The Aggregate Consequences of Local Capital Taxation

Antonin Bergeaud[1] Jean-Félix Brouillette[2]

Louis de Lachapelle[3] Clément Malgouyres[4]

April 24, 2026

Abstract

We study the repeal of France's *Taxe Professionnelle*, a large and spatially dispersed local capital tax whose rates were set by nearly 35,000 municipalities. Combining administrative data with a dynamic spatial general equilibrium model disciplined by reduced-form estimates of firms' investment responses, we find that the reform raises real income per worker by 8% in the long run and worker welfare by 3% in consumption-equivalent terms. Counterfactual experiments reveal that the bulk of these gains come from the reduction in the overall tax burden, which raises real wages across all locations. In contrast, eliminating the spatial dispersion of tax rates alone leaves real income per worker essentially unchanged, as it reallocates activity away from large low-tax, high-income hubs toward lower-wage locations.

[1]HEC Paris, CEP-LSE, and CEPR. E-mail: bergeaud@hec.fr
[2]HEC Montréal. E-mail: jean-felix.brouillette@hec.ca
[3]CREST. E-mail: louis.delachapelle@ensae.fr
[4]CREST, IPP, and IZA. E-mail: clement.malgouyres@ensae.fr

1 Introduction

Taxes on capital that vary across locations create dispersion in the user cost of capital, a source of resource misallocation that can reduce aggregate productivity and income (Hsieh and Klenow, 2009; Restuccia and Rogerson, 2008). Until recently, France offered a textbook case of such distortions: the *Taxe Professionnelle* (TP) was a local tax on the book value of firms' tangible assets (both equipment and real estate) whose rates were determined independently by each of the country's nearly 35,000 municipalities. This system created a complex landscape of large and spatially differentiated capital tax distortions that persisted for decades.[1]

This tax was widely criticized (Bergeaud, Jousselin and Malgouyres, 2021) and in 2010, the French government abolished the TP through a fiscal reform consisting of two main measures. First, it removed the book value of *equipment* capital from the tax base. Second, it introduced a new tax on value-added, applied at a nationally uniform rate.[2] However, this reform was not revenue neutral. By cutting the overall tax burden by about 5 billion euros in the year of implementation, the reform simultaneously reduced the *level* and eliminated the spatial *dispersion* of equipment capital taxes.

When distortions are local in nature and affect returns to capital investment, two forces shape the aggregate consequences of their removal. On the one hand, spatial frictions—such as trade and migration costs—as well as differences in local amenities may limit the reallocation of resources toward more productive locations. On the other hand, capital deepening may amplify the aggregate gains from repealing distortions beyond what a static reallocation of existing resources would deliver. The French reform sits squarely at the intersection of these two forces: it eliminated distortions that were both fundamentally local and directly tied to capital. Does capital deepening compensate for the limited scope of spatial reallocation, or do spatial frictions ultimately constrain the gains from the reform?

To answer this question, we proceed in two steps. We first exploit cross-firm heterogeneity in exposure to the reform to estimate its impact on firm-level investment using a dynamic difference-in-differences empirical design. Second, we embed these reduced-form estimates in a dynamic spatial general equilibrium model to evaluate the aggregate implications of the reform, accounting for capital accumulation, trade costs,

[1]The capital-weighted average tax rate was above 20% and a firm at the 90th percentile of the tax distribution faced a rate more than twice that of a firm at the 10th percentile.

[2]The *Cotisation sur la Valeur Ajoutée des Entreprises* (CVAE) has a nominal rate of 1.5% of value-added, but effective rates are progressive in turnover, ranging from 0% for firms below €500,000 to the full 1.5% for firms above €50 million. We model it as a 1% uniform tax on value-added, matching CVAE revenue as a share of aggregate value-added in the years following the reform.

migration frictions, and transition dynamics.

Methodologically, our empirical analysis relies on administrative data allowing us to track detailed firm-level outcomes before and after the reform. The setting is particularly well suited for our purposes for several reasons. First, the pre-2010 design of the TP generated substantial spatial heterogeneity in effective tax rates, leading to significant cross-firm differences in exposure to the reform. Second, because much of this variation reflects municipal decisions about local tax rates, it is plausibly exogenous to firms' investment decisions. Third, the shift in the tax base from the book value of *all* tangible assets before 2010 to that of real-estate assets only thereafter induced additional variation: firms with equipment-intensive balance sheets experienced larger tax cuts than those with more real-estate holdings. We exploit this identifying variation within a dynamic difference-in-differences framework, constructing a continuous measure of ex-ante exposure to the policy change following the standard approach of Auten and Carroll (1999).

Our findings show that the reform substantially reduced firms' tax burdens, with the average firm experiencing a decline in total taxes over value-added of approximately 7.7%. This tax relief translated into a large and gradually building expansion of equipment capital, consistent with adjustment frictions: the average firm expanded its equipment stock by about 7% by the end of our sample period. We also document positive effects on quarterly sales, which rise by about 2.9% for the average firm, and on hourly wages, which increase by approximately 1.3%. In contrast, total hours worked are essentially unaffected. We further show that these results are robust to concerns about mean reversion by recomputing the instrument from alternative base years and by defining exposure solely on the basis of local tax rates.

While these reduced-form estimates provide informative causal evidence, they only capture partial-equilibrium responses. In our empirical specification, industry-by-year fixed effects absorb all variation common to firms within an industry in a given year, including changes in local factor prices, migration responses, and the effect of the nationally uniform value-added tax introduced as part of the reform. To account for such general-equilibrium feedbacks and aggregate shocks, we develop a dynamic spatial general equilibrium model featuring capital accumulation as well as migration and trade frictions.

Our model builds on the framework of Kleinman, Liu and Redding (2023). The economy consists of multiple locations and sectors. Locations differ in amenities and land endowments; sectors differ in their relative intensity in equipment versus real estate capital; and productivity varies at the location-sector level. Two types of agents populate the economy: workers, who are mobile across locations subject to migration costs and idiosyncratic preference shocks, and immobile capitalists, who own and accumulate both types of location-specific capital subject to adjustment costs. In each location-sector pair, competitive firms produce differentiated products by renting capital from local capitalists and employing workers. These products are traded across space subject to iceberg trade costs. Finally, a housing sector produces local housing services using real estate capital and land, consumed by both workers and capitalists.

To calibrate the model, we combine our reduced-form estimates with a structural inversion procedure. Fundamentals such as productivity, amenities, land endowments, and bilateral migration and trade costs are chosen so that the model's initial steady state matches the observed spatial distribution of wages, employment, relative housing prices, capital-income moments, and migration patterns in France as closely as possible under the equilibrium restrictions of the model. Our reduced-form estimate of firms' investment response to changes in the user cost of capital provides the key elasticity that disciplines the model's dynamic capital accumulation process. We then simulate the reform as a shift from local capital taxation to a uniform value-added tax, calibrating the location-specific lognormal tax distributions to match the empirical level and dispersion of these taxes within each French department.[3]

The reform raises real income per worker by 8.04% in the long run. Most of this gain comes from within-department responses: holding the spatial distribution of employment fixed, real income per worker rises by 8.17% on average, driven by a 36.6% expansion in equipment capital and an accompanying 7.45% decline in the cost of living. Spatial reallocation slightly offsets these gains, generating a composition effect of -0.116%. This negative composition effect reflects reallocation away from large, low-tax, high-income locations such as Paris toward destinations that, on average, offer lower wages and only modest amenity gains, which slightly reduces average real income even though these flows remain quantitatively small.

However, these long-run gains do not materialize overnight. The transition to the new steady state reveals a clear hierarchy of adjustment speeds: goods prices and equipment capital adjust on similar horizons, with half-lives of 12.8 and 12.8 years, respectively, followed by real wages (16.1 years), while real estate capital (45.5 years) and especially employment reallocation (150 years) are much slower. This sequencing reinforces the main message of the paper: the reform's gains are realized primarily through early capital deepening and lower prices, while the costly spatial reallocation is heavily dampened by adjustment frictions. Accounting for these dynamics, the reform is equivalent to a 2.99% permanent increase in worker consumption.[4]

[3]We assume that local tax revenues finance wasteful local government expenditures. In practice, the central government compensated municipalities for forgone revenue through increased transfers.

[4]For comparison, Fajgelbaum, Morales, Suárez Serrato and Zidar (2018) find that harmonizing state

To disentangle the different forces at work, we compare counterfactuals that isolate each margin of adjustment. To quantify the capital accumulation channel, we shift the entire distribution of equipment tax rates downward until aggregate equipment tax revenue falls to zero, while preserving the pre-reform spatial dispersion in tax rates. This counterfactual raises real income per worker by 9.73%, driven by substantial equipment capital deepening across all locations. To quantify the spatial reallocation channel, we instead consider a revenue-neutral harmonization of equipment tax rates across space. This counterfactual leaves average real income per worker essentially unchanged. The reason is that harmonization raises taxes precisely in the locations where equipment capital is most concentrated. In the model, these locations are also, on an employment-weighted basis, capital-rich and high-wage. Harmonization therefore shifts activity away from these high-income places toward lower-wage locations. Because real income per worker is an employment-weighted average, this adverse composition effect offsets the modest within-location efficiency gain from eliminating spatial tax dispersion.

We also assess the role of the value-added tax introduced alongside the repeal of the TP. A common narrative is that the reform stimulated investment not only by shifting the tax base away from equipment capital, but also by reducing firms' overall tax burden. To evaluate this claim, we compute the revenue-neutral VAT rate, i.e., the rate that keeps total government revenue unchanged in the post-reform equilibrium. The required rate is 5.03% rather than 1%. Under this revenue-neutral counterfactual, average real income per worker still rises by 1.29%, but by much less than under the actual reform. This confirms that the bulk of the reform's gains comes from lowering the overall tax burden.

Related literature. Our paper contributes to several strands of the literature. First, it speaks to the literature on misallocation and aggregate productivity. Hsieh and Klenow (2009) show that dispersion in marginal revenue products reflects misallocation and may entail large productivity losses, while Restuccia and Rogerson (2008) highlight taxes as a key source of such dispersion. Gopinath, Kalemli-Özcan, Karabarbounis and Villegas-Sanchez (2017) show that distortions in the cost of capital contributed to growing capital misallocation and productivity losses in Southern Europe. With nearly 35,000 local tax rates generating substantial dispersion in the user cost of capital, our setting is a natural laboratory for these ideas. However, when distortions are local and fall on capital, two additional forces become central. On the one hand, spatial frictions limit the reallocation of factors across locations (Arkolakis, Costinot and Rodríguez-Clare, 2012; Redding, 2016), and the correlation of distortions with local fundamentals determines whether eliminating their dispersion raises or lowers aggregate efficiency.

taxes in the U.S. would increase worker welfare by 0.6%.

On the other hand, capital deepening can amplify the macroeconomic consequences of eliminating distortions, a mechanism emphasized by Moll (2014) and Buera, Kaboski and Shin (2011) in the context of financial frictions. Our contribution is to study these forces jointly in a setting with local capital taxes, where both spatial frictions and capital accumulation shape the aggregate consequences of the reform.

Second, we contribute to the literature on spatial equilibrium and local taxation. Roback (1982) shows how compensating differentials in wages and rents offset differences in amenities and productivity across locations. Suárez Serrato and Zidar (2016) develop a spatial equilibrium framework to study the incidence of U.S. state corporate taxes, while Fajgelbaum et al. (2018) quantify welfare gains from harmonizing state taxes—a natural benchmark for our results. Both Fajgelbaum et al. (2018) and Albouy (2009) study settings where the correlation between taxes and local fundamentals is such that harmonization improves both income and welfare. Our French setting reverses the income sign: on an employment-weighted basis, the large low-tax locations are high-income and capital-rich, with Paris and Île-de-France being the most prominent example, so harmonization raises taxes where labor income and equipment capital are concentrated and reallocates activity toward lower-wage destinations. This illustrates that the welfare effects of removing local tax distortions are not determined a priori—they depend on the specific correlation structure between taxes, productivity, and amenities, as formalized by Donald, Fukui and Miyauchi (2025). A further difference is that Fajgelbaum et al. (2018) find larger welfare gains when tax revenue funds local public goods endogenously; in our setting, the central government compensated municipalities for forgone revenue through dedicated transfers, limiting the scope for this channel. Using U.S. establishment-level data, Giroud and Rauh (2019) show that corporate tax changes cause multi-state firms to reallocate employment across states, though Rathelot and Sillard (2008) find limited relocation effects of the *Taxe Professionnelle* in France. Relative to these contributions, we further introduce capital accumulation and transition dynamics. Methodologically, we build on the quantitative spatial economics framework surveyed by Redding and Rossi-Hansberg (2017) and adapt the dynamic spatial general equilibrium model of Kleinman et al. (2023) to our setting, incorporating two types of capital (equipment and real estate) and a tax structure that varies across locations and asset classes.

Third, we relate to the theoretical literature on capital taxation. The foundational framework is the user cost of capital (Jorgenson, 1963), which formalizes how taxes on capital raise the effective cost of investment and thereby depress capital accumulation (Hall and Jorgenson, 1967). De Long and Summers (1991) provide cross-country evidence that equipment investment is a key driver of economic growth, underscoring the macroeconomic importance of policies that affect the cost of equipment capital. The classic results of Chamley (1986) and Judd (1985) suggest that optimal capital taxes converge to zero in the long run, a conclusion that has been challenged by Straub and Werning (2020). Our findings confirm that the level of capital taxes drives the aggregate effects of the French reform, even in a spatial economy where tax rates vary widely across locations. However, the spatial dimension adds nuance: the gains depend on which locations bear the tax and how those locations rank in terms of productivity and amenities.

Fourth, we contribute to the empirical literature estimating firm-level investment responses to tax policy. Cummins, Hassett and Hubbard (1994) pioneered the use of tax reforms as natural experiments to estimate investment elasticities, and Bond and Van Reenen (2007) survey the subsequent literature, highlighting mixed evidence on whether corporate income taxes affect investment. House and Shapiro (2008) exploit U.S. bonus depreciation deductions, finding large investment responses. Zwick and Mahon (2017) study the same policy and show that firms respond strongly when the policy generates immediate cash flows, but not when the benefits are deferred through loss carryforwards because of non positive profits. Yagan (2015) studies the U.S. 2003 dividend tax cut and finds no effect on corporate investment. The *Taxe Professionnelle* provides a compelling setting by impacting more directly the user cost, as it was levied on the book value of capital, independently of present and future profits. The removal of equipment from the tax base thus generated a substantial and immediate cost reduction for all firms holding equipment. It therefore provides an ideal source of exogenous variation to estimate how investment responds to changes in the user cost of capital. Closest to our setting, Bergeaud et al. (2021) provide descriptive evidence on the same French reform, documenting that it reduced the marginal cost of equipment investment and increased firm activity. We build on this work by developing a more comprehensive empirical strategy that exploits cross-firm variation in tax exposure, and embedding our reduced-form estimates within a structural model to quantify the general equilibrium effects of the reform.

The remainder of the paper is organized as follows. Section 2 describes the institutional context and data. Section 3 presents our empirical strategy. Section 4 reports the reduced-form evidence. Section 5 develops the theoretical framework. Section 6 quantifies the macroeconomic consequences of the reform. Section 7 concludes.

2 Background and data

This section describes the institutional design of the *Taxe Professionnelle*, the 2010 reform that abolished it, and the administrative data we use. We highlight two features central to our empirical strategy: the cross-firm heterogeneity in tax exposure and the two distinct timing channels through which the reform affected firms.

2.1 Institutional context

Before the reform. The *Taxe Professionnelle* (TP) was a local business tax levied on the rental value of firms' stock of tangible assets. Created in 1975, it accounted for roughly half of the tax revenue of French local governments.[5]

The tax base had two components: equipment capital and real-estate assets. For equipment, the rental value was fixed by statute at 16% of historical acquisition cost; for real estate, it was based on the cadastral value. The base was never adjusted for economic depreciation: a fully depreciated machine still on the books generated the same tax base as when it was first acquired. The TP therefore fell disproportionately on capital-intensive firms, as the tax base reflected the accumulated stock of past investment rather than current returns.

The tax rate τ_c applied in a given city was the sum of rates voted independently at the city, department, and regional levels; these rates varied widely across space. Local authorities set rates during year $t-1$, while the base reflected the value of assets declared in $t-2$. For a firm i with establishments $j \in i$ located in cities $c(j)$, the tax owed in year t was:

$$T_{i,t} = \sum_{j \in i} \tau_{c(j),t} \cdot \left(KE_{j,t-2} + KB_{j,t-2}\right),$$

where KE_j and KB_j denote the assessed rental values of real-estate and equipment capital at establishment j, respectively. The total tax owed was bounded by a floor of 1.5% of value added (for firms with turnover above €7.6 million) and a ceiling of 3.5%.

To our knowledge, France was the only advanced economy to levy a local tax on non-real-estate tangible assets. The tax was repeatedly criticized for discouraging investment, and successive governments narrowed the base, most notably by removing the wage bill component between 1999 and 2003, but the core structure remained in place until 2010.

The 2010 reform. The abolition of the TP was announced in two steps. On October 23, 2008, as part of a stimulus package in response to the financial crisis, President Nicolas Sarkozy declared that all new investments made between that date and January 1, 2010 would be permanently exempt from the TP. On February 5, 2009, he announced that the TP would be abolished entirely starting January 1, 2010. The reform was

[5] Senate Information Report No. 611 (2012) provides a comprehensive review of the TP and its replacement.

enacted through the Finance Law for 2010, which replaced the TP with the *Contribution Économique Territoriale* (CET).

The CET has two components. The first, the *Cotisation Foncière des Entreprises* (CFE), is a local tax based on the real-estate component of the former TP base, with rates still set by each city, but equipment capital is excluded entirely. The second, the *Cotisation sur la Valeur Ajoutée des Entreprises* (CVAE), is a nationally uniform tax on value added, with an effective rate rising progressively in turnover from 0% (for firms below €500,000) to 1.5% (above €50 million). The CET owed by firm i in year t is:

$$T_{i,t} = \sum_{j \in i} \left(\tau_{c(j),t} \cdot KB_{j,t-2} \right) + \eta(S_{i,t}) \cdot Y_{i,t},$$

where $\tau_{c(j),t}$ is the local CFE rate in the city of establishment j, $\eta(S_{i,t})$ is the CVAE rate,[6] and $Y_{i,t}$ is the firm's value added. As under the TP, the total CET owed is capped as a fraction of value added, now at 3%.

The reform was not revenue neutral. Although the CVAE partially offset the loss of revenue from removing equipment capital from the tax base, its rates were far too low to compensate for the elimination of local taxes on equipment. Aggregate local business taxation fell from approximately 1.1% of GDP before the reform to 0.8% afterward, a net reduction of about €5 billion in the year of implementation.[7] The reform therefore represented a substantial cut in the overall tax burden on firms, not merely a shift in the tax base.

Implications for identification. Two features of the reform are central to our empirical strategy.

First, it generated substantial cross-firm heterogeneity in the size of the tax cut. The TP taxed both real-estate and equipment capital at locally determined rates, while the post-reform local tax applies only to real estate. A firm's gain from the reform therefore depends on how much equipment capital it held in each city and on the local tax rate applied there. Firms with large equipment stocks in high-rate cities benefited the most; firms with mostly real-estate assets in low-rate cities saw little change.

Second, the reform creates two distinct timing effects. As described above, the exemption of new investment announced in October 2008, followed by the full abolition announced in February 2009, meant that any equipment acquired from late 2008 onward

[6]The CVAE rate η is a function of turnover S (in millions of euros): $\eta(S) = 0$ if $S < 0.5$; $\eta(S) = 0.5\% \times \frac{S-0.5}{2.5}$ if $0.5 \leq S < 3$; $\eta(S) = 0.5\% + 0.9\% \times \frac{S-3}{7}$ if $3 \leq S < 10$; $\eta(S) = 1.4\% + 0.1\% \times \frac{S-10}{40}$ if $10 \leq S < 50$; and $\eta(S) = 1.5\%$ if $S \geq 50$.

[7]See DG Trésor, *Rapport Économique, Social et Financier*, 2018, p. 207.

would never be subject to the TP. Recall that the TP base was assessed with a two-year lag: equipment purchased in 2009, for instance, would first enter the tax base in 2011, but since the TP was repealed in 2010, this liability would never materialize. The expected marginal tax rate on new equipment therefore fell to zero as soon as the reform was credibly announced, lowering the user cost of capital for forward-looking firms. Actual tax payments, however, did not fall until 2010, when the CET replaced the TP. Throughout 2009, firms continued to pay the TP based on the value of assets held in 2007. The reform therefore had two distinct channels of impact: a change in investment incentives (2009) and a cash-flow relief (2010).

2.2 Databases and sample restrictions

We use information from four administrative sources. Data on the local tax base and tax rates are drawn from the *Taxe Professionnelle* (TP) database. Information on firms' financial performance is obtained from the BIC-RN database, which contains detailed corporate income tax returns under the standard tax regime. Matched employer-employee data come from the DADS database, which provides detailed information on wages, employment, and job characteristics at the employee $\times$ establishment level. We also use data on firm-level quarterly sales from the VAT database, to study the dynamic impact on sales at a more granular level. In this section, we describe these four data sources, the matching procedure and sample restrictions, and the dependent variables.

Taxe professionnelle database. The *Taxe Professionnelle* (TP) database is an administrative dataset covering the years 2002 to 2010, the final year before the tax was abolished. It offers detailed information on local business tax rates (τ) and their tax base components: the current rental value of buildings (KB) and equipment capital (KE). This tax base is reported annually and, because of the local nature of the tax, at the establishment level. It therefore offers precise geographical information on the distribution of firms' capital and the current valuation of their assets. This tax base being very specific to the French context, we believe this provides a granularity that is unique in the literature. We use it to construct a firm-level measure of exposure to the reform.

French firm tax returns (BIC-RN). The *BIC-RN* database consists of corporate income tax returns filed by firms subject to the standard tax regime (*régime normal*) in France. This dataset, maintained by the French tax administration (*Direction Générale des Finances Publiques*, DGFiP), provides detailed firm-level information derived from official tax reports. The database offers extensive financial and economic data, including variables such as assets, sales, and taxes paid. From this database, we are therefore able to build an exhaustive panel of French firms under the standard tax regime. Because equipment capital was removed from the tax base after the reform, the TP database, described above, no longer reports equipment in the post-reform period. To study equipment capital as an outcome, we therefore reconstruct it from firms' tax returns by aggregating the balance-sheet items corresponding to equipment assets.

Linked employer-employee data (DADS). The *DADS* (*Déclarations Annuelles des Données Sociales*) is a matched employer-employee administrative database based on social security records, covering all French firms and private-sector jobs. It provides detailed annual information on employment and wages at the establishment and firm level. The *DADS Postes* file, a key component of the dataset, captures each employment spell with details on the employer, wages, hours worked, job type, occupation, employment conditions (e.g., full-time or part-time), and workplace location. It also includes corresponding data from the previous year. Each job position (*poste*) represents the intersection of an employee and an establishment, consolidating all employment periods within the same establishment during the year.

VAT data. The VAT database, maintained by the *Direction Générale des Finances Publiques* (DGFiP), is a centralized dataset that includes all value-added tax declarations submitted by firms operating in France. It provides detailed records of transactions related to the purchase and sale of goods and services. This dataset allows the observation of firm-level sales on a monthly basis, therefore offering a high level of granularity for analyzing economic dynamics. We aggregate the monthly sales data at the quarterly level, enabling a dynamic analysis of the effect of the reform on firm sales across quarters.

Periods, matching and sample restrictions. We construct a firm-level panel for the years 2004–2015 by merging all administrative sources using the firm identifier (SIREN). The datasets are fully joined, and the final panel is balanced in the sense that each firm must appear in every year of the observation window in at least one of the underlying databases. The estimation sample is restricted to firms that were subject to the *Taxe Professionnelle* in 2008, as exposure to the reform is computed from the 2008 TP base. We then apply two additional filters. First, we exclude firms that are always classified as micro-enterprises throughout the entire period.[8] Second, we drop firms that are always

[8] Over our sample period, firms qualified as micro-enterprises if their annual turnover was below roughly €80,000 for commercial activities and €30,000 for service activities, with only minor indexation adjustments to these thresholds over time.

constrained by the statutory value-added cap in 2007, 2008, and 2009.[9] For these firms, the effective tax burden is determined by value-added rather than by local tax rates and the stock of capital, so the variation in local tax rates and capital composition used to construct our exposure measure does not translate into meaningful variation in their tax burden. Table A.5 in appendix A.1 reports summary statistics for the estimation sample. Our yearly panel consists of 1,627,749 firm - year observations corresponding to 139,179 distinct firms. Equipment capital represent on average 20% of total assets, with a median of 16%, indicating that equipment capital covered a meaningful but not dominant share of firms' balance sheets.

3 Empirical strategy

We exploit cross-firm variation in exposure to the reform to estimate its impact on firm-level outcomes. This section describes the construction of our instrument, the estimating equations, and the identification strategy.

3.1 Construction of the instrument

A primary identification challenge lies in the classical issue of simultaneity: firm-level outcomes may themselves influence the realized post-reform tax base. To overcome this bias, we construct the exposure measure exclusively from pre-reform (2008) characteristics, i.e. before firms could react to the 2009 announcement. For each firm i, the instrument Z_i captures the predicted proportional reduction in its tax burden generated by excluding equipment from the base:

$$Z_i = \frac{\sum_{j \in i} \tau_{c(j)} \, KE_j}{\sum_{j \in i} (KE_j + KB_j)}.$$

The tax rates $\tau_{c(j)}$ are the 2008 city-specific tax rates (expressed between 0 and 1, not in percentage points). The values KE_j and KB_j are taken from the 2008 TP base, which, given the two-year assessment lag described in Section 2.1, reflects the value of assets held in 2006. The numerator weights each city-specific rate by the equipment capital located there, the denominator reconstructs the total pre-reform tax base (equipment and real estate) of firm i. The instrument therefore reflects the predicted reduction in a firm's tax burden from removing equipment from the base, and is larger for firms whose pre-reform base relied more heavily on equipment. Because it uses only pre-

[9]This drops 6.8% of remaining observations, corresponding to 14301 distinct firms

reform values, this measure is unaffected by any behavioral response or economic shock occurring after the announcement of the reform.

Table A.5 reports that the instrument Z_i has a mean of 0.21. The equipment capital share KEshare_i averages 0.78, with a median of 0.84, indicating that it constituted a large share of the TP base for most firms.

3.2 Estimating equations

We present two complementary specifications: a static difference-in-differences estimator that summarizes the average post-reform effect, and a dynamic event-study design that traces the temporal path of the treatment effect.

Static difference-in-differences. Our baseline specification estimates the average impact of the reform on firm-level outcomes by comparing more and less exposed firms before and after the reform:

$$Y_{it} = \beta\, Z_i \times \text{Post}_t + \sum_{h \neq 2008} (\delta_h\, \text{KEshare}_i)\, \mathbf{1}\{t = h\} + \gamma_{g,t} + \alpha_i + \varepsilon_{it}, \tag{1}$$

where Y_{it} is the outcome of firm i in time period t (year or quarter), $\text{Post}_t = \mathbf{1}\{t \geq 2009\}$ is an indicator for the post-reform period, Z_i is the instrument defined in Section 3.1, $\gamma_{g,t}$ denotes 2-digit industry-by-period fixed effects, and α_i firm fixed effects. The coefficient β captures the average causal effect of reform exposure on Y_{it} after 2009. KEshare_i is the equipment share of the pre-reform tax base : $\text{KEshare}_i = \frac{\sum_{j \in i} KE_j}{\sum_{j \in i} (KE_j + KB_j)}$. The rationale for including this control is discussed in the next section (Section 3.3). Standard errors are clustered at the 5-digit industry level.

The post-reform period is defined as starting in 2009 because the reform was announced that year, which immediately changed firms' investment incentives (see Section 2.1). Since the tax base of the TP was computed using capital stocks lagged by two years, investments undertaken in 2009 would never enter the tax base once the tax was abolished in 2010. As a result, the expected user cost of capital declined as soon as the reform was announced, making 2009 the first treatment year in our empirical specification, even though the reduction in tax payments only materialized in 2010 when the tax was effectively abolished.

Dynamic event study. To examine the temporal pattern of the treatment effect and to assess the identifying assumption of parallel pre-trends, we estimate a dynamic version that interacts the firm-level exposure with time period dummies:

$$Y_{it} = \sum_{h \neq 2008} \left(b_h \, Z_i + \delta_h \, \text{KEshare}_i \right) \mathbf{1}\{t = h\} + \gamma_{g,t} + \alpha_i + \varepsilon_{it}, \tag{2}$$

All other variables are as defined in equation (1). The reference year is 2008, the last year before the reform announcement. The coefficients $\{b_h\}$ trace the dynamic impact of reform exposure: flat pre-trends ($b_h \approx 0$ for $h < 2009$) support the identifying assumption, while post-reform coefficients capture the evolving treatment effect. We once again cluster standard errors at the 5-digit industry level.

Quarterly sales. For the quarter-level regressions (quarterly sales), we additionally control in both the static and dynamic regressions for seasonal patterns by interacting Z_i with quarter-of-year fixed effects.

3.3 Identification: role of the equipment share

To clarify the source of identifying variation, it is useful to decompose the instrument into its constituent parts. Z_i can be written as

$$Z_i = \tilde{\tau}_i \times \text{KEshare}_i,$$

where the firm-level effective tax rate is defined as

$$\tilde{\tau}_i \equiv \frac{\sum_{j \in i} \tau_{c(j)} \, KE_j}{\sum_{j \in i} KE_j},$$

i.e., the equipment-weighted average of municipal marginal tax rates across firm i's establishments, and KEshare_i is the share of equipment in the firm's pre-reform tax base (see Section 3.2).

This decomposition reveals that variation in Z_i stems from two distinct sources:

1. *Tax-rate variation* ($\tilde{\tau}_i$). This component is driven by the fiscal decisions of the municipalities in which firm i operates. Because municipal tax rates were set independently and reflected local public finance needs, this source of variation is plausibly orthogonal to firm-level transitory shocks.

2. *Capital-composition variation* (KEshare_i). This component reflects technological characteristics of the firm in 2008, which may be correlated with unobserved deter-

minants such as productivity growth, sectoral demand trends, or mean reversion in capital stocks following a transitory shock.

The key identification concern is that the part of variation in Z_i coming from the equipment capital share may not satisfy the exclusion restriction. Firms with high equipment intensity in 2008 could differ systematically in their growth trajectories from those with low equipment intensity, for reasons unrelated to the reform. This is a standard concern in the literature on mechanical tax-change instruments (Auten and Carroll, 1999; Gruber and Saez, 2002; Weber, 2014): when the instrument is constructed from pre-reform characteristics that also predict subsequent outcomes, omitting controls for those characteristics can generate spurious treatment effects.

We address this concern by including KEshare_i interacted with year dummies in both specifications (1) and (2). This flexible control allows the equipment share to have a time-varying linear effect on outcomes, absorbing systematic differences in trends across firms with different equipment shares in 2008. Conditional on these controls, identification relies primarily on the tax-rate component $\tilde{\tau}_i$, comparing firms with similar equipment shares but different geographic exposure to municipal tax rates.

As a further check against mean reversion, we recompute Z_i and KEshare_i using 2007 and 2006 data instead of 2008 values and verify that the results are robust to these alternative base years in Section 4.2. This test is informative because, if a firm experienced an unusually high equipment share or tax base in 2008 due to a transitory shock, this deviation would mechanically reverse in subsequent years, generating a spurious correlation between Z_i and post-reform outcomes. The stability of the coefficients across base years would therefore suggest that identification is unlikely to be contaminated by such transitory shocks.

We also conduct an additional robustness check in which the treatment variable is defined using only the tax-rate component $\tilde{\tau}_i$, the firm-level weighted average of municipal tax rates. Because this measure does not mechanically incorporate the firm's equipment share, it is potentially less susceptible to contamination from firm-level transitory shocks or endogenous variation in capital composition. In this regression we therefore do not control for the effects of the equipment share.[10]

[10] As in the baseline, for the regression on quarterly sales we additionally control for seasonal patterns in treatment by interacting $\tilde{\tau}_i$ with quarter-of-year fixed effects.

4 Reduced form evidence

We present the reduced-form estimates from both the static and dynamic specifications described in Section 3. The results document the reform's effects on taxes, capital accumulation, output, and labor outcomes at the firm level.

4.1 Baseline results

We present results from both the static difference-in-differences specification (1) and the dynamic event-study design (2). Table 1 reports the static estimates, which summarize the average post-reform treatment effect across a range of firm-level outcomes. Figures 1 and 2 display the event-study coefficients $\{b_h\}$ for the key outcomes, allowing us to assess parallel pre-trends and to trace the temporal dynamics of the reform's impact. Additional event-study figures for all other outcomes are reported in Appendix A.2.

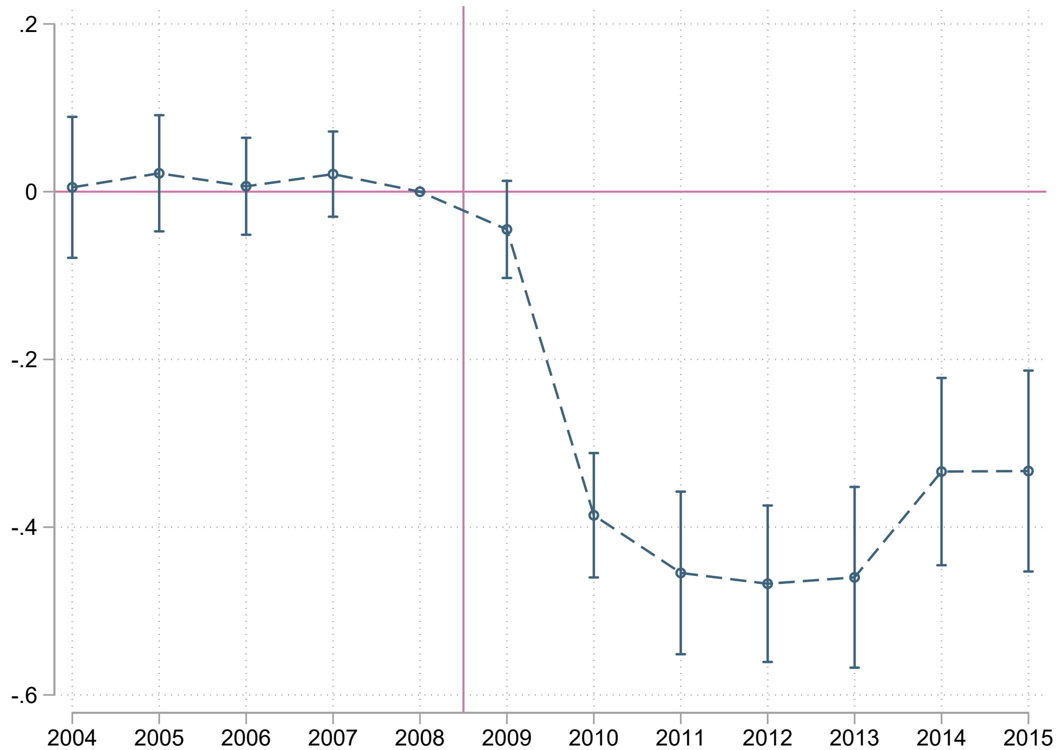
Impact on taxes. We begin by assessing whether Z_i predicts actual changes in firms' tax burdens. Panel A of Table 1 reports the static estimates. A one-unit increase in Z_i reduces total taxes paid over value-added by 36.5 log points ($p < 0.01$), and local taxes over value-added by 79.9 log points ($p < 0.01$). Given that the sample mean of Z_i is 0.21 (Table A.5), the average firm experienced a reduction in total taxes over value-added of approximately $0.365 \times 0.21 \approx 7.7\%$ and a reduction in local taxes of approximately $0.799 \times 0.21 \approx 16.8\%$. These magnitudes confirm that the reform substantially reduced the tax burden on more-exposed firms.

Table 1: Static Regression Results

Dependent variable (log)	$\hat{\beta}$	R^2
Panel A: Taxes		
All taxes paid / value-added	-0.365^{***}	0.700
	(0.046)	
Local taxes / value-added	-0.799^{***}	0.643
	(0.115)	
Panel B: Capital		
Equipment capital	0.241^{***}	0.921
	(0.042)	
Other assets	0.091^{***}	0.961
	(0.030)	
Panel C: Output		
Quarterly sales	0.137^{**}	0.864
	(0.054)	
Sales	0.072^{*}	0.917
	(0.040)	
Panel D: Labor		
Total hours worked	0.028	0.911
	(0.036)	
Hourly wage	0.060^{***}	0.842
	(0.010)	
Residualized hourly wage	0.069^{***}	0.734
	(0.014)	

Notes: Each row corresponds to a different dependent variable. The reported coefficient is on $Z_i \times \mathbf{1}\{t \geq 2009\}$. All specifications include firm fixed effects, 2-digit industry $\times$ year fixed effects, and control for KEshare$_i$ interacted with year dummies. The instrument Z_i is computed from 2008 pre-reform data. In the quarterly sales regression, we additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. Standard errors clustered at the 5-digit industry level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 1: **First stage: impact on all taxes paid over value-added (log)**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is the total amount of taxes paid over value-added, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure 1 displays the event-study coefficients for total taxes over value-added. The pre-reform coefficients are flat and statistically indistinguishable from zero in all years prior to 2009, supporting the parallel-trends assumption. The effect materializes sharply in 2010 when the tax base change takes full effect, and stabilizes around -0.4 from 2010 onward. This timing is consistent with the institutional design of the reform (Section 2.1), as the TP was effectively abolished in 2010.

Impact on capital. Panel B of Table 1 shows that the reform induced a large and significant increase in equipment capital. The static coefficient is 0.241 ($p < 0.01$). Other assets also respond positively, with a coefficient of 0.091 ($p < 0.01$), suggesting spillover effects on non-equipment capital accumulation, though the magnitude is roughly one-third of the equipment response.

Figure 2 shows that the equipment capital effect builds gradually over time. Pre-reform coefficients are flat and centered around zero, again supporting the parallel-trends assumption. The effect becomes visible starting in 2009, reaches approximately 0.15 by 2010, and continues to grow steadily through 2015, reaching 0.34. For the average firm, this implies an equipment capital expansion of about $0.34 \times 0.217 \approx 7.4\%$ by the end of the sample period. This gradual ramp-up is consistent with adjustment frictions in capital accumulation, which cause firms to adjust capital stocks only gradually over time.

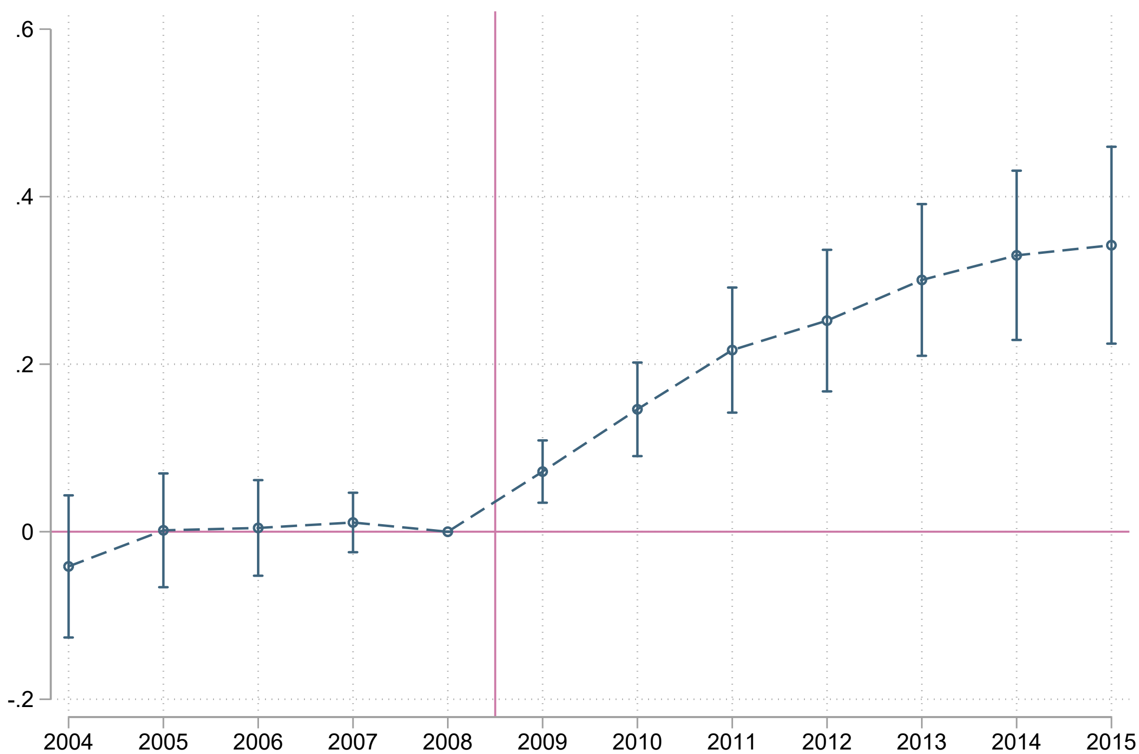
The timing is once again consistent with the institutional design of the reform. Although the reduction in tax payments only materializes in 2010, when the TP is effectively abolished, firms understand as early as 2009 that the user cost of capital has fallen. Because the tax base was computed using capital stocks lagged by two years, investments undertaken in 2009 would never enter the tax base once the tax is repealed. Anticipating that these investments will not be taxed in the future, firms adjust their investment decisions immediately, which explains why the capital response begins before the observed decline in tax payments.

Impact on output. Panel C of Table 1 reports effects on two measures of sales. The strongest response appears in quarterly sales from the VAT database (0.137, $p < 0.05$), while the effect on annual sales from tax returns is lower (0.072, $p < 0.10$). The event-study figures for these outcomes (Appendix Figures A.12, A.13) show that output increases after the reform. The quarterly sales specification, which offers higher-frequency variation, is consistent with a response during 2009, before the tax-payment decline observed in 2010. The weaker response estimated using annual sales from corporate tax returns likely reflects pre-trends in this regression, as the event-study coefficients for annual sales are already slightly above zero in the pre-treatment period. Quarterly sales from the VAT data instead display a very slight pre-trend in the opposite direction. Taken together, these patterns suggest that the true effect on sales likely lies between the estimates obtained from the two sources, namely between approximately $0.072 \times 0.21 \approx 1.5\%$ and $0.137 \times 0.21 \approx 2.9\%$ for the average firm.

Impact on labor. Panel D of Table 1 reveals a clear contrast between the extensive and intensive margins of labor. Total hours worked are essentially unaffected (0.028, not significant), suggesting that the reform did not lead to meaningful changes in employment at the firm level over our sample period. In contrast, hourly wages increase significantly: the estimated coefficient is 0.060 ($p < 0.01$).

To account for potential changes in workforce composition due to the reform, we also compute residualized log wages by removing the effects of age and skill, both interacted with gender, and examine the response of the average residual log wage. This measure increases by 0.069 ($p < 0.01$). These magnitudes imply that the average firm raised hourly wages by approximately $0.06 \times 0.21 \approx 1.3\%$, with a slightly larger effect for residualized wages. The event-study patterns (Appendix Figures A.14, A.15, and A.16) show flat pre-trends for all labor outcomes and a gradual post-reform increase in wages.

Figure 2: **Impact on the stock of equipment capital (log)**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is the stock of equipment capital, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Summary. The reduced-form evidence paints a coherent picture: the reform substantially reduced firms' tax burdens, which led to large increases in equipment capital that built up gradually over the years, generated positive output responses, and raised wages without significantly affecting hours worked. These partial-equilibrium estimates motivate the theoretical model developed in Section 5, which allows us to account for general-equilibrium mechanisms, and thereby to quantify both the aggregate effects of the reform and the reallocation of economic activity across space.[11]

4.2 Robustness

Varying the instrument base year. As discussed in Section 3.3, a potential threat to identification is that transitory shocks to firms' capital composition or tax base in 2008 could generate mechanical mean reversion in subsequent years, biasing our estimates. In our baseline specification, we already mitigate this concern by flexibly controlling for the equipment share interacted with year dummies, which absorbs time-varying confounds operating through capital composition. As an additional robustness check, we reconstruct both the instrument Z_i and the control KEshare_i using 2006 and 2007 data instead of the 2008 baseline, and re-estimate both the static and dynamic specifications. This test is informative because finding similar estimates when the instrument is constructed from different years provides reassurance that our results are not driven by transitory fluctuations.

Tables A.6 and A.7 in Appendix A.1 report the static regression results on taxes, equipment capital and quarterly sales using these alternative base years. The key coefficients are remarkably stable across all three base years. For total taxes over value-added, the coefficient is -0.415 (2006 base), -0.390 (2007 base), and -0.365 (2008 base), all highly significant and of comparable magnitude. For equipment capital, the coefficients are 0.206 (2006), 0.217 (2007), and 0.241 (2008). For quarterly sales, the estimates are 0.128 (2006), 0.130 (2007), and 0.137 (2008).

Appendix Figures A.17–A.22 display the event-study coefficients from these robustness specifications. The resulting dynamic patterns closely mirror those obtained in the baseline specification. This stability in both the timing and magnitude of the treatment effects across base years provides strong reassurance that our results are not driven by transitory shocks to the 2008 instrument, and that the identifying variation reflects persistent cross-firm differences in exposure to tax rates.

Using the average tax rate as the instrument. As an additional robustness check, we redefine the treatment variable as $\tilde{\tau}_i$, the firm-level weighted average of tax rates, thus excluding the equipment-share component of the baseline instrument. As discussed in

[11] We also find no significant effect of the reform on either firm entry or firm exit. This result suggests that the reform operated primarily through the intensive margin—existing firms adjusting their capital stocks—rather than through the creation or destruction of firms. This finding motivates our modeling choice in Section 5 of a fixed number of firms without endogenous entry and exit.

Section 3.3, this specification isolates variation arising from differences in tax rates and should therefore eliminate potential contamination coming from mean reversion in the equipment capital share.

Table A.8 reports the corresponding static regression results on taxes, equipment capital and quarterly sales. The estimates remain qualitatively similar to the baseline specification. Firms exposed to higher pre-reform tax rates experience significantly larger reductions in total taxes over value-added, confirming that the reform effectively reduced the tax burden of more exposed firms. The magnitude of the tax effect is somewhat smaller than in the baseline specification (-0.310 compared with -0.365). This difference is mechanical: in the baseline specification the treatment variable is $Z_i = \tilde{\tau}_i \times \text{KEshare}_i$, whereas here it is defined directly using $\tilde{\tau}_i$. Since the equipment share averages about 0.78 in the data, the baseline instrument is mechanically smaller, which mechanically scales up the estimated coefficients. Consistent with the baseline results, we also find a positive and statistically significant effect on equipment capital. The estimated coefficient (0.173) is again somewhat smaller than in the baseline regression (0.241), but of comparable magnitude once the difference in scaling of the treatment variable is taken into account. The effect on quarterly sales remains positive and statistically significant, with a coefficient of 0.087 compared with 0.137 in the baseline specification.

Appendix Figures A.23–A.25 report the corresponding event-study coefficients. Once again the flat pre-trends and the timing of post-reform responses are very similar to the baseline. In particular, equipment capital displays the same gradual build-up consistent with the slow adjustment of capital stocks.

Summary. Taken together, these results provide further reassurance that the baseline estimates are not driven by time-varying endogeneity in firms' equipment shares. Recomputing the instrument using alternative base years yields estimates that are highly stable in both magnitude and dynamics, suggesting that the results are not driven by mean reversion in the 2008 capital structure. Even when identification relies exclusively on the tax-rate component of the instrument, the estimated effects on taxes, capital accumulation, and output remain very consistent in both magnitude and timing.

5 Theoretical framework

We develop a dynamic spatial general equilibrium model that incorporates both forces emphasized in the introduction: spatial frictions—through costly trade and migration—that shape the reallocation of resources across locations, and capital dynamics—through accumulation with adjustment costs—that amplify the effects of capital tax reductions.

5.1 The economic environment

Consider a continuous-time economy where time is indexed by $t \in [0, \infty)$. This economy consists of $D \in \mathbb{N}$ locations (which we think of as French departments), indexed by $d \in \{1, \ldots, D\}$ and $S \in \mathbb{N}$ sectors, indexed by $s \in \{1, \ldots, S\}$. Each location-sector pair contains a continuum of firms (of unit-measure), indexed by $i \in [0, 1]$. The population of each location is composed of two types of infinitely-lived agents: workers and capitalists. Across all locations, the total measure of workers is equal to one.

Workers. Workers living in location d at time t have instantaneous utility:

$$U_{dt}^W = \eta \ln(C_{dt}^W) + (1 - \eta) \ln(H_{dt}^W) + \ln(A_d) \tag{3}$$

with a rate of time preference of $\rho > 0$, where C_{dt}^W is their consumption of final goods, H_{dt}^W is their consumption of housing services, $A_d > 0$ is a location-specific amenity, and $\eta \in (0, 1)$ measures relative preferences over final goods and housing. Housing services in location d are assembled from a continuum of differentiated housing varieties using a Cobb-Douglas aggregator:

$$\ln(H_{dt}^W) = \int_0^1 \ln(H_{dt}^W(j))\mathrm{d}j \tag{4}$$

where $H_{dt}^W(j)$ is the quantity of housing variety j consumed by workers in location d at time t.

Workers can commute frictionlessly within a location but to change location, they must incur a migration cost. In particular, they receive migration opportunities at Poisson rate $\epsilon > 0$ at which point they draw extreme-value distributed idiosyncratic preference shocks for potential destinations, with dispersion parameter $\nu > 0$. If a worker chooses to migrate from origin o to destination d, they incur a symmetric bilateral moving cost $\Delta_{od}^M \geq 0$ such that $\Delta_{od}^M = \Delta_{do}^M$ and $\Delta_{oo}^M = 0$ for all $o \in \{1, \ldots, D\}$. Once settled in a location, a worker inelastically supplies one unit of labor.

Capitalists. Capitalists differ from workers in two key dimensions: they are immobile across locations and supply no labor. Instead, they own the fixed land endowment $\mathcal{L}_d$ and capital stock in their location. The instantaneous utility of a capitalist residing in location d at time t is given by:

$$U^K_{dt} = \eta \ln(C^K_{dt}) + (1-\eta)\ln(H^K_{dt}) \tag{5}$$

where C^K_{dt} and H^K_{dt} are their final goods and housing services consumption, respectively. Capitalists discount the future at rate $\rho > 0$ and have the same preferences over housing varieties as workers:

$$\ln(H^K_{dt}) = \int_0^1 \ln(H^K_{dt}(j))\mathrm{d}j \tag{6}$$

Capitalists accumulate two types of location-specific capital: equipment (E) and real estate (R). Both capital stocks are immobile across locations and evolve according to:

$$\dot{K}^T_{dt} = I^T_{dt} - \delta_T K^T_{dt}, \quad \forall T \in \{E, R\} \tag{7}$$

where K^T_{dt} is the type-T capital stock in location d, $\delta_T > 0$ is its depreciation rate, and I^T_{dt} is investment. However, investment in type-T capital is subject to a quadratic adjustment cost à la Hayashi (1982) given by:

$$X^T_{dt} = \frac{\xi_T}{2} \cdot \left(\frac{I^T_{dt}}{K^T_{dt}} - \delta_T\right)^2 K^T_{dt}$$

where $\xi_T > 0$ determines the size of adjustment costs.

Firms. In every location-sector pair, there is a unit-measure continuum of firms, each producing a single differentiated product. Production requires both types of capital and labor, which are combined according to a Cobb-Douglas technology:

$$y_{dst}(i) = Z_{ds} \cdot k^E_{dst}(i)^{\alpha^E_s} \cdot k^R_{dst}(i)^{\alpha^R_s} \cdot l_{dst}(i)^{1-\alpha_s} \quad \text{where} \quad \alpha_s \equiv \alpha^E_s + \alpha^R_s. \tag{8}$$

Here, $y_{dst}(i)$ is the output of firm i from sector s in location d, $k^T_{dst}(i)$ and $l_{dst}(i)$ are the quantities of type-T capital and labor used in production, Z_{ds} is the location-sector-specific level of productivity, and $\alpha^E_s, \alpha^R_s \in (0,1)$ are the output elasticities of equipment and real estate capital in sector s, respectively.

In addition to these production firms, each location d hosts a unit-measure continuum of *housing* firms, indexed by $j \in [0,1]$, which produce differentiated housing services. Housing production is non-tradable across locations and uses real estate capital and land as inputs.[12] Specifically, housing firm j in location d produces according to the Cobb-Douglas technology:

$$h_{dt}(j) = k_{dt}^{R,H}(j)^{\gamma} \cdot \ell_{dt}(j)^{1-\gamma} \tag{9}$$

where $h_{dt}(j)$ is the output of housing variety j in location d, $k_{dt}^{R,H}(j)$ and $\ell_{dt}(j)$ are the quantities of real estate capital and land used in production, and $\gamma \in (0,1)$ is the output elasticity of real estate capital in housing production.

Final sectors. In each location, a final sector combines products sourced from all firms across all location-sector pairs to produce local final goods. Production follows a two-tier nested structure. At the upper level, final goods are assembled from sector-specific composites using a Cobb–Douglas aggregator:

$$Y_{dt} = \prod_{s=1}^{S} Y_{dst}^{\beta_s} \quad \text{with} \quad \sum_{s=1}^{S} \beta_s = 1 \tag{10}$$

where Y_{dt} is the final sector's output in location d, Y_{dst} is the composite input from sector s, and $\beta_s \in (0,1)$ measures the importance of that sector in final demand. At the lower level, the sector-s composite is itself a Dixit and Stiglitz (1977) aggregate of differentiated products sourced from all locations:

$$Y_{dst} = \left(\sum_{o=1}^{D} \int_0^1 Y_{odst}(i)^{\frac{\theta-1}{\theta}} \mathrm{d}i \right)^{\frac{\theta}{\theta-1}} \tag{11}$$

where $Y_{odst}(i)$ is the quantity of product i produced in sector s and origin location o that is used by the final sector in location d, and $\theta > 1$ is the elasticity of substitution across products. However, delivering products across locations is subject to symmetric iceberg trade costs: to receive one unit of the product in destination d, $\Delta_{od}^{I} \geq 1$ units must be shipped from origin o, with $\Delta_{oo}^{I} = 1$.

Local governments. Each location is served by a local government that produces G_{dt} units of public goods using local final goods as inputs. In the counterfactual exercises below, these public goods are assumed to be fully wasted, consistent with the view that the central government compensated municipalities for forgone revenue through transfers rather than by changing local amenity provision.

[12] According to EU-KLEMS data for France, the "real estate activities" sector has a capital share close to one and relies almost exclusively on real estate rather than equipment capital.

Resource constraints. The aggregate and local labor resource constraints are given by:

$$\sum_{d=1}^{D} L_{dt} \leq 1 \quad \text{and} \quad \sum_{s=1}^{S} \int_0^1 l_{dst}(i)\mathrm{d}i \leq L_{dt}. \tag{12}$$

The local capital resource constraints are given by:

$$\sum_{s=1}^{S} \int_0^1 k_{dst}^{T}(i)\mathrm{d}i + \mathbb{1}_{\{T=R\}} \int_0^1 k_{dt}^{T,H}(j)\mathrm{d}j \leq K_{dt}^{T}. \tag{13}$$

The local land resource constraints are given by:

$$\int_0^1 \ell_{dt}(j)\mathrm{d}j \leq \mathcal{L}_d \tag{14}$$

where $\mathcal{L}_d$ is the exogenous land endowment in location d. The resource constraints for products are given by:

$$\sum_{d=1}^{D} \Delta_{od}^{I} Y_{odst}(i) \leq y_{ost}(i). \tag{15}$$

The resource constraints for housing services are given by:

$$H_{dt}^{W}(j)L_{dt} + H_{dt}^{K}(j) \leq h_{dt}(j). \tag{16}$$

Finally, the resource constraints for local final goods are given by:

$$C_{dt}^{W}L_{dt} + C_{dt}^{K} + \textstyle\sum_{T\in\{E,R\}}(I_{dt}^{T} + X_{dt}^{T}) + G_{dt} \leq Y_{dt}. \tag{17}$$

5.2 The market equilibrium allocation

The firm's problem. Both production and housing firms operate under perfect competition and therefore set prices equal to marginal cost. Both types of firms are subject to the location-specific capital tax, while only production firms are subject to the nationally uniform value-added tax.[13] Capital tax rates vary across locations and are assumed to be drawn from a location-specific log-normal distribution with mean and standard deviation parameters $\mu_d > 0$ and $\sigma_d > 0$, respectively:

$$\ln(1 + \tau_d^{K}) \sim \mathcal{N}(\mu_d, \sigma_d^2).$$

[13] In practice, capital tax rates were uniform within each commune (municipality). In the model, we treat firms and communes interchangeably, as France has approximately 35,000 communes.

Hence, a production firm's "free on board" price before trade costs in location d is:

$$p_{dst}(i) = \frac{(1+\tau_d^K(i))^{\hat{\alpha}_{st}}}{(1-\tau_t^v)Z_{ds}} \cdot \left(\frac{r_{dt}^E}{\alpha_s^E}\right)^{\alpha_s^E} \left(\frac{r_{dt}^R}{\alpha_s^R}\right)^{\alpha_s^R} \left(\frac{w_{dt}}{1-\alpha_s}\right)^{1-\alpha_s}$$

where r_{dt}^T is the local rental rate of type-T capital, w_{dt} is the local wage, $\tau_t^v \in [0,1)$ is the nationally uniform value-added tax rate, and $\hat{\alpha}_{st}$ is defined as:

$$\hat{\alpha}_{st} \equiv \mathbb{1}_{\{E \text{ is taxed in } t\}}\alpha_s^E + \mathbb{1}_{\{R \text{ is taxed in } t\}}\alpha_s^R.$$

Similarly, a housing firm's price in location d is given by:

$$p_{dt}^H(j) = [1 + \mathbb{1}_{\{R \text{ is taxed in } t\}}\tau_d^K(j)]^\gamma \cdot \left(\frac{r_{dt}^R}{\gamma}\right)^\gamma \left(\frac{r_{dt}^L}{1-\gamma}\right)^{1-\gamma}$$

where r_{dt}^L is the local rental rate of land.[14]

The final sector's problem. The final sector in location d operates under perfect competition, assembling the local final good by sourcing varieties from all locations and sectors. Taking prices as given, the final sector's cost-minimization problem yields the standard demand functions:

$$Y_{odst}(i) = \left[\frac{P_{dst}^Y}{\Delta_{od}^I \cdot p_{ost}(i)}\right]^\theta \cdot \frac{\beta_s P_{dt}^Y Y_{dt}}{P_{dst}^Y}.$$

The corresponding ideal price index for final goods in location d is:

$$\ln(P_{dt}^Y) = \sum_{s=1}^S \beta_s \ln\left(\frac{P_{dst}^Y}{\beta_s}\right) \quad \text{where} \quad P_{dst}^Y \equiv \left(\sum_{o=1}^D \int_0^1 (\Delta_{od}^I \cdot p_{ost}(i))^{1-\theta} \mathrm{d}i\right)^{\frac{1}{1-\theta}}.$$

The worker's problem. Workers do not have access to a saving technology and thus simply consume final goods and housing services up to the value of their labor income. Hence, the instantaneous utility of a worker in origin location o is given by:

$$U_{ot}^W = \ln\left(\frac{w_{ot}}{P_{ot}}\right) + \ln(A_o) \quad \text{where} \quad \ln(P_{ot}) \equiv \eta \ln\left(\frac{P_{ot}^Y}{\eta}\right) + (1-\eta)\ln\left(\frac{P_{ot}^H}{1-\eta}\right).$$

[14]Housing firms are not subject to the value-added tax in the model. Indeed, in the data we use to calibrate it, the real estate sector largely reflects imputed rents from owner-occupied real estate, not operating firms; those imputed rents were outside the CVAE base and thus not targeted.

Here, P_{ot} is the overall cost-of-living index in location o, and P^H_{ot} is the ideal housing price index defined as:

$$\ln(P^H_{ot}) = \int_0^1 \ln(p^H_{ot}(j))\mathrm{d}j.$$

Given this flow utility, the worker's problem is to choose where to migrate if such an opportunity arrives given prices, migration costs, and preference shocks. This problem satisfies the following Hamilton-Jacobi-Bellman (HJB) equation:

$$\rho V^W_{ot} = U^W_{ot} + \epsilon[\ln(\textstyle\sum_{d=1}^D e^{\nu(V^W_{dt}-\Delta^M_{od})})/\nu - V^W_{ot}] + \dot{V}^W_{ot}$$

and among those who migrate from origin o, the share going to destination d:

$$M_{odt} = \frac{e^{\nu(V^W_{dt}-\Delta^M_{od})}}{\sum_{d'=1}^D e^{\nu(V^W_{d't}-\Delta^M_{od'})}}.$$

Therefore, the working population of location d evolves according to:

$$\dot{L}_{dt} = \epsilon\left(\sum_{o=1}^D M_{odt}L_{ot} - L_{dt}\right).$$

The capitalist's problem. In contrast to workers, capitalists cannot migrate across locations, but they can save through capital accumulation. Hence, the capitalist's problem involves a consumption-saving decision, which delivers the following optimal investment policy:

$$I^T_{dt} = K^T_{dt}\left(\delta_T + \frac{q^T_{dt}-1}{\xi_T}\right)$$

where q^T_{dt} is Tobin's q for type-T capital in location d. Intuitively, this equation states the capitalist will invest more than the replacement rate only when the market value of capital exceeds its book value ($q^T_{dt} > 1$). Tobin's q satisfies the standard asset pricing equation:

$$\dot{q}^T_{dt} = \left(\rho + \delta_T + \frac{\dot{C}^K_{dt}}{C^K_{dt}}\right)q^T_{dt} - \left\{\frac{r^T_{dt}}{P^Y_{dt}} + \frac{\xi_T}{2}\cdot\left[\left(\frac{I^T_{dt}}{K^T_{dt}}\right)^2 - \delta^2_T\right]\right\}$$

where the change in the price of capital must be equal the return on this asset net of the "dividend" (the real rental rate plus the marginal savings on future adjustment costs).

Finally, the capitalist must respect the budget constraint which is given by:

$$r_{dt}^E K_{dt}^E + r_{dt}^R K_{dt}^R + r_{dt}^L \mathcal{L}_d = P_{dt}^Y (C_{dt}^K/\eta + I_{dt}^E + I_{dt}^R + X_{dt}^E + X_{dt}^R).$$

The local government's problem. Local governments finance their production of public goods by collecting capital and value-added taxes from firms located within their location. Importantly, we assume that local governments balance their budgets at each point in time, which implies that:

$$\begin{aligned} P_{dt}^Y G_{dt} = {} & \tau_t^v \sum_{s=1}^S \int_0^1 p_{dst}(i) y_{dst}(i) \mathrm{d}i \\ & + \sum_{T \in \{E,R\}} \sum_{s=1}^S \int_0^1 \mathbb{1}_{\{T \text{ is taxed in } t\}} \tau_d^K(i) r_{dt}^T k_{dst}^T(i) \mathrm{d}i \\ & + \int_0^1 \mathbb{1}_{\{R \text{ is taxed in } t\}} \tau_d^K(j) r_{dt}^R k_{dt}^{R,H}(j) \mathrm{d}j. \end{aligned}$$

Equilibrium definition. We can now formally define a market equilibrium allocation in this economy in Definition 1.

Definition 1. *Given initial conditions $\{K_{d0}^E, K_{d0}^R, L_{d0}\}_{d=1}^D$, a market equilibrium allocation consists of times paths for prices and quantities such that:*

1. $\{\{\{\{l_{dst}(i), k_{dst}^E(i), k_{dst}^R(i)\}_{i=0}^1\}_{s=1}^S\}_{d=1}^D\}_{t\geq 0}$ *solve the production firms' problem.*
2. $\{\{\{k_{dt}^{R,H}(j), \ell_{dt}(j)\}_{j=0}^1\}_{d=1}^D\}_{t\geq 0}$ *solve the housing firms' problem.*
3. $\{\{\{\{\{Y_{odst}(i)\}_{i=0}^1\}_{s=1}^S\}_{o=1}^D\}_{d=1}^D\}_{t\geq 0}$ *solve the final sectors' problem.*
4. $\{\{C_{ot}^W, H_{ot}^W, \{M_{odt}\}_{d=1}^D\}_{o=1}^D\}_{t\geq 0}$ *solve the workers' problem.*
5. $\{\{C_{dt}^K, H_{dt}^K, \{I_{dt}^T, X_{dt}^T\}_{T\in\{E,R\}}\}_{d=1}^D\}_{t\geq 0}$ *solve the capitalists' problem.*
6. $\{\{w_{dt}\}_{d=1}^D\}_{t\geq 0}$ *clear the local labor markets.*
7. $\{\{r_{dt}^E, r_{dt}^R\}_{d=1}^D\}_{t\geq 0}$ *clear the local capital markets.*
8. $\{\{r_{dt}^L\}_{d=1}^D\}_{t\geq 0}$ *clear the local land markets.*
9. $\{\{\{\{p_{dst}(i)\}_{i=0}^1\}_{s=1}^S\}_{d=1}^D\}_{t\geq 0}$ *clear the local product markets.*
10. $\{\{\{p_{dt}^H(j)\}_{j=0}^1\}_{d=1}^D\}_{t\geq 0}$ *clear the local housing markets.*

11. $\{\{q^E_{dt}, q^R_{dt}\}^D_{d=1}\}_{t\geq 0}$ *satisfy the arbitrage conditions.*

12. *The local final goods resource constraints are satisfied at all times.*

13. *The government budget constraints are satisfied at all times.*

14. *The numéraire is* $\sum_{d=1}^D w_{dt} L_{dt} = 1$.

5.3 Calibration

We calibrate the model using a combination of standard parameter values from the macro-trade-spatial literature, our reduced-form estimates from Section 4, and French macroeconomic data moments. The calibrated parameters are summarized in Table 2.

Assigned parameters. We set the rate of time preference to a standard value of $\rho = 0.05$. The elasticity of substitution between the product baskets of different locations is set to $\theta = 6$ to match the trade elasticity reported by Costinot and Rodríguez-Clare (2014).[15] For the migration elasticity parameter, we use the value estimated by Caliendo, Dvorkin and Parro (2019) of $\nu = 0.2$, which provides one of the few direct estimates of this parameter. We set the elasticity of housing production with respect to real estate capital to $\gamma = 0.65$, following the estimates of Combes, Duranton and Gobillon (2021) for the French housing production function.

Table 2: Calibration

Parameter	Value	Source
ρ	0.05	Standard
θ	6	Costinot and Rodríguez-Clare (2014)
δ_E	0.151	Equipment capital depreciation rate
δ_R	0.059	Real estate capital depreciation rate
ξ_E	20.6	Indirect inference (Appendix B)
ξ_R	52.6	$\xi_E \cdot \delta_E / \delta_R$
ν	0.2	Caliendo et al. (2019)
ϵ	0.35	1.13% French annual outmigration rate
η	0.813	18.7% housing-services share of household consumption
γ	0.65	Combes et al. (2021)

[15] This estimate is also consistent with the findings of Broda and Weinstein (2006).

Calibrated parameters. To discipline the model's capital accumulation process, we use French macroeconomic data together with our reduced-form estimates from Section 4. First, we use the law of motion for capital in equation (7) together with data on investment and capital stocks to back out the implied depreciation rate for each type of capital.[16] This procedure yields depreciation rates of $\delta_E = 0.151$ and $\delta_R = 0.059$.

To calibrate the capital-share parameters, we use observed income shares of equipment and real estate capital across broadly defined non-agricultural and non-financial sectors in France. Specifically, we aggregate NACE Rev. 2 industries into four categories. The first category combines manufacturing, resources, and utilities. The second corresponds to construction. The third consists of market services, including wholesale and retail trade, transportation and storage, and accommodation and food service activities. The fourth comprises business services, namely information and communication, professional, scientific and technical activities, and administrative and support service activities. The most capital-intensive sector is the first category (manufacturing, resources, and utilities), with an equipment capital share of 29.8% and a real estate capital share of 14.1%. In contrast, the least capital-intensive sector is construction with an equipment capital share of 21.3% and a real estate capital share of 12.8%.

We then identify the adjustment cost parameters ξ_E and ξ_R using a two-step strategy. First, we estimate the equipment capital adjustment cost ξ_E by indirect inference, matching the event-study coefficients presented in Section 4 for equipment capital to the predictions of the linearized transition dynamics of our model. More specifically, we simulate the model's response to the reform and estimate an event study on the simulated data using the same specification as in equation (2).[17] We obtain a value of $\xi_E = 20.6$, implying a half-life of 10.9 years for equipment capital adjustment. Second, we derive the real estate adjustment cost as $\xi_R = 52.6 = \xi_E \delta_E / \delta_R$, imposing that the steady-state elasticity of Tobin's q with respect to the investment rate is equal across capital types, which implies a half-life of 28.6 years for real estate.

Finally, we calibrate the sectoral expenditure shares $\{\beta_s\}_{s=1}^{S}$ to match the sectoral composition of French nominal GDP as reported in EU-KLEMS, and we calibrate η to match the housing-services share of household final consumption expenditure in France. Using the INSEE annual national accounts, we measure housing services as the "real estate services" expenditure category and divide it by household final consumption expenditure, both averaged over 2000–2008. This yields $1 - \eta = 0.187$ and therefore $\eta = 0.813$. We also set the Poisson arrival rate of migration opportunities to $\epsilon = 0.35$

[16] We include computing, communications, and transport equipment as well as "other machinery and equipment" in our measure of equipment capital, while we include non-residential buildings and structures in our measure of real estate capital.

[17] More details are presented in Appendix B.

to replicate the observed average annual outmigration rate of 1.13% across French departments (2003–2006). The complete set of calibrated sector-specific parameters is reported in Table 3.

Table 3: Calibrated sector-specific parameters

Sector (NACE Rev. 2)	Parameter	Value
Manufacturing, resources, and utilities	α_s^E	0.298
	α_s^R	0.141
	β_s	0.311
Construction	α_s^E	0.213
	α_s^R	0.128
	β_s	0.087
Market services	α_s^E	0.208
	α_s^R	0.154
	β_s	0.301
Business services	α_s^E	0.298
	α_s^R	0.112
	β_s	0.301

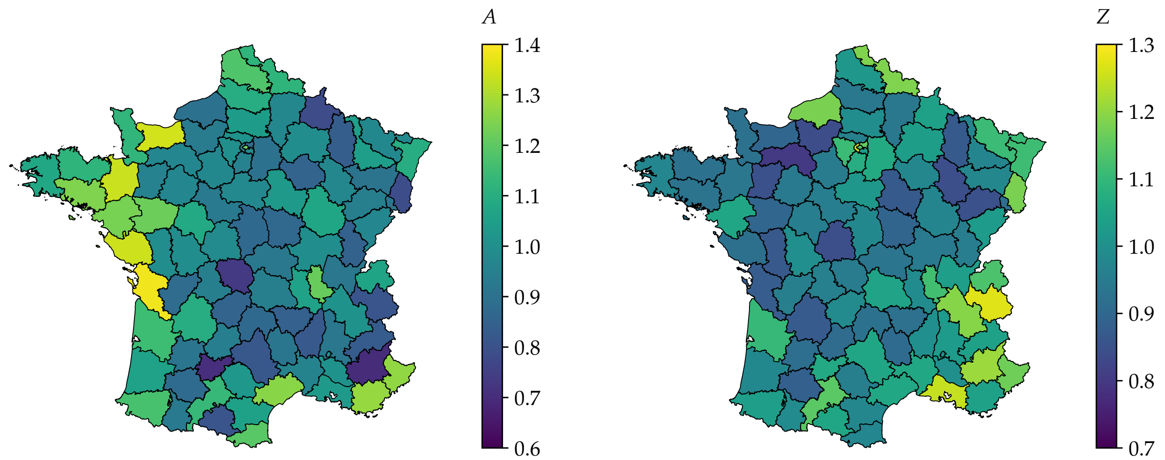
Model inversion. The sector-location-specific productivity levels Z_{ds}, location-specific land endowments ($\mathcal{L}_d$) and amenity (A_d) levels, and bilateral trade and migration costs Δ_{od}^I and Δ_{od}^M are inferred using the model and the French spatial data. In particular, bilateral trade and migration flows discipline the iceberg trade costs Δ_{od}^I and migration costs Δ_{od}^M. The bilateral trade flows come from the *SITRAM* database of origin–destination road-freight shipments between French departments, following Combes, Lafourcade and Mayer (2005), while migration flows are measured using the INSEE census migration matrices. Conditional on these bilateral frictions, the remaining fundamentals are chosen jointly so that the model's initial steady state matches the observed cross-section of wages, employment, relative housing prices, and capital-income moments as closely as possible under the full equilibrium restrictions of the model.

Figure 3 presents the inferred department-level amenity and productivity levels. We observe substantial heterogeneity across locations in both dimensions. Intuitively, the model assigns high productivity to departments that capture a large share of national demand despite high local production costs, and high amenity to departments that attract residents despite comparatively low real wages. These inferred fundamentals

Figure 3: Inferred local fundamentals

(a) Amenity levels

(b) Productivity levels



Note: This figure plots the department-level amenity and productivity levels inferred from the model inversion procedure. Department-level productivity is calculated as the β_s-weighted average of sector-level productivity within each department.

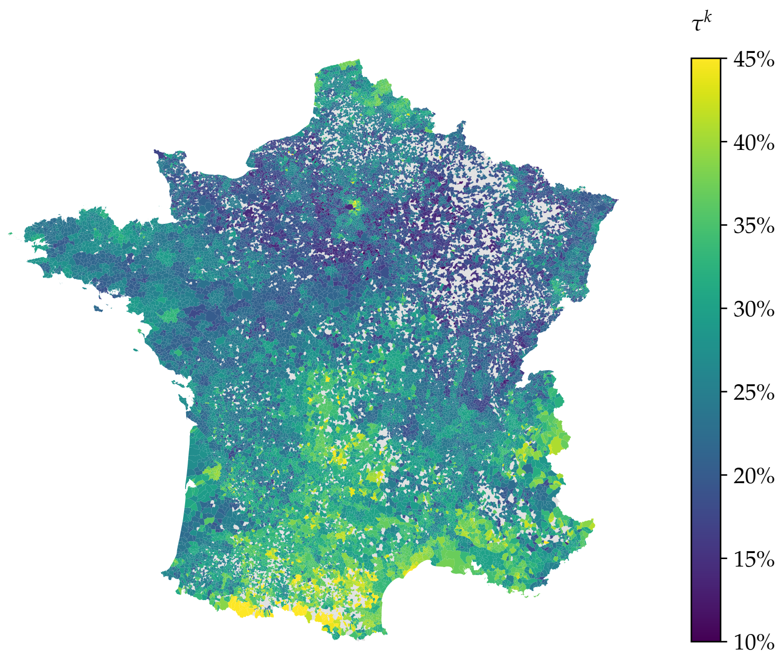
summarize the persistent spatial differences that the model uses to rationalize the observed initial allocation.

Local capital taxes. The parameters governing the distribution of capital taxes within each department, μ_d and σ_d, are chosen to match the weighted department-level mean and variance of commune tax rates. Specifically, we treat $1 + \tau$ as log-normal and recover the implied log-normal parameters from the empirical first two moments of the weighted tax-rate distribution in each department.

Figure 4 plots the local capital tax rates across communes prior to the reform. The data reveals substantial spatial heterogeneity, but despite this variation, tax levels were generally high across all departments, and particularly so in the southern region of France. This North-South divide was primarily driven by the composition of economic activity; the South's reliance on labor-intensive service sectors offered a smaller taxable capital base compared to the industrial North, forcing local governments to impose higher rates to fund public spending.

The correlation between average department-level capital tax rates and the local fundamentals inferred from the model, weighted by initial employment shares, is 0.0478 with productivity and 0.00608 with amenities, both close to zero. The harmonization

Figure 4: Local capital tax rates



Note: This map displays the local capital tax rates for each municipality (commune) prior to the reform. These tax rates were particularly high in the south of France.

result is therefore not driven by a strong tax-productivity or tax-amenity gradient. Instead, it reflects the fact that the initially low-tax departments are large, capital-rich, and high-income in the initial equilibrium. Harmonization raises taxes in these hubs, including Paris, and shifts activity toward lower-wage destinations. The fact that worker welfare still rises slightly under harmonization reflects only modest amenity gains in the destinations that attract workers.

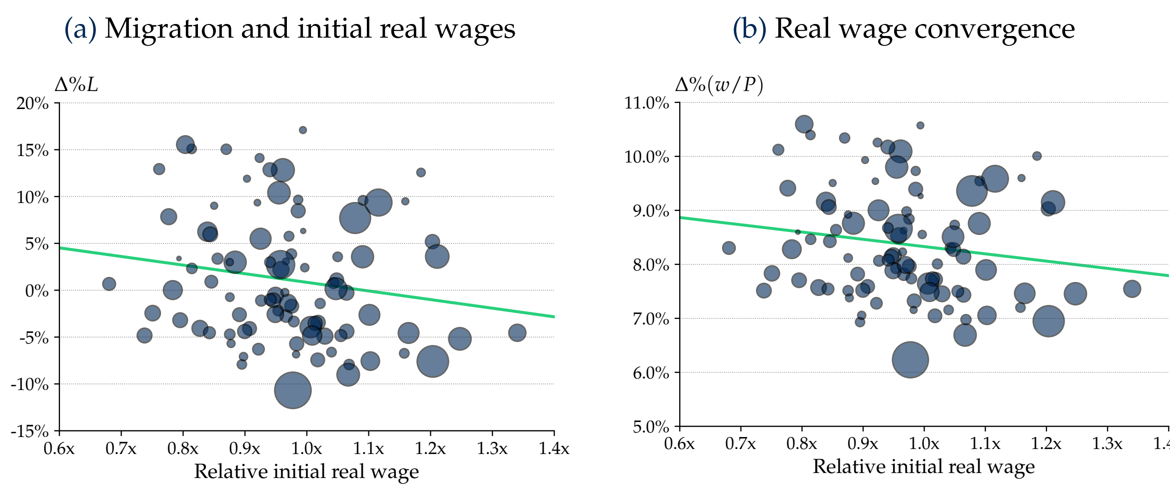
6 Macroeconomic consequences of the reform

We now use the calibrated model to quantify the macroeconomic consequences of the reform. We first compare the initial and final steady states, documenting the aggregate and spatial effects of the tax change. We then analyze the transition between these two steady states, and finally use counterfactual experiments to disentangle the respective roles of spatial reallocation and capital accumulation.

6.1 Long-run consequences

In the long run, the reform delivers substantial aggregate economic gains. Comparing the initial and final steady states, we find that average real income per worker rises by 8.04%. Most of this gain comes from within-department responses: holding the spatial distribution of employment fixed, real incomes would rise by 8.17% on average due to equipment capital deepening, accompanying real-estate accumulation, and lower prices. Spatial reallocation only modestly offsets these gains, generating a composition effect of -0.116%. This negative composition effect is driven by reallocation away from large, low-tax, high-income locations, especially Paris, toward destinations that combine lower wages with only modest amenity gains. Figure 5(a) shows that the relationship between initial real wages and employment changes is very weak, consistent with the small size of the reallocation channel.

Figure 5: Migration and real wage convergence



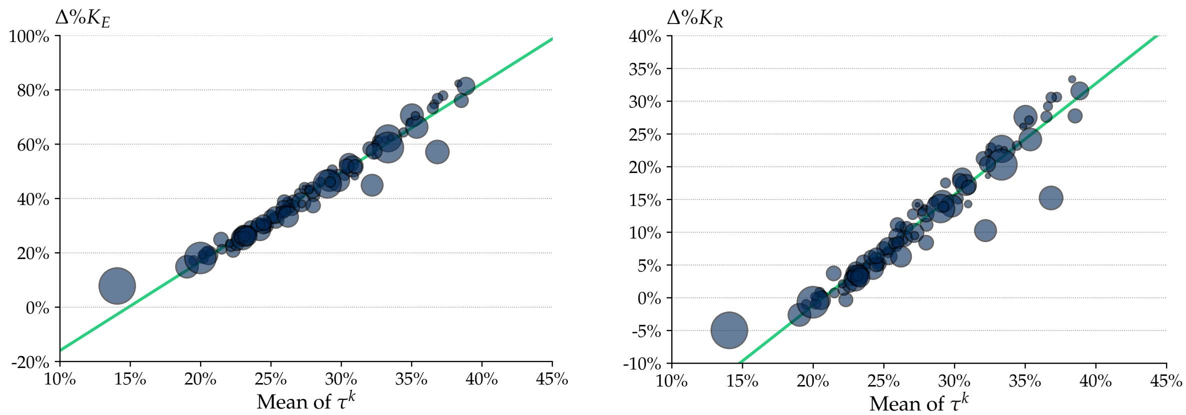
Note: Panel 5(a) plots employment changes against initial real wages across departments. The correlation (-0.166) is close to zero, indicating that the reform induces only limited reallocation toward initially low-wage locations. Panel 5(b) shows that departments with lower initial real wages experience larger real wage gains in the long run, indicating a convergence in living standards across locations. The size of each point is proportional to the corresponding department's employment.

The reform induces a dramatic expansion of the aggregate equipment capital stock, which rises by 36.6%. This large response reflects the direct effect of removing equipment from the tax base, which substantially lowers the user cost of capital. The aggregate real estate capital stock also increases, by 9.01%, with production real estate rising by 8.15% due to complementarity with equipment in the production function and housing real estate by 10.2%. As Figure 6 shows, departments with higher initial tax rates experience systematically larger capital gains in both types.

Figure 6: Long-run capital accumulation and taxes

(a) Equipment capital and tax rates

(b) Real estate capital and tax rates



Note: Panels (a) and (b) show that departments with higher capital tax rates prior to the reform experience systematically larger long-run changes in both types of capital stocks. The size of each point is proportional to the corresponding department's employment.

The aggregate real estate capital expansion masks some spatial reallocation. At the department level, real estate capital growth varies widely, with gains exceeding 30% in some southern and coastal departments (Figure 7). Paris—which initially holds 7.16% of the national real estate stock—sees a 4.97% decline as workers move away from the capital region. This illustrates the direction of the reallocation channel, but its aggregate contribution remains limited relative to the broad-based capital deepening documented above.

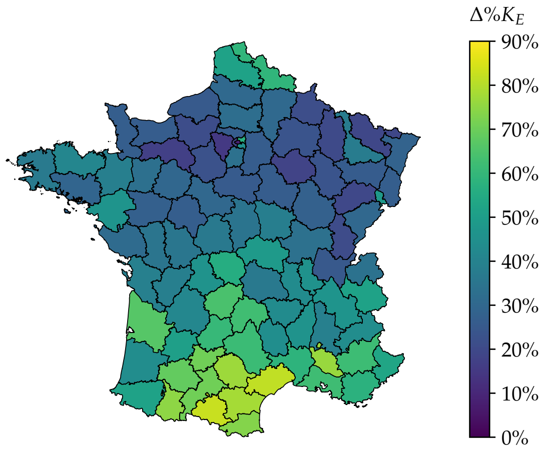
Finally, the reform lowers average prices: goods prices fall by 8.02% and housing prices decline by 5.62%. The reduction in goods prices stems from lower production costs as equipment capital accumulates, while housing prices fall due to the combination of lower goods prices (which enter housing production costs) and reduced housing demand in costly locations like Paris. These price declines are larger in initially high-tax departments, contributing to a convergence of real wages across space as shown in Figure 5(b).

6.2 Transition dynamics

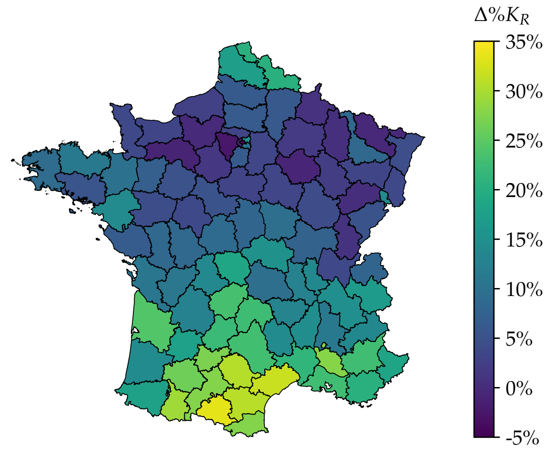
The long-run gains from the reform are substantial, but their welfare relevance also depends on how quickly they materialize. If the transition to the new steady state

Figure 7: Long-run consequences across space

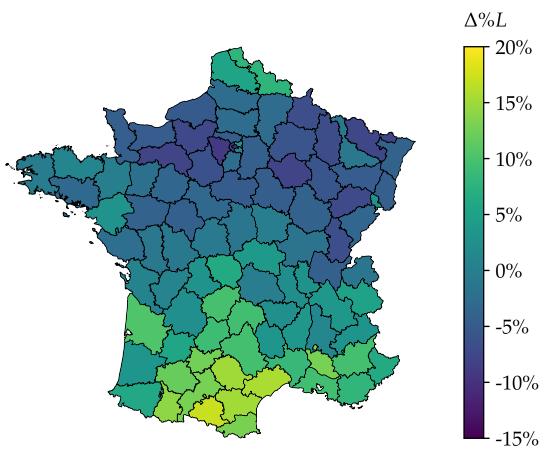
(a) Equipment capital



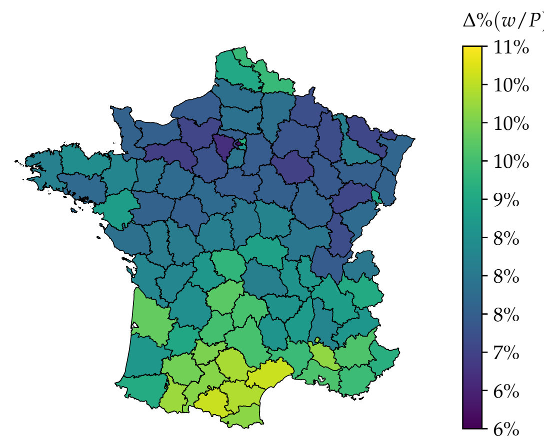
(b) Real estate capital



(c) Employment



(d) Real wages



Note: Panels (a), (b), (c), and (d) illustrate the spatial distribution of long-run capital accumulation (of both types), migration, and real wage gains across departments, respectively.

takes decades, the discounted welfare gains may fall well short of what the long-run comparison suggests. We turn to this question next.

The transition from the initial to the final steady state reveals a clear hierarchy of adjustment speeds. Table 4 reports the distribution of department-level half-lives for each variable. At the median department, goods prices and equipment capital adjust on similar horizons, with half-lives of 12.8 and 12.8 years, respectively, followed by real wages (16.1 years). Real estate capital adjusts much more slowly (45.5 years), housing prices similarly (36.4 years), and employment reallocation is slowest of all at 150 years. The speed hierarchy reflects the underlying economics: local capital stocks can respond through investment and depreciation, whereas reallocating activity across space requires wages, prices, and migration incentives to adjust jointly through the trade and migration network. The key implication is that the reform's real-income gains accrue mainly through capital deepening and price reductions well before substantial spatial reallocation takes place.

Table 4: Adjustment speed

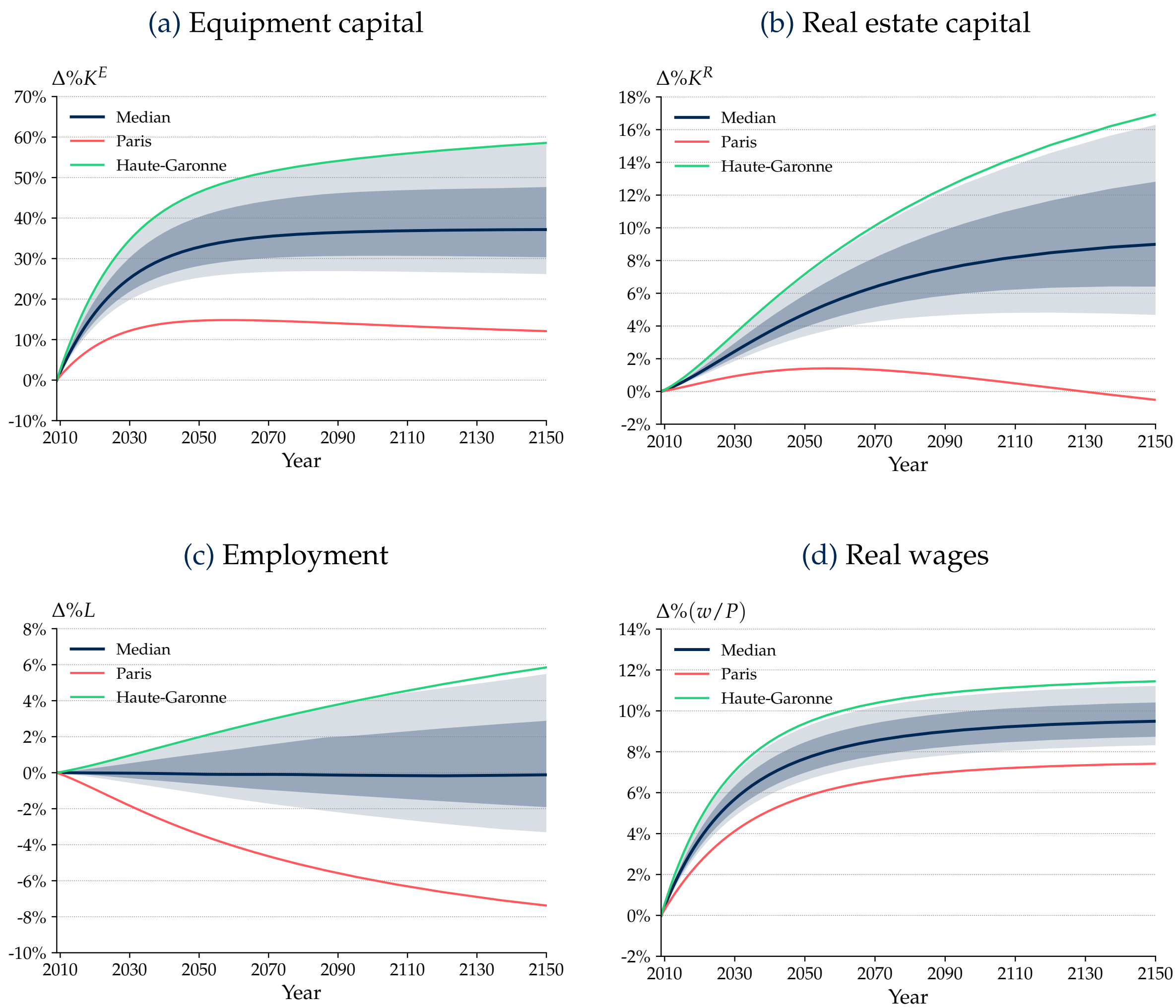
Variable	Symbol	Half-life percentile (years)				
		10th	25th	50th	75th	90th
Equipment capital	K^E	8.5	10.1	12.8	16.7	20.0
Real estate capital	K^R	16.8	25.1	45.5	74.3	90.5
Employment	L	84.2	116.8	149.8	193.3	278.2
Real wage	w/P	15.3	15.7	16.1	16.7	17.2
Goods price	P^Y	12.1	12.3	12.8	13.7	14.4
Housing price	P^H	32.6	34.2	36.4	40.8	45.7

Note: Each cell reports the half-life (in years) at the corresponding percentile of the cross-departmental distribution. Half-lives are computed as the time of first crossing: the first time a department's path reaches the midpoint between its initial and final steady-state values.

We measure worker consumption-equivalent welfare (CEW) through the Fréchet expected utility, which reflects the ex ante expected utility of a worker drawing idiosyncratic taste shocks over locations (Donald et al., 2025). The transition-inclusive worker CEW gain is 2.99%. For reference, the corresponding steady-state-to-steady-state worker CEW is 8.28%. The gap reflects the heavy discounting of slowly materializing gains: with equipment capital taking 12.8 years to half-adjust and employment reallocation taking 150 years, much of the long-run benefit arrives in the distant future. This again points to the same asymmetry as in the steady-state decomposition: capital deepening delivers gains relatively quickly, while the reallocation channel is much slower and quantitatively limited.

The plots in Figure 8 reveal substantial cross-departmental dispersion in transition paths. For equipment capital, all departments accumulate steadily, but the magnitude varies with pre-reform tax exposure. For real estate capital, the dispersion is even wider and the adjustment far slower. Employment reallocation is strikingly sluggish: even after fifty years, the median department has completed only a small fraction of its long-run workforce change. Despite this slow migration, real wages adjust at a pace similar to equipment capital, underscoring that the main gains from the reform come from local capital accumulation rather than from rapid spatial resorting.

Figure 8: Transition dynamics across space

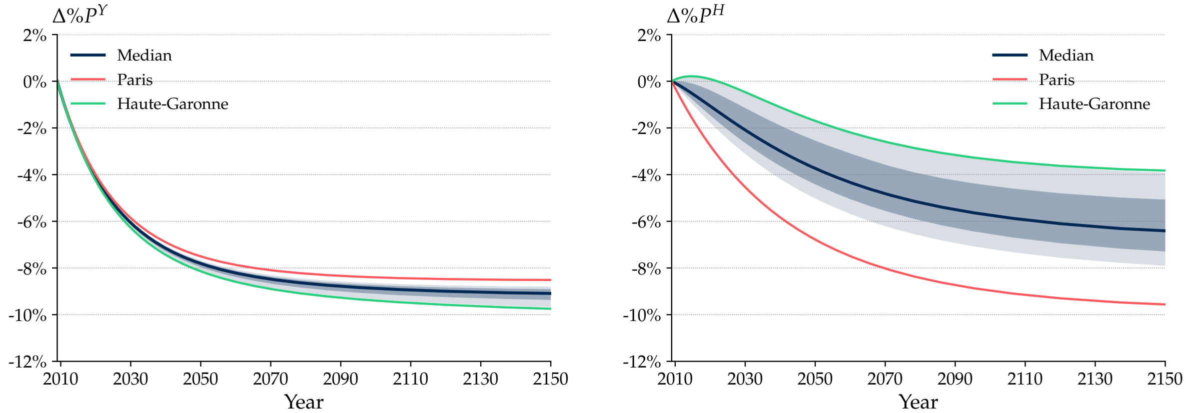


Note: Panels (a), (b), (c), and (d) illustrate the transition path of capital stocks (of both types), employment, and real wages across departments, respectively. The dark and pale shaded areas represent the 25th–75th and 10th–90th percentiles of the distribution across departments, respectively.

Figure 9 shows the transition dynamics of the cost of living. Goods prices fall rapidly and with tight cross-departmental dispersion, reflecting both an immediate announcement effect and the subsequent broad-based reduction in production costs as equipment capital deepens. Housing prices display richer and more persistent dynamics: in departments that gain workers, housing demand initially rises faster than real estate supply can respond, temporarily pushing prices up before the sluggish housing capital stock catches up. In Paris, the outflow of workers produces a steep, monotonic decline in housing prices.

Figure 9: Cost of living

(a) Goods prices (b) Housing prices



Note: These panels show the transition path of the aggregate price level of goods and housing, respectively. The dark and pale shaded areas represent the 25th–75th and 10th–90th percentiles of the distribution across departments, respectively.

Spectral decomposition of the transition. The preceding figures document a striking pattern: equipment capital adjusts within decades while employment takes generations. A spectral decomposition of the linearized transition dynamics (Appendix B.4) reveals that these two timescales reflect two distinct effects of the reform (Kleinman et al., 2023). The first is a broad-based *level* effect: the reform lowers the user cost of equipment capital in every department, so equipment accumulates quickly everywhere and real estate follows more gradually through complementarity. Wages rise and goods prices fall—all without requiring a single worker to relocate. This is why the reform's real-income gains accrue over two decades rather than over generations. However, the new steady state also requires a different *spatial distribution* of economic activity, and this adjustment is far slower.

The spatial redistribution of activity is far slower. While the aggregate capital stock rises quickly, the *differences* in capital across departments change only gradually, because capital and labor delay each other's spatial reallocation. In an initially low-tax department, where abundant capital had attracted a large workforce, the high capital stock keeps wages elevated, delaying the departure of workers; and the abundance of workers keeps the return to investment high, delaying the departure of capital. Each factor's presence sustains the other's, and the converse holds in initially high-tax departments where both factors are slow to arrive. In our setting, the reform affects workers primarily through capital-driven changes in local wages and prices rather than through a direct labor-market shock. This complementarity, rather than high moving costs, is what makes the median employment half-life (150 years) so much longer than the migration elasticity alone would predict.

6.3 Alternative counterfactuals

The previous subsections analyzed the actual reform—removing capital equipment from the tax base and introducing a 1% tax on value-added. We now use the model to assess alternative counterfactual reforms that isolate different mechanisms through which the tax change operates.

A budget-neutral reform. The pre-reform policy consensus in France was to change the tax *base*, not to cut its *level*. The Fouquet (2004) commission proposed a revenue-neutral reform that would shift the burden away from industrial firms without reducing public revenues: the base needed modernizing, but the overall taxation of firms should be preserved. What was actually implemented was quite different. The reform delivered a substantial net tax cut—exceeding 5 billion euros annually. Politically, the reform was sold not as a modernization of the tax base but as a cost cut—suppressing the tax "so that France could keep its factories."

Our budget-neutral counterfactual is designed to disentangle these two margins. We simulate a revenue-neutral reform in which the value-added tax rate is set to balance the government's budget in the post-reform equilibrium. The required rate is 5.03%, substantially higher than the actual 1%. Under this counterfactual, real income per worker still rises by 1.29%, but far less than under the actual reform, while steady-state worker CEW rises by 1.51%. Because we do not solve transition dynamics for this counterfactual, this worker-CEW number is a steady-state-to-steady-state comparison. The comparison with the actual reform shows that much of the aggregate gain comes from lowering the overall burden on capital, while the remaining gap reflects the distortionary cost of financing the reform through a cascading CVAE rather than through a less distortive tax instrument. Conversely, removing the value-added tax entirely while keeping the rest of the reform unchanged would raise real income by 9.74%, *more* than the actual reform's 8.04%. The 1% CVAE therefore materially reduces the gains from the reform because it lacks input credits and cascades through production chains.[18]

[18] Unlike a standard value-added tax, the CVAE offers no input credit, so the tax paid at each production stage is embedded in downstream input prices. In the model, this cascading is amplified through capital accumulation: the tax raises goods prices, which raises capital costs, which raises goods prices further. With an average capital share of approximately 0.4, the amplification factor is $1/(1-0.4) \approx 1.67$.

Level vs. dispersion of capital taxes. As emphasized in the introduction, the reform simultaneously reduced the *level* and eliminated the *spatial dispersion* of equipment capital taxes. To disentangle these two channels, we compare two counterfactuals that isolate each margin. First, we replace the spatially heterogeneous equipment tax rates with a single uniform rate calibrated to keep total equipment tax revenue unchanged—a revenue-neutral harmonization. Second, we shift the entire distribution of equipment tax rates downward until aggregate equipment tax revenue reaches zero, while preserving the pre-reform spatial dispersion.

Harmonization alone has a negligible effect on real income per worker, changing it by only 0.01%, while reducing the level alone raises it by 9.73%. The level reduction therefore accounts for nearly all of the reform's income gains. The harmonization result is nevertheless informative: eliminating spatial tax dispersion generates small efficiency gains, but these are largely offset by worse spatial sorting. In the model, harmonization raises taxes in initially low-tax, high-wage hubs such as Paris and shifts activity toward lower-wage locations, leaving aggregate real income per worker almost unchanged. This welfare effect remains quantitatively small relative to the gains generated by lowering the level of capital taxation.

7 Conclusion

This paper studies the aggregate consequences of correcting spatial capital tax distortions, using the repeal of France's *Taxe Professionnelle* as a laboratory. Combining reduced-form evidence from administrative data with a dynamic spatial general equilibrium model, we find that the reform raises real income per worker by 8.04% in the long run and is equivalent to a 2.99% permanent increase in consumption when accounting for transition dynamics. The central quantitative result is that reducing the level of local capital taxation generates large gains through capital deepening and lower prices, while the spatial reallocation channel is much slower, much smaller in aggregate, and close to neutral for average real income on its own.

These findings highlight that the aggregate effects of correcting local distortions on capital depend on two features specific to this context. First, when distortions are local in nature, trade and migration frictions limit how much activity can be reallocated across space, so eliminating their dispersion need not generate large aggregate gains. Second, when distortions fall squarely on capital, lowering their level triggers dynamic capital deepening that amplifies the gains beyond what a static reallocation of existing resources would imply. In our setting, this second force is quantitatively dominant.

An important limitation of our analysis is that we treat local tax rates as exogenous. In practice, local governments may set rates strategically, as documented by a substantial literature on fiscal competition among French municipalities (Leprince, Madiès and Paty, 2007; Charlot and Paty, 2007). Three features of our setting mitigate this concern. First, the TP rate structure was highly persistent, reflecting institutional inertia in local fiscal decisions. Second, the 2010 reform was a national policy imposed by the central government, not the outcome of local fiscal competition. Third, the central government compensated municipalities for forgone revenue through dedicated transfers, limiting strategic adjustments in local rates. Endogenizing local tax competition within a dynamic spatial general equilibrium framework (Wilson, 1986; Zodrow and Mieszkowski, 1986) remains an important avenue for future research.

References

Albouy, David, "The Unequal Geographic Burden of Federal Taxation," *Journal of Political Economy*, 2009, *117* (4), 635–667.

Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102* (1), 94–130.

Auten, Gerald and Robert Carroll, "The Effect of Income Taxes on Household Income," *Review of Economics and Statistics*, 1999, *81* (4), 681–693.

Bergeaud, Antonin, Édouard Jousselin, and Clément Malgouyres, "Ten Years on from the Business Tax Reform: How Has It Affected Companies' Behaviour?," *Economic Research*, 2021, *238*, 4.

Bond, Stephen and John Van Reenen, "Microeconometric Models of Investment and Employment," in James J. Heckman and Edward E. Leamer, eds., *Handbook of Econometrics*, Vol. 6A, Elsevier, 2007, pp. 4417–4498.

Broda, Christian and David E. Weinstein, "Globalization and the Gains From Variety*," *The Quarterly Journal of Economics*, 05 2006, *121* (2), 541–585.

Buera, Francisco J., Joseph P. Kaboski, and Yongseok Shin, "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 2011, *101* (5), 1964–2002.

Caliendo, Lorenzo, Maximiliano Dvorkin, and Fernando Parro, "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock," *Econometrica*, 2019, *87* (3), 741–835.

Chamley, Christophe, "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives," *Econometrica*, 1986, *54* (3), 607–622.

Charlot, Sylvie and Sonia Paty, "Market Access Effect and Local Tax Setting: Evidence from French Panel Data," *Journal of Economic Geography*, 2007, *7* (3), 247–263.

Combes, Pierre-Philippe, Gilles Duranton, and Laurent Gobillon, "The Production Function for Housing: Evidence from France," *Journal of Political Economy*, 2021, *129* (10), 2766–2816.

__ , Miren Lafourcade, and Thierry Mayer, "The trade-creating effects of business and social networks: evidence from France," *Journal of International Economics*, 2005, *66* (1), 1–29.

Costinot, Arnaud and Andrés Rodríguez-Clare, "Chapter 4 - Trade Theory with Numbers: Quantifying the Consequences of Globalization," in Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4 of *Handbook of International Economics*, Elsevier, 2014, pp. 197–261.

Cummins, Jason G., Kevin A. Hassett, and R. Glenn Hubbard, "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments," *Brookings Papers on Economic Activity*, 1994, *1994* (2), 1–74.

Dixit, Avinash K. and Joseph E. Stiglitz, "Monopolistic Competition and Optimum Product Diversity," *The American Economic Review*, 1977, *67* (3), 297–308.

Donald, Eric, Masao Fukui, and Yuhei Miyauchi, "Unpacking Aggregate Welfare in a Spatial Economy," Working Paper 34075, National Bureau of Economic Research July 2025.

Fajgelbaum, Pablo D, Eduardo Morales, Juan Carlos Suárez Serrato, and Owen Zidar, "State Taxes and Spatial Misallocation," *The Review of Economic Studies*, 09 2018, *86* (1), 333–376.

Fouquet, Olivier, "Commission de Réforme de la Taxe Professionnelle: Rapport Définitif," Technical Report, Rapport au Premier Ministre 2004.

Giroud, Xavier and Joshua Rauh, "State Taxation and the Reallocation of Business Activity: Evidence from Establishment-Level Data," *Journal of Political Economy*, 2019, *127* (3), 1262–1316.

Gopinath, Gita, Şebnem Kalemli-Özcan, Loukas Karabarbounis, and Carolina Villegas-Sanchez, "Capital Allocation and Productivity in South Europe," *Quarterly Journal of Economics*, 2017, *132* (4), 1915–1967.

Gruber, Jon and Emmanuel Saez, "The Elasticity of Taxable Income: Evidence and Implications," *Journal of Public Economics*, 2002, *84* (1), 1–32.

Hall, Robert E. and Dale W. Jorgenson, "Tax Policy and Investment Behavior," *The American Economic Review*, 1967, *57* (3), 391–414.

Hayashi, Fumio, "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 1982, *50* (1), 213–224.

House, Christopher L. and Matthew D. Shapiro, "Temporary Investment Tax Incentives: Theory with Evidence from Bonus Depreciation," *American Economic Review*, 2008, *98* (3), 737–768.

Hsieh, Chang-Tai and Peter J. Klenow, "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 11 2009, *124* (4), 1403–1448.

Jorgenson, Dale W., "Capital Theory and Investment Behavior," *The American Economic Review*, 1963, *53* (2), 247–259.

Judd, Kenneth L., "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of Public Economics*, 1985, *28* (1), 59–83.

Kleinman, Benny, Ernest Liu, and Stephen J. Redding, "Dynamic Spatial General Equilibrium," *Econometrica*, 2023, *91* (2), 385–424.

Leprince, Matthieu, Thierry Madiès, and Sonia Paty, "Business Tax Interactions Among Local Governments: An Empirical Analysis of the French Case," *Journal of Regional Science*, 2007, *47* (3), 603–621.

Long, J. Bradford De and Lawrence H. Summers, "Equipment Investment and Economic Growth," *Quarterly Journal of Economics*, 1991, *106* (2), 445–502.

Moll, Benjamin, "Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?," *American Economic Review*, 2014, *104* (10), 3186–3221.

Rathelot, Roland and Patrick Sillard, "The Importance of Local Corporate Taxes in Business Location Decisions: Evidence from French Micro Data," *Economic Journal*, 2008, *118* (527), 499–514.

Redding, Stephen J., "Goods Trade, Factor Mobility and Welfare," *Journal of International Economics*, 2016, *101*, 148–167.

_ **and Esteban Rossi-Hansberg**, "Quantitative Spatial Economics," *Annual Review of Economics*, 2017, *9*, 21–58.

Restuccia, Diego and Richard Rogerson, "Policy Distortions and Aggregate Productivity with Heterogeneous Establishments," *Review of Economic Dynamics*, 2008, *11* (4), 707–720.

Roback, Jennifer, "Wages, Rents, and the Quality of Life," *Journal of Political Economy*, 1982, *90* (6), 1257–1278.

Serrato, Juan Carlos Suárez and Owen Zidar, "Who Benefits from State Corporate Tax Cuts? A Local Labor Markets Approach with Heterogeneous Firms," *American Economic Review*, 2016, *106* (9), 2582–2624.

Straub, Ludwig and Iván Werning, "Positive Long-Run Capital Taxation: Chamley-Judd Revisited," *American Economic Review*, 2020, *110* (1), 86–119.

Weber, Caroline E., "Toward Obtaining a Consistent Estimate of the Elasticity of Taxable Income Using Difference-in-Differences," *Journal of Public Economics*, 2014, *117* (C), 90–103.

Wilson, John D., "A Theory of Interregional Tax Competition," *Journal of Urban Economics*, 1986, *19* (3), 296–315.

Yagan, Danny, "Capital Tax Reform and the Real Economy: The Effects of the 2003 Dividend Tax Cut," *American Economic Review*, 2015, *105* (12), 3531–3563.

Zodrow, George R. and Peter Mieszkowski, "Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods," *Journal of Urban Economics*, 1986, *19* (3), 356–370.

Zwick, Eric and James Mahon, "Tax Policy and Heterogeneous Investment Behavior," *American Economic Review*, 2017, *107* (1), 217–248.

Appendix

A Empirical appendix

A.1 Tables

Table A.5: Descriptive Statistics

	Mean	Median
Panel A: Firm Activity and Employment		
Sales (m€)	20.05	2.32
EBITDA (k€)	4,049.27	116.16
Headcount	77.49	21.00
Wage bill (m€)	1.88	0.46
Hourly wage (€)	18.60	15.28
Panel B: Balance sheet		
Tangible assets (m€)	5.76	0.38
Equipment capital (m€)	3.11	0.28
Total assets (m€)	75.66	1.98
Equipment capital / total assets (%)	20.38	15.65
Panel C: Tax exposure		
Z_i	0.21	0.21
KEshare_i	0.78	0.84
Firm × year observations	1,627,749	
Distinct firms	139,179	

Notes: Sales, tangible assets, equipment capital, total assets, and wage bill are in millions of euros; EBITDA in thousands of euros; hourly wage in euros. Z_i is the firm-level instrument defined in Section 3.1. KEshare_i is the equipment share of the TP base defined in Section 3.3. The sample is restricted to firms subject to the TP in 2008, excluding permanent micro-enterprises and firms constrained by the value-added cap (Section 2).

Table A.6: Robustness: Instrument Computed from 2006 Data

Dependent variable (log)	$\hat{\beta}$	R^2
All taxes paid / value-added	-0.415^{***}	0.701
	(0.048)	
Equipment capital	0.206^{***}	0.922
	(0.044)	
Quarterly sales	0.128^{**}	0.864
	(0.052)	

Notes: Each row corresponds to a different dependent variable. The reported coefficient is on $Z_i \times \mathbf{1}\{t \geq 2009\}$. All specifications include firm fixed effects, 2-digit industry $\times$ time period fixed effects, and control for KEshare$_i$ interacted with year dummies. The instrument Z_i is computed from 2006 data as a robustness check. In the quarterly sales regression, we additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. Standard errors clustered at the 5-digit industry level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.7: Robustness: Instrument Computed from 2007 Data

Dependent variable (log)	$\hat{\beta}$	R^2
All taxes paid / value-added	-0.390^{***}	0.700
	(0.047)	
Equipment capital	0.217^{***}	0.921
	(0.041)	
Quarterly sales	0.130^{**}	0.864
	(0.051)	

Notes: Each row corresponds to a different dependent variable. The reported coefficient is on $Z_i \times \mathbf{1}\{t \geq 2009\}$. All specifications include firm fixed effects, 2-digit industry $\times$ time period fixed effects, and control for KEshare$_i$ interacted with year dummies. The instrument Z_i is computed from 2007 data as a robustness check. In the quarterly sales regression, we additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. Standard errors clustered at the 5-digit industry level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

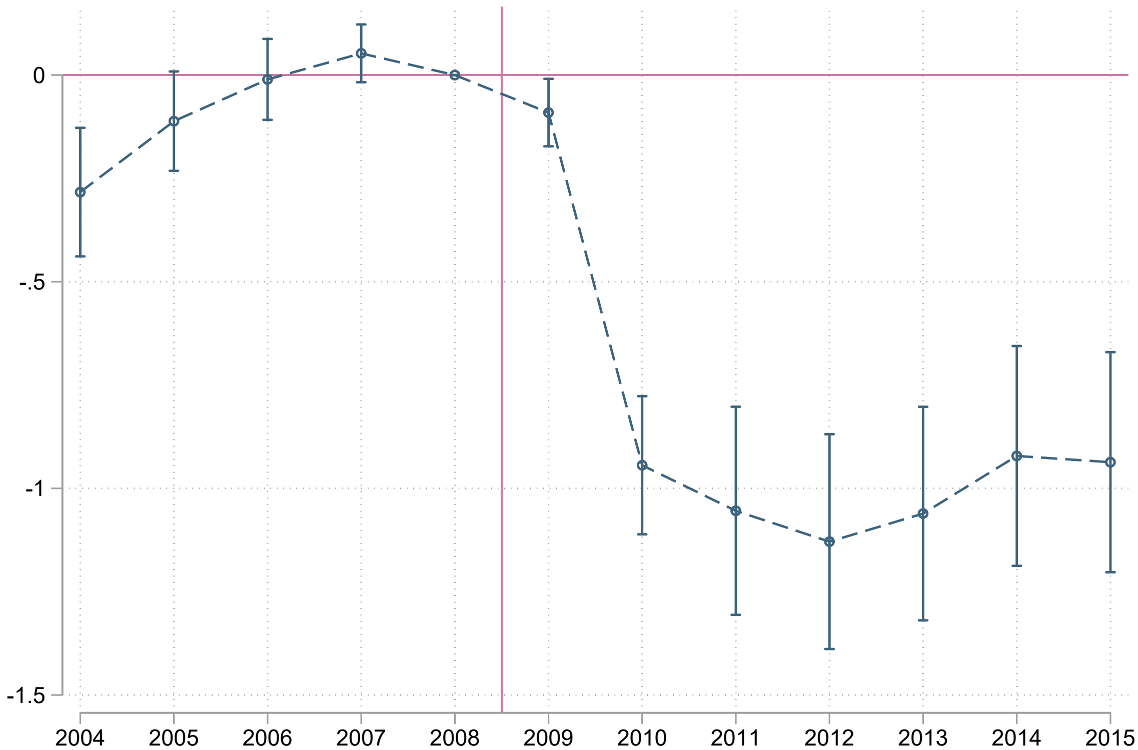
Table A.8: Robustness: Using the average tax rate as the instrument

Dependent variable (log)	$\hat{\beta}$	R^2
All taxes paid / value-added	-0.310^{***}	0.697
	(0.039)	
Equipment capital	0.173^{***}	0.921
	(0.035)	
Quarterly sales	0.087^{*}	0.868
	(0.051)	

Notes: Each row corresponds to a different dependent variable. The reported coefficient is on $\tilde{\tau}_i \times \mathbf{1}\{t \geq 2009\}$. All specifications include firm fixed effects and 2-digit industry $\times$ time period fixed effects. The instrument is $\tilde{\tau}_i$, the weighted average tax rate in 2008. We do not include the KEshare_i control (see Section 3.3). In the quarterly sales regression, we additionally interact $\tilde{\tau}_i$ with quarter-of-year fixed effects to account for seasonality. Standard errors clustered at the 5-digit industry level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

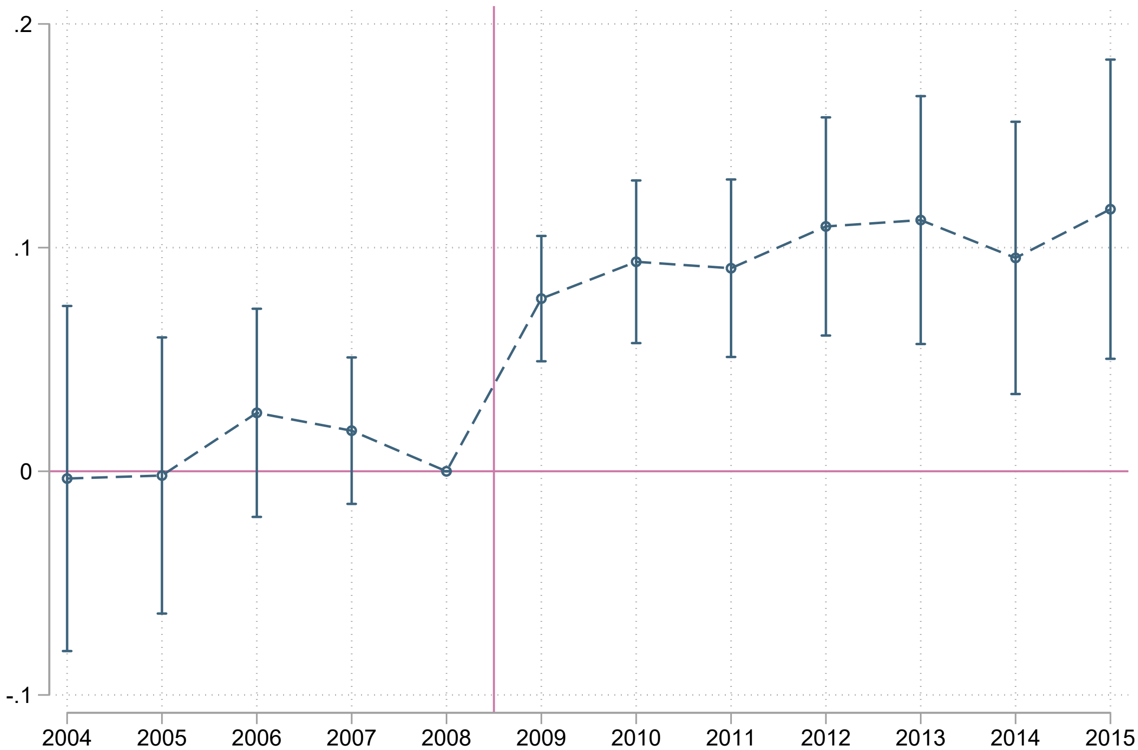
A.2 Additional empirical results

Figure A.10: **First stage: impact on local taxes over value-added (log)**



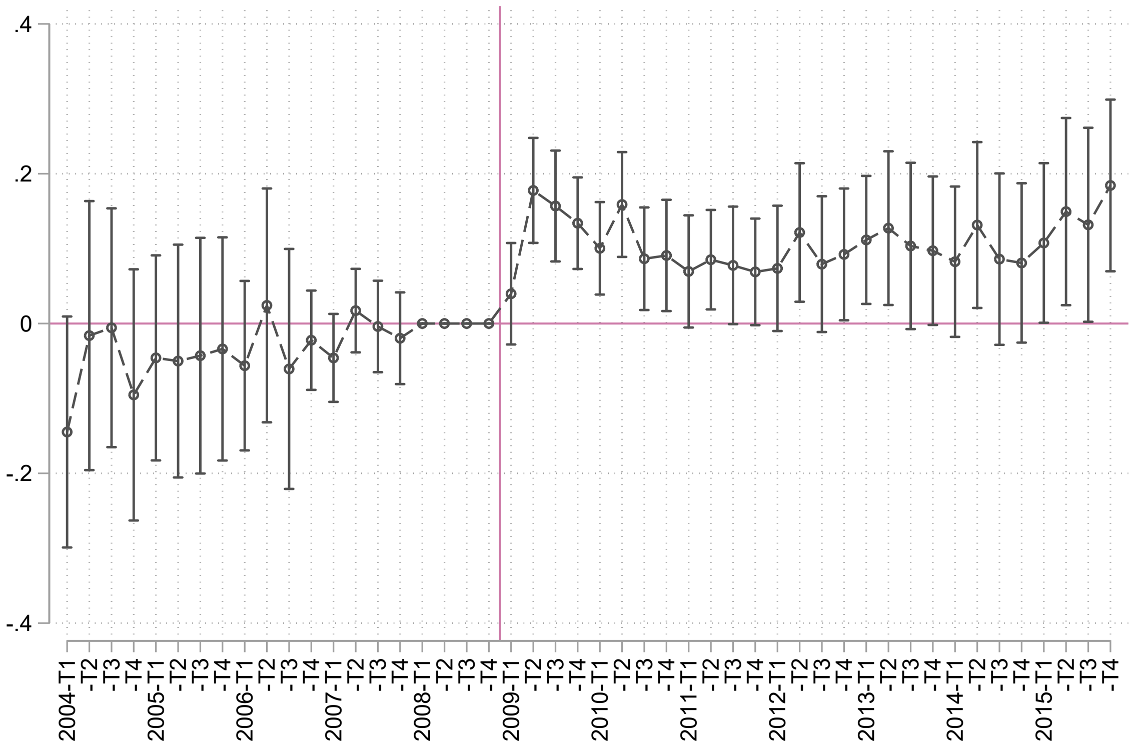
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is the total amount of local taxes over value-added, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.11: **Impact on all other assets than equipment capital (log)**



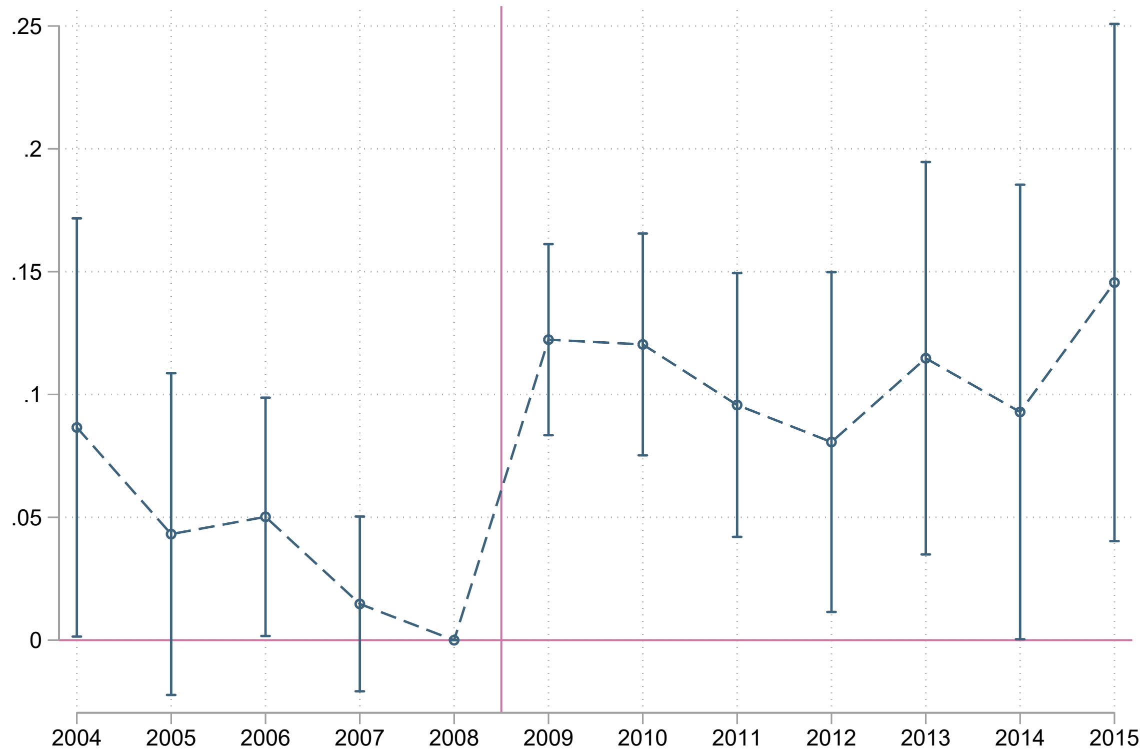
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is all other assets than equipment capital, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.12: **Impact on quarterly sales (log)**



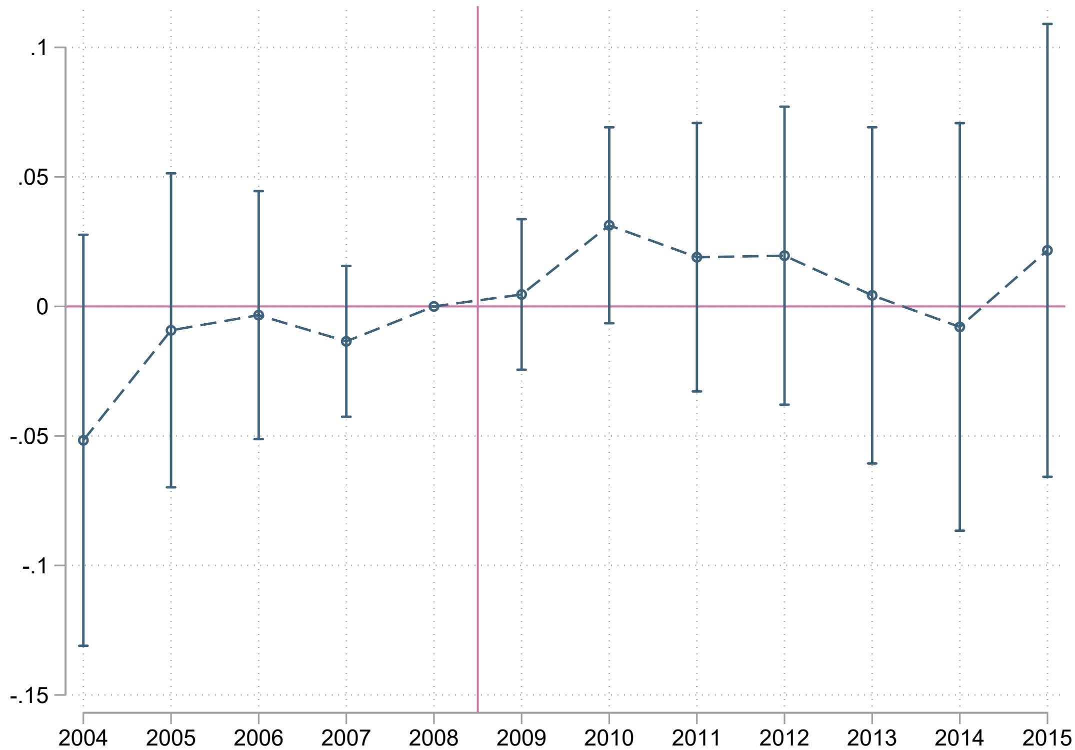
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. We additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. The dependent variable is the quarterly sales, in logs. 2008 (i.e. all quarters from 2008) is the reference period. Standard errors are clustered at the 5-digit sectoral level.

Figure A.13: **Impact on sales (log)**



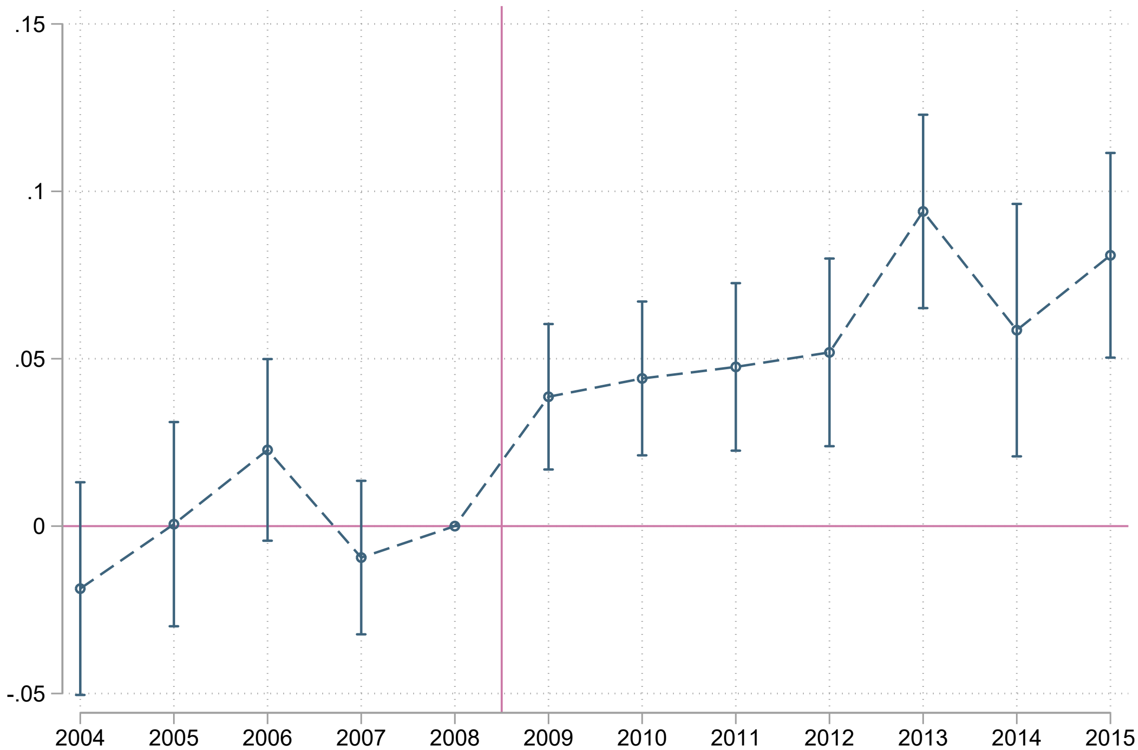
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is total sales, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.14: **Impact on total hours worked (log)**



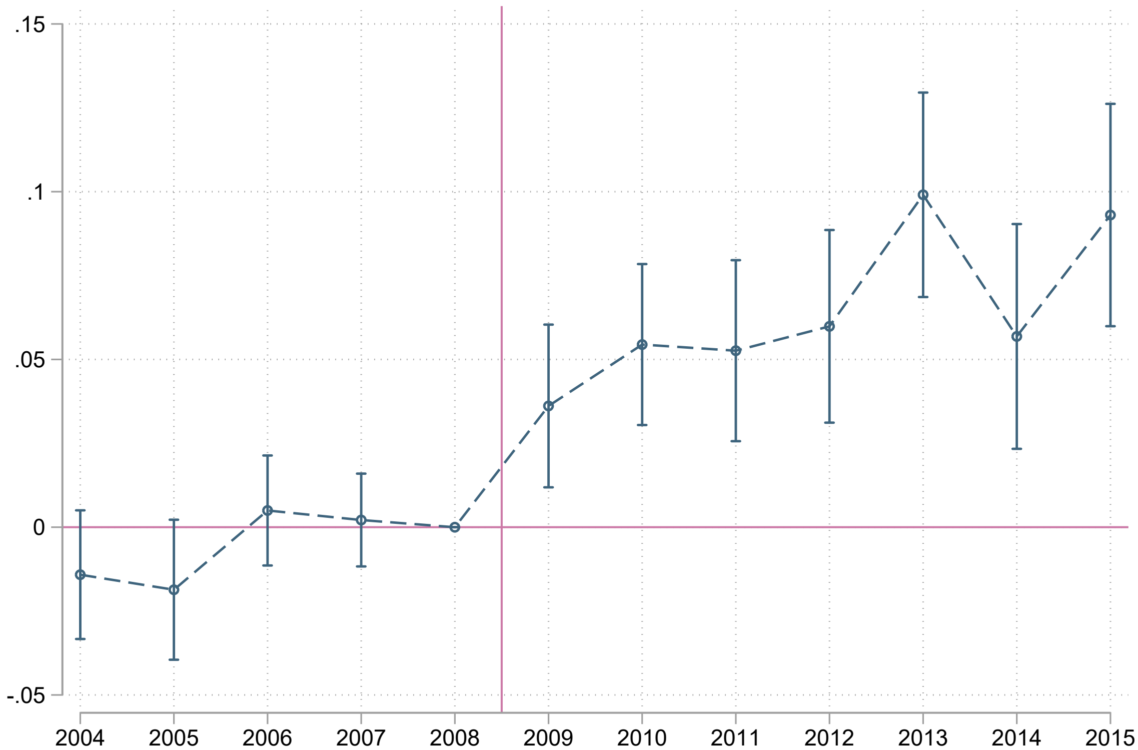
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is total hours worked, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.15: **Impact on hourly wage (log)**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is hourly wage, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

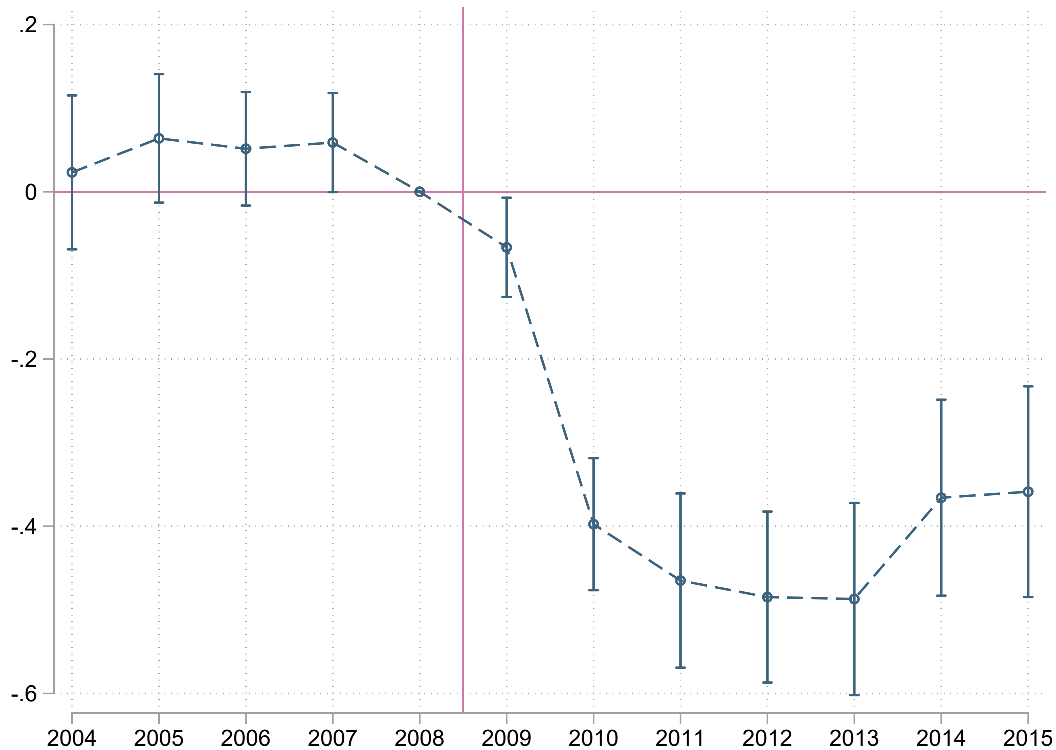
Figure A.16: **Impact on residualized hourly wage (log)**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2). The unit of observation is the firm. The dependent variable is residualized hourly wage, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

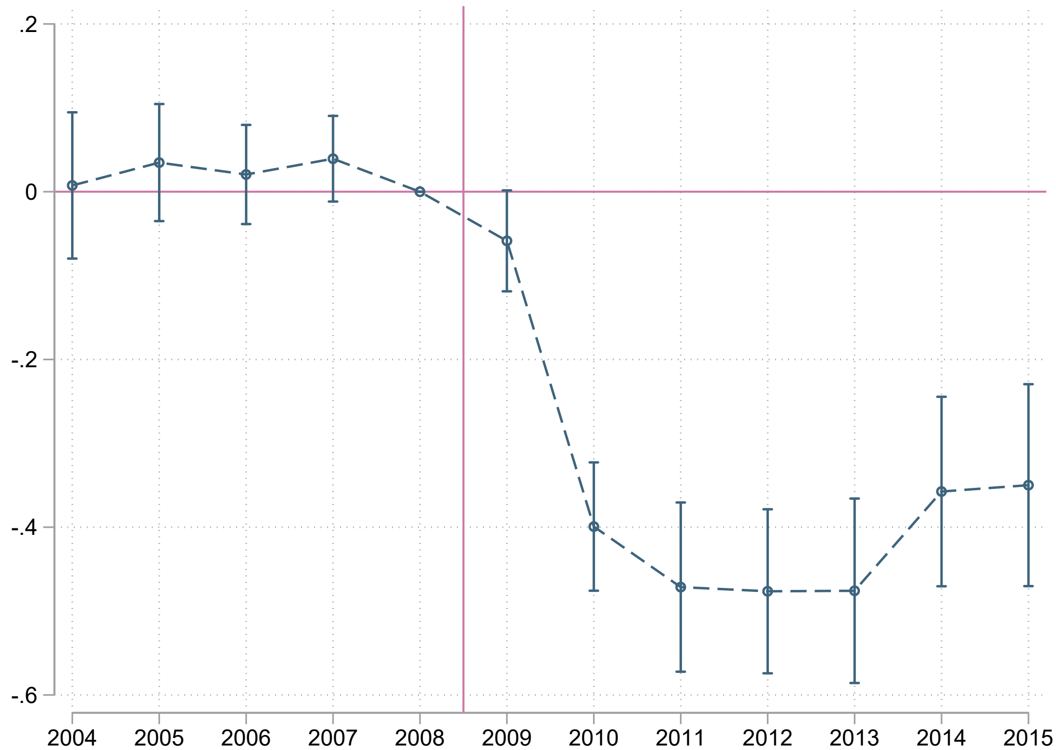
A.3 Robustness: event studies with alternative base years

Figure A.17: **First stage: impact on all taxes paid over value-added (log) — 2006 instrument**



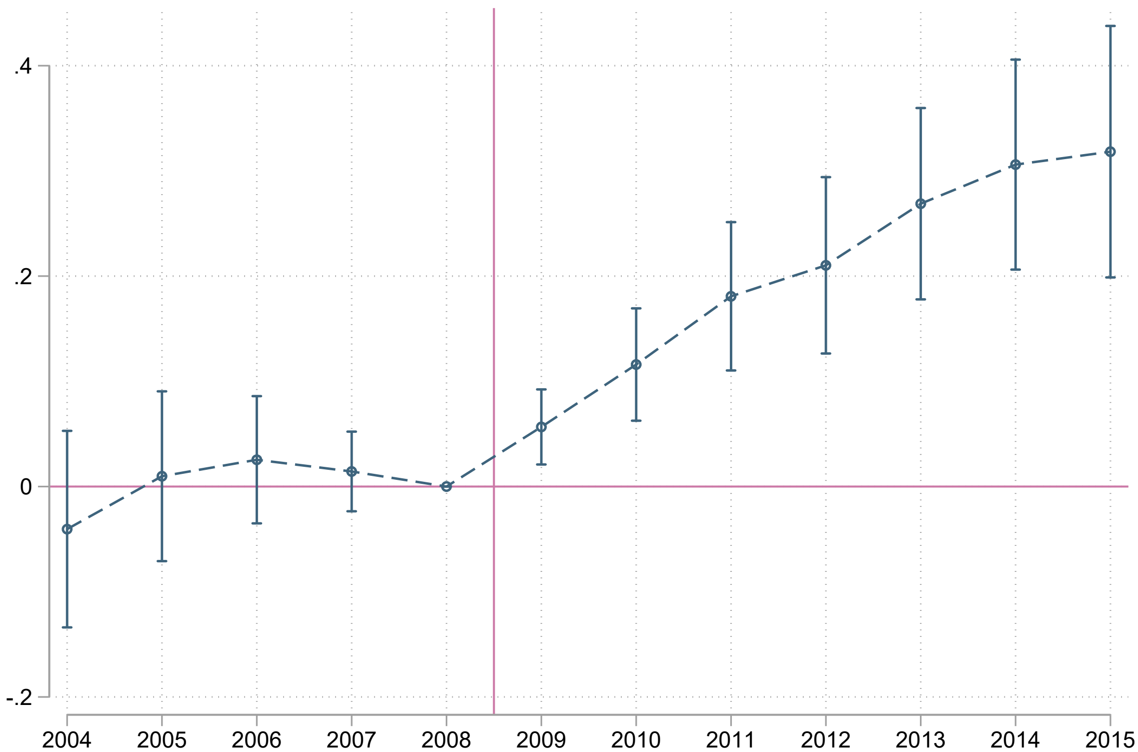
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare_i computed from 2006 data. The dependent variable is the total amount of taxes paid over value-added, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.18: **First stage: impact on all taxes paid over value-added (log) — 2007 instrument**



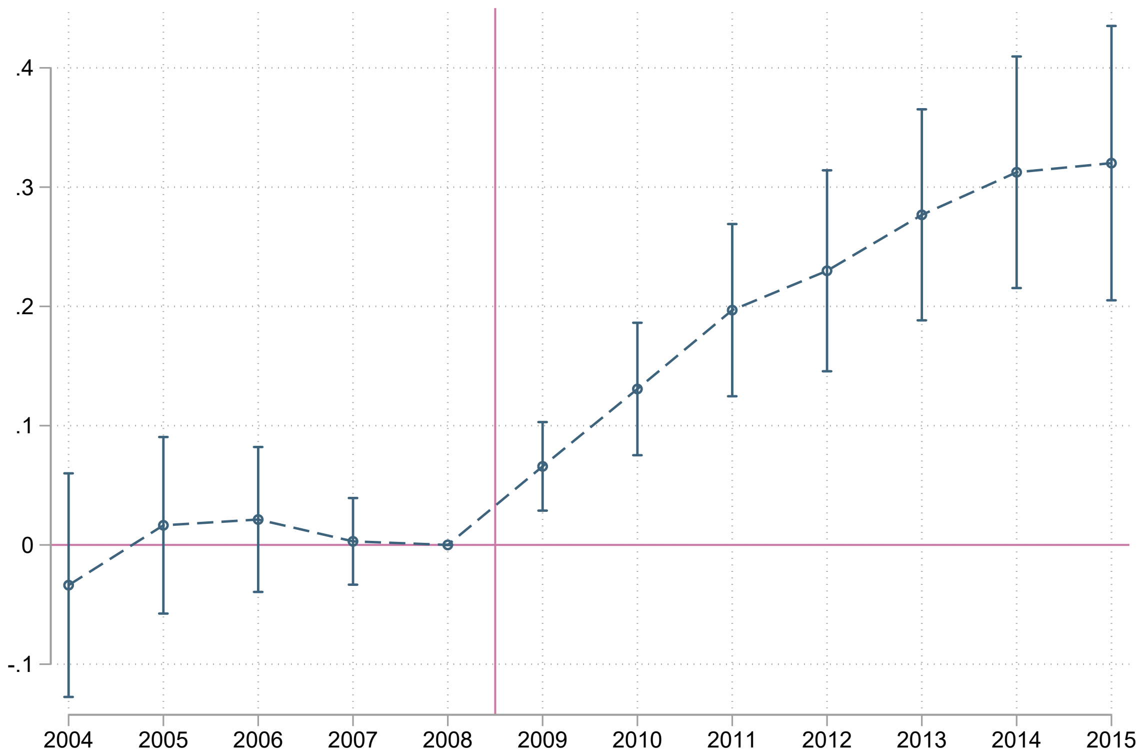
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare$_i$ computed from 2007 data. The dependent variable is the total amount of taxes paid over value-added, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.19: **Robustness: impact on equipment capital (log) — 2006 instrument**



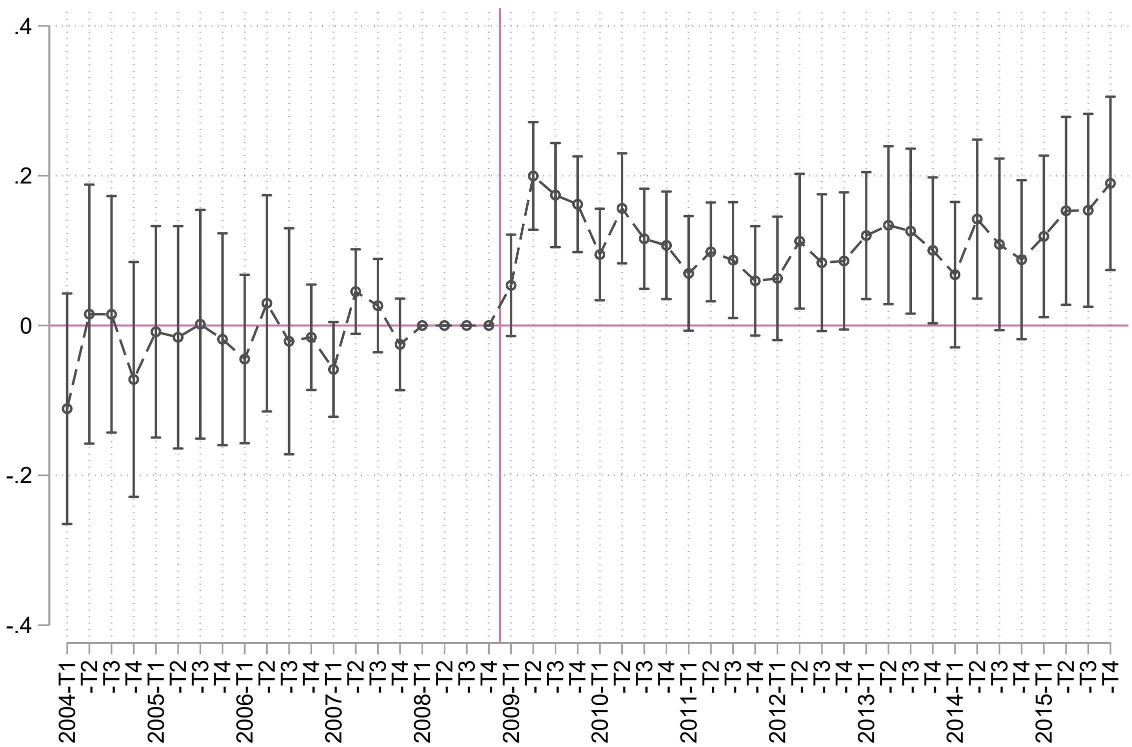
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare_i computed from 2006 data. The dependent variable is the stock of equipment capital, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit sectoral level.

Figure A.20: **Robustness: impact on equipment capital (log) — 2007 instrument**



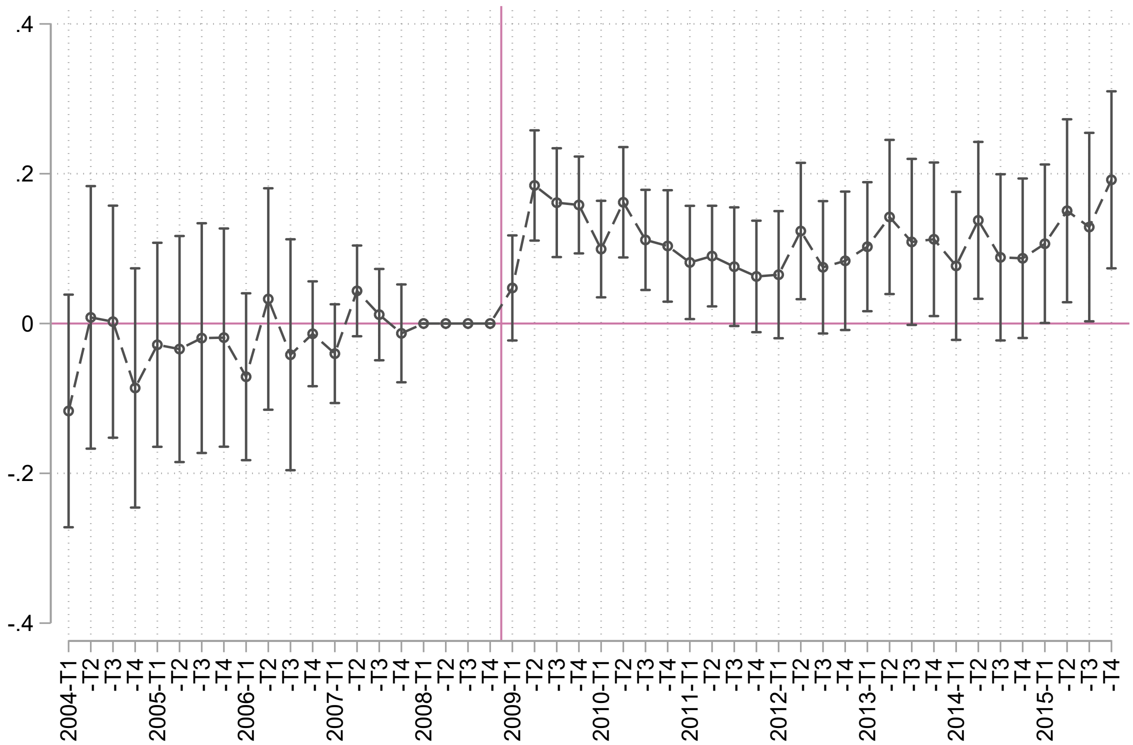
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare_i computed from 2007 data. The dependent variable is the stock of equipment capital, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit sectoral level.

Figure A.21: **Robustness: impact on quarterly sales (log) — 2006 instrument**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare_i computed from 2006 data. We additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. The dependent variable is the quarterly sales, in logs. 2008 (i.e. all quarters from 2008) is the reference period. Standard errors are clustered at the 5-digit sectoral level.

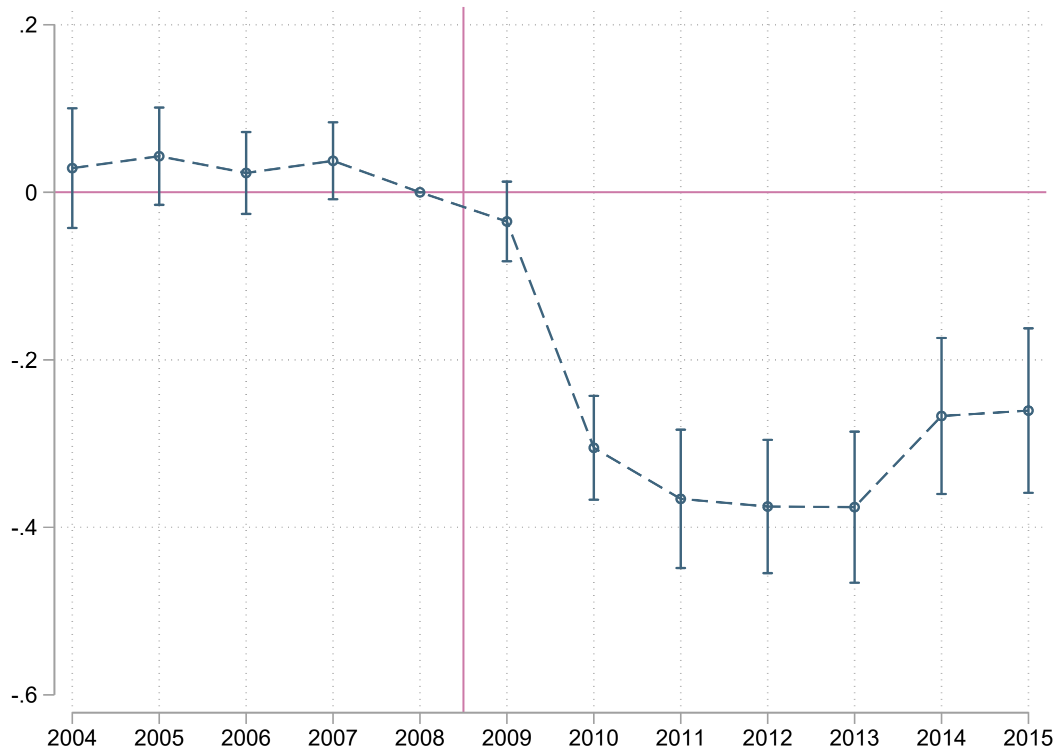
Figure A.22: **Robustness: impact on quarterly sales (log) — 2007 instrument**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), with Z_i and KEshare_i computed from 2007 data. We additionally interact Z_i with quarter-of-year fixed effects to account for seasonality. The dependent variable is the quarterly sales, in logs. 2008 (i.e. all quarters from 2008) is the reference period. Standard errors are clustered at the 5-digit sectoral level.

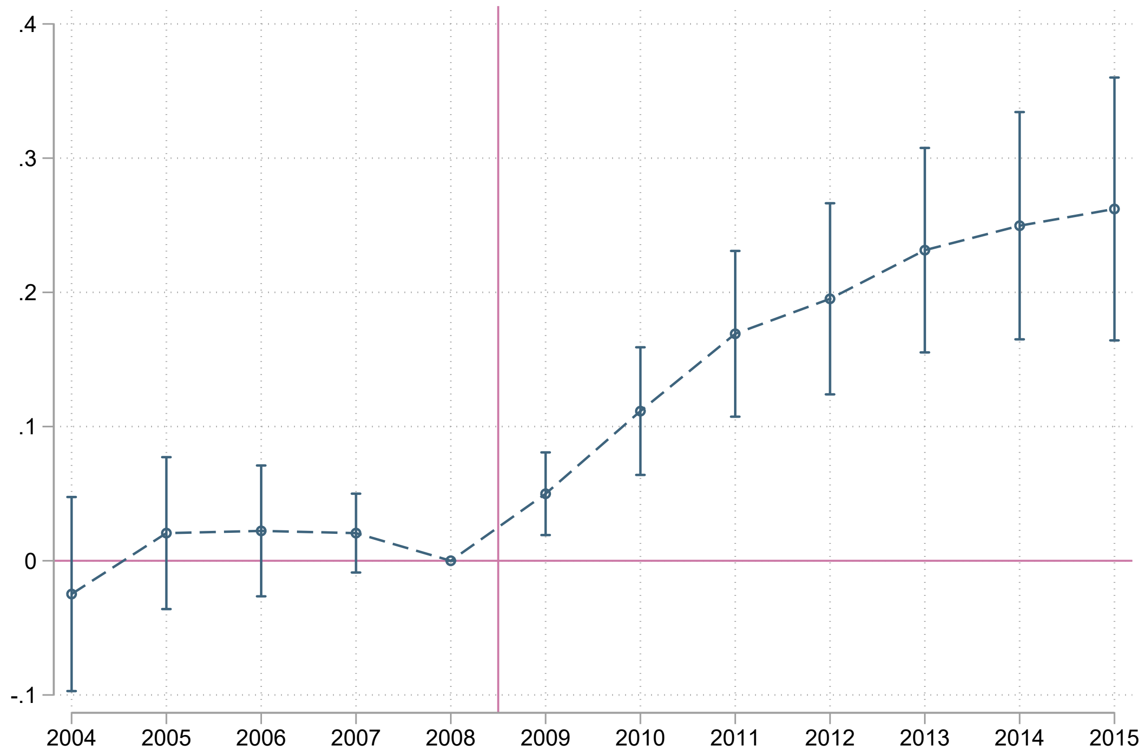
A.4 Robustness: event studies with the average tax rate as a treatment

Figure A.23: **First stage: impact on all taxes paid over value-added (log) — $\tilde{\tau}_i$ instrument**



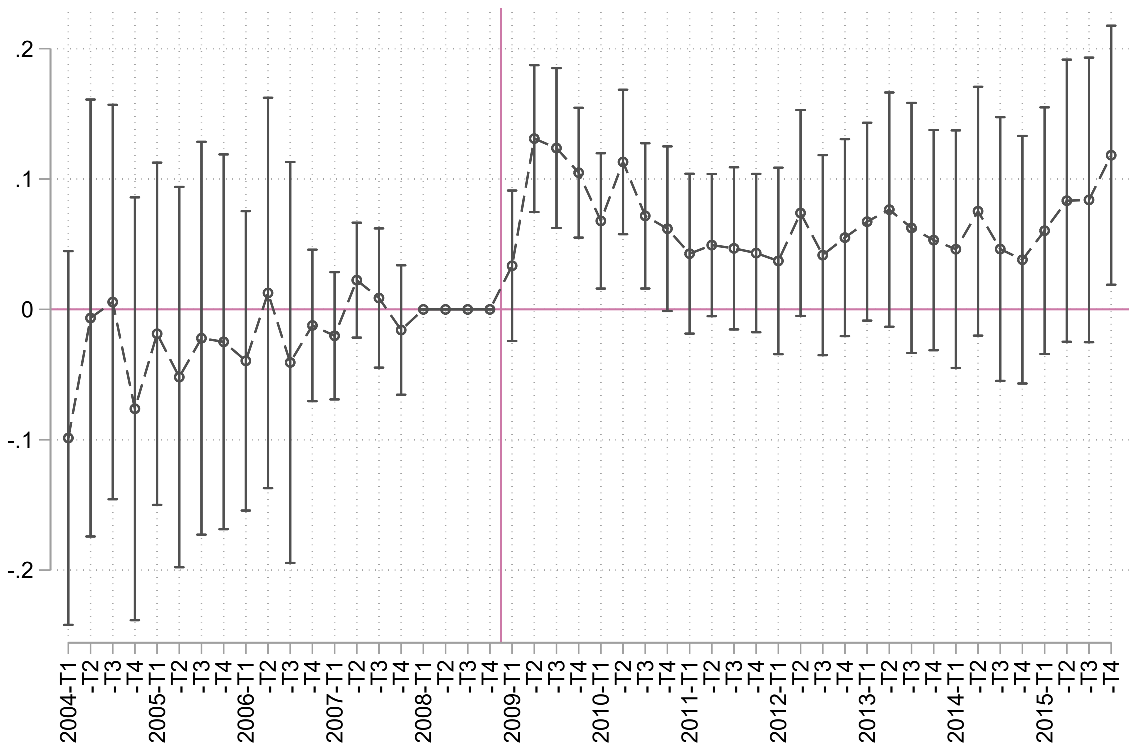
Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), but with $\tilde{\tau}_i$ – the average tax rate in 2008 – as treatment, without the $KEshare_i$ control (see Section 3.3). The dependent variable is the total amount of taxes paid over value-added, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit (4-digit and one letter) sectoral level.

Figure A.24: **Robustness: impact on equipment capital (log) — $\tilde{\tau}_i$ instrument**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), but with $\tilde{\tau}_i$ – the average tax rate in 2008 – as treatment, without the KEshare$_i$ control (see Section 3.3). The dependent variable is the stock of equipment capital, in logs. 2008 is the reference year. Standard errors are clustered at the 5-digit sectoral level.

Figure A.25: **Robustness: impact on quarterly sales (log) — $\tilde{\tau}_i$ instrument**



Note: This figure plots the point estimates and 95-percent confidence intervals from the event study regression defined in Eq. (2), but with $\tilde{\tau}_i$ – the average tax rate in 2008 – as treatment, without the KEshare_i control (see Section 3.3). We additionally interact $\tilde{\tau}_i$ with quarter-of-year fixed effects to account for seasonality. The dependent variable is the quarterly sales, in logs. 2008 (i.e. all quarters from 2008) is the reference period. Standard errors are clustered at the 5-digit sectoral level.

B Theoretical appendix

B.1 The market equilibrium allocation

The firm's problem. Production firms choose capital and labor inputs to minimize costs taking prices and taxes as given. Thus, the firm's problem in sector s of location d at time t is given by:

$$\min_{k^E_{dst}(i),k^R_{dst}(i),l_{dst}(i)} \left\{ \sum_{T\in\{E,R\}} [1+\mathbb{1}_{\{T \text{ is taxed in } t\}}\tau^K_d(i)] r^T_{dt} k^T_{dst}(i) + w_{dt} l_{dst}(i) \right\}$$

subject to the production function in equation (8). The first-order conditions imply the standard factor demand functions:

$$k^T_{dst}(i) = \frac{\alpha^T_s \lambda_{dst}(i) y_{dst}(i)}{[1+\mathbb{1}_{\{T \text{ is taxed in } t\}}\tau^K_d(i)] r^T_{dt}} \quad \text{and} \quad l_{dst}(i) = \frac{(1-\alpha_s)\lambda_{dst}(i) y_{dst}(i)}{w_{dt}}$$

where $\lambda_{dst}(i)$ is the firm's marginal cost, which is given by:

$$\lambda_{dst}(i) = \frac{(1+\tau^K_d(i))^{\hat{\alpha}_{st}} \mathcal{C}_{dst}}{Z_{ds}}$$

where we have the following two definitions:

$$\mathcal{C}_{dst} \equiv \left(\frac{r^E_{dt}}{\alpha^E_s}\right)^{\alpha^E_s} \left(\frac{r^R_{dt}}{\alpha^R_s}\right)^{\alpha^R_s} \left(\frac{w_{dt}}{1-\alpha_s}\right)^{1-\alpha_s} \quad \text{and} \quad \hat{\alpha}_{st} \equiv \sum_{T\in\{E,R\}} \mathbb{1}_{\{T \text{ is taxed in } t\}} \alpha^T_s.$$

Since firms are perfectly competitive, profits are zero and thus the price is given by:

$$p_{dst}(i) = \frac{(1+\tau^K_d(i))^{\hat{\alpha}_{st}} \mathcal{C}_{dst}}{(1-\tau^v_t) Z_{ds}}.$$

Similarly, housing firm j in location d sets its price equal to its marginal cost:

$$p^H_{dt}(j) = [1+\mathbb{1}_{\{R \text{ is taxed in } t\}}\tau^K_d(j)]^\gamma \cdot \left(\frac{r^R_{dt}}{\gamma}\right)^\gamma \left(\frac{r^L_{dt}}{1-\gamma}\right)^{1-\gamma}.$$

The final sector's problem. The final sector minimizes expenditures taking prices as given. Therefore, the final sector's problem in location d at time t is given by:

$$\min_{\{\{\{Y_{odst}(i)_{i=0}^{1}\}\}_{s=1}^{S}\}_{o=1}^{D}} \left\{ \sum_{o=1}^{D} \sum_{s=1}^{S} \int_0^1 \Delta_{od}^{I} p_{ost}(i) Y_{odst}(i) \mathrm{d}i \right\}$$

subject to the aggregators in equations (10) and (11). The first-order conditions imply the standard demand functions:

$$Y_{odst}(i) = \left[\frac{P_{dst}^{Y}}{\Delta_{od}^{I} p_{ost}(i)} \right]^{\theta} \cdot \frac{\beta_s P_{dt}^{Y} Y_{dt}}{P_{dst}^{Y}}$$

where the price indices for final goods are given by:

$$\ln(P_{dt}^{Y}) = \sum_{s=1}^{S} \beta_s \ln \left(\frac{P_{dst}^{Y}}{\beta_s} \right) \quad \text{where} \quad P_{dst}^{Y} = \left(\sum_{o=1}^{D} \int_0^1 (\Delta_{od}^{I} p_{ost}(i))^{1-\theta} \mathrm{d}i \right)^{\frac{1}{1-\theta}}.$$

The worker's problem. Part of the worker's "static" problem is to choose its relative consumption of final goods and housing services to maximize flow utility given prices:

$$\max_{C_{dt}^{W}, H_{dt}^{W}} \left\{ \eta \ln(C_{dt}^{W}) + (1-\eta) \ln(H_{dt}^{W}) \right\}$$

subject to the worker's budget constraint:

$$P_{dt}^{Y} C_{dt}^{W} + P_{dt}^{H} H_{dt}^{W} = w_{dt}.$$

The first-order conditions imply the standard demand functions:

$$C_{dt}^{W} = \frac{\eta w_{dt}}{P_{dt}^{Y}} \quad \text{and} \quad H_{dt}^{W} = \frac{(1-\eta) w_{dt}}{P_{dt}^{H}}.$$

Workers must also choose their consumption of different housing varieties to minimize expenditures taking prices as given:

$$\min_{\{H_{dt}^{W}(j)\}_{j \in [0,1]}} \left\{ \int_0^1 p_{dt}^{H}(j) H_{dt}^{W}(j) \mathrm{d}j \right\}$$

subject to the aggregator in equation (4). The first-order conditions imply the standard demand functions:

$$H_{dt}^W(j) = \frac{P_{dt}^H H_{dt}^W}{p_{dt}^H(j)}$$

where the local housing price index is given by:

$$\ln(P_{dt}^H) = \int_0^1 \ln(p_{dt}^H(j))\mathrm{d}j.$$

Hence, the overall cost of living index in location d is given by:

$$\ln(P_{dt}) \equiv \eta \ln\left(\frac{P_{dt}^Y}{\eta}\right) + (1-\eta)\ln\left(\frac{P_{dt}^H}{1-\eta}\right).$$

Then, the worker's "dynamic" problem is to choose where to migrate if such an opportunity arrives given prices, migration costs, and preference shocks. This problem satisfies the following HJB equation in origin location o:

$$(\rho+\epsilon)V_{ot}^W = \ln(w_{ot}/P_{ot}) + \ln(A_o) + (\epsilon/\nu)\ln\left[\sum_{d=1}^{D} e^{\nu(V_{dt}^W - \Delta_{od}^M)}\right] + \dot{V}_{ot}^W$$

and among those who migrate from origin o, the share going to destination d is:

$$M_{odt} = \frac{e^{\nu(V_{dt}^W - \Delta_{od}^M)}}{\sum_{d'=1}^{D} e^{\nu(V_{d't}^W - \Delta_{od'}^M)}}.$$

Therefore, the working population of location d evolves according to:

$$\dot{L}_{dt} = \epsilon\left(\sum_{o=1}^{D} M_{odt}L_{ot} - L_{dt}\right).$$

The capitalist's problem. The capitalist's problem is to choose time paths for consumption and investment to maximize lifetime utility given prices:

$$\max_{\{C_{dt}^K, H_{dt}^K, I_{dt}^E, I_{dt}^R\}_{t\geq 0}} \int_0^\infty e^{-\rho t}[\eta\ln(C_{dt}^K) + (1-\eta)\ln(H_{dt}^K)]\mathrm{d}t$$

subject to the following budget constraint:

$$r_{dt}^E K_{dt}^E + r_{dt}^R K_{dt}^R + r_{dt}^L \mathcal{L}_d \geq P_{dt}^Y(C_{dt}^K + I_{dt}^E + I_{dt}^R + X_{dt}^E + X_{dt}^R) + P_{dt}^H H_{dt}^K$$

and capital accumulation equations:

$$\dot{K}_{dt}^{T} = I_{dt}^{T} - \delta_T K_{dt}^{T}$$

where the price indices are the same as those defined above. The current-value Hamiltonian for this problem is given by:

$$\begin{aligned}\mathcal{H}_{dt} &= \eta \ln(C_{dt}^{K}) + (1-\eta)\ln(H_{dt}^{K}) \\ &\quad + \lambda_{dt}^{B}[r_{dt}^{E}K_{dt}^{E} + r_{dt}^{R}K_{dt}^{R} + r_{dt}^{L}\mathcal{L}_d - P_{dt}^{Y}(C_{dt}^{K} + I_{dt}^{E} + I_{dt}^{R} + X_{dt}^{E} + X_{dt}^{R}) - P_{dt}^{H}H_{dt}^{K}] \\ &\quad + \sum\nolimits_{T\in\{E,R\}} \lambda_{dt}^{T}(I_{dt}^{T} - \delta_T K_{dt}^{T}).\end{aligned}$$

The first-order conditions are given by:

$$\begin{aligned}\frac{\partial \mathcal{H}_{dt}}{\partial C_{dt}^{K}} &= \eta / C_{dt}^{K} - \lambda_{dt}^{B} P_{dt}^{Y} = 0, \\ \frac{\partial \mathcal{H}_{dt}}{\partial H_{dt}^{K}} &= (1-\eta)/H_{dt}^{K} - \lambda_{dt}^{B} P_{dt}^{H} = 0, \\ \frac{\partial \mathcal{H}_{dt}}{\partial I_{dt}^{T}} &= -\lambda_{dt}^{B} P_{dt}^{Y}[1 + \xi_T(I_{dt}^{T}/K_{dt}^{T} - \delta_T)] + \lambda_{dt}^{T} = 0, \\ \frac{\partial \mathcal{H}_{dt}}{\partial K_{dt}^{T}} &= \lambda_{dt}^{B}\{r_{dt}^{T} + \xi_T P_{dt}^{Y}[(I_{dt}^{T}/K_{dt}^{T})^2 - \delta_T^2]/2\} - \lambda_{dt}^{T}\delta_T = \rho\lambda_{dt}^{T} - \dot{\lambda}_{dt}^{T}, \\ \frac{\partial \mathcal{H}_{dt}}{\partial \lambda_{dt}^{B}} &= r_{dt}^{E}K_{dt}^{E} + r_{dt}^{R}K_{dt}^{R} + r_{dt}^{L}\mathcal{L}_d - P_{dt}^{Y}(C_{dt}^{K} + I_{dt}^{E} + I_{dt}^{R} + X_{dt}^{E} + X_{dt}^{R}) - P_{dt}^{H}H_{dt}^{K} = 0, \\ \frac{\partial \mathcal{H}_{dt}}{\partial \lambda_{dt}^{T}} &= I_{dt}^{T} - \delta_T K_{dt}^{T} = \dot{K}_{dt}^{T},\end{aligned}$$

and the transversality conditions:

$$\lim_{t\to\infty} e^{-\rho t}\lambda_{dt}^{T}K_{dt}^{T} = 0, \quad \forall T \in \{E, R\}.$$

First, the consumption first-order conditions imply:

$$P_{dt}^{H}H_{dt}^{K} = (1/\eta - 1)P_{dt}^{Y}C_{dt}^{K}.$$

Then, let us define Tobin's q for type-T capital as:

$$q_{dt}^{T} \equiv \frac{\lambda_{dt}^{T}}{\lambda_{dt}^{B}P_{dt}^{Y}} = \frac{\lambda_{dt}^{T}C_{dt}^{K}}{\eta}.$$

Substituting this definition in the investment first-order conditions, we obtain:

$$q_{dt}^T = 1 + \xi_T \left(\frac{I_{dt}^T}{K_{dt}^T} - \delta_T \right).$$

Solving for investment rates, we have:

$$\frac{I_{dt}^T}{K_{dt}^T} = \delta_T + \frac{q_{dt}^T - 1}{\xi_T}.$$

The growth rate of Tobin's q is given by:

$$\frac{\dot{q}_{dt}^T}{q_{dt}^T} = \frac{\dot{\lambda}_{dt}^T}{\lambda_{dt}^T} + \frac{\dot{C}_{dt}^K}{C_{dt}^K}.$$

Using the capital first-order conditions, we can rewrite:

$$\dot{q}_{dt}^T = \left(\rho + \delta_T + \frac{\dot{C}_{dt}^K}{C_{dt}^K} \right) q_{dt}^T - \left\{ \frac{r_{dt}^T}{P_{dt}^Y} + \frac{\xi_T}{2} \cdot \left[\left(\frac{I_{dt}^T}{K_{dt}^T} \right)^2 - \delta_T^2 \right] \right\}.$$

Finally, the budget constraint must hold with equality:

$$P_{dt}^Y (C_{dt}^K / \eta + I_{dt}^E + I_{dt}^R + X_{dt}^E + X_{dt}^R) = r_{dt}^E K_{dt}^E + r_{dt}^R K_{dt}^R + r_{dt}^L \mathcal{L}_d$$

and the laws of motion for capital are:

$$\dot{K}_{dt}^T = I_{dt}^T - \delta_T K_{dt}^T.$$

The local government's problem. The government's budget constraint requires that:

$$\begin{aligned} P_{dt}^Y G_{dt} = \tau_t^v & \sum_{s=1}^S \int_0^1 p_{dst}(i) y_{dst}(i) \mathrm{d}i \\ & + \sum_{T \in \{E,R\}} \sum_{s=1}^S \int_0^1 \mathbb{1}_{\{T \text{ is taxed in } t\}} \tau_d^K(i) r_{dt}^T k_{dst}^T(i) \mathrm{d}i \\ & + \int_0^1 \mathbb{1}_{\{R \text{ is taxed in } t\}} \tau_d^K(j) r_{dt}^R k_{dt}^{R,H}(j) \mathrm{d}j. \end{aligned}$$

Market clearing. The labor demand of firm i in sector s of location o is:

$$l_{ost}(i) = \frac{(1-\alpha_s)(1+\tau_o^K(i))^{\hat{\alpha}_{st}} y_{ost}(i) \mathcal{C}_{ost}}{w_{ot} Z_{os}}.$$

Substituting the firm's competitive price into this expression, we can rewrite:

$$w_{ot} l_{ost}(i) = (1-\alpha_s)(1-\tau_t^v) p_{ost}(i) y_{ost}(i).$$

Integrating over all firms in sector s within location o, we obtain the local labor market clearing condition:

$$w_{ot} L_{ost} = (1-\tau_t^v)(1-\alpha_s) \int_0^1 p_{ost}(i) y_{ost}(i) \mathrm{d}i.$$

The type-T capital demand of production firm i in sector s of location o is:

$$k_{ost}^T(i) = \frac{\alpha_s^T (1-\tau_t^v) p_{ost}(i) y_{ost}(i)}{(1+\mathbb{1}_{\{T \text{ is taxed in } t\}} \tau_o^K(i)) r_{ot}^T}$$

where the demand faced by that firm is given by:

$$y_{ost}(i) = \frac{\mathcal{Y}_{ost}}{p_{ost}(i)^\theta}$$

and where we defined:

$$\mathcal{Y}_{ost} = \sum_{d=1}^{D} (P_{dst}^Y / \Delta_{od}^I)^{\theta-1} \beta_s [\eta w_{dt} L_{dt} + r_{dt}^E K_{dt}^E + r_{dt}^R K_{dt}^R + r_{dt}^L \mathcal{L}_d - (1/\eta - 1) P_{dt}^Y C_{dt}^K + T_{dt}].$$

Here, T_{dt} is the total tax revenue collected by location d at time t, and to arrive to that expression, we have used the workers', capitalists', and governments' budget constraints. Substituting this expression into the firms' capital demand, we obtain:

$$k_{ost}^T(i) = \frac{\alpha_s^T (1-\tau_t^v) p_{ost}(i)^{1-\theta} \mathcal{Y}_{ost}}{(1+\mathbb{1}_{\{T \text{ is taxed in } t\}} \tau_o^K(i)) r_{ot}^T}.$$

Integrating the demand for type-T capital from all production firms in sector s within location o, we obtain the aggregate local type-T capital demand:

$$r_{ot}^T K_{ost}^{T,Y} = (1-\tau_t^v) \alpha_s^T \mathcal{Y}_{ost} \int_0^1 \frac{p_{ost}(i)^{1-\theta}}{1+\mathbb{1}_{\{T \text{ is taxed in } t\}} \tau_o^K(i)} \mathrm{d}i.$$

Substituting in the expression for production firms' competitive price, we can rewrite:

$$(1+\overline{\tau}^{K,T}_{ost})r^T_{ot}K^{T,Y}_{ost} = (1-\tau^v_t)\alpha^T_s \int_0^1 p_{ost}(i)y_{ost}(i)\mathrm{d}i$$

where $\overline{\tau}^{K,T}_{ost}$ is defined according to:

$$1+\overline{\tau}^{K,T}_{ost} \equiv \exp\{\mathbb{1}_{\{T=\text{taxed in } t\}}[\mu_o + (2\hat{\alpha}_{st}(1-\theta)-1)\sigma^2_o/2]\}.$$

Substituting the location-sector-specific labor demands in this equation, we obtain:

$$(1+\overline{\tau}^{K,T}_{ost})r^T_{ot}K^{T,Y}_{ost} = \frac{\alpha^T_s}{1-\alpha_s}\cdot w_{ot}L_{ost}.$$

Analogously, the real estate capital demand of housing firm j in location o is:

$$k^{R,H}_{ot}(j) = \frac{\gamma[(1-\eta)w_{ot}L_{ot} + (1/\eta-1)P^Y_{ot}C^K_{ot}]}{[1+\mathbb{1}_{\{R \text{ is taxed in } t\}}\tau^K_o(j)]r^R_{ot}}.$$

Integrating the demand for real estate capital from all housing firms in location o, we obtain the aggregate local real estate capital demand:

$$(1+\overline{\tau}^{K,H}_{ot})r^R_{ot}K^{R,H}_{ot} = \gamma[(1-\eta)w_{ot}L_{ot} + (1/\eta-1)P^Y_{ot}C^K_{ot}]$$

where $\overline{\tau}^{K,H}_{ot}$ is defined according to:

$$1+\overline{\tau}^{K,H}_{ot} \equiv \exp[\mathbb{1}_{\{R \text{ is taxed in } t\}}(\mu_o - \sigma^2_o/2)]$$

Similarly, the land demand of housing firm j in location o is:

$$\ell_{ot}(j) = (1-\gamma)[(1-\eta)w_{ot}L_{ot} + (1/\eta-1)P^Y_{ot}C^K_{ot}]/r^L_{ot}.$$

Integrating the demand for land from all housing firms in location o, we obtain the aggregate local land demand:

$$r^L_{ot}\mathcal{L}_o = (1-\gamma)[(1-\eta)w_{ot}L_{ot} + (1/\eta-1)P^Y_{ot}C^K_{ot}].$$

As stated above, the demand for the product of production firm i in sector s of location o is given by:

$$y_{ost}(i) = \frac{\mathcal{Y}_{ost}}{p_{ost}(i)^\theta}.$$

Multiplying both sides by the production firm's competitive price and integrating over all such firms within location o operating in sector s, we obtain:

$$\frac{w_{ot}L_{ost}}{(1-\alpha_s)(1-\tau_t^v)} = \sum_{d=1}^{D} \mathcal{S}_{odst}\beta_s[\eta w_{dt}L_{dt} + r_{dt}^E K_{dt}^E + r_{dt}^R K_{dt}^R + r_{dt}^L \mathcal{L}_d - (1/\eta - 1)P_{dt}^Y C_{dt}^K + T_{dt}]$$

where $\mathcal{S}_{odst}$ is the share of location d's expenditures on sector s that is sourced from location o, which is given by:

$$\mathcal{S}_{odst} \equiv \frac{\int_0^1 (\Delta_{od}^I \cdot p_{ost}(i))^{1-\theta} \mathrm{d}i}{\sum_{o'=1}^{D} \int_0^1 (\Delta_{o'd}^I \cdot p_{o'st}(i))^{1-\theta} \mathrm{d}i}.$$

Substituting in the expression for the firm's competitive price, we can rewrite:

$$\mathcal{S}_{odst} \equiv \frac{[\Delta_{od}^I(1+\hat{\tau}_{ost}^K)\mathcal{C}_{ost}/Z_{os}]^{1-\theta}}{\sum_{o'=1}^{D}[\Delta_{o'd}^I(1+\hat{\tau}_{o'st}^K)\mathcal{C}_{o'st}/Z_{o's}]^{1-\theta}}$$

where we defined:

$$1+\hat{\tau}_{ost}^K \equiv \exp[\hat{\alpha}_{st}\mu_o + (\hat{\alpha}_{st}\sigma_o)^2(1-\theta)/2].$$

Total capital tax revenue in location d is given by:

$$
\begin{aligned}
T^K_{dt} = & \sum_{T\in\{E,R\}} \sum_{s=1}^{S} \int_0^1 [1+\mathbb{1}_{\{T \text{ is taxed in } t\}} \tau^K_d(i)] r^T_{dt} k^T_{dst}(i)\mathrm{d}i \\
& + \int_0^1 [1+\mathbb{1}_{\{R \text{ is taxed in } t\}} \tau^K_d(j)] r^R_{dt} k^{R,H}_{dt}(j)\mathrm{d}j \\
& - \sum_{T\in\{E,R\}} \sum_{s=1}^{S} \int_0^1 r^T_{dt} k^T_{dst}(i)\mathrm{d}i - \int_0^1 r^R_{dt} k^{R,H}_{dt}(j)\mathrm{d}j \\
& = \sum_{T\in\{E,R\}} \sum_{s=1}^{S} \alpha^T_s (1-\tau^v_t) \int_0^1 p_{dst}(i) y_{dst}(i)\mathrm{d}i - \sum_{T\in\{E,R\}} \sum_{s=1}^{S} r^T_{dt} K^{T,Y}_{dst} \\
& + \gamma[(1-\eta) w_{dt} L_{dt} + (1/\eta - 1) P^Y_{dt} C^K_{dt}] - r^R_{dt} K^{R,H}_{dt} \\
& = \sum_{T\in\{E,R\}} \sum_{s=1}^{S} \frac{\alpha^T_s w_{dt} L_{dst}}{1-\alpha_s} - \sum_{T\in\{E,R\}} \sum_{s=1}^{S} r^T_{dt} K^{T,Y}_{dst} + \overline{\tau}^{K,H}_{dt} r^R_{dt} K^{R,H}_{dt} \\
& = \sum_{T\in\{E,R\}} \sum_{s=1}^{S} (1+\overline{\tau}^{K,T}_{dst}) r^T_{dt} K^{T,Y}_{dst} - \sum_{T\in\{E,R\}} \sum_{s=1}^{S} r^T_{dt} K^{T,Y}_{dst} + \overline{\tau}^{K,H}_{dt} r^R_{dt} K^{R,H}_{dt} \\
& = \sum_{T\in\{E,R\}} \sum_{s=1}^{S} \overline{\tau}^{K,T}_{dst} r^T_{dt} K^{T,Y}_{dst} + \overline{\tau}^{K,H}_{dt} r^R_{dt} K^{R,H}_{dt}
\end{aligned}
$$

and value-added tax revenue is given by:

$$
T^v_{dt} = \tau^v_t \sum_{s=1}^{S} \int_0^1 p_{dst}(i) y_{dst}(i)\mathrm{d}i = \sum_{s=1}^{S} \frac{\tau^v_t w_{dt} L_{dst}}{(1-\alpha_s)(1-\tau^v_t)}.
$$

Therefore, total tax revenue can be written as:

$$
T_{dt} = T^K_{dt} + T^v_{dt}.
$$

Substituting this expression into the local goods market clearing condition, we obtain:

$$
\frac{w_{ot} L_{ost}}{1-\alpha_s} = \sum_{d=1}^{D} \mathcal{S}_{odst} \beta_s \sum_{s'=1}^{S} \frac{w_{dt} L_{ds't}}{1-\alpha_{s'}}.
$$

Finally, we close the model by imposing the numéraire condition:

$$
\sum_{d=1}^{D} w_{dt} L_{dt} = 1.
$$

Stationary equilibrium. In a stationary equilibrium, the distribution of workers across space is stationary and so is their value function, which implies:

$$L_d = \sum_{o=1}^{D} M_{od} L_o \quad \text{where} \quad M_{od} = \frac{\exp[\nu(V_d^W - \Delta_{od}^M)]}{\sum_{d'=1}^{D} \exp[\nu(V_{d'}^W - \Delta_{od'}^M)]} \tag{B.1}$$

and where the value function of a worker living in location o is given by:

$$(\rho + \epsilon) V_o^W = \ln(w_o) - \ln(P_o) + \ln(A_o) + (\epsilon/\nu) \ln \left[\sum_{d=1}^{D} e^{\nu(V_d^W - \Delta_{od}^M)} \right]. \tag{B.2}$$

Investment in both types of capital simply replaces depreciated capital, which implies:

$$I_d^T = \delta_T K_d^T \quad \text{and} \quad q_d^T = 1.$$

In turn, the arbitrage condition for capital implies:

$$r_d^T = (\rho + \delta_T) P_d^Y.$$

Substituting these expressions into the capitalist's budget constraint, we obtain:

$$C_d^K = \frac{\eta\rho(K_d^E + K_d^R) + \eta(1-\eta)(1-\gamma)(w_d/P_d^Y)L_d}{1 - (1-\gamma)(1-\eta)}.$$

Therefore, the local production capital market clearing conditions imply:

$$(1 + \overline{\tau}_{ds}^{K,T})(\rho + \delta_T) P_d^Y K_{ds}^{T,Y} = \frac{\alpha_s^T}{1 - \alpha_s} \cdot w_d L_{ds}$$

and the local real estate capital market clearing conditions imply:

$$(1 + \overline{\tau}_d^{K,H})(\rho + \delta_R) P_d^Y K_d^{R,H} = \gamma[(1-\eta) w_d L_d + (1/\eta - 1) P_d^Y C_d^K].$$

Then, the overall capital market clearing conditions:

$$K_d^E = \sum_{s=1}^{S} K_{ds}^{E,Y} \quad \text{and} \quad K_d^R = K_d^{R,H} + \sum_{s=1}^{S} K_{ds}^{R,Y}.$$

The different local ideal price indices are given by:

$$\ln(P_d) = \eta \ln\left(\frac{P_d^Y}{\eta}\right) + (1-\eta)\ln\left(\frac{P_d^H}{1-\eta}\right)$$

$$\ln(P_d^Y) = \sum_{s=1}^{S} \beta_s \ln\left(\frac{P_{ds}^Y}{\beta_s}\right)$$

$$P_{ds}^Y = \left\{\sum_{o=1}^{D}\left[\frac{\Delta_{od}^I(1+\hat{\tau}_{os}^K)\mathcal{C}_{os}}{(1-\tau^v)Z_{os}}\right]^{1-\theta}\right\}^{\frac{1}{1-\theta}}$$

$$P_d^H = (1+\hat{\tau}_d^{K,H})^{\gamma}\cdot\left(\frac{r_d^R}{\gamma}\right)^{\gamma}\left(\frac{r_d^L}{1-\gamma}\right)^{1-\gamma}$$

where we defined:

$$1+\hat{\tau}_d^{K,H} \equiv \exp(\mathbb{1}_{\{R\text{ is taxed}\}}\mu_d).$$

Substituting the expression for $\mathcal{C}_{ds}$ and the capital market clearing conditions in P_{ds}^Y, we can rewrite:

$$P_{ds}^Y = \left\{\sum_{o=1}^{D}\left[\frac{\Delta_{od}^I w_o(1+\tilde{\tau}_{os}^K)L_{os}^{\alpha_s}}{(1-\alpha_s)(1-\tau^v)Z_{os}K_{os}^{E,Y^{\alpha_s^E}}K_{os}^{R,Y^{\alpha_s^R}}}\right]^{1-\theta}\right\}^{\frac{1}{1-\theta}} \tag{B.3}$$

where we defined:

$$1+\tilde{\tau}_{os}^K \equiv \frac{1+\hat{\tau}_{os}^K}{(1+\overline{\tau}_{os}^{K,E})^{\alpha_s^E}(1+\overline{\tau}_{os}^{K,R})^{\alpha_s^R}} = \exp\{[1+\hat{\alpha}_s(\theta-1)]\hat{\alpha}_s\sigma_o^2/2\}.$$

Similarly, substituting the housing capital and land market clearing conditions in P_d^H, we can rewrite:

$$P_d^H = \frac{(1+\tilde{\tau}_d^{K,H})^{\gamma}(1-\eta)(w_dL_d + P_d^Y C_d^K/\eta)}{K_d^{R,H^{\gamma}}\mathcal{L}_d^{1-\gamma}} \tag{B.4}$$

where we defined:

$$1+\tilde{\tau}_d^{K,H} \equiv \exp(\sigma_d^2/2).$$

Finally, we have the local goods market clearing conditions:

$$\frac{w_oL_{os}}{1-\alpha_s} = \sum_{d=1}^{D}\mathcal{S}_{ods}\beta_s\sum_{s'=1}^{S}\frac{w_dL_{ds'}}{1-\alpha_{s'}} \tag{B.5}$$

with the constant expenditure shares given by:

$$\mathcal{S}_{ods} \equiv \frac{[\Delta^I_{od}(1+\hat{\tau}^K_{os})\mathcal{C}_{os}/Z_{os}]^{1-\theta}}{\sum_{o'=1}^{D}[\Delta^I_{o'd}(1+\hat{\tau}^K_{o's})\mathcal{C}_{o's}/Z_{o's}]^{1-\theta}}.$$

Substituting in the expression for $\mathcal{C}_{os}$ and the capital market clearing conditions, we can rewrite:

$$\mathcal{S}_{ods} \equiv \frac{\left[\frac{\Delta^I_{od} w_o (1+\hat{\tau}^K_{os}) L^{\alpha_s}_{os}}{Z_{os} K^{E,Y\alpha^E_s}_{os} K^{R,Y\alpha^R_s}_{os}}\right]^{1-\theta}}{\sum_{o'=1}^{D}\left[\frac{\Delta^I_{o'd} w_{o'} (1+\hat{\tau}^K_{o's}) L^{\alpha_s}_{o's}}{Z_{o's} K^{E,Y\alpha^E_s}_{o's} K^{R,Y\alpha^R_s}_{o's}}\right]^{1-\theta}}. \tag{B.6}$$

B.2 Calibration

Model inversion. The location-sector-specific productivity levels Z_{ds}, location-specific amenities A_d and land endowments $\mathcal{L}_d$, and bilateral trade and migration costs Δ^I_{od} and Δ^M_{od} are inferred using the model and the spatial data. In particular, since trade costs are symmetric, equation (B.6) can be rearranged as follows:

$$\frac{\mathcal{S}_{od}(s)\mathcal{S}_{do}(s)}{\mathcal{S}_{dd}(s)\mathcal{S}_{oo}(s)} = \left(\frac{1}{\Delta^I_{od}}\right)^{2(\theta-1)}.$$

Hence, with information on bilateral trade flows—taken from the *SITRAM* database of inter-departmental road-freight shipments maintained by the French Ministry of Transport, following Combes et al. (2005)—we can recover the bilateral trade costs Δ^I_{od} assuming symmetry across sectors. Similarly, leveraging the symmetry of migration costs, we can rearrange the migration shares in equation (B.1) to obtain:

$$\frac{M_{od}M_{do}}{M_{dd}M_{oo}} = e^{-2\nu\Delta^M_{od}}.$$

Therefore, one can use data on migration flows across locations to recover the bilateral migration costs Δ^M_{od}. Conditional on these bilateral frictions, the remaining fundamentals are chosen jointly so that the model's initial steady state matches the observed cross-section of wages, employment, relative housing prices, and capital-income moments as closely as possible under the full equilibrium restrictions of the model.

Calibrating the capital depreciation parameters. To calibrate the depreciation rates δ_T, we combine French macroeconomic data on investment and capital stocks from

EU-KLEMS with the capital accumulation equation:

$$\delta_T = \frac{I_{dt}^T - \dot{K}_{dt}^T}{K_{dt}^T}.$$

We use annual data from 1995 to 2006 for the entire French market economy (excluding the agricultural and financial sectors). Computing, communications, and transport equipment, along with "other machinery and equipment," are grouped into our measure of equipment capital, while non-residential buildings and structures constitute our measure of real estate capital. For each year, we compute a depreciation rate for each capital type, and then aggregate across types using capital-stock weights. Averaging these annual rates over the sample period yields our calibrated depreciation parameters: $\delta_E = 0.151$ and $\delta_R = 0.059$.

Calibrating the expenditure weight on goods. The Cobb-Douglas preference parameter η governs the share of household expenditure allocated to final goods, so we calibrate $1-\eta$ directly to the housing-services share of household final consumption expenditure rather than to a GDP share. Using the INSEE annual national accounts, we measure housing services with the "real estate services" consumption category and divide it by household final consumption expenditure, averaging both series over 2000–2008. This yields $1-\eta = 0.187$ and therefore $\eta = 0.813$.

Calibrating the capital-share parameters. We then calibrate the capital-share parameters to match the observed income shares of equipment and real estate capital across four broadly defined non-agricultural and non-financial sectors of the French market economy. To do so, we aggregate NACE Rev. 2 industries into four sectoral groups. The first group combines manufacturing, mining, and utilities (sections B–C–D–E). The second group corresponds to construction (F). The third group comprises market services, including wholesale and retail trade, transportation and storage, and accommodation and food service activities (G–H–I). The fourth group consists of business services, namely information and communication, professional, scientific and technical activities, and administrative and support service activities (J, M, and N).

In the stationary equilibrium of our model, factor payments satisfy:

$$\frac{\alpha_s^T w_d L_{ds}}{1-\alpha_s} = (1+\overline{\tau}_{ds}^{K,T})(\rho + \delta_T) P_d^Y K_{ds}^{T,Y}.$$

Defining the nominal value of the capital stock as $\mathcal{K}_{ds}^{T,Y} \equiv P_d^Y K_{ds}^{T,Y}$ and summing over all locations, we obtain:

$$\frac{\alpha_s^T}{1-\alpha_s} = \frac{(1+\overline{\tau}_s^{K,T})(\rho+\delta_T)\mathcal{K}_s^{T,Y}}{\sum_{d=1}^D w_d L_{ds}} \quad \text{where} \quad 1+\overline{\tau}_s^{K,T} \equiv \sum_{d=1}^D \frac{(1+\overline{\tau}_{ds}^{K,T})\mathcal{K}_{ds}^{T,Y}}{\mathcal{K}_s^{T,Y}}$$

and where $\mathcal{K}_s^{T,Y} \equiv \sum_{d=1}^D \mathcal{K}_{ds}^{T,Y}$ is the total nominal capital stock of type T in sector s. Taking the ratio of this equation for equipment and real estate capital, we obtain:

$$\frac{\alpha_s^E}{\alpha_s^R} = \frac{(1+\overline{\tau}_s^{K,E})(\rho+\delta_E)\mathcal{K}_s^{E,Y}}{(1+\overline{\tau}_s^{K,R})(\rho+\delta_R)\mathcal{K}_s^{R,Y}} \approx \frac{(\rho+\delta_E)\mathcal{K}_s^{E,Y}}{(\rho+\delta_R)\mathcal{K}_s^{R,Y}}.$$

This approximation holds for symmetric taxation on both types of capital and small within-location dispersion in tax rates, which were both true before the implementation of the reform. Hence, using data on nominal capital stocks by type together with our calibrated depreciation rates and a time preference rate of $\rho = 0.05$, we recover the relative magnitudes of the capital shares. Combining these with the labor share in each sector yields our final calibration values. The calibrated capital-share parameters are reported in Table 3.

Calibrating the capital adjustment cost parameters. Finally, we calibrate the adjustment cost parameters ξ_E and ξ_R using a two-step approach. First, we estimate ξ_E by indirect inference, matching the time profile of the capital equipment event-study coefficients from Section 4 to the predictions of the linearized transition dynamics of the model. In the model, firms rent capital to maximize static profits each period. The adjustment costs in equation (7) are borne by capitalists (capital suppliers), not firms. This means firm-level capital demand responds instantly to rental rate changes, and the sluggishness in capital adjustment comes entirely from the supply side.

From the theoretical appendix, the equipment capital demand of production firm i in sector s of location d at time t is:

$$k_{dst}^E(i) = \frac{\alpha_s^E(1-\tau_t^v)p_{dst}(i)^{1-\theta}\mathcal{Y}_{dst}}{[1+\mathbb{1}_{\{E \text{ taxed in } t\}}\tau_d^K(i)]r_{dt}^E} \quad \text{where} \quad p_{dst}(i) = \frac{(1+\tau_d^K(i))^{\hat{\alpha}_{st}}\mathcal{C}_{dst}}{(1-\tau_t^v)Z_{ds}}$$

and where $\mathcal{Y}_{dst}$ is a location-sector-specific demand shifter. Taking logarithms yields:

$$\ln(k_{dst}^E(i)) = \mathcal{X}_{dst} + \left[\hat{\alpha}_{st}(1-\theta) - \mathbb{1}_{\{E \text{ taxed in } t\}}\right]\ln(1+\tau_d^K(i))$$

where $\mathcal{X}_{dst}$ collects all location-sector-time terms that are common across firms within location d and sector s at time t. At the final steady state, capital equipment is not taxed:

$$\ln(k_{ds}^{E,\text{final}}(i)) = \mathcal{X}_{ds}^{\text{final}} + \alpha_s^R(1-\theta)\ln(1+\tau_d^K(i)).$$

At any post-reform time t, the tax structure is identical to the final steady state—only location-level prices and quantities differ:

$$\ln(k_{dst}^E(i)) = \mathcal{X}_{dst} + \alpha_s^R(1-\theta)\ln(1+\tau_d^K(i)).$$

Defining the firm-level deviation from the final steady state as:

$$\hat{k}_{dst}^E(i) \equiv \ln(k_{dst}^E(i)) - \ln(k_{ds}^{E,\text{final}}(i))$$

the firm-specific $\tau_d^K(i)$ terms cancel exactly:

$$\hat{k}_{dst}^E(i) = \mathcal{X}_{dst} - \mathcal{X}_{ds}^{\text{final}}.$$

Note that $K_{dst}^{E,Y} = \exp(\mathcal{X}_{dst})\int_0^1(1+\tau_d^K(i))^{\alpha_s^R(1-\theta)}\mathrm{d}i$, where the integral is a time-invariant constant determined by the log-normal distribution (μ_d, σ_d). Therefore, we have that:

$$\hat{K}_{dst}^{E,Y} = \mathcal{X}_{dst} - \mathcal{X}_{ds}^{\text{final}}$$

which in turn implies that the firm-level deviation from the final steady state is equal to the aggregate deviation of the location-sector's capital equipment demand from its final steady state value:

$$\hat{k}_{dst}^E(i) = \hat{K}_{dst}^{E,Y}.$$

All firms in location d deviate from their final steady state values by the same amount in logarithms. The within-location distribution of capital across firms is time-invariant after the reform.

In contrast, at the initial steady state, both capital types are taxed:

$$\ln(k_{ds0}^E(i)) = \mathcal{X}_{ds0} + [(\alpha_s^E + \alpha_s^R)(1-\theta) - 1]\ln(1+\tau_d^K(i)).$$

Taking the deviation from the final steady state:

$$\hat{k}_{ds0}^E(i) = \hat{\mathcal{X}}_{ds0} - [1 + \alpha_s^E(\theta - 1)]\ln(1+\tau_d^K(i))$$

where $\hat{\mathcal{X}}_{ds0} \equiv \mathcal{X}_{ds0} - \mathcal{X}_{ds}^{\text{final}}$ is a location-sector-specific constant. Unlike the post-reform case, the firm-level deviation depends on $\tau_d^K(i)$: firms facing higher initial tax rates are further below their final steady state capital demand.

We match the model to a robustness specification that regresses firm-level capital changes on the firm's average tax rate $\tau_d^K(i)$:

$$\ln(k_{dst}^E(i)) - \ln(k_{ds0}^E(i)) = \sum_{h\neq 0} \mathbb{1}_{\{t=h\}} b_h \, \tau_d^K(i) + \phi_{st} + \phi(i) + \varepsilon_{dst}(i)$$

where ϕ_{st} are sector-by-year fixed effects and $\phi(i)$ are firm fixed effects. The firm fixed effect absorbs the reference year, such that b_h is identified from the cross-sectional regression of $\ln(k_{dst}^E(i)) - \ln(k_{ds0}^E(i))$ on $\tau_d^K(i)$, after removing industry-by-year fixed effects. The OLS coefficient is:

$$b_h = \frac{\mathbb{C}[\ln(k_{dsh}^E(i)) - \ln(k_{ds0}^E(i)),\, \tau_d^K(i)]}{\mathbb{V}[\tau_d^K(i)]}.$$

In the covariance term, since both capital observations are measured relative to the same final steady state, we have:

$$\begin{aligned} \ln(k_{dsh}^E(i)) - \ln(k_{ds0}^E(i)) &= \hat{k}_{dsh}^E(i) - \hat{k}_{ds0}^E(i) \\ &= \hat{K}_{dsh}^{E,Y} - \hat{\mathcal{X}}_{ds0} + [1 + \alpha_s^E(\theta - 1)] \ln(1 + \tau_d^K(i)) \end{aligned}$$

The firm-specific term $[1 + \alpha_s^E(\theta - 1)] \ln(1 + \tau_d^K(i))$ generates within-department covariance through $\tau_d^K(i)$. To compute this covariance, write $x \equiv \ln(1+\tau) \sim \mathcal{N}(\mu_d, \sigma_d^2)$, so that $\tau = e^x - 1$. Then, the covariance is given by:

$$\mathbb{C}_d[\tau, \ln(1+\tau)] = \mathbb{C}_d[e^x - 1, x] = \mathbb{E}_d[xe^x] - \mathbb{E}_d[x] \cdot \mathbb{E}_d[e^x].$$

Differentiating the moment generating function $\mathbb{E}_d[e^{tx}] = e^{t\mu_d + t^2\sigma_d^2/2}$ with respect to t gives $\mathbb{E}_d[xe^{tx}] = (\mu_d + t\sigma_d^2)e^{t\mu_d + t^2\sigma_d^2/2}$. Evaluating at $t = 1$:

$$\mathbb{E}_d[xe^x] = (\mu_d + \sigma_d^2)e^{\mu_d + \sigma_d^2/2}, \quad \mathbb{E}_d[x] = \mu_d, \quad \mathbb{E}_d[e^x] = e^{\mu_d + \sigma_d^2/2},$$

such that $\mathbb{C}_d(\tau, \ln(1+\tau)) = \sigma_d^2 e^{\mu_d + \sigma_d^2/2}$. Within department d, the aggregate deviation $\hat{K}_{dsh}^{E,Y}$ and the location-sector constant $\hat{\mathcal{X}}_{ds0}$ are common to all firms in (d, s), so the only source of within-department covariance with $\tau_d^K(i)$ is the firm-specific term involving the capital tax. The within-department contribution to the covariance numerator of b_h is therefore:

$$\mathbb{C}_d\left[\hat{k}_{dsh}^E(i) - \hat{k}_{ds0}^E(i),\, \tau_d^K(i)\right] = [1 + \alpha_s^E(\theta - 1)]\, \sigma_d^2\, e^{\mu_d + \sigma_d^2/2}.$$

By the law of total covariance, the OLS numerator decomposes into within- and between-department components, each weighted by the observation share of department d in the firm-level regression. We approximate this observation share by L_d, i.e., the number of firm observations per department is proportional to employment. Summing the within-department contributions and dividing by $\mathbb{V}[\tau_d^K(i)]$, the within-sector static coefficient is:

$$b_s^{\text{static}} = \frac{[1 + \alpha_s^E(\theta - 1)] \sum_{d=1}^{D} L_d \, \sigma_d^2 \, e^{\mu_d + \sigma_d^2/2}}{\mathbb{V}[\tau_d^K(i)]}.$$

This is time-invariant: it reflects the instantaneous reallocation of capital across firms within each department when the reform removes equipment taxes, and is independent of the adjustment cost parameters. Since the regressor $\tau_d^K(i)$ is common across sectors, pooling across sectors simply averages the sector-specific coefficients with employment weights β_s:

$$b^{\text{static}} = \frac{\sum_s \beta_s [1 + \alpha_s^E(\theta - 1)] \sum_{d=1}^{D} L_d \, \sigma_d^2 \, e^{\mu_d + \sigma_d^2/2}}{\mathbb{V}[\tau_d^K(i)]}.$$

The aggregate deviation $\hat{K}_{dsh}^{E,Y}$ also generates *between*-department covariance with $\tau_d^K(i)$, because it is a department-level quantity that covaries with the department mean tax rate $\overline{\tau}_d \equiv \mathbb{E}_d[\tau_d^K(i)] = e^{\mu_d + \sigma_d^2/2} - 1$. Specifically, $\hat{K}_{dsh}^{E,Y}$ is constant across firms within (d, s), so its covariance with $\tau_d^K(i)$ operates entirely through the between-department channel:

$$\mathbb{C}[\hat{K}_{dsh}^{E,Y}, \tau_d^K(i)]_{\text{between}} = \sum_{d=1}^{D} L_d \hat{K}_{dsh}^{E,Y} \left(\overline{\tau}_d - \overline{\tau}_{\text{national}}\right)$$

where $\overline{\tau}_{\text{national}} = \sum_d L_d \overline{\tau}_d$ is the employment-weighted national mean. This between-department covariance is nonzero even at $h = 0$: departments that had higher initial tax rates ($\overline{\tau}_d > \overline{\tau}_{\text{national}}$) are further below their final steady state capital demand ($\hat{K}_{ds0}^{E,Y}$ more negative), generating positive covariance between $\hat{K}_{ds0}^{E,Y}$ and $\overline{\tau}_d$. This $h = 0$ component is time-invariant and independent of ξ—it is absorbed into b^{static}.

The ξ-dependent part comes from the *change* in aggregate capital relative to the initial steady state. Define:

$$\Delta\hat{K}_{dsh}^{E,Y} \equiv \hat{K}_{dsh}^{E,Y} - \hat{K}_{ds0}^{E,Y},$$

which satisfies $\Delta\hat{K}_{ds0}^{E,Y} = 0$ by construction. At $h > 0$, departments with higher initial tax rates experience larger capital inflows after the reform ($\Delta\hat{K}_{dsh}^{E,Y} > 0$), and the speed at which this capital accumulates is governed by (ξ_E, ξ_R). Dividing by $\mathbb{V}[\tau_d^K(i)]$ and pooling across sectors with employment weights β_s, the dynamic component of the event-study coefficient is:

$$b_h^{\text{dynamic}} = \frac{\sum_s \beta_s \sum_{d=1}^{D} L_d (\overline{\tau}_d - \overline{\tau}_{\text{national}}) \Delta\hat{K}_{dsh}^{E,Y}}{\mathbb{V}[\tau_d^K(i)]}.$$

Larger adjustment costs slow the accumulation of $\Delta\hat{K}_{dsh}^{E,Y}$ and flatten the time profile of the post-reform coefficients, providing the source of identification for ξ_E.

A direct matching of the model-predicted b_h^{model} to the empirical b_h^{data} is problematic because, in the model, capital is instantaneously reallocated across firms within a department, generating a large static component b^{static} in the impact year. Throughout this appendix, we index event-study coefficients by event time h, with $h = 0$ corresponding to calendar year 2009. We then difference all post-reform coefficients relative to the impact-year coefficient:

$$\Delta b_h \equiv b_h - b_0.$$

In the model, we have:

$$b_h^{\text{model}} = b^{\text{static}} + b_h^{\text{dynamic}} \quad \Longrightarrow \quad \Delta b_h^{\text{model}} = b_h^{\text{dynamic}} - b_0^{\text{dynamic}}.$$

Because capital is predetermined on impact, $b_0^{\text{dynamic}} = 0$ and $\Delta \hat{K}_{ds0}^{E,Y} = 0$ by definition. The expression for b_h^{dynamic} involves sector-level capital changes $\Delta \hat{K}_{dsh}^{E,Y}$, which are not state variables of the linearized transition model. The state variable is the aggregate department-level equipment capital $K_{dh}^E = \sum_{s=1}^S K_{dsh}^{E,Y}$. Therefore, define:

$$\Delta \hat{K}_{dh}^E \equiv \hat{K}_{dh}^E - \hat{K}_{d0}^E = \ln(K_{dh}^E) - \ln(K_{d0}^E).$$

To see why $\Delta \hat{K}_{dsh}^{E,Y} \approx \Delta \hat{K}_{dh}^E$, note that during the transition ($h \geq 0$), equipment is untaxed. From the firm-level Cobb-Douglas first-order conditions, $\alpha_s^E p_{ds}(i) y_{ds}(i) = r_{dh}^E k_{dsh}^E(i)$ and $(1-\alpha_s) p_{ds}(i) y_{ds}(i) = w_{dh} l_{dsh}(i)$, so that $k_{dsh}^E(i) = (\alpha_s^E/(1-\alpha_s)) \cdot w_{dh} l_{dsh}(i)/r_{dh}^E$. This ratio holds for every firm i regardless of its real estate tax $\tau_d^R(i)$: the heterogeneous real estate tax affects each firm's scale, but the equipment-to-labor ratio is uniform because both equipment and labor are untaxed. Summing over firms, $K_{dsh}^{E,Y} = (\alpha_s^E/(1-\alpha_s)) \cdot w_{dh} L_{dsh}/r_{dh}^E$, so that in log-changes from $h = 0$:

$$\Delta \hat{K}_{dsh}^{E,Y} = \underbrace{\Delta \hat{w}_{dh} - \Delta \hat{r}_{dh}^E}_{\text{common across sectors in } d} + \Delta \hat{L}_{dsh}.$$

The department-level wage w_{dh} and equipment rental rate r_{dh}^E are common to all sectors within department d. The only source of cross-sector variation is the sector-level employment change $\Delta \hat{L}_{dsh}$. Equivalently, writing $\varepsilon_{dsh} \equiv \Delta \ln(K_{dsh}^{E,Y}/K_{dh}^E)$ for the change in the within-department sector composition, we have $\Delta \hat{K}_{dsh}^{E,Y} = \Delta \hat{K}_{dh}^E + \varepsilon_{dsh}$, and the approximation $\Delta \hat{K}_{dsh}^{E,Y} \approx \Delta \hat{K}_{dh}^E$ amounts to neglecting ε_{dsh}. Since the linearized transition model solves for aggregate K_{dh}^E as a state variable rather than the sector-level allocation, we adopt this approximation. Comparing initial and final steady states, the approximation error is small: the mean $|\varepsilon_{dsh}|$ is less than 5% of the mean $|\Delta \hat{K}_{dh}^E|$. Under it, $\Delta \hat{K}_{dsh}^{E,Y}$

no longer depends on s, so $\sum_s \beta_s = 1$ factors out:

$$\Delta b_h^{\text{model}} = \frac{\sum_{d=1}^{D} L_d(\overline{\tau}_d - \overline{\tau}_{\text{national}})\Delta \hat{K}_{dh}^E}{\mathbb{V}[\tau_d^K(i)]}.$$

This is the between-department covariance of the mean tax rate $\overline{\tau}_d$ with the aggregate capital change $\Delta \hat{K}_{dh}^E$, scaled by the total variance of $\tau_d^K(i)$. At $h = 0$, $\Delta \hat{K}_{dh}^E = 0$ for all d, so $\Delta b_0^{\text{model}} = 0$—consistent with the differencing by construction. Identification of ξ_E comes entirely from the *time profile* of the post-reform coefficients: larger adjustment costs slow the accumulation of $\Delta \hat{K}_{dh}^E$ and flatten the curvature of Δb_h.

We estimate ξ_E by minimizing:

$$Q(\xi_E) = \sum_{h=2010}^{2015} \frac{[\Delta b_h^{E,\text{model}}(\xi_E) - \Delta b_h^{E,\text{data}}]^2}{\text{SE}(\Delta b_h^{E,\text{data}})^2}$$

where $\Delta b_h^{E,\text{model}}(\xi_E)$ denotes the model-predicted differenced equipment event-study coefficient at ξ_E, with $\xi_R = \xi_E \cdot \delta_E/\delta_R$, which imposes that the steady-state elasticity of Tobin's q with respect to the investment rate is equal across capital types. Indeed, in the Hayashi (1982) adjustment cost model, the price of capital in a stationary equilibrium satisfies:

$$q_{dt}^T = \xi_T \left(\frac{I_{dt}^T}{K_{dt}^T} - \delta_T \right) + 1.$$

The elasticity of Tobin's q with respect to the investment rate is:

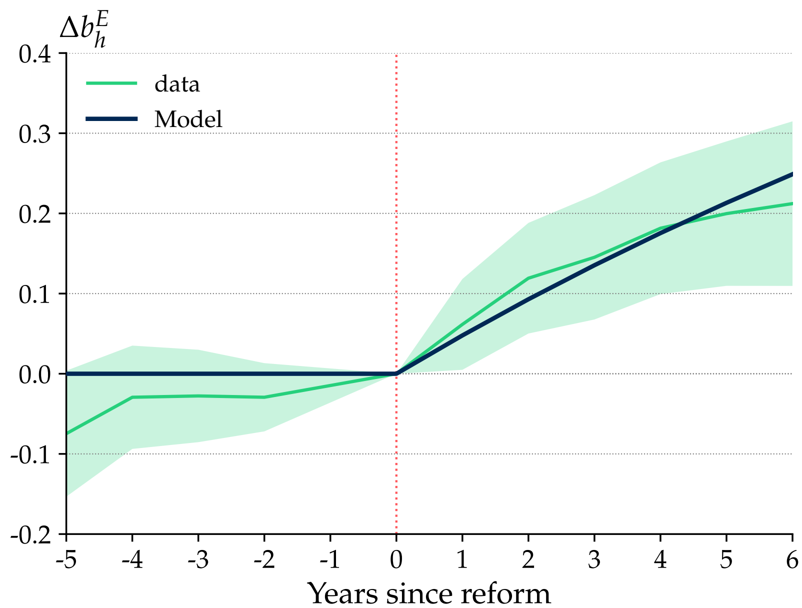
$$\frac{\partial q_{dt}^T}{\partial (I_{dt}^T/K_{dt}^T)} \cdot \frac{I_{dt}^T/K_{dt}^T}{q_{dt}^T} = \frac{\xi_T (I_{dt}^T/K_{dt}^T)}{\xi_T (I_{dt}^T/K_{dt}^T - \delta_T) + 1},$$

which simplifies in a stationary equilibrium (where $I/K = \delta$ and $q = 1$) to $\xi_T \cdot \delta_T$. The equal-elasticity assumption imposes $\xi_E \delta_E = \xi_R \delta_R$, yielding:

$$\xi_R = \xi_E \cdot \frac{\delta_E}{\delta_R}.$$

Figure B.26 plots the differenced event-study coefficients from the data and from the model at the estimated value of ξ_E. The model closely matches the curvature of the post-reform coefficients, which is the key identifying feature for ξ_E. The estimated adjustment cost parameters are reported in Table 3.

Figure B.26: Event-study coefficients: data vs. model



Note: This figure plots the differenced event-study coefficients from the data and from the model at the estimated value of ξ_E.

B.3 Linearized transition dynamics

We linearize the transition dynamics around the final steady state to obtain a tractable characterization of the economy's adjustment path. This section provides a complete, self-contained derivation of the linearized system, defining every matrix and coefficient explicitly.

Notation and system dimensions. For any variable x_d in location d, define the log-deviation from the final steady state as $\hat{x}_d \equiv \ln(x_d / x_{d,ss})$, where $x_{d,ss}$ denotes the final steady-state value. The exception is the worker value function V_d, for which we use the level deviation $\hat{V}_d \equiv V_d - V_{d,ss}$, since V_d is already in utils (log) units.

The system has $2D + D_L = 281$ state variables (backward-looking):

- $\hat{K}_d^E$ for $d = 1, \ldots, D$: equipment capital ($D = 94$ departments),
- $\hat{K}_d^R$ for $d = 1, \ldots, D$: total real estate capital,
- $\hat{L}_d$ for $d = 1, \ldots, D_L$: employment ($D_L = D - 1 = 93$),

and $3D = 282$ costate variables (forward-looking):

- $\hat{q}_d^E$ for $d = 1, \ldots, D$: Tobin's q for equipment,
- $\hat{q}_d^R$ for $d = 1, \ldots, D$: Tobin's q for real estate,
- $\hat{V}_d$ for $d = 1, \ldots, D$: worker value function.

Employment has only $D - 1$ free variables because the aggregate labor constraint $\sum_d L_d = 1$ implies, in log-deviations, that $\sum_d L_{d,ss} \hat{L}_d = 0$. We eliminate $\hat{L}_D$ using:

$$\hat{L}_D = -\sum_{d=1}^{D-1} \frac{L_{d,ss}}{L_{D,ss}} \hat{L}_d.$$

The total system dimension is $N = 2D + D_L + 3D = 563$. Stacking all deviations into the vector $z \in \mathbb{R}^N$, the linearized system takes the form $\dot{z} = Az$.

Capital accumulation. From the law of motion $\dot{K}_{dt}^T = I_{dt}^T - \delta_T K_{dt}^T$ and the optimal investment rule $I_{dt}^T = K_{dt}^T(\delta_T + (q_{dt}^T - 1)/\xi_T)$, substituting yields:

$$\dot{K}_{dt}^T = \frac{K_{dt}^T(q_{dt}^T - 1)}{\xi_T}.$$

Linearizing around the steady state (where $q_{ss}^T = 1$): since $q_{dt}^T - 1 \approx \hat{q}_{dt}^T$ and $K_{dt}^T \approx K_{d,ss}^T(1 + \hat{K}_d^T)$, we have $\dot{K}_{dt}^T \approx K_{d,ss}^T \hat{q}_d^T / \xi_T$ to first order. Since $\dot{\hat{K}}_d^T = \dot{K}_d^T / K_{d,ss}^T$ to first order:

$$\dot{\hat{K}}_d^T = \frac{1}{\xi_T} \hat{q}_d^T, \quad T \in \{E, R\}. \tag{B.7}$$

This is diagonal: each department's capital evolves independently given its Tobin's q.

Employment dynamics. From the law of motion $\dot{L}_d = \varepsilon(\sum_o M_{od} L_o - L_d)$, we linearize both M_{od} and L_o around the steady state, where $\sum_o M_{od}^{ss} L_{o,ss} = L_{d,ss}$. The migration probability depends on value functions through:

$$M_{od} = \frac{\exp\big(\nu(V_d - \Delta_{od}^M)\big)}{\mathcal{V}_o}, \quad \text{where} \quad \mathcal{V}_o \equiv \sum_{d'=1}^{D} \exp\big(\nu(V_{d'} - \Delta_{od'}^M)\big).$$

Taking the first-order expansion of M_{od} in the level deviation $\hat{V}_d = V_d - V_{d,ss}$:

$$\frac{\delta M_{od}}{M_{od}^{ss}} = \nu \hat{V}_d - \frac{\delta \mathcal{V}_o}{\mathcal{V}_{o,ss}} = \nu \hat{V}_d - \nu \sum_{j=1}^{D} M_{oj}^{ss} \hat{V}_j,$$

where the last equality uses $\delta \mathcal{V}_o = \sum_j \exp(\nu(V_{j,ss} - \Delta^M_{oj})) \cdot \nu \hat{V}_j = \nu \mathcal{V}_{o,ss} \sum_j M^{ss}_{oj} \hat{V}_j$. Linearizing the product $M_{od} L_o$ to first order:

$$M_{od} L_o \approx M^{ss}_{od} L_{o,ss} \left(1 + \hat{L}_o + \nu \hat{V}_d - \nu \sum_j M^{ss}_{oj} \hat{V}_j \right).$$

Summing over origins, subtracting L_d, and dividing by $L_{d,ss}$:

$$\dot{\hat{L}}_d = \varepsilon \left[\sum_{o=1}^{D} E_{od} \hat{L}_o - \hat{L}_d + \nu \hat{V}_d - \nu \sum_{j=1}^{D} \mathrm{ETM}_{dj} \hat{V}_j \right], \tag{B.8}$$

where $E_{od} \equiv M^{ss}_{od} L_{o,ss} / L_{d,ss}$ is the inmigration weight (the fraction of d's steady-state population that came from o), and $\mathrm{ETM}_{dj} \equiv \sum_o E_{od} M^{ss}_{oj}$ is the composition matrix capturing how destination d's population weights the migration probabilities toward alternative location j.

The static general equilibrium. At each instant during the transition, the current state-costate tuple $(\hat{K}^E, \hat{K}^R, \hat{L}, \hat{q}^E, \hat{q}^R)$ pins down wages, goods prices, rental rates, and capitalist consumption through a static equilibrium block. The key point is that, once real estate can be reallocated between production and housing, unit costs depend on $\hat{C}^K$. As a result, $(\hat{w}, \hat{P}^Y)$ are no longer state-only objects: they inherit dependence on $(\hat{q}^E, \hat{q}^R)$ through capitalist consumption.

Factor market clearing and unit costs. From the Cobb-Douglas production technology (8), factor demands are proportional to revenue in each sector. Aggregating across the S sectors using the Cobb-Douglas expenditure shares β_s:

$$r^E_d K^E_d = \frac{\bar{\alpha}^E}{1 - \bar{\alpha}} w_d L_d, \qquad r^R_d K^{R,Y}_d = \frac{\bar{\alpha}^R}{1 - \bar{\alpha}} w_d L_d, \tag{B.9}$$

where $K^{R,Y}_d$ denotes production real estate (excluding housing) and we define the β-weighted average capital shares:

$$\bar{\alpha}^E \equiv \sum_{s=1}^{S} \beta_s \alpha^E_s, \qquad \bar{\alpha}^R \equiv \sum_{s=1}^{S} \beta_s \alpha^R_s, \qquad \bar{\alpha} \equiv \bar{\alpha}^E + \bar{\alpha}^R.$$

Taking log-deviations of (B.9):

$$\hat{r}^E_d = \hat{w}_d + \hat{L}_d - \hat{K}^E_d. \tag{B.10}$$

For real estate, the factor demand uses production real estate $K_d^{R,Y}$, not total real estate K_d^R. Since $K_d^R = K_d^{R,Y} + K_d^{R,H}$ and housing capital responds to housing demand, the log-deviation of r_d^R expressed in terms of the state variable $\hat{K}_d^R$ is:

$$\hat{r}_d^R = (1 - f_d)(\hat{w}_d + \hat{L}_d) + f_d(\hat{P}_d^Y + \hat{C}_d^K) - \hat{K}_d^R, \tag{B.11}$$

where $f_d \equiv s_{H,d}(1 - a_{L,d})$, with $s_{H,d} \equiv K_{d,ss}^{R,H} / K_{d,ss}^R$ and $a_{L,d}$ the worker share of housing demand. This correction accounts for the fact that an increase in housing demand (driven by capitalist consumption or goods prices) shifts real estate capital toward housing, raising the production rental rate for a given total K_d^R. In what follows, we use (B.10) for the equipment rental rate and (B.11) for the real estate rental rate.

The β-weighted average unit cost deviation, $\hat{c}_d \equiv \sum_s \beta_s \hat{c}_{ds}$ where $\hat{c}_{ds} = (1 - \alpha_s)\hat{w}_d + \alpha_s^E \hat{r}_d^E + \alpha_s^R \hat{r}_d^R$, becomes after substituting (B.10) and (B.11):

$$\hat{c}_d = \hat{w}_d - \kappa_d + \bar{\alpha}^R f_d \big[(\hat{P}_d^Y + \hat{C}_d^K) - (\hat{w}_d + \hat{L}_d) \big], \quad \text{where} \quad \kappa_d \equiv \bar{\alpha}^E \hat{K}_d^E + \bar{\alpha}^R \hat{K}_d^R - \bar{\alpha} \hat{L}_d. \tag{B.12}$$

The term κ_d captures the standard capital-deepening effect. The last term is a housing-reallocation wedge: stronger housing demand shifts real estate out of production and raises unit costs for a given total $\hat{K}_d^R$.

Trade shares, goods prices, and the wage equation. Define the bilateral trade share S_{od} as the fraction of location d's expenditure sourced from origin o (aggregated across sectors with β_s weights), and the income-weighted trade matrix:

$$W_{di} \equiv S_{di} \cdot \frac{w_{i,ss} L_{i,ss}}{w_{d,ss} L_{d,ss}}.$$

Note that $\sum_i W_{di} = 1$ by goods market clearing at steady state.

Let $B \equiv \operatorname{diag}(\bar{\alpha}^R f)$. Since $\hat{P}^Y = S' \hat{c}$, equation (B.12) implies

$$(I - BS')\hat{c} = (I - B)\hat{w} - \kappa - B\hat{L} + B\hat{C}^K. \tag{B.13}$$

Define $M_c \equiv (I - BS')^{-1}$. Then

$$\hat{P}^Y = P_w \hat{w} - P_\kappa \kappa - P_C \hat{L} + P_C \hat{C}^K, \qquad P_w \equiv S' M_c (I - B), \quad P_\kappa \equiv S' M_c, \quad P_C \equiv S' M_c B. \tag{B.14}$$

We now derive the wage equation from goods market clearing. Revenue in location d is $w_d L_d = \sum_i S_{di} w_i L_i$. Log-linearizing the trade share $S_{di} \propto c_d^{1-\theta}$ gives $\hat{S}_{di} = (1 - \theta)(\hat{c}_d -$

$\hat{P}_i^Y$). Linearizing total revenue and collecting terms yields, in matrix notation:

$$(I - W)(\hat{w} + \hat{L}) = (1 - \theta)(I - WS')\hat{c}.$$

Substituting (B.13) gives the first static equation:

$$J_{11}\hat{w} + J_{12}\hat{C}^K = H_1^E \hat{K}^E + H_1^R \hat{K}^R + H_1^L \hat{L}, \tag{B.15}$$

where

$$\begin{aligned}
J_{11} &\equiv (I - W) + (\theta - 1)(I - WS')M_c(I - B),\\
J_{12} &\equiv (\theta - 1)(I - WS')M_c B,\\
H_1^E &\equiv (\theta - 1)(I - WS')M_c \bar{\alpha}^E I,\\
H_1^R &\equiv (\theta - 1)(I - WS')M_c \bar{\alpha}^R I,\\
H_1^L &\equiv (\theta - 1)(I - WS')M_c(B - \bar{\alpha}I) - (I - W).
\end{aligned}$$

Rental rates. Define the real rental rate $R_d^T \equiv r_d^T / P_d^Y$. Then

$$\hat{R}_d^E = \hat{w}_d + \hat{L}_d - \hat{P}_d^Y - \hat{K}_d^E, \qquad \hat{R}_d^R = (1 - f_d)(\hat{w}_d + \hat{L}_d - \hat{P}_d^Y) + f_d \hat{C}_d^K - \hat{K}_d^R. \tag{B.16}$$

It is useful to define the non-$\hat{C}^K$ part of the real-estate rental rate:

$$\hat{R}_d^{R,0} \equiv (1 - f_d)(\hat{w}_d + \hat{L}_d - \hat{P}_d^Y) - \hat{K}_d^R, \qquad \text{so that} \qquad \hat{R}_d^R = \hat{R}_d^{R,0} + f_d \hat{C}_d^K.$$

Tobin's q dynamics. From the asset pricing equation in Section 5.2:

$$\dot{q}_{dt}^T = (\rho + \delta_T + g_{dt})\, q_{dt}^T - \left\{ \frac{r_{dt}^T}{P_{dt}^Y} + \frac{\xi_T}{2} \left[\left(\frac{I_{dt}^T}{K_{dt}^T} \right)^2 - \delta_T^2 \right] \right\}$$

where $g_{dt} \equiv \dot{C}_{dt}^K / C_{dt}^K$ is the capitalist consumption growth rate. We linearize each term around the steady state, where $q_{ss} = 1$, $g_{ss} = 0$, $I_{ss}^T / K_{ss}^T = \delta_T$, and $R_{ss}^T = \rho + \delta_T$:

- First term: $(\rho + \delta_T + g)(1 + \hat{q}) \approx (\rho + \delta_T) + (\rho + \delta_T)\hat{q} + \hat{g}$.
- Rental rate term: $(\rho + \delta_T)(1 + \hat{R}^T)$.
- Adjustment cost profit: since $I/K = \delta_T + \hat{q}/\xi_T$, we have $(\xi_T/2)[(I/K)^2 - \delta_T^2] = \delta_T \hat{q} + O(\hat{q}^2)$.

Combining:

$$\dot{\hat{q}}_d^T = (\rho + \delta_T)\hat{q}_d^T + \hat{g}_d - (\rho + \delta_T)\hat{R}_d^T - \delta_T \hat{q}_d^T.$$

The coefficient on $\hat{q}$ simplifies to ρ:

$$\dot{\hat{q}}_d^T = \rho\, \hat{q}_d^T + \hat{g}_d - (\rho + \delta_T)\hat{R}_d^T. \tag{B.17}$$

This cancellation is economically meaningful: the δ_T from $(\rho + \delta_T)q$ represents the required return to compensate for depreciation, and it cancels exactly against $\delta_T \hat{q}$ from the marginal savings on adjustment costs. The relevant discount rate for the q dynamics is therefore the pure time preference rate ρ, not $\rho + \delta_T$.

For real estate, substituting $\hat{R}_d^R = \hat{R}_d^{R,0} + f_d \hat{C}_d^K$:

$$\dot{\hat{q}}_d^R = \rho\, \hat{q}_d^R + \hat{g}_d - (\rho + \delta_R)\hat{R}_d^{R,0} - (\rho + \delta_R) f_d \hat{C}_d^K.$$

The last term captures the housing reallocation channel: higher capitalist consumption raises housing demand, shifting real estate toward housing, which increases the production rental rate and depresses real estate Tobin's q.

Capitalist consumption. From the budget constraint, capitalist consumption satisfies:

$$C_d^K = \frac{\eta}{\Omega}\left[\frac{r_d^E K_d^E + r_d^R K_d^R}{P_d^Y} + (1-\gamma)(1-\eta)\frac{w_d L_d}{P_d^Y} - I_d^E - I_d^R - X_d^E - X_d^R\right],$$

where $\Omega \equiv 1 - (1-\gamma)(1-\eta)$. At steady state, $X_{ss}^T = (\xi_T/2)(I_{ss}/K_{ss} - \delta_T)^2 K_{ss} = 0$ since $I_{ss}/K_{ss} = \delta_T$, so δX is second-order and drops out of the linearization.

We linearize each remaining term. For capital income, using $r_d^T K_d^T / P_d^Y = R_d^T K_d^T$:

$$\delta(R_d^T K_d^T) = R_{d,ss}^T K_{d,ss}^T (\hat{R}_d^T + \hat{K}_d^T) = (\rho + \delta_T) K_{d,ss}^T (\hat{R}_d^T + \hat{K}_d^T).$$

For investment, using $I_d^T = K_d^T(\delta_T + (q_d^T - 1)/\xi_T)$:

$$\delta I_d^T = \delta_T K_{d,ss}^T \hat{K}_d^T + K_{d,ss}^T \hat{q}_d^T / \xi_T.$$

Combining the $\hat{K}_d^T$ terms from capital income and investment:

$$(\rho + \delta_T) K_{d,ss}^T \hat{K}_d^T - \delta_T K_{d,ss}^T \hat{K}_d^T = \rho\, K_{d,ss}^T \hat{K}_d^T.$$

The linearized capitalist consumption deviation is therefore:

$$\hat{C}_d^K = a_d^{K^E}\hat{K}_d^E + a_d^{K^R}\hat{K}_d^R + a_d^{R^E}\hat{R}_d^E + a_d^{R^R}\hat{R}_d^R + a_d^L(\hat{w}_d + \hat{L}_d - \hat{P}_d^Y) + a_d^{q^E}\hat{q}_d^E + a_d^{q^R}\hat{q}_d^R, \quad \text{(B.18)}$$

where the coefficients (all evaluated at steady state) are:

$$a_d^{K^T} = \frac{\eta}{\Omega}\cdot\frac{\rho\, K_{d,ss}^T}{C_{d,ss}^K}, \qquad a_d^{R^T} = \frac{\eta}{\Omega}\cdot\frac{(\rho+\delta_T)K_{d,ss}^T}{C_{d,ss}^K},$$

$$a_d^L = \frac{\eta}{\Omega}\cdot\frac{(1-\gamma)(1-\eta)\, w_{d,ss}L_{d,ss}}{P_{d,ss}^Y C_{d,ss}^K}, \qquad a_d^{q^T} = -\frac{\eta}{\Omega}\cdot\frac{K_{d,ss}^T}{\xi_T\, C_{d,ss}^K}.$$

The coefficient $a_d^{K^T}$ captures the net income effect of capital accumulation (ρ, not $\rho+\delta_T$, because the additional depreciation cost exactly offsets the gross rental income from the marginal unit). The coefficient $a_d^{R^T}$ captures the effect of rental rate changes on existing capital income. The coefficient a_d^L captures land income (which equals $(1-\gamma)(1-\eta)w_d L_d$ in the housing equilibrium). Finally, $a_d^{q^T} < 0$ because higher q means more investment spending, reducing consumption.

To solve the static block, substitute (B.16) into (B.18) and collect the local $\hat{R}_d^R \leftrightarrow \hat{C}_d^K$ circularity. Define

$$\begin{aligned}
\chi_d &\equiv \frac{1}{1-a_d^{R^R} f_d},\\
h_d &\equiv \chi_d\big[a_d^{R^E} + a_d^{R^R}(1-f_d) + a_d^L\big],\\
d_d^{K^E} &\equiv \chi_d(a_d^{K^E} - a_d^{R^E}), \qquad d_d^{K^R} \equiv \chi_d(a_d^{K^R} - a_d^{R^R}),\\
d_d^{q^E} &\equiv \chi_d a_d^{q^E}, \qquad d_d^{q^R} \equiv \chi_d a_d^{q^R}.
\end{aligned}$$

Let D_h, D_{K^E}, D_{K^R}, D_{q^E}, and D_{q^R} denote the corresponding diagonal matrices. Using (B.14) and $\kappa = \bar{\alpha}^E\hat{K}^E + \bar{\alpha}^R\hat{K}^R - \bar{\alpha}\hat{L}$, the capitalist-consumption equation becomes

$$J_{21}\hat{w} + J_{22}\hat{C}^K = H_2^E\hat{K}^E + H_2^R\hat{K}^R + H_2^L\hat{L} + D_{q^E}\hat{q}^E + D_{q^R}\hat{q}^R, \quad \text{(B.19)}$$

where

$$\begin{aligned}
J_{21} &\equiv -D_h(I-P_w), \qquad J_{22} \equiv I + D_h P_C,\\
H_2^E &\equiv D_{K^E} + D_h P_\kappa \bar{\alpha}^E I,\\
H_2^R &\equiv D_{K^R} + D_h P_\kappa \bar{\alpha}^R I,\\
H_2^L &\equiv D_h(I + P_C - \bar{\alpha}P_\kappa).
\end{aligned}$$

Stacking (B.15) and (B.19) yields a $2D \times 2D$ linear system for $(\hat{w}, \hat{C}^K)$ as a function of $(\hat{K}^E, \hat{K}^R, \hat{L}, \hat{q}^E, \hat{q}^R)$. Goods prices follow from (B.14), and rental rates from (B.16). These static derivatives are the objects used below to assemble the linearized transition matrix.

Nominal normalization. When recovering wage and goods-price paths from these derivative matrices, we impose the income-weighted numéraire by subtracting the same scalar from the raw wage and goods-price vectors:

$$\omega_d^I \equiv \frac{w_{d,ss} L_{d,ss}}{\sum_{o=1}^D w_{o,ss} L_{o,ss}},$$
$$m_t \equiv \sum_{d=1}^D \omega_d^I \left(\hat{w}_d^{\text{raw}}(t) + \hat{L}_d(t) \right),$$
$$\hat{w}(t) = \hat{w}^{\text{raw}}(t) - m_t \mathbf{1},$$
$$\hat{P}^Y(t) = \hat{P}^{Y,\text{raw}}(t) - m_t \mathbf{1}.$$

This normalization imposes $\sum_d \omega_d^I (\hat{w}_d + \hat{L}_d) = 0$. Because the same common nominal shift is applied to both $\hat{w}$ and $\hat{P}^Y$, real objects such as $\hat{w} - \hat{P}^Y$, $\hat{R}^T$, and $\widehat{w/P}$ are unchanged.

Housing prices. The housing price is determined by market clearing: $P_d^H \cdot H_d = D_{H,d}$, where $H_d = (K_d^{R,H})^\gamma \mathcal{L}_d^{1-\gamma}$ is housing output and $D_{H,d} \equiv (1-\eta)(w_d L_d + P_d^Y C_d^K / \eta)$ is total housing demand from workers and capitalists.

The total real estate capital K_d^R is a state variable, allocated between production $(K_d^{R,Y})$ and housing $(K_d^{R,H})$ via rental rate equalization. From factor demands, $K_d^{R,H} = \gamma D_{H,d} / r_d^R$ (housing capital demand), while $K_d^{R,Y} = \bar{\alpha}^R w_d L_d / ((1-\bar{\alpha}) r_d^R)$ (production capital demand from (B.9)). The constraint $K_d^R = K_d^{R,Y} + K_d^{R,H}$ pins down r_d^R.

Since land $\mathcal{L}_d$ is fixed, $\hat{P}_d^H = \hat{D}_{H,d} - \gamma \hat{K}_d^{R,H}$. Linearizing $D_{H,d}$:

$$\hat{D}_{H,d} = a_{L,d}(\hat{w}_d + \hat{L}_d) + (1 - a_{L,d})(\hat{P}_d^Y + \hat{C}_d^K),$$

where $a_{L,d} \equiv (1-\eta) w_{d,ss} L_{d,ss} / D_{H,d,ss}$ is the worker share of housing demand. To express $\hat{K}_d^{R,H}$ in terms of the state variables, we use $K_d^{R,H} = \gamma D_{H,d} / r_d^R$ and $r_d^R = (\bar{\alpha}^R w_d L_d / (1 - \bar{\alpha}) + \gamma D_{H,d}) / K_d^R$. Defining $s_{H,d} \equiv K_{d,ss}^{R,H} / K_{d,ss}^R$ (housing share of total real estate at steady state), the linearized $\hat{K}_d^{R,H}$ can be shown to satisfy:

$$\hat{K}_d^{R,H} = \hat{K}_d^R + (1 - s_{H,d})(1 - a_{L,d}) \left[(\hat{P}_d^Y + \hat{C}_d^K) - (\hat{w}_d + \hat{L}_d) \right].$$

Substituting into $\hat{P}_d^H = \hat{D}_{H,d} - \gamma \hat{K}_d^{R,H}$ and collecting terms:

$$\hat{P}_d^H = \omega_{1,d}(\hat{w}_d + \hat{L}_d) + \omega_{2,d}(\hat{P}_d^Y + \hat{C}_d^K) - \gamma \hat{K}_d^R, \tag{B.20}$$

where:

$$\omega_{1,d} \equiv a_{L,d} + \gamma(1 - s_{H,d})(1 - a_{L,d}), \qquad \omega_{2,d} \equiv (1 - a_{L,d})\big[1 - \gamma(1 - s_{H,d})\big]. \tag{B.21}$$

Note that $\omega_{1,d} + \omega_{2,d} = 1$. The first coefficient captures worker housing demand and the reallocation of production real estate to housing when workers arrive; the second captures capitalist housing demand net of the housing real estate reallocation.

Real wage and worker value function. The real wage (in terms of the consumption basket) is w_d / P_d, where $\ln P_d = \eta \ln P_d^Y + (1-\eta) \ln P_d^H$ up to constants. The log-deviation of the real wage is:

$$\begin{aligned}\widehat{w/P}_d &= \hat{w}_d - \eta \hat{P}_d^Y - (1-\eta)\hat{P}_d^H \\ &= \hat{w}_d - \eta \hat{P}_d^Y - (1-\eta)\big[\omega_{1,d}(\hat{w}_d + \hat{L}_d) + \omega_{2,d}(\hat{P}_d^Y + \hat{C}_d^K) - \gamma \hat{K}_d^R\big].\end{aligned}$$

Collecting terms:

$$\widehat{w/P}_d = \phi_{w,d}\hat{w}_d - \phi_{P,d}\hat{P}_d^Y - (1-\eta)\omega_{1,d}\hat{L}_d - (1-\eta)\omega_{2,d}\hat{C}_d^K + (1-\eta)\gamma \hat{K}_d^R, \tag{B.22}$$

where:

$$\phi_{w,d} \equiv 1 - (1-\eta)\omega_{1,d}, \qquad \phi_{P,d} \equiv \eta + (1-\eta)\omega_{2,d}. \tag{B.23}$$

The worker value function satisfies the HJB equation (from Section 5.2):

$$\rho V_d = \ln(w_d/P_d) + \ln(A_d) + \varepsilon \left[\frac{1}{\nu} \ln \mathcal{V}_d - V_d\right] + \dot{V}_d,$$

where $\mathcal{V}_d = \sum_{d'} \exp(\nu(V_{d'} - \Delta_{dd'}^M))$ is the migration option value. Rearranging: $\dot{V}_d = (\rho + \varepsilon)V_d - \ln(w_d/P_d) - \ln(A_d) - (\varepsilon/\nu)\ln \mathcal{V}_d$. At steady state, $\dot{V}_{d,ss} = 0$. Taking the deviation:

$$\dot{\hat{V}}_d = (\rho + \varepsilon)\hat{V}_d - \widehat{w/P}_d - \frac{\varepsilon}{\nu}\hat{\mathcal{V}}_d,$$

where $\hat{\mathcal{V}}_d$ is the log-deviation of the option value. Since $\delta \mathcal{V}_d = \nu \mathcal{V}_{d,ss} \sum_{d'} M_{dd'}^{ss} \hat{V}_{d'}$:

$$\frac{\varepsilon}{\nu}\hat{\mathcal{V}}_d = \frac{\varepsilon}{\nu} \cdot \nu \sum_{d'} M_{dd'}^{ss} \hat{V}_{d'} = \varepsilon \sum_{d'} M_{dd'}^{ss} \hat{V}_{d'}.$$

Therefore:

$$\dot{\hat{V}}_d = \rho \hat{V}_d + \varepsilon \left(\hat{V}_d - \sum_{d'=1}^{D} M^{ss}_{dd'} \hat{V}_{d'} \right) - \widehat{w/P}_d, \tag{B.24}$$

where the $\varepsilon(\cdot)$ term captures the "migration drag": the option to migrate pulls V_d toward the population-weighted average of all values. Note that $\hat{C}^K_d$ enters $\widehat{w/P}_d$ at the level (not as the growth rate $\hat{g}$), so its dependence on the current state and costate variables substitutes directly into the coefficient matrix without creating additional implicit terms.

The system matrices. We now assemble the full linearized system. Define C as the $N \times N$ "explicit" coefficient matrix and G as the $N \times N$ "implicit" matrix arising from the capitalist consumption growth rate $\hat{g}_d = \dot{\hat{C}}^K_d$ appearing in the $\dot{\hat{q}}$ equations.

The C matrix. The matrix C has the following block structure, where rows correspond to $(\dot{\hat{K}}^E, \dot{\hat{K}}^R, \dot{\hat{L}}, \dot{\hat{q}}^E, \dot{\hat{q}}^R, \dot{\hat{V}})$:

Capital rows: from (B.7), $C[\hat{K}^E_d, \hat{q}^E_d] = 1/\xi_E$ and $C[\hat{K}^R_d, \hat{q}^R_d] = 1/\xi_R$. All other entries zero.

Employment rows: from (B.8), for each $d = 1, \ldots, D_L$:

$$C[\hat{L}_d, \hat{L}_o] = \varepsilon(E_{od} - \mathbf{1}_{o=d}),$$
$$C[\hat{L}_d, \hat{V}_j] = \varepsilon\nu(\mathbf{1}_{j=d} - \mathrm{ETM}_{dj}).$$

Tobin's q rows: from (B.17) and (B.16), for each $d = 1, \ldots, D$, each $T \in \{E, R\}$, and each non-value variable $z_k \in \{\hat{K}^E_o, \hat{K}^R_o, \hat{L}_o, \hat{q}^E_o, \hat{q}^R_o\}$:

$$C[\hat{q}^T_d, z_k] = \rho \cdot \mathbf{1}_{\{z_k = \hat{q}^T_d\}} - (\rho + \delta_T)\frac{\partial \hat{R}^T_d}{\partial z_k}.$$

For $T = R$, these derivatives include the additional housing-reallocation term $-(\rho + \delta_R) f_d\, \partial \hat{C}^K_d / \partial z_k$.

Value function rows: from (B.24) and (B.22), each $\dot{\hat{V}}_d$ row contains contributions from all state and costate variables. The $\hat{V}$ block has:

$$C[\hat{V}_d, \hat{V}_d] = \rho + \varepsilon(1 - M^{ss}_{dd}), \qquad C[\hat{V}_d, \hat{V}_{d'}] = -\varepsilon M^{ss}_{dd'} \text{ for } d' \neq d.$$

For each non-value variable z_k,

$$C[\hat{V}_d, z_k] = -\phi_{w,d}\frac{\partial \hat{w}_d}{\partial z_k} + \phi_{P,d}\frac{\partial \hat{P}^Y_d}{\partial z_k} + (1-\eta)\omega_{2,d}\frac{\partial \hat{C}^K_d}{\partial z_k} + (1-\eta)\omega_{1,d}\mathbf{1}_{\{z_k = \hat{L}_d\}} - (1-\eta)\gamma \mathbf{1}_{\{z_k = \hat{K}^R_d\}}.$$

These derivatives are read from the joint static block (B.15)–(B.19), together with (B.14) and (B.16).

The G matrix. Since $\hat{g}_d = \dot{\hat{C}}_d^K$ appears in the Tobin's q equations (B.17), and $\dot{\hat{C}}_d^K = \sum_k (\partial \hat{C}_d^K / \partial z_k) \dot{z}_k$, the q equations depend on $\dot{z}$, creating an implicit system. The G matrix encodes the coefficients $\partial \hat{C}_d^K / \partial z_k$ in the rows corresponding to $\dot{\hat{q}}_d^E$ and $\dot{\hat{q}}_d^R$. For each $d = 1, \ldots, D$:

$$G[\hat{q}_d^T, z_k] = \frac{\partial \hat{C}_d^K}{\partial z_k}, \qquad z_k \in \{\hat{K}_o^E, \hat{K}_o^R, \hat{L}_o, \hat{q}_o^E, \hat{q}_o^R\}.$$

Note that G has identical entries for both $\hat{q}_d^E$ and $\hat{q}_d^R$ rows corresponding to the same department d, since the consumption growth rate $\hat{g}_d$ is common to both capital types. All rows of G outside the $\hat{q}$ block are zero.

The final system matrix. The linearized system is $(I - G)\dot{z} = Cz$. Inverting:

$$\dot{z} = (I - G)^{-1} C\, z \equiv A\, z. \tag{B.25}$$

The matrix A is 563×563.

The Blanchard-Kahn solution. The saddle-path stability of $\dot{z} = Az$ requires exactly $n_s = 281$ eigenvalues with negative real part (matching the 281 state variables) and $n_u = 282$ eigenvalues with positive real part (matching the 282 costate variables). We verify this condition numerically.

Let $\{\lambda_j\}_{j=1}^{n_s}$ denote the stable eigenvalues (with $\mathrm{Re}(\lambda_j) < 0$) and $P_s \in \mathbb{R}^{N \times n_s}$ the matrix of associated right eigenvectors, partitioned as:

$$P_s = \begin{bmatrix} P_s^x \\ P_s^y \end{bmatrix}, \quad P_s^x \in \mathbb{R}^{n_s \times n_s}, \quad P_s^y \in \mathbb{R}^{n_u \times n_s},$$

where P_s^x contains the state-variable rows and P_s^y the costate rows.

The general solution restricted to the stable manifold is $z(t) = P_s \,\mathrm{diag}(e^{\lambda_j t})\, c$, where $c \in \mathbb{R}^{n_s}$ is the vector of eigenvector coefficients. The initial state deviation $x(0) = \ln x_{\text{initial}} - \ln x_{\text{final}}$ determines c through:

$$x(0) = P_s^x c \quad \Longrightarrow \quad c = (P_s^x)^{-1} x(0).$$

The initial costate "jump" (the instantaneous response of forward-looking variables when the reform is announced) is then:

$$y(0) = P_s^y \, c.$$

The full transition path of state and costate variables is:

$$z(t) = \sum_{j=1}^{n_s} c_j \, e^{\lambda_j t} \, p_j,$$

where p_j is the j-th column of P_s and c_j the j-th element of c. By construction, $z(t) \to 0$ as $t \to \infty$, since all $\mathrm{Re}(\lambda_j) < 0$. Prices, rental rates, and capitalist consumption along the transition path are then recovered from the joint static block (B.15)–(B.19), together with (B.14), (B.16), and (B.20).

B.4 Spectral decomposition of the transition dynamics

We follow the spectral analysis of Kleinman et al. (2023) to characterize the roles of capital and labor dynamics in shaping the economy's adjustment to the reform. The key objects are the eigenvalues and eigenvectors of the linearized system $\dot{z} = Az$, which jointly determine both the speed of convergence to steady state and the spatial pattern of adjustment along the transition path.

Eigendecomposition. The matrix A has $n_s = 281$ stable eigenvalues $\{\lambda_j\}_{j=1}^{n_s}$ (with $\mathrm{Re}(\lambda_j) < 0$), matching the 281 state variables, as required by the Blanchard-Kahn condition. Let $\{p_j\}_{j=1}^{n_s}$ denote the associated full right eigenvectors of A, so that $Ap_j = \lambda_j p_j$ with $p_j \in \mathbb{R}^{563}$. Partition each eigenvector into its state and costate blocks,

$$p_j = \begin{bmatrix} u_j \\ v_j \end{bmatrix}, \qquad u_j \in \mathbb{R}^{281}, \quad v_j \in \mathbb{R}^{282}.$$

The spatial pattern of joint capital-labor adjustment is encoded in the state block u_j, whose entries correspond to $\hat{K}_d^E$, $\hat{K}_d^R$, and $\hat{L}_d$ across departments.

Eigenshocks and loadings. Following Kleinman et al. (2023), we define an *eigenshock* as a perturbation to fundamentals whose impact on the state variables is proportional to a state-block eigenvector u_j. The eigenshocks form a basis for the state space. The reform's impact on initial state conditions, $x(0) = \ln x_{\text{initial}} - \ln x_{\text{final}}$, can be decomposed as a linear combination of eigenshocks:

$$x(0) = \sum_{j=1}^{n_s} c_j \, u_j, \tag{B.26}$$

where the coefficient c_j is the *loading*—the weight that the reform places on eigenshock j. Since each eigencomponent evolves independently, the transition path of the state variables is

$$x(t) = \sum_{j=1}^{n_s} c_j \, e^{\lambda_j t} \, u_j. \tag{B.27}$$

and the corresponding full state-costate path is $z(t) = \sum_{j=1}^{n_s} c_j e^{\lambda_j t} p_j$. This is the continuous-time analog of Proposition 4 in Kleinman et al. (2023). The loading $|c_j|$ measures how strongly the reform excites eigenshock j, and each component decays exponentially at a rate determined by its eigenvalue. The half-life of eigencomponent j is

$$t_{1/2}^{(j)} = \frac{\ln 2}{|\mathrm{Re}(\lambda_j)|}. \tag{B.28}$$

Incidence on state variables. As emphasized by Kleinman et al. (2023), the speed of convergence depends not only on the structural parameters of the model but also on the *incidence* of each eigenshock on the capital and labor state variables in each location. Each eigenvector u_j has entries for all three state variables across all 94 departments. We define the capital composition of eigenvector j as the share of its squared norm in the real estate block, $\|u_j^{K^R}\|^2 / (\|u_j^{K^E}\|^2 + \|u_j^{K^R}\|^2)$, which ranges from 0 (pure equipment) to 1 (pure real estate). Similarly, the labor content $\|u_j^{L}\|^2 / \|u_j\|^2$ measures the fraction of the eigenvector's energy in the employment block.

Three timescales of adjustment. Figure B.27 plots the loading $|c_j|$ against the half-life for each eigenshock, with continuous color indicating capital composition and marker size indicating labor content. In the estimated-ξ linearization used for the reported dynamic diagnostics, the heavily loaded modes fall into three distinct timescales.

The first cluster is a fast equipment block. Its dominant eigenshocks are nearly spatially uniform, capturing broad-based capital deepening rather than spatial reallocation. The reform loads heavily on this block, which is why aggregate equipment adjustment is relatively rapid.

The second cluster is an intermediate real-estate block. These modes fall primarily on the real-estate capital block, with little labor content. They are slower because real estate depreciates more slowly and faces larger adjustment costs than equipment.

The third cluster is a slow mixed block. These eigenshocks have substantial incidence on all three state variables—equipment, real estate, and labor move together—and they are spatially heterogeneous, with some locations gaining and others losing. These coupled capital-labor-reallocation modes govern the long-run spatial adjustment, which is why the full redistribution of activity across departments takes much longer than the aggregate capital response.

Level versus spatial adjustment. The contrast between the spatially uniform fast modes and the spatially heterogeneous slow modes has a simple mathematical explanation. Capital dynamics are primarily *local*: each department's equipment adjustment is governed by its own depreciation rate δ^E, adjustment cost parameter ξ^E, and rental rate. Cross-departmental spillovers—through trade prices and migration flows—enter only as second-order corrections. When every department faces the same structural parameters and the same direction of shock (lower taxes $\rightarrow$ more capital), they can all adjust in parallel, each at its local rate, without requiring any coordination across space. In the language of the spectral decomposition, this local, independent adjustment is captured by the spatially uniform eigenvector, whose eigenvalue reflects the Hayashi investment dynamics (δ^E, ξ^E, ρ) and is therefore fast.

The spatial component of the reform—the fact that some departments need *more* capital than others—requires a fundamentally different type of adjustment. Differential capital accumulation changes *relative* goods prices across locations (through the trade network), which changes *relative* wages, which changes migration incentives. These cross-departmental channels are slower, and they couple the capital and labor state variables across space. When the spatial pattern requires capital and labor to move in the same direction—as in the slow modes of the third cluster—the mutual dependence between the two factors further delays convergence.

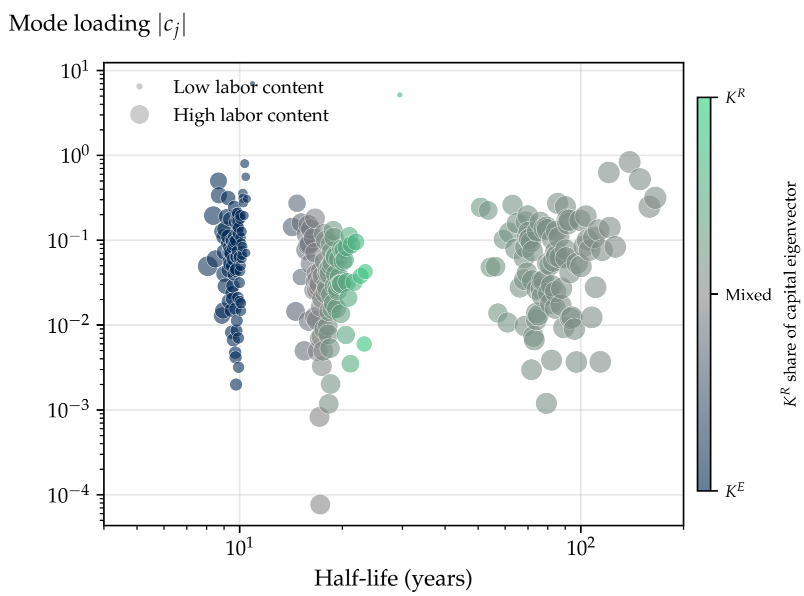
To see the quantitative importance of this decomposition, write the initial equipment gap as $x^{K^E}(0) = \bar{z} \cdot \mathbf{1} + \tilde{z}$, where $\bar{z}$ is the cross-departmental mean and $\tilde{z}$ is the spatial deviation. In our reform, the level component accounts for 94.1% of the norm:

$$\frac{\|\bar{z} \cdot \mathbf{1}\|}{\|x^{K^E}(0)\|} = 0.94.$$

The reform is overwhelmingly a level shock to equipment capital, which is why it projects strongly onto the fast, spatially uniform eigenvector.

Capital-labor complementarity. Perhaps the most striking feature of the spectrum is the near-absence of pure labor content. Employment adjustment appears mainly through mixed capital-labor modes rather than through labor-dominated eigenshocks. This is the mechanism formalized by Kleinman et al. (2023) (Propositions 4–5): the speed of convergence depends on the incidence of the shock on both capital and labor in each location. In the fast modes, capital and labor gaps are negatively correlated across departments, so the two factors help correct each other's imbalances and convergence is rapid. In the slow modes of the third cluster, the gaps are positively correlated: a department that has too much capital relative to the new steady state also has too many workers. The high capital stock keeps wages elevated, delaying out-migration, while the abundant workforce keeps the return to investment high, delaying disinvestment. Each factor's presence sustains the other's departure from steady state. This capital-labor complementarity, rather than high moving costs per se, explains the 150-year median employment half-life.

Figure B.27: Eigenshock decomposition of the reform



Note: Each point represents one stable eigenshock of the 563-dimensional linearized system, computed with the estimated adjustment-cost parameters. The horizontal axis shows the half-life $t_{1/2}^{(j)} = \ln 2/|\mathrm{Re}(\lambda_j)|$ and the vertical axis shows the loading $|c_j|$, which measures how strongly the reform excites eigenshock j. Color indicates the capital composition of the state-block eigenvector: the share of the squared norm in the real estate block relative to total capital, ranging from K^E (blue) to K^R (green). Marker size is proportional to labor content (the share of the squared norm in the employment block). The spectrum features a fast equipment cluster, an intermediate real-estate cluster, and a slow mixed capital-labor cluster.