = \left(\sum_{k=1}^N M_k (t_{nk}^S p_k^S)^{1-\sigma_S}\right)^{\frac{1}{1-\sigma_S}}$;

  where $t_{nk}^G = \exp(\kappa^{\text{shop},G}\bar{\tau}_{nk})$ and $t_{nk}^S = \exp(\kappa^{\text{shop},S}\bar{\tau}_{nk})$.

**Step 2: Iterate on Amenities**;

**while** *not converged* **do**

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

    Compute systematic utility component (Attractiveness):;

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

  **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:;

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

    Update amenity (noting $\lambda_n^g \propto (B_n^g)^{\epsilon^g}$):;

    $B_n^g \leftarrow B_n^g \cdot \left(\frac{L_{Rn}^g}{\hat{L}_{Rn}^g}\right)^{1/\epsilon^g}$

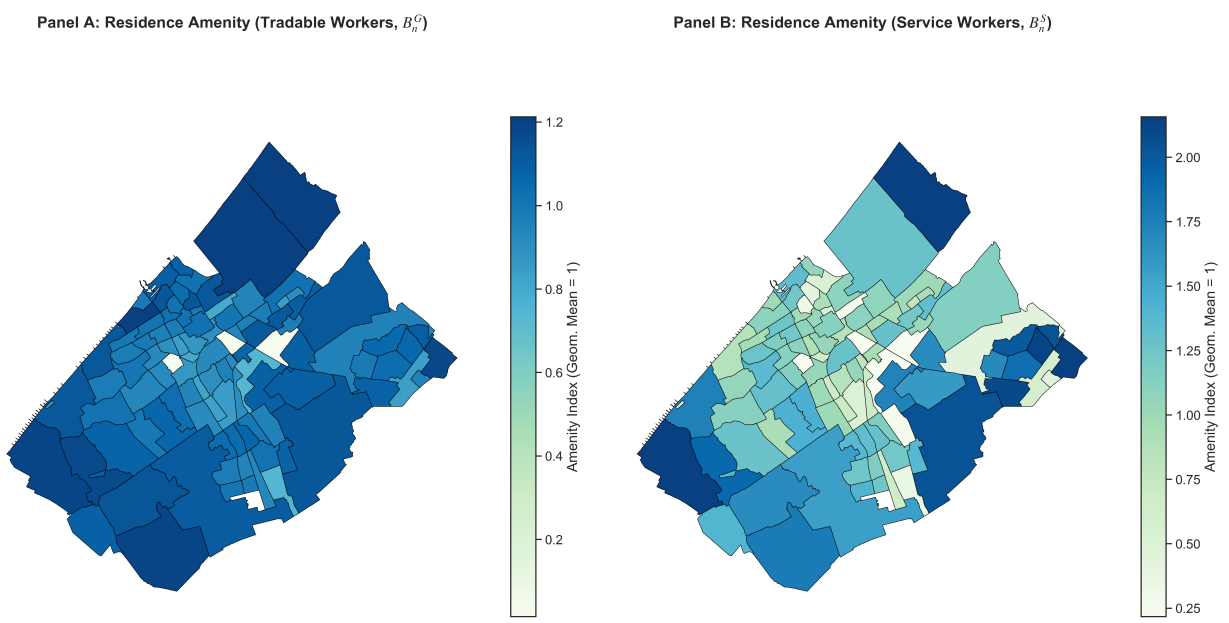



Figure D.15: Spatial Distribution of Calibrated Residence Amenities

*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.

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.

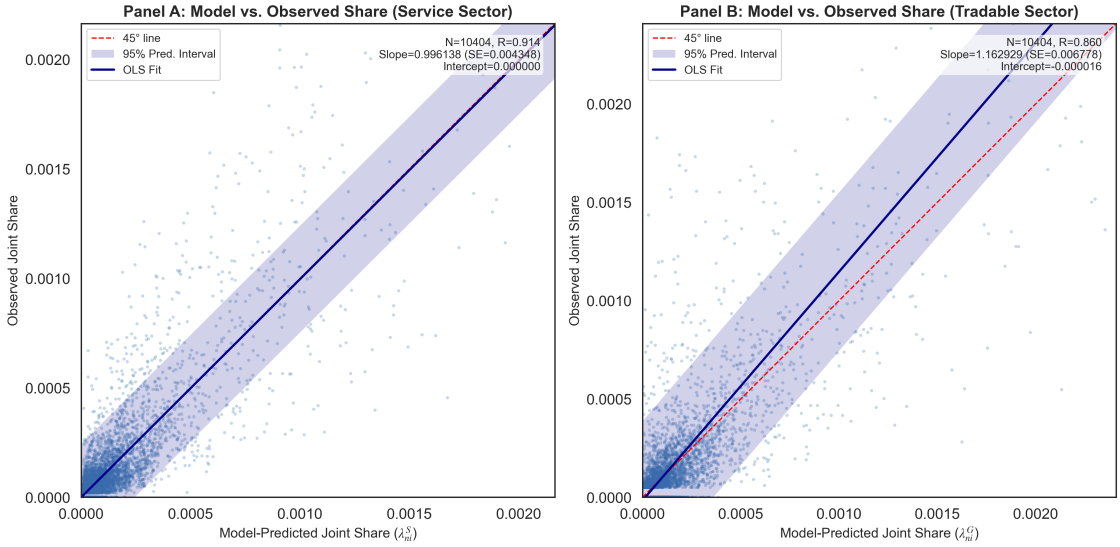



Figure D.16: Model Fit for Joint Commuting Probabilities

*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.

### D.3.2 Housing Parameter Calibration

The housing supply elasticity $\eta_n$ is estimated externally (as discussed in Section C.6). Given $\eta_n$ and the baseline equilibrium values for all land demands $(D_n^R, D_n^G, D_n^S)$ and the land rent $q_n$, the housing supply shifter $\pi_n$ is calibrated by directly inverting the land market clearing condition (Eq. 26 in the main text), as shown in Algorithm 5.

**Algorithm 5:** Housing Supply Shifter ($\pi_n$)

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

**Output:** Calibrated housing supply shifter $\pi_n$

**Step 1:** Compute total residential demand for land (Stone-Geary):

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

*Note: The housing expenditure share depends only on preference parameters, not on price indices $P^G$ or $P^S$.*

**Step 2:** Compute goods sector land demand (from Wage Bill):

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

**Step 3:** Compute services sector land demand (from Wage Bill):

$$D^S_n = \frac{(1-\alpha_S)}{\alpha_S}\frac{w^S_n L^S_{W,n}}{q_n}.$$

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

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

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

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

**Step 6:** Solve for $\pi_n$:

$$\pi_n = \frac{q_n}{(D^{\text{Total}}_n)^{1/\eta_n}}.$$

## D.4 General Equilibrium Algorithm for Counterfactuals

**Algorithm 6:** General Equilibrium: Nested Fixed-Point with Endogenous Agglomeration

**Require:** Counterfactual shocks (e.g., $\pi'_n, \bar{L}^{g'}$), calibrated parameters.

**Ensure:** Equilibrium $\{\lambda_{ni}^{g*}, q_n^*, w_i^{g*}, p_n^{G*}, p_n^{S*}\}$

**Initialize:** $\lambda_{ni}^g, q_n, w_n^G, w_n^S$ from baseline.

**while** outer loop not converged **do**

  **Step 1: Aggregate Labor and Update Agglomeration**

    Labor Supply: $L_{W,i}^g = \sum_n \lambda_{ni}^g \bar{L}^g, \quad L_{R,n}^g = \sum_i \lambda_{ni}^g \bar{L}^g$

    Total Density: $L_{W,i}^{\text{Tot}} = L_{W,i}^G + L_{W,i}^S$

    Update Productivities:

    $A_i^{G,\text{eff}} = \bar{A}_i^G (\Omega_i^G)^{\psi_G}, \quad a_i^{S,\text{eff}} = \bar{a}_i^S (\Omega_i^S)^{\psi_S}$

  **Step 2: Solve Joint Market Clearing (Inner Loop)**

    Call Algorithm 7 *(wage-based iteration with wage-bill rescaling)*:

    $\{w^G, w^S, p^G, p^S, M\} \leftarrow \texttt{SolveMarkets}(w^G, w^S, \lambda, q, A^{\text{eff}}, a^{\text{eff}}, L_W, L_R)$

  **Step 3: Compute Land Demand**

    Expected Wage: $\mathbb{E}_n[w^g] = \sum_i w_i^g \lambda^g(i|n)$

    Discretionary Income: $Y_n^{\text{disp},g} = \max(\mathbb{E}_n[w^g] - q_n \bar{h}^g,\ 0)$

    $D_n^R = \sum_g L_{Rn}^g [\bar{h}^g + (1 - \beta^g - \gamma^g) Y_n^{\text{disp},g} / q_n]$

    $D_n^G = \frac{(1-\alpha_G) w_n^G L_{W,n}^G}{\alpha_G\, q_n}, \quad D_n^S = \frac{(1-\alpha_S) w_n^S L_{W,n}^S}{\alpha_S\, q_n}$

    Total: $D_n^{\text{Tot}} = D_n^R + D_n^G + D_n^S$

  **Step 4: Update Land Rents (Market Clearing)**

    $q_n^{\text{new}} = \pi_n (D_n^{\text{Tot}})^{1/\eta_n}$

  **Step 5: Update Population Distribution**

    Cost of Living:

    $P_n^{G,\text{eff}} = [\sum_k (t_{nk}^G p_k^G)^{1-\sigma_G}]^{\frac{1}{1-\sigma_G}}$

    $P_n^{S,\text{eff}} = [\sum_k M_k (t_{nk}^S p_k^S)^{1-\sigma_S}]^{\frac{1}{1-\sigma_S}}$

    Utility Value $\Phi_{ni}^g$:

    $\Phi_{ni}^g \propto (B_n^g)^{\epsilon^g} (P_n^{G,\text{eff}})^{-\beta^g \epsilon^g} (P_n^{S,\text{eff}})^{-\gamma^g \epsilon^g} (q_n)^{-(1-\beta^g-\gamma^g)\epsilon^g} (w_i^g - q_n \bar{h}^g)_+^{\epsilon^g} (d_{ni}^g)^{-\epsilon^g} E_i^g$

    $\lambda_{ni}^{g,\text{new}} = \Phi_{ni}^g / \sum_{m,j} \Phi_{mj}^g$

  **Step 6: Check Convergence & Dampen $(q, \lambda)$**

    Apply damping: $q_n \leftarrow (1-\rho) q_n + \rho\, q_n^{\text{new}}$

    Apply damping: $\lambda_{ni}^g \leftarrow (1-\rho) \lambda_{ni}^g + \rho\, \lambda_{ni}^{g,\text{new}}$

**end while**

**Algorithm 7:** Joint Goods & Services Market Equilibrium (Inner Loop: Wage-Based Iteration)

**Require:** Labor $L^g_{W,i}$, Residents $L^g_{R,n}$, Rents $q_n$, Conditional $\lambda^g(i|n)$, Productivities $A_i^{G,\text{eff}}, a_i^{S,\text{eff}}$.

**Ensure:** Wages $w$, Prices $p$, Varieties $M$.

**Initialize:** Wages $w_n^G, w_n^S$ from previous outer iteration.

**Record initial wage bills:** $\text{WB}^G = \sum_i w_i^G L_{W,i}^G, \quad \text{WB}^S = \sum_i w_i^S L_{W,i}^S$.

**while** inner loop not converged **do**

**Step 1: Prices and Varieties from Current Wages**

Unit Costs:

$c_n^G = \left(\frac{w_n^G}{\alpha_G}\right)^{\alpha_G}\left(\frac{q_n}{1-\alpha_G}\right)^{1-\alpha_G}, \quad r_n^S = \alpha_S^{-\alpha_S}(1-\alpha_S)^{-(1-\alpha_S)}(w_n^S)^{\alpha_S}(q_n)^{1-\alpha_S}$

Output Prices:

$p_n^G = c_n^G / A_n^{G,\text{eff}}, \quad p_n^S = \mu_S\, r_n^S / a_n^{S,\text{eff}}$

Revenues from Current Wages: $R_n^G = \frac{w_n^G L_{W,n}^G}{\alpha_G}, \quad R_n^S = \frac{w_n^S L_{W,n}^S}{\alpha_S}$

Service Varieties: $M_n = \frac{R_n^S}{\sigma_S\, r_n^S\, f}$

**Step 2: Shopping Shares (Gravity)**

Goods: $\pi_{m\to n}^G = \frac{(t_{mn}^G p_n^G)^{1-\sigma_G}}{\sum_k (t_{mk}^G p_k^G)^{1-\sigma_G}}$

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

**Step 3: Resident Budgets**

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

Discretionary Income: $Y_m^{\text{disp},g} = \max(\mathbb{E}_m[w^g] - q_m \bar{h}^g,\ 0)$

Goods Budget: $B_m^G = \sum_g \beta^g L_{R,m}^g\, Y_m^{\text{disp},g}$

Service Budget: $B_m^S = \sum_g \gamma^g L_{R,m}^g\, Y_m^{\text{disp},g}$

**Step 4: Implied Revenue & Wages**

$R_n^{G,\text{impl}} = \zeta_G \sum_m B_m^G\, \pi_{m\to n}^G, \quad R_n^{S,\text{impl}} = \zeta_S \sum_m B_m^S\, \pi_{m\to n}^S$

$w_n^{G,\text{impl}} = \frac{\alpha_G\, R_n^{G,\text{impl}}}{L_{W,n}^G}, \quad w_n^{S,\text{impl}} = \frac{\alpha_S\, R_n^{S,\text{impl}}}{L_{W,n}^S}$

**Step 5: Wage-Bill Rescaling (Stabilization)**

$w_n^{G,\text{impl}} \leftarrow w_n^{G,\text{impl}} \times \frac{\text{WB}^G}{\sum_i w_i^{G,\text{impl}} L_{W,i}^G}$

$w_n^{S,\text{impl}} \leftarrow w_n^{S,\text{impl}} \times \frac{\text{WB}^S}{\sum_i w_i^{S,\text{impl}} L_{W,i}^S}$

**Step 6: Damped Update & Update Wage Bills**

$w_n^G \leftarrow (1-\rho)\, w_n^G + \rho\, w_n^{G,\text{impl}}$

$w_n^S \leftarrow (1-\rho)\, w_n^S + \rho\, w_n^{S,\text{impl}}$

Update: $\text{WB}^G \leftarrow \sum_i w_i^G L_{W,i}^G, \quad \text{WB}^S \leftarrow \sum_i w_i^S L_{W,i}^S$

**Step 7: Check Convergence**

Convergence criterion: $\max_n \frac{|w_n^{G,\text{new}} - w_n^G|}{w_n^G} < \epsilon_w$ (similarly for $S$)

**end while**

**return** Converged $\{w^G, w^S, p^G, p^S, M\}$.

**Remark 2** (Stability of the Inner Loop Iteration)**.** *The inner loop mapping from current wages to*

*implied wages has two qualitatively distinct modes:*

(a) ***Distribution mode*** *(relative wages across locations):* Stable. *When $\sigma_G, \sigma_S > 1$, the Armington/Dixit-Stiglitz shopping shares provide* negative price feedback*: a location with a higher-than-equilibrium wage produces goods at higher cost, loses shopping share, receives less revenue, and its implied wage decreases. This mechanism contracts the cross-sectional wage distribution toward the fixed point.*

(b) ***Aggregate mode*** *(overall wage level):* Unstable. *Consider a uniform downward perturbation $w_i \to (1-\delta)w_i$ for all $i$, holding rents $q$ fixed. Shopping shares are invariant to uniform price scaling (CES ratios are unchanged). However, Stone-Geary budgets*

$$\beta^g L^g_{R,m}(\mathbb{E}_m[w^g] - q_m \bar{h}^g)$$

*decrease by* more *than $\delta$ in proportional terms, because the subsistence term $q_m \bar{h}^g > 0$ is fixed. Specifically, the proportional budget change is $\delta\bar{w}/(\bar{w} - q\bar{h}) > \delta$. Since implied revenue is proportional to budgets (with invariant shopping shares), implied wages fall faster than the perturbation, creating a destabilizing positive feedback loop that drives wages to zero.*

*The wage-bill rescaling in Step 5 of Algorithm 7 projects out the unstable aggregate mode by constraining implied wages to preserve the current total wage bill. This is equivalent to iterating only on the stable distribution subspace. The aggregate wage level is then determined by the* outer *loop through the land market clearing condition $q_n = \pi_n D_n^{1/\eta_n}$, which provides the model's nominal anchor.*

*At the fixed point, the rescaling factor equals unity ($\sum_i w_i^{impl} L_{W,i} = \sum_i w_i L_{W,i}$), so the converged wages satisfy the* unrestricted *market-clearing conditions exactly. The rescaling affects only the iterative path, not the equilibrium itself.*

*This approach is consistent with the wage calibration algorithm (Algorithm 1), which employs the same wage-bill anchoring in its second step.*

### D.5 Semi-Open City

In the semi-open city setting, the total population of each type is exogenously adjusted to reflect a projected demographic response, rather than endogenously determined by a utility-equalization condition. The solver runs the closed-city equilibrium (Algorithms 6–7) twice: once at baseline populations, once at the adjusted populations.

**Algorithm 8:** Semi-Open City Counterfactual

**Require:** Baseline populations $\bar{L}_0^G, \bar{L}_0^S$; scaling factors $s^G, s^S$.

**Ensure:** Baseline and counterfactual equilibria.

1: **Baseline (Post):** Solve Algorithms 6–7 with CF = false, populations ($\bar{L}_0^G$, $\bar{L}_0^S$).

2: **Counterfactual (Pre):** Set $\bar{L}^{G'} = s^G \bar{L}_0^G$, $\bar{L}^{S'} = s^S \bar{L}_0^S$.

3: Solve Algorithms 6–7 with CF = true, populations ($\bar{L}^{G'}$, $\bar{L}^{S'}$).

4: Use the baseline solution as warm start.

In our application, $s^G = 1.1/1.3 \approx 0.846$ and $s^S = 1.1/1.19 \approx 0.924$, reflecting reduced in-migration when new housing supply is restricted.

## D.6 Open City

In the open city setting, both $\bar{L}^G$ and $\bar{L}^S$ adjust endogenously until the expected utility of each worker type in the counterfactual equals its baseline level. This requires solving a two-dimensional root-finding problem:

$$F(\bar{L}^G, \bar{L}^S) \;=\; \begin{pmatrix} (U^G(\bar{L}^G, \bar{L}^S) - U_0^G)/U_0^G \\ (U^S(\bar{L}^G, \bar{L}^S) - U_0^S)/U_0^S \end{pmatrix} \;=\; \mathbf{0}. \tag{D.48}$$

### D.6.1 Computational Challenges

Two features make (D.48) difficult to solve with simple bisection:

1. **Competing congestion and agglomeration forces.** More residents raise land rents $q_n$ (reducing utility), but more workers raise effective productivity $A_i^{G,\text{eff}}$, $a_i^{S,\text{eff}}$ via urbanization externalities (raising utility). This can create non-monotonicity in $U^g$ with respect to the total population.
2. **Asymmetric elasticities.** The Fréchet shape parameters differ substantially ($\epsilon^G = 16.38$ vs. $\epsilon^S = 3.24$), so the two worker types respond very differently to the same proportional population change. Consequently, scaling both populations by a common factor $s$ can drive the average gap $\frac{1}{2}(\text{gap}^G + \text{gap}^S)$ to zero while leaving individual gaps of opposite sign ($\text{gap}^G \approx +0.9\%$, $\text{gap}^S \approx -0.9\%$).

We therefore adopt a two-phase strategy: proportional bisection to reach a good initial guess, followed by a 2D Newton method to converge exactly.

### D.6.2 Algorithm

**Algorithm 9:** Open City Solver: Proportional Bisection + 2D Newton

**Require:** Baseline utilities $U_0^G, U_0^S$; baseline populations $\bar{L}_0^G, \bar{L}_0^S$; tolerance $\epsilon_U$.

**Ensure:** Counterfactual populations $(\bar{L}^{G*}, \bar{L}^{S*})$ with $|U^g - U_0^g|/U_0^g < \epsilon_U$ for $g \in \{G, S\}$.

**Phase 0: Baseline.** Solve Algorithm 6 with CF = false to obtain $U_0^G$, $U_0^S$.

**Phase 1: Proportional bisection.**

Set $\bar{L}^g = s \cdot \bar{L}_0^g$ for both $g$, preserving the baseline $G/S$ ratio.

Bracket: find $s_{\text{lo}}, s_{\text{hi}}$ such that combined gap $\bar{F}(s) \equiv \frac{1}{2}(F^G(s) + F^S(s))$ changes sign.

**while** $|s_{\text{hi}} - s_{\text{lo}}| > 10^{-4} \cdot s_{\text{mid}}$ **do**

  $s_{\text{mid}} \leftarrow \frac{1}{2}(s_{\text{lo}} + s_{\text{hi}})$.

  Solve spatial equilibrium at $(s_{\text{mid}}\bar{L}_0^G,\ s_{\text{mid}}\bar{L}_0^S)$ with CF = true.

  If $\bar{F}(s_{\text{mid}}) > 0$: $s_{\text{lo}} \leftarrow s_{\text{mid}}$; else $s_{\text{hi}} \leftarrow s_{\text{mid}}$.

**end while**

Set $\bar{L}^G \leftarrow s_{\text{mid}} \cdot \bar{L}_0^G$, $\bar{L}^S \leftarrow s_{\text{mid}} \cdot \bar{L}_0^S$.

**Phase 2: 2D Newton refinement.**

**while** $\max(|F^G|, |F^S|) > \epsilon_U$ **do**

  Evaluate $\mathbf{f} = F(\bar{L}^G, \bar{L}^S)$ by solving spatial equilibrium.

  Compute the Jacobian by finite differences ($\delta = 0.5\%$ perturbation):

$$J \;=\; \begin{pmatrix} \partial F^G/\partial \bar{L}^G & \partial F^G/\partial \bar{L}^S \\ \partial F^S/\partial \bar{L}^G & \partial F^S/\partial \bar{L}^S \end{pmatrix} \;\approx\; \begin{pmatrix} \Delta F^G/\Delta \bar{L}^G & \Delta F^G/\Delta \bar{L}^S \\ \Delta F^S/\Delta \bar{L}^G & \Delta F^S/\Delta \bar{L}^S \end{pmatrix}.$$

  Newton step with damping:

$$\begin{pmatrix} \bar{L}^G \\ \bar{L}^S \end{pmatrix} \;\leftarrow\; \begin{pmatrix} \bar{L}^G \\ \bar{L}^S \end{pmatrix} \;-\; \alpha\, J^{-1}\mathbf{f}, \qquad \alpha \in (0, 1].$$

  Clamp step: $|\Delta \bar{L}^g| \le 0.3\, \bar{L}^g$ per iteration.

**end while**

**Remark 3** (Design rationale)**.** *Phase 1 exploits the fact that proportional scaling preserves the spatial structure and converges the* average *gap rapidly (typically in 10–15 bisection steps to $|\bar{F}| < 10^{-4}$). However, because $\epsilon^G \neq \epsilon^S$, this leaves residual individual gaps of order $\pm 1\%$ that cannot be eliminated by further bisection along the proportional ray. Phase 2 resolves this by treating $(\bar{L}^G, \bar{L}^S)$ as independent controls. Each Newton iteration requires three spatial equilibrium solves (one base point and two perturbations), but convergence is quadratic, so only 3–5 iterations are typically needed.*

**Remark 4** (Wasteland treatment in utility calculation)**.** *Under the counterfactual (*CF = true*),*

*Vinex locations have $q_n = 10^6$ (wasteland). Because the Fréchet shape parameter for the service sector is relatively low ($\epsilon^S = 3.24$), the term $q_n^{-\epsilon^S(1-\beta^S-\gamma^S)} \approx 10^{-3.4}$ at wasteland locations is not numerically negligible, creating a spurious positive contribution to $\sum_{n,i} \Phi^S_{ni}$ and hence to $U^S$. We eliminate this by setting $\Phi^g_{ni} = 0$ for all wasteland residence locations $n$, reflecting the economic constraint that no agent chooses to reside where land costs are prohibitive.*

## D.7 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 preceding 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.

The results of this exercise are presented in the figure below. The figure plots the forward-solved values for key endogenous variables (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. All data points lie on the 45-degree line with $R = 1.0000$ for each variable, confirming that the solver correctly identifies the model's fixed-point equilibrium.

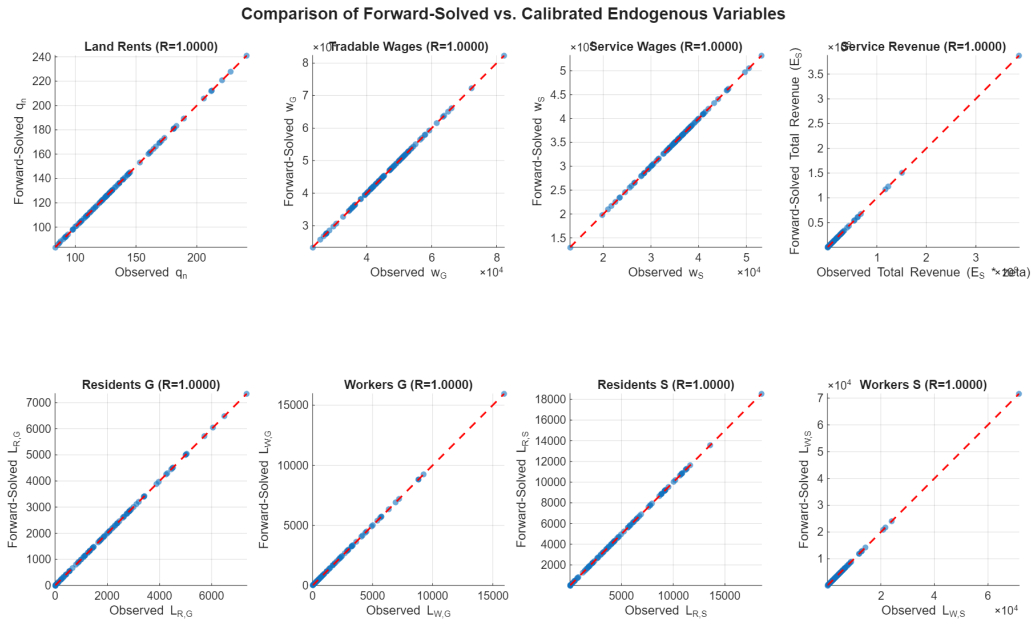



Figure D.17: Forward Equilibrium For Baseline (No Parameter Changed)

# E Open-City Counterfactual Results

This section reports the open-city counterfactual results. In the open-city scenario, both $\bar{L}^G$ and $\bar{L}^S$ adjust endogenously until expected utility in the counterfactual equals the baseline utility for each worker type, representing a full migration equilibrium. We view this as a theoretical benchmark rather than the empirically relevant case, since the implied population adjustments are unrealistically large relative to what was observed over the 1995–2015 period.

Table E.18: Welfare and Population Changes: Open-City Benchmark

| Metric | (1) Pre | (2) Post | (3) Δ% |
|---|---|---|---|
| **Panel A. Population & Net Income** | | | |
| Population: G ($L^G$) | 122,454 | 199,214 | 62.68% |
| Population: S ($L^S$) | 163,319 | 497,032 | 204.33% |
| Avg. net income: G ($\bar{y}^G$) | 45,097 | 41,830 | −7.24% |
| Avg. net income: S ($\bar{y}^S$) | 36,853 | 32,646 | −11.41% |
| | (1) **G** | (2) **S** | |
| **Panel B. Welfare** | | | |
| $\Delta\%W$ | −0.01% | 0.01% | |
| EV (EUR) | −6 | 4 | |
| CV (EUR) | −5 | 4 | |

*Notes:* G = tradable-goods sector; S = non-tradable service sector. "Pre" denotes the no-Vinex counterfactual equilibrium ($t = 0$); "Post" denotes the observed 2015 post-policy equilibrium ($t = 1$). Panel A: $\Delta\% = 100 \times (\text{Post}/\text{Pre} - 1)$. Average net income is choice-probability-weighted: $\bar{y}_t^g = \sum_{n,i} \lambda_{ni,t}^g (w_{i,t}^g - q_{n,t}\bar{h}^g)$. Panel B: $\Delta\%W = 100 \times (W_1^g/W_0^g - 1)$, where $W_t^g$ is the expected maximum indirect utility (equation 31). EV and CV are per-capita money-metric welfare measures (equations 32–33). In the open-city scenario, population adjusts until expected utility is equalized, so EV and CV are approximately zero for both groups. The implied population changes (63% for G-Sector, 204% for S-Sector) are far larger than observed over the sample period. All monetary values are in 2015 euros.

Table E.19: Aggregate Economic Outcomes: Open-City Benchmark

| Metric | (1) Pre | (2) Post | (3) Δ% |
|---|---|---|---|
| **Panel A. Output** | | | |
| Goods, nominal ($Y_G^{\text{nom}}$) | 6.52B | 10.55B | 61.84% |
| Goods, real ($Y_G^{\text{real}}$) | 205.7K | 345.2K | 67.86% |
| Services, nominal ($Y_S^{\text{nom}}$) | 7.21B | 21.31B | 195.64% |
| Services, real ($Y_S^{\text{real}}$) | 83.5K | 246.1K | 194.67% |
| **Panel B. Wages and Prices** | | | |
| Avg. wage: goods ($\bar{w}_G$) | 49,497 | 49,241 | −0.52% |
| Avg. wage: services ($\bar{w}_S$) | 41,041 | 39,869 | −2.85% |
| Avg. land rent ($\bar{q}$) | 71 | 122 | 72.43% |
| Avg. goods price ($\bar{p}_G$) | 31,688 | 30,553 | −3.58% |
| Avg. service price ($\bar{p}_S$) | 41,362 | 39,164 | −5.32% |
| **Panel C. Land Demand** | | | |
| Residential ($D_R$) | 45.70M | 76.60M | 67.61% |
| Goods ($D_G$) | 5.97M | 5.76M | −3.49% |
| Services ($D_S$) | 7.03M | 12.01M | 70.80% |
| Total ($D_{\text{total}}$) | 58.71M | 94.38M | 60.76% |

*Notes:* "Pre" denotes the no-Vinex counterfactual equilibrium ($t = 0$); "Post" denotes the observed 2015 post-policy equilibrium ($t = 1$). $\Delta\% = 100 \times (\text{Post}/\text{Pre} - 1)$. Nominal output ($Y_g^{\text{nom}}$) is total sectoral revenue; real output ($Y_g^{\text{real}}$) sums physical output across locations. Average wages are employment-weighted: $\bar{w}_g = \sum_i w_i^g L_{W,i}^g / \sum_i L_{W,i}^g$. Average rent is land-demand-weighted: $\bar{q} = \sum_i q_i D_i^{\text{total}} / \sum_i D_i^{\text{total}}$. Average goods price is output-weighted: $\bar{p}_G = \sum_i p_i^G Y_i^G / \sum_i Y_i^G$, where $p_i^G$ is the unit cost at location $i$ (Section 5). Average service price is output-weighted: $\bar{p}_S = \sum_i p_i^S Y_i^S / \sum_i Y_i^S$, where $p_i^S$ is the markup-over-cost price and $Y_i^S = M_i y_i$ is real service output (Section 5). $D_R$, $D_G$, $D_S$ denote total land demand by residential, goods-production, and service-production use. In the open-city scenario, the policy supports a much larger city, with G-Sector employment roughly 63% higher and S-Sector employment more than tripling. Average land rents rise by over 70%, reflecting substantial in-migration that bids up land prices. B = billions, M = millions, K = thousands. Land demand is in square meters. All monetary values are in 2015 euros.