Online Appendix: Land development and frictions to housing supply over the business cycle[*]

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A Section 2

A.1 Proof of Proposition 1

We first derive the following lemma:

Lemma 1 (log-linearized dynamic housing supply equilibrium) *Let each hatted variable be the log deviation from its steady-state value. The following log-linearized equilibrium conditions summarize the TTD model of housing investment:*

$$\begin{aligned}
\hat{I}_t &= \frac{1}{B(P)} \sum_{p=0}^{P} \left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^p \hat{U}_{t-p|t}, \\
\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t|t+p} &= \frac{1}{\theta}\mathbb{E}_t \hat{I}_{t+p} + \mathbb{E}_t \hat{q}_{t+p} + \frac{1-\alpha}{\alpha}\hat{M}_{t+p-P|t+p} - \hat{w}_t + \mathbb{E}_t(\hat{\lambda}_{t+p} - \hat{\lambda}_t), \\
\hat{U}_{t|t+p} &= (1-\alpha)\hat{M}_{t+p-P|t+p} + \alpha \hat{N}_{t|t+p}, \\
\hat{N}_t &= \left(\frac{1-\tilde{\beta}}{1-\tilde{\beta}^{1+P}}\right) \sum_{p=0}^{P} \tilde{\beta}^p \hat{N}_{t|t+p}, \\
\hat{M}_{t|t+P} &= \gamma \hat{q}_t,
\end{aligned}$$

where

$$\Lambda_{t|t+p} = \beta^p \frac{\lambda_{t+p}}{\lambda_t},\ \tilde{\beta} = \beta^{\frac{\theta}{\theta+\alpha(1-\theta)}},\ \textit{and}\ \ B(t) = \frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+t)} - 1}{\tilde{\beta}^{\alpha(\theta-1)/\theta} - 1}.$$

Proof.

Recap the following six optimality conditions:

$$\begin{aligned}
I_t &= \left(\sum_{p=0}^{P} U_{t-p|t}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \\
U_{t|t+p} &= M_{t+p-P|t+p}^{1-\alpha} N_{t|t+p}^{\alpha}, \quad \text{for } p = 0, 1, \cdots, P, \\
N_t &= \sum_{p=0}^{P} N_{t|t+p}, \\
M_{t|t+P} &= \bar{M} q_t^{\gamma}, \\
\mu_{t|t+p} &= \mathbb{E}_t \left[\beta^p \left(\frac{\lambda_{t+p}}{\lambda_t}\right) q_{t+p} \left(\frac{I_{t+p}}{U_{t|t+p}}\right)^{\frac{1}{\theta}}\right] \quad \text{for } p = 0, 1, \cdots, P, \\
w_t &= \alpha \mu_{t|t+p} M_{t+p-P|t+p}^{1-\alpha} N_{t|t+p}^{\alpha-1} \quad \text{for } p = 0, 1, \cdots, P,
\end{aligned}$$

where $\Lambda_{t|t+p} = \beta^p \lambda_{t+p}/\lambda_t$. Denoting the steady state variables of each variable with the subscript ss, the following holds at the steady state:

$$I_{ss} = \left(\sum_{p=0}^{P} U_{0|p,ss}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

$$
\begin{aligned}
U_{0|p,ss} &= M_{ss}^{1-\alpha} N_{0|p,ss}^{\alpha}, \quad \text{for } p = 0, 1, \cdots, P, \\
N_{ss} &= \sum_{p=0}^{P} N_{0|p,ss}, \\
M_{ss} &= \bar{M} q_{ss}^{\gamma}, \\
\mu_{0|p,ss} &= \beta^p q_{ss} \left(\frac{I_{ss}}{U_{0|p,ss}} \right)^{\frac{1}{\theta}} \quad \text{for } p = 0, 1, \cdots, P, \\
w_{ss} &= \alpha \mu_{0|p,ss} M_{ss}^{1-\alpha} N_{0|p,ss}^{\alpha-1} \quad \text{for } p = 0, 1, \cdots, P.
\end{aligned}
$$

This implies the following conditions for $p = 1, \cdots, P$:

$$
\begin{aligned}
\frac{U_{0|p,ss}}{U_{0|p-1,ss}} &= \left(\frac{N_{0|p,ss}}{N_{0|p-1,ss}} \right)^{\alpha}, \\
\frac{\mu_{0|p,ss}}{\mu_{0|p-1,ss}} &= \beta \left(\frac{U_{0|p-1,ss}}{U_{0|p,ss}} \right)^{\frac{1}{\theta}}, \\
\frac{\mu_{0|p,ss}}{\mu_{0|p-1,ss}} &= \left(\frac{N_{0|p,ss}}{N_{0|p-1,ss}} \right)^{1-\alpha}.
\end{aligned}
$$

Using these, we derive the following equations:

$$
\begin{aligned}
N_{0|p,ss} &= N_{0|p-1,ss} \tilde{\beta}, \\
U_{0|p,ss} &= U_{0|p-1,ss} \tilde{\beta}^{\alpha}, \\
\mu_{0|p,ss} &= \mu_{0|p-1,ss} \tilde{\beta}^{1-\alpha},
\end{aligned}
$$

where $\tilde{\beta} = \beta^{\frac{\theta}{\theta + \alpha(1-\theta)}}$.

Based on the computed steady state values, it is straightforward to derive the five log-linearized conditions above. For instance, the second equation can be derived by using $\mu_{t|t+p}$ to plug the fifth optimality condition to the sixth optimality condition and then plugging in the second optimality condition using $N_{t|t+p}$. ■

Note that in Lemma 1, we introduced the deterministic per-period discount factor parameter $\beta < 1$. As such, the stochastic discount factor between period t and $t+p$, $\Lambda_{t|t+p}$, is decomposed into the deterministic discount factor β^p and the net stochastic discount factor λ_{t+p}/λ_t.

As the economy was in its steady state equilibrium before period 0, the hatted values are zero for those periods. Given a shock in period 0, the variables respond in period 0 and afterwards consistent with expectations formed in period 0. Without loss of generality, assume that $P > 2$. To derive the period-0 housing supply curve, some equations in Lemma 1 could be written as follows:

$$
\begin{aligned}
\hat{I}_0 &= \frac{1}{B(P)} \hat{U}_{0|0}, \\
\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta} \right) \hat{U}_{0|0} &= \frac{1}{\theta} \hat{I}_0 + \hat{q}_0 - \hat{w}_0 + \mathbb{E}_0(\hat{\lambda}_1 - \hat{\lambda}_0).
\end{aligned}
$$

Netting out $\hat{U}_{0|0}$ from the two equations, we get the period-0 housing supply curve:

$$\hat{I}_0 = \frac{1}{\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)B(P)-\frac{1}{\theta}}\hat{q}_0 - \frac{1}{\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)B(P)-\frac{1}{\theta}}\hat{w}_0,$$

which can be expressed as

$$\hat{I}_0 = \Upsilon_0(P)\hat{q}_0 - \frac{\Upsilon_0(P)}{B(0)}\hat{w}_0.$$

Similarly, the equations in Lemma 1 that are relevant to derive the period-1 housing supply curve are as follows:

$$\hat{I}_1 = \frac{1}{B(P)}\left(\hat{U}_{1|1}+\tilde{\beta}^{\alpha(\theta-1)/\theta}\hat{U}_{0|1}\right),$$
$$\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)\hat{U}_{1|1} = \frac{1}{\theta}\hat{I}_1 + \hat{q}_1 - \hat{w}_1,$$
$$\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)\hat{U}_{0|1} = \frac{1}{\theta}\hat{I}_1 + \hat{q}_1 - \hat{w}_0 + \left(\hat{\lambda}_1-\hat{\lambda}_0\right).$$

Plugging $\hat{U}_{1|1}$ and $\hat{U}_{0|1}$ from the last two equations to the first equation, we get the period-1 housing supply curve:

$$\begin{aligned}\hat{I}_1 =& \frac{1+\tilde{\beta}^{\alpha(\theta-1)/\theta}}{\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)B(P)-\frac{1}{\theta}\left(1+\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)}\hat{q}_1 \\ &- \frac{1}{\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)B(P)-\frac{1}{\theta}\left(1+\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)}\left(\hat{w}_1+\tilde{\beta}^{\alpha(\theta-1)/\theta}\hat{w}_0+\tilde{\beta}^{\alpha(\theta-1)/\theta}(\hat{\lambda}_0-\hat{\lambda}_1)\right),\end{aligned}$$

which can be expressed as

$$\hat{I}_1 = \Upsilon_1(P)\hat{q}_1 - \frac{\Upsilon_1(P)}{B(1)}\sum_{j=0}^{1}\left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^j\left(\hat{w}_{1-j}+\hat{\lambda}_{1-j}-\hat{\lambda}_1\right).$$

Similarly, the equations in Lemma 1 that are relevant to derive the period-2 housing supply elasticity are as follows:

$$\hat{I}_2 = \frac{1}{B(P)}\left(\hat{U}_{2|2}+\tilde{\beta}^{\alpha(\theta-1)/\theta}\hat{U}_{1|2}+\left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^2\hat{U}_{0|2}\right),$$
$$\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)\hat{U}_{2|2} = \frac{1}{\theta}\hat{I}_2 + \hat{q}_2 - \hat{w}_2,$$
$$\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)\hat{U}_{1|2} = \frac{1}{\theta}\hat{I}_2 + \hat{q}_2 - \hat{w}_1 + \left(\hat{\lambda}_2-\hat{\lambda}_1\right),$$
$$\left(\frac{1-\alpha}{\alpha}+\frac{1}{\theta}\right)\hat{U}_{0|2} = \frac{1}{\theta}\hat{I}_2 + \hat{q}_2 - \hat{w}_0 + \left(\hat{\lambda}_2-\hat{\lambda}_0\right).$$

Plugging $\hat{U}_{2|2}$, $\hat{U}_{1|2}$ and $\hat{U}_{0|2}$ from the last three equations to the first equation, we get the period-2 housing supply curve:

$$\hat{I}_2 = \Upsilon_2(P)\hat{q}_2 - \frac{\Upsilon_2(P)}{B(2)} \sum_{j=0}^{2} \left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^j \left(\hat{w}_{2-j} + \hat{\lambda}_{2-j} - \hat{\lambda}_2\right).$$

In general for $t < P$, the equations in Lemma 1 that are relevant to derive the period-2 housing supply elasticity are as follows:

$$\hat{I}_t = \frac{1}{B(P)} \left(\sum_{j=0}^{t} \left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^j \hat{U}_{t-j|t} \right),$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t - \hat{w}_t,$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t-1|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t - \hat{w}_{t-1} + \left(\hat{\lambda}_t - \hat{\lambda}_{t-1}\right),$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t-2|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t - \hat{w}_{t-2} + \left(\hat{\lambda}_t - \hat{\lambda}_{t-2}\right),$$

$$\vdots$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{0|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t - \hat{w}_0 + \left(\hat{\lambda}_t - \hat{\lambda}_0\right).$$

Plugging $\{U_{t-j|t}\}_{j=0}^{t}$ from the last $t+1$ equations to the first equation, we can derive the period-t housing supply curve as in the proposition.

For $t \geq P$, note that $\hat{M}_{t-P|t} = \gamma \hat{q}_{t-P}$. The relevant equations in this case are

$$\hat{I}_t = \frac{1}{B(P)} \sum_{p=0}^{P} \left(\tilde{\beta}^{\alpha(\theta-1)/\theta}\right)^p \hat{U}_{t-p|t},$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t + \left(\frac{1-\alpha}{\alpha}\right) \gamma \hat{q}_{t-P} - \hat{w}_t,$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t-1|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t + \left(\frac{1-\alpha}{\alpha}\right) \gamma \hat{q}_{t-P} - \hat{w}_{t-1} + \left(\hat{\lambda}_t - \hat{\lambda}_{t-1}\right),$$

$$\vdots$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t-P+1|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t + \left(\frac{1-\alpha}{\alpha}\right) \gamma \hat{q}_{t-P} - \hat{w}_{t-P+1} + \left(\hat{\lambda}_t - \hat{\lambda}_{t-P+1}\right),$$

$$\left(\frac{1-\alpha}{\alpha} + \frac{1}{\theta}\right) \hat{U}_{t-P|t} = \frac{1}{\theta}\hat{I}_t + \hat{q}_t + \left(\frac{1-\alpha}{\alpha}\right) \gamma \hat{q}_{t-P} - \hat{w}_{t-P} + \left(\hat{\lambda}_t - \hat{\lambda}_{t-P}\right).$$

Substituting out $\{U_{t-j|t}\}_{j=0}^{t-P}$ in the first equation and rearranging, we get

$$\left[B(P) - \left(\frac{\frac{1}{\theta}}{\frac{1-\alpha}{\alpha} + \frac{1}{\theta}} \right) \left(\frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+P)} - 1}{\tilde{\beta}^{\alpha(\theta-1)/\theta} - 1} \right) \right] \hat{I}_t =$$

$$\left(\frac{1}{\frac{1-\alpha}{\alpha}+\frac{1}{\theta}}\right)\left(\frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+P)}-1}{\tilde{\beta}^{\alpha(\theta-1)/\theta}-1}\right)\hat{q}_t+\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+P)}-1}{\tilde{\beta}^{\alpha(\theta-1)/\theta}-1}\right)\gamma\hat{q}_{t-P}+\text{etc.}$$

Since

$$B(P)=\frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+P)}-1}{\tilde{\beta}^{\alpha(\theta-1)/\theta}-1},$$

the proposition holds for $t \geq P$.

A.2 Proof of Corollary 2

Since $\beta < 1$, $\theta > 0$, and $\alpha \in (0,1)$,

$$\tilde{\beta}=\beta^{\frac{\theta}{\theta+\alpha(1-\theta)}}<1.$$

To verify that $\Upsilon_t(P)$ ($t \in [0,P]$) is positive and an increasing function of t, it suffices to show that $B(t)$ is positive and an increasing function of t. First, we show that $B(t)$ is positive. Note that when $\theta > 1$, $\tilde{\beta}^{\alpha(\theta-1)/\theta} < 1$. Therefore,

$$B(t)=\frac{1-\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+t)}}{1-\tilde{\beta}^{\alpha(\theta-1)/\theta}}>0.$$

Likewise, when $\theta < 1$, $\tilde{\beta}^{\alpha(\theta-1)/\theta} > 1$. which implies

$$B(t)=\frac{\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+t)}-1}{\tilde{\beta}^{\alpha(\theta-1)/\theta}-1}>0.$$

Second, we show that $B(t)$ is an increasing function of t by taking its derivative with respect to t:

$$\frac{dB(t)}{dt}=\frac{\alpha\left(\frac{\theta-1}{\theta}\right)(\ln\tilde{\beta})}{\tilde{\beta}^{\alpha(\theta-1)/\theta}-1}\tilde{\beta}^{(\alpha(\theta-1)/\theta)(1+t)}>0.$$

The above inequality holds as $\ln\tilde{\beta} < 0$.

The second part of the corollary follows from the fact that $B(P) < B(\tilde{P})$ for $P < \tilde{P}$, as $\Upsilon_t(P)$ is a decreasing function of $B(P)$ (and P).

B Section 3

B.1 Descriptive statistics

The year-by-year Census Bureau's Survey of Construction (SOC) coverage of our data set is provided in Table A.1. We find that our SOC coverage remained relatively stable over time. Excluding 2003, the lowest and highest coverage for total housing is 39 percent and 55 percent, respectively.

B.2 Overview of the land development process

Land development is generally defined as the conversion of land from one use to another. The land development design process is lengthy and is broadly categorized into three stages: the pre-design stage, the design stage, and the post-design stage. Our data set records sites from the design stage when the preliminary site plan is submitted to and approved by the municipality. In this part, we sketch the whole land development process. The description borrows from the handbook of Dewberry (2019) where further details could be found.

Pre-design stage. At the beginning of this stage, the developer identifies a site or multiple potential sites of interest, labeled as the site selection process. Then comes the due diligence process where the site engineer performs a technical desk review of the site focusing on the regulatory aspects. Afterwards, the site engineer performs site analysis to understand the physical conditions of the site including a study on the engineering feasibility. At this phase, a particular emphasis is on the identification of environmental, cultural, and infrastructure resources.

Design stage. This stage includes both a preliminary design phase and a detailed design phase. Based on the constraints and development opportunities identified at the pre-design stage, a preliminary design is drawn to deliver the intent of the project. These preliminary design plans are submitted for an entitlement review by some municipalities. Approvals at this stage are not necessarily a guarantee of the final site plan approval, but they provide a guideline of what is to be expected during subsequent reviews. The detailed design phase builds from the approved preliminary design plan to focus on the engineering details necessary for permitting and construction. The site engineer eventually comes up with a final site plan which is submitted for a regulatory review and permit processing.

Post-design stage. After the approval of the final site plan, land development enters the post-design stage. This stage includes permits and construction. While the approval of the final site plan is typically treated as a milestone of land development, major construction activity can initiate only after permits are issued. The approval of a final site plan is a key input for permit issuance, but depending on the type and scope of the project, project bonds and other legal agreements might also be needed. Depending on the jurisdiction, a series of permits might be needed for infrastructure work such as a site permit which is often required prior to commencing any land disturbance. For the construction of structures, a building permit is typically required. Environmental permits might also be required based on site locations, natural resources present, type of construction etc. After the necessary permits are acquired and a construction contract agreement is signed, construction begins. At this stage, the general contractor coordinates with the design team to ensure compliance with the approved design documents.

B.3 TTD regression

The local controls we use in Table 3 of the main draft are listed below. Some of these are taken from Davidoff (2016).

1. Bartik: Computes the 1980 Census share of people working in each industry for each county and multiplies that with the national industry employment growth (net of the location of interest) between 1980 and the 2010-2012 American Community Survey.

2. Sand state: Dummy variable for counties in Arizona, California, Florida, and Nevada.

3. Coastal state: Dummy variable for counties adjacent to the Pacific Ocean and stops on the Acela line between Washington, D.C. and New York.

4. Immigrant: The share of adult population in 1980 that were born outside the U.S.

5. College+: The share of adult population in 1980 that had college education or more.

6. Population density: Taken from the 1980 Census.

7. County GDP: Annual county-level real GDP.

The regression coefficients of the local controls in regression (2) of Table 3 in the main text are shown in Table A.2.

B.4 Alternative TTD definitions

We first present the sensitivity of our results in Section 2 based on alternative definitions for the end date of TTD. Then, we discuss our choice of the start date of TTD.

Alternative end date of TTD. For the end date of TTD, we assume that section development is completed when 25 percent of the total units are built. Using this alternative definition, Tables 2-4 in the main text are reproduced. Table A.3 presents the section TTD statistics shown in Table 2 of the main text. As expected, the mean of total TTD decreases from 1,329 days to 1,141 days. The standard deviation as well as the IQR also decreases from 1,077 days to 1,009 days and from 1,006 days to 911 days, respectively. The relatively smaller decrease in the standard deviation and the IQR relative to the mean suggests that the heterogeneity in TTD remains robust to this definition. Note that as the end of TTD is defined as only 25 percent of completion, there are additional completed sections included in our sample.

Using this definition, Table A.4 presents the regression results in Table 3 of the main text. The regression results are quite similar.

The county-level TTD statistics using the alternative TTD definition (Table 4 in the main text) is presented in Table A.5. Despite the lower mean county-level TTD, the standard deviation and IQR remains relatively intact, suggesting that the cross-regional variation is less sensitive to the end date definition of TTD.

Beginning date of TTD. For the beginning date of TTD, our baseline definition is the first quarter when we observe the total number of future lots to be the same as the total number of planned lots in the subdivision/section. With the help of maps submitted to the municipality, this is typically detected both by on-site drives each quarter and by acquiring satellite images from another company.

For some completed sections, our data set also includes the preliminary approval date from the municipality (typically from the planning department) as the first step in the official process of land development. Therefore, the data set with 222,868 completed sections could be classified into 4 cases:

- Case 1: Baseline missing and prelim. date missing (77,787 sections or 34.9%).
- Case 2: Baseline missing and prelim. date available (23,287 sections or 10.5%).
- Case 3: Baseline available and prelim. date missing (74,981 sections or 33.6%).
- Case 4: Baseline available and prelim. date available (46,813 sections or 21.0%).

Accordingly, we use the completed sections in cases 3 and 4 in the main text, which consists of 54.6% of the completed sections between 2003 and 2019 in the data set.

First, we show that when the start dates from our baseline definition and the official preliminary approval date are both available (case 4), our TTD definition is also consistent with an alternative definition that takes the official preliminary approval date as the start of TTD. In panel A of figure A.1, we plot the distribution of the two TTD definitions for the 46,813 completed sections in case 4. The density mostly overlaps each other. In this case, using an alternative definition does not quantitatively matter for our results.

Second, we decide to drop case 2 from our analysis even though the preliminary approval date is available. In case 2, we do not directly observe the beginning date of raw land development. We typically only observe development from an *active* stage, i.e., after the raw land development is completed. Moreover, we tend to observe the preliminary approval date to be much earlier than when the section is first recorded in the data set. In panel B of figure A.1, we plot the distribution of TTD in case 2 using the preliminary approval date as the beginning of TTD, and compare that with the same TTD distribution using sections in case 4. We find that TTD using the preliminary approval date tends to be much longer in case 2. This suggests that development in case 2 are likely to have gone through other stages not assumed in our model, such as a clearer gap between the plannings of raw land development and structures development that leads to a lengthy pause. As our goal is to understand the supply-side determinants of TTD under a comprehensive development planning at the beginning, the lengthy TTD as well as the obscure starting date of raw land development in case 2 is problematic and we decided to drop this data.

B.5 Missing data adjustment

Table A.6 compares observable characteristics between projects with non-missing TTD measures and those for which TTD is unavailable. Lot sizes are broadly similar across the two groups, but projects included in the estimation sample contain more units and have higher townhouse or condo shares. Sampled projects are also located in denser counties with higher immigrant shares and somewhat lower educational attainment, while county GDP levels appear comparable. These differences suggest that TTD may be missing in a non-random manner correlated with underlying project and county characteristics.

To assess whether such non-random missingness affects our results, we conduct a sensitivity check that adjusts for potential sample-selection bias using inverse probability weighting. Specifically, we estimate a probit model where the dependent variable equals one for observations with non-missing TTD and zero otherwise. Explanatory variables include all characteristics used in the balance test. We then re-estimate the TTD measure using the inverse of the predicted inclusion probability as weights.

Figure A.2 plots the baseline and reweighted county-median TTD measures in logs. The points lie closely along the 45-degree line, indicating a high degree of alignment between the two measures. This evidence suggests that missing TTD observations do not materially distort our TTD measure based on observable characteristics, although we acknowledge that unobserved factors may still contribute to missingness.

C Section 4

C.1 Calibration of θ

To simulate the partial equilibrium model in section 3, we need to specify its driving forces. The stochastic discount factor, $\Lambda_{t|t+1}$, is set as constant, while log-deviations of both the real house price q_t and the real variable construction cost w_t are time-varying subject to the following first-order autoregressive processes:

$$\hat{q}_t = \rho_q \hat{q}_{t-1} + \sigma_q \varepsilon_{q,t}, \qquad \varepsilon_{q,t} \sim iid(0,1),$$
$$\hat{w}_t = \rho_w \hat{w}_{t-1} + \sigma_w \varepsilon_{w,t}, \qquad \varepsilon_{w,t} \sim iid(0,1).$$

We construct the real house price and the real variable construction cost series using the median sales price for new houses sold (Census Bureau) and the average hourly earnings of production and nonsupervisory employees in the construction sector (Bureau of Labor Statistics) respectively, both divided by the consumer price index (Bureau of Labor Statistics). We use the quarterly series between 1963q1 and 2019q4, apply the Hamilton filter for each series (i.e. a regression of the variable at quarter t on the four most recent values as of quarter $t-8$) to extract their cyclical components, and use those components to estimate the parameters ρ_q, σ_q, ρ_w, and σ_w based on an ordinary least squares approach.

Using these parameters, we simulate the time series of $\hat{q}_t$ and $\hat{w}_t$ for $t \in \{1, \cdots, 550\}$ and generate the implied housing market outcomes for each county i for a given value of θ. Using those, we construct the expected number of housing units in each period t conditional on investing the same construction inputs as in the initial period $t - P_i$:

$$\left[(1+P_i) \times (U_{i,t-P_i|t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}.$$

As the realized number of housing units completed in time t is I_t in the model, the log absolute difference between the two moments in each county i and period t is defined as $\hat{d}_{i,t}(\theta)$, where

$$\hat{d}_{i,t}(\theta) = \left| \log\left(I_{i,t}\right) - \left(\frac{\theta}{\theta-1}\right) \log\left((1+P_i) \times \left(U_{i,t-P_i|t}\right)^{\frac{\theta-1}{\theta}}\right) \right|.$$

Denoting the total number of counties as N, we collect simulated data for the log absolute difference conditional on θ, $\{\hat{d}_{i,t}(\theta)\}$, for $i \in \{1, \cdots, N\}$ and $t \in \{51, \cdots, 550\}$. For a given value of θ, we calculate the frequency of observations that $\hat{d}_{i,t}(\theta)$ is at least 5 percent, which is defined as $f(\theta)$:

$$f(\theta) \equiv \frac{\sum_{t=51}^{550} \sum_{i=1}^{N} 1(\hat{d}_{i,t}(\theta) \geq 5\%)}{500 \times N},$$

where $1(\cdot)$ is an indicator function where $1(x) = 1$ when x is true and $1(x) = 0$ otherwise.

We calibrate $\theta = \hat{\theta}$ such that $f(\hat{\theta})$ is equal to the empirical frequency of observations that the log difference between the planned and realized housing unit completions is at least 5 percent. In our empirical data, the frequency of sections to have their completed housing units different from their initial plan by at least 5 percent is 0.324, as shown in Table A.7. The frequency is obviously a declining function of this threshold. Note that our model's unit of observation for each development project is per county i in time t, whereas in the data, the unit of observation for each development project is a completed section in time t. As developers are representative for each county in our model, we cannot generate a distribution of sections within a county, which is also why we cannot calibrate different θs for each county.

C.2 Alternative measure of the long-run supply elasticity

Our baseline uses Saiz (2010) as the long-run housing supply elasticity. In this section, we alternatively use Baum-Snow and Han (2024) as the long-run housing supply elasticity and calculate the short-run housing supply elasticity to plot the equivalent of Figure 3 in the main text. Specifically, we rely on their quadratic finite mixture model estimates of supply elasticity for new housing units and take the average of the track level to each county. We drop estimates with negative values of the supply elasticity. Figure A.3 plots the equivalent of Figure 3 in the main text but using Baum-Snow and Han (2024) as the long-run supply elasticity. As discussed in Baum-Snow and Han (2024), the elasticities are on average much smaller than Saiz (2010), which implies an even smaller short-run elasticity than in the main text. Still, the distribution tends to be smaller in the coastal region relative to the sunbelt region. We find that this rank reverses in the short-run elasticity, as the sunbelt elasticity tends to be to the left of the coastal elasticity. These results are qualitatively consistent with our baseline using Saiz (2010).

D Section 5

D.1 Details of the local general equilibrium model

The local general equilibrium model described in Section 5 closes the partial equilibrium model of housing developers and the local government in Section 3 by incorporating local households and the nondurable goods sector. Since the local economy is in a monetary union, we assume that the interest rate is exogenous. As such, the bond and nondurable goods markets do not clear, analogous to small open economy models in the international macro literature. In the next part, the local general equilibrium model is extended to a two-region New Keynesian economy with nominal rigidities for nondurable goods, national interest rates set by a standard Taylor rule by the central bank, and the bond and nondurable good markets clearing at the national level.

D.1.1 Optimality conditions

We solve the model in Section 5 with a fixed interest rate ($R_t = \bar{R} = 1/\beta$). The optimality conditions of the local general equilibrium model could be summarized as below.

1. Endogenous variables (3(P+1)+11):
   (a) TTD (3(P+1)): $U_{t|t+p}$, $N_{t|t+p}$, $\mu_{t|t+p}$ for $p = 0, 1, \cdots, P$
   (b) Quantity (8): $M_{t|t+P}$, N_t, I_t, Y_t, $N_{n,t}$, H_t, C_t, B_{t+1}
   (c) Price (3): w_t, $w_{n,t}$, q_t
2. Exogenous variable (1): φ_t
3. Predetermined values: B_0, H_{-1}.

Equations for the endogenous variables:

$$U_{t|t+p} = N_{t|t+p}^{\alpha} M_{t+p-P|t+p}^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P, \tag{D.1}$$

$$\mu_{t|t+p} = \mathbb{E}_t \left[\beta^p q_{t+p} \left(\frac{I_{t+p}}{U_{t|t+p}} \right)^{\frac{1}{\theta}} \right] \quad \text{for } p = 0, 1, \cdots, P, \tag{D.2}$$

$$w_t = \alpha \mu_{t|t+p} M_{t+p-P|t+p}^{1-\alpha} N_{t|t+p}^{\alpha-1} \quad \text{for } p = 0, 1, \cdots, P, \tag{D.3}$$

$$I_t = \left(\sum_{p=0}^{P} U_{t-p|t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \tag{D.4}$$

$$N_t = \sum_{p=0}^{P} N_{t|t+p}, \tag{D.5}$$

$$Y_t = \bar{Z} N_{n,t}, \tag{D.6}$$

$$w_{n,t} = \bar{Z}, \tag{D.7}$$

$$H_t = (1-\delta)H_{t-1} + I_t, \tag{D.8}$$

$$1 + \frac{\psi_b}{\beta}B_{t+1} = \mathbb{E}_t\left[\frac{u_c(t+1)}{u_c(t)}\right], \tag{D.9}$$

$$-u_{nn}(t) = u_c(t)w_{n,t}, \tag{D.10}$$

$$-u_n(t) = u_c(t)w_t, \tag{D.11}$$

$$u_h(t) = u_c(t)q_t - \beta(1-\delta)\mathbb{E}_t u_c(t+1)q_{t+1}, \tag{D.12}$$

$$M_{t|t+P} = q_t^{\gamma}, \tag{D.13}$$

$$C_t + \beta B_{t+1} = w_{n,t}N_{n,t} + B_t. \tag{D.14}$$

Functional forms. For household utility, we follow Guren, McKay, Nakamura and Steinsson (2020) in assuming that nondurable consumption and leisure are substitutable in household utility in the style of Greenwood, Hercowitz and Huffman (1988). The housing demand shock φ_t is modeled in a Stone-Geary fashion:

$$u(C_t, H_t, N_{n,t}, N_t; \varphi_t) = \left[\frac{1}{1-\sigma}\left(C_t - \frac{\psi_n}{1+\nu}N_{n,t}^{1+\nu} - \frac{\psi}{1+\nu}N_t^{1+\nu}\right)^{\kappa}(H_t - \varphi_t)^{1-\kappa}\right]^{1-\sigma}.$$

By defining variables $\tilde{C}_t$ and $\tilde{H}_t$ as

$$\begin{aligned}
\tilde{C}_t &\equiv C_t - \frac{\psi_n}{1+\nu}N_{n,t}^{1+\nu} - \frac{\psi}{1+\nu}N_t^{1+\nu}, \\
\tilde{H}_t &\equiv H_t - \varphi_t,
\end{aligned}$$

we can express the marginal utilities as follows:

$$\begin{aligned}
u_c(t) &= \kappa\left(\tilde{C}_t^{\kappa}\tilde{H}_t^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{C}_t}, \\
u_{nn}(t) &= -\kappa\psi_n\left(\tilde{C}_t^{\kappa}\tilde{H}_t^{1-\kappa}\right)^{1-\sigma}\frac{N_{n,t}^{\nu}}{\tilde{C}_t}, \\
u_n(t) &= -\kappa\psi\left(\tilde{C}_t^{\kappa}\tilde{H}_t^{1-\kappa}\right)^{1-\sigma}\frac{N_t^{\nu}}{\tilde{C}_t}, \\
u_h(t) &= (1-\kappa)\left(\tilde{C}_t^{\kappa}\tilde{H}_t^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{H}_t}.
\end{aligned}$$

These marginal utilities imply that the labor supply conditions of households depend solely on the real wage:

$$\begin{aligned}
-u_{nn}(t) = u_c(t)w_{n,t} \quad &\Rightarrow \quad \psi_n N_{n,t}^{\nu} = w_{n,t}, \\
-u_n(t) = u_c(t)w_t \quad &\Rightarrow \quad \psi N_t^{\nu} = w_t.
\end{aligned}$$

Using the above functional forms, we can rewrite the equilibrium conditions for the endogenous variables $\{U_{t|t+p}, N_{t|t+p}, \mu_{t|t+p}\}_{p=0}^{P}, M_{t|t+P}, N_t, I_t, N_{n,t}, H_t, C_t, B_{t+1}, w_t, q_t$ as follows:

$$U_{t|t+p} = N_{t|t+p}^{\alpha}M_{t+p-P|t+p}^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P, \tag{D.15}$$

$$\mu_{t|t+p} = \mathbb{E}_t\left[\beta^p q_{t+p}\left(\frac{I_{t+p}}{U_{t|t+p}}\right)^{\frac{1}{\theta}}\right] \quad \text{for } p = 0, 1, \cdots, P, \tag{D.16}$$

$$w_t = \alpha\mu_{t|t+p} M_{t+p-P|t+p}^{1-\alpha} N_{t|t+p}^{\alpha-1} \quad \text{for } p = 0, 1, \cdots, P, \tag{D.17}$$

$$I_t = \left(\sum_{p=0}^{P} U_{t-p|t}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \tag{D.18}$$

$$N_t = \sum_{p=0}^{P} N_{t|t+p}, \tag{D.19}$$

$$H_t = (1-\delta)H_{t-1} + I_t, \tag{D.20}$$

$$1 + \frac{\psi_b}{\beta} B_{t+1} = \mathbb{E}_t\left[\frac{u_c(t+1)}{u_c(t)}\right], \tag{D.21}$$

$$\psi_n N_{n,t}^{\nu} = \bar{Z}, \tag{D.22}$$

$$\psi N_t^{\nu} = w_t, \tag{D.23}$$

$$u_h(t) = u_c(t)q_t - \beta(1-\delta)\mathbb{E}_t u_c(t+1)q_{t+1}, \tag{D.24}$$

$$M_{t|t+P} = q_t^{\gamma}, \tag{D.25}$$

$$C_t + \beta B_{t+1} = \bar{Z} N_{n,t} + B_t. \tag{D.26}$$

D.1.2 Steady state

The relevant steady states (with zero net bond holdings) are expressed as follows:

$$U_{0|p} = N_{0|p}^{\alpha} M_{0|P}^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P,$$

$$\mu_{0|p} = \beta^p q_0 \left(\frac{I_0}{U_{0|p}}\right)^{\frac{1}{\theta}} \quad \text{for } p = 0, 1, \cdots, P,$$

$$w_0 = \alpha\mu_{0|p} M_{0|P}^{1-\alpha} N_{0|p}^{\alpha-1} \quad \text{for } p = 0, 1, \cdots, P,$$

$$I_0 = \left(\sum_{p=0}^{P} U_{0|p}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

$$N_0 = \sum_{p=0}^{P} N_{0|p},$$

$$\delta H_0 = I_0,$$

$$\psi_n = \frac{\bar{Z}}{N_{n,0}^{\nu}},$$

$$\psi = \frac{w_0}{N_0^{\nu}},$$

$$\left(\frac{1-\kappa}{\kappa}\right)\frac{\tilde{C}_0}{\tilde{H}_0} = (1-\beta(1-\delta))q_0,$$

$$M_{0|P} = q_0^{\gamma},$$
$$C_0 = \bar{Z} N_{n,0}.$$

As such, the steady state ratios of TTD variables for each $p = 1, \cdots, P$ are as follows:

$$\frac{U_{0|p}}{U_{0|p-1}} = \left(\frac{N_{0|p}}{N_{0|p-1}}\right)^{\alpha},$$
$$\frac{\mu_{0|p}}{\mu_{0|p-1}} = \beta \left(\frac{U_{0|p-1}}{U_{0|p}}\right)^{\frac{1}{\theta}},$$
$$\frac{\mu_{0|p}}{\mu_{0|p-1}} = \left(\frac{N_{0|p}}{N_{0|p-1}}\right)^{1-\alpha}.$$

This implies the TTD ratios as follows:

$$\frac{N_{0|p}}{N_{0|p-1}} = \beta^{\frac{\theta}{\alpha+\theta(1-\alpha)}} \equiv \bar{\beta}_n,$$
$$\frac{U_{0|p}}{U_{0|p-1}} = \beta^{\frac{\theta\alpha}{\alpha+\theta(1-\alpha)}} \equiv \bar{\beta}_u,$$
$$\frac{\mu_{0|p}}{\mu_{0|p-1}} = \beta^{\frac{\theta(1-\alpha)}{\alpha+\theta(1-\alpha)}} \equiv \bar{\beta}_{\mu}.$$

Using these ratios, we can reduce the steady state expressions as follows:

$$U_{0|0} = N_{0|0}^{\alpha} M_{0|P}^{1-\alpha},$$
$$\mu_{0|0} = q_0 \left(\frac{I_0}{U_{0|0}}\right)^{\frac{1}{\theta}},$$
$$w_0 = \alpha \mu_{0|0} M_{0|P}^{1-\alpha} N_{0|0}^{\alpha-1},$$
$$I_0 = U_{0|0} \left[\sum_{p=0}^{P} \left(\bar{\beta}_u^{\frac{\theta-1}{\theta}}\right)^p\right]^{\frac{\theta}{\theta-1}} = U_{0|0} \left[\frac{1-\left(\bar{\beta}_u^{\frac{\theta-1}{\theta}}\right)^{P+1}}{1-\bar{\beta}_u^{\frac{\theta-1}{\theta}}}\right]^{\frac{\theta}{\theta-1}},$$
$$N_0 = N_{0|0} \left(\sum_{p=0}^{P} \bar{\beta}_n^p\right) = N_{0|0} \left[\frac{1-\bar{\beta}_n^{P+1}}{1-\bar{\beta}_n}\right],$$
$$\delta H_0 = I_0,$$
$$\psi_n = \frac{\bar{Z}}{N_{n,0}^{\nu}},$$
$$\psi = \frac{w_0}{N_0^{\nu}},$$
$$\left(\frac{1-\kappa}{\kappa}\right) \frac{\tilde{C}_0}{\tilde{H}_0} = (1-\beta(1-\delta)) q_0,$$

$$M_{0|P} = q_0^{\gamma},$$
$$C_0 = \bar{Z} N_{n,0}.$$

We calibrate the utility parameters ψ_n, ψ, and κ to target the given steady state values of N_n, N, and C/H. The following steady state values are similarly derived as above: $\boxed{B_0 = 0}$, $\boxed{\psi_n = \frac{\bar{Z}}{N_{n,0}^{\nu}}}$, $\boxed{C_0 = \bar{Z} N_{n,0}}$, $\boxed{H_0 = C_0/(C_0/H_0)}$, $\boxed{I_0 = \delta H_0}$, $\boxed{U_{0|0} = I_0 \left[\sum_{p=0}^{P} \left(\bar{\beta}_u^{\frac{\theta-1}{\theta}}\right)^p\right]^{-\frac{\theta}{\theta-1}}}$, $\boxed{N_{0|0} = N_0 \left(\sum_{p=0}^{P} \bar{\beta}_n^p\right)^{-1}}$, $\boxed{M_{0|P} = \left(\frac{U_{0|0}}{N_{0|0}^{\alpha}}\right)^{\frac{1}{1-\alpha}}}$, $\boxed{q_0 = M_{0|P}^{\frac{1}{\gamma}}}$, $\boxed{\mu_{0|0} = q_0 \left(\frac{I_0}{U_{0|0}}\right)^{\frac{1}{\theta}}}$, and $\boxed{w_0 = \alpha \mu_{0|0} M_{0|P}^{1-\alpha} N_{0|0}^{\alpha-1}}$. In turn, we obtain $\boxed{\psi = \frac{w_0}{N_0^{\nu}}}$. Plugging these into the following variables

$$\tilde{C}_0 = C_0 - \frac{\psi_n}{1+\nu} N_{n,0}^{1+\nu} - \frac{\psi}{1+\nu} N_0^{1+\nu}, \qquad \tilde{H}_0 = H_0 - \varphi_0,$$

we obtain κ by the equation $\boxed{\frac{1-\kappa}{\kappa} = (1 - \beta(1-\delta)) q_0 \frac{\tilde{H}_0}{\tilde{C}_0}}$. Finally, the remaining TTD variables for each $p = 1, \cdots, P$ are computed as $\boxed{N_{0|p} = N_{0|p-1} \bar{\beta}_n}$, $\boxed{U_{0|p} = U_{0|p-1} \bar{\beta}_u}$, $\boxed{\mu_{0|p} = \mu_{0|p-1} \bar{\beta}_{\mu}}$.

D.1.3 Log-linearized conditions

Define $B_{t+1}^* \equiv e^{B_{t+1}}$. Log-linearizing the variables at their respective steady state values, we get the following $3(P+1) + 11$ equations:

$$\hat{u}_{t|t+p} = \alpha \hat{n}_{t|t+p} + (1-\alpha) \hat{m}_{t+p-P|t+p} \quad \text{for } p = 0, 1, \cdots, P,$$
$$\hat{\mu}_{t|t+p} = \mathbb{E}_t \hat{q}_{t+p} + \frac{1}{\theta} \mathbb{E}_t \hat{i}_{t+p} - \frac{1}{\theta} \hat{u}_{t|t+p} \quad \text{for } p = 0, 1, \cdots, P,$$
$$\hat{w}_t = \hat{\mu}_{t|t+p} + (1-\alpha) \hat{m}_{t+p-P|t+p} + (\alpha - 1) \hat{n}_{t|t+p} \quad \text{for } p = 0, 1, \cdots, P,$$
$$\left[\frac{1 - \left(\bar{\beta}_u^{\frac{\theta-1}{\theta}}\right)^{P+1}}{1 - \bar{\beta}_u^{\frac{\theta-1}{\theta}}}\right] \hat{i}_t = \sum_{p=0}^{P} \left(\bar{\beta}_u^{\frac{\theta-1}{\theta}}\right)^p \hat{u}_{t-p|t},$$
$$\left(\frac{1 - \bar{\beta}_n^{P+1}}{1 - \bar{\beta}_n}\right) \hat{n}_t = \sum_{p=0}^{P} \left(\bar{\beta}_n\right)^p \hat{n}_{t|t+p},$$
$$\hat{h}_t = (1-\delta) \hat{h}_{t-1} + \delta \hat{i}_t,$$
$$\frac{\psi_b}{\beta} \hat{b}_{t+1}^* = [\kappa(1-\sigma) - 1](\mathbb{E}_t \hat{\tilde{c}}_{t+1} - \hat{\tilde{c}}_t) + (1-\kappa)(1-\sigma)(\mathbb{E}_t \hat{\tilde{h}}_{t+1} - \hat{\tilde{h}}_t),$$
$$\hat{n}_{n,t} = 0,$$
$$\nu \hat{n}_t = \hat{w}_t,$$
$$[1 - (\kappa - \kappa\sigma)\beta(1-\delta)] \hat{\tilde{c}}_t - [1 - (\kappa - \kappa\sigma)] \beta (1-\delta) \mathbb{E}_t \hat{\tilde{c}}_{t+1} =$$

$$[1-(\kappa+\sigma-\kappa\sigma)\beta(1-\delta)]\hat{\tilde{h}}_t-(1-(\kappa+\sigma-\kappa\sigma))\beta(1-\delta)\mathbb{E}_t\hat{\tilde{h}}_{t+1}+\hat{q}_t-\beta(1-\delta)\mathbb{E}_t\hat{q}_{t+1},$$

$$\hat{m}_{t|t+P}=\gamma\hat{q}_t,$$

$$\bar{C}\hat{c}_t+\beta\hat{b}^*_{t+1}=\bar{Z}\bar{N}_n\hat{n}_{n,t}+\hat{b}^*_t,$$

$$\bar{\tilde{C}}\hat{\tilde{c}}_t=\bar{C}\hat{c}_t-\psi_n\bar{N}_n^{1+\nu}\hat{n}_{n,t}-\psi\bar{N}^{1+\nu}\hat{n}_t,$$

$$\bar{\tilde{H}}\hat{\tilde{h}}_t=\bar{H}\hat{h}_t-\bar{\varphi}\hat{\varphi}_t.$$

The $3(P+1)+11$ endogenous variables are $\{\hat{u}_{t|t+p},\hat{n}_{t|t+p},\hat{\mu}_{t|t+p}\}_{p=0}^{P}$, $\hat{m}_{t|t+P}$, $\hat{q}_t$, $\hat{i}_t$, $\hat{w}_t$, $\hat{n}_t$, $\hat{h}_t$, $\hat{b}^*_{t+1}$, $\hat{\tilde{c}}_t$, $\hat{\tilde{h}}_t$, $\hat{n}_{n,t}$, $\hat{c}_t$.

D.1.4 Calibration

Table A.8 presents our calibration for the local GE model. The model is calibrated at a quarterly frequency with a time discount factor of $\beta=0.98^{\frac{1}{4}}$. We set the inverse of the Frisch elasticity (ν) to be 1 and the inverse of the elasticity of intertemporal substitution (σ) to be 2, following Guren et al. (2020). We follow the calibration procedure described in Section C.1 and set the elasticity of substitution across construction stages (θ) at 0.334 as our baseline.

The construction labor share (α) is set at 0.3852 which implies that a county with the smallest Saiz's supply elasticity has a permit elasticity at its lower bound of zero. Of note, this value is consistent with our estimate of the construction labor income of 37 percent in the KLEMS account when we assume that overhead labor costs are about 10 percent of the total labor cost. We set the preference weight on effective consumption (κ) as 0.75 to target a 25% expenditure share on housing, which is the average housing expenditure in the Consumer Expenditure Survey (CEX).

We set the depreciation rate on housing (δ) to 3% annually and the scale of the portfolio holding cost (ψ_b) to 0.001 as in Guren et al. (2020).

D.2 Empirical exercise

Regression of house price dynamics with short- and long-run elasticities. Section 5.2 in the main text presents the following regression:

$$\Delta\log\left(P_i/P_N\right)=\kappa_T\tilde{\mathcal{E}}^i_T+\Omega\mathbf{X_i}+u_i, \tag{D.27}$$

In Figure A.4, we run regressions with local controls, including the population share of college graduates, Bartik-type predicted industry employment growth, indicators for sand states and coastal states, the population share of immigrants, population density, and county-level real GDP growth.

In Figure A.5, we present regression results using Baum-Snow and Han (2024)'s measure of housing supply elasticity as the long-run supply elasticity to construct *T*-horizon housing supply elasticities. Specifically, we rely on their quadratic finite mixture model estimates of supply elasticity for new housing units. Consistent with our baseline specification, the regressions include controls for sand state and coastal state indicators.

D.3 Extension: Two-region general equilibrium model

In this part, we develop a two-region general equilibrium model to study the general equilibrium forces that govern new construction and house price responses when house price elasticities are different across regions. The model consists of two regions with local governments that belong to a monetary union. We refer to the regions as "home" and "foreign". The population of the entire economy is normalized to one and the population of the home region is denoted by n.

D.3.1 Household

Utility. Home households maximize their expected lifetime utility,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t, H_t, N_t, N_{c,t}; \varphi_t\right), \tag{D.28}$$

where C_t is the household consumption of a composite consumption good, H_t is the service flow of housing, N_t is the labor supply for the (non-construction) output sector, $N_{c,t}$ is the labor supply for the construction sector, and φ_t is an exogenous process for housing demand. The parameter β is the household subjective discount factor. Foreign households maximize the same utility and we use the asterisk (*) to denote foreign variables.

Consumption good. The composite consumption good of the home region, C_t, is a constant elasticity of substitution (CES) aggregator of final goods produced in both home and foreign regions:

$$C_t = \left[\phi^{\frac{1}{\eta}} \left(C_{H,t}\right)^{\frac{\eta-1}{\eta}} + (1-\phi)^{\frac{1}{\eta}} \left(C_{F,t}\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $C_{H,t}$ is home consumption of goods produced in the home region and $C_{F,t}$ is home consumption of goods produced in the foreign region. The parameter ϕ captures the degree of home bias in the demand for goods at the home region and η is the elasticity of substitution between home and foreign goods. Similarly, the composite consumption good of the foreign region, C_t^*, is

$$C_t^* = \left[(\phi^*)^{\frac{1}{\eta}} \left(C_{F,t}^*\right)^{\frac{\eta-1}{\eta}} + (1-\phi^*)^{\frac{1}{\eta}} \left(C_{H,t}^*\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where $C_{F,t}^*$ is foreign consumption of goods produced in the foreign region, $C_{H,t}^*$ is foreign consumption of goods produced in the home region, and ϕ^* captures the foreign region's degree of home bias.

The regional final goods, $C_{H,t}$ and $C_{F,t}$, are given by

$$C_{H,t} = \left(\int_0^1 \left(C_{H,t}(j)\right)^{\frac{\theta_c-1}{\theta_c}} dj\right)^{\frac{\theta_c}{\theta_c-1}} \text{ and } C_{F,t} = \left(\int_0^1 \left(C_{F,t}(j)\right)^{\frac{\theta_c-1}{\theta_c}} dj\right)^{\frac{\theta_c}{\theta_c-1}},$$

where $C_{H,t}(j)$ and $C_{F,t}(j)$ are the home consumption of variety $j \in [0,1]$ of home- and foreign-produced goods, respectively. We assume that goods markets are competitive and integrated across regions. Thus, home and foreign households face the same prices for each variety j of goods produced in the economy, denoted by $P_{H,t}(j)$ and $P_{F,t}(j)$.

Solving the cost minimization problem of home households, we obtain the following home region's demand for home- and foreign-produced goods:

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\theta_c} C_{H,t}, \quad C_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\theta_c} C_{F,t},$$

$$C_{H,t} = \phi \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t, \quad \text{and} \quad C_{F,t} = (1-\phi)\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t,$$

where

$$P_{H,t} = \left(\int_0^1 (P_{H,t}(j))^{1-\theta_c} dj\right)^{\frac{1}{1-\theta_c}}, \quad P_{F,t} = \left(\int_0^1 (P_{F,t}(j))^{1-\theta_c} dj\right)^{\frac{1}{1-\theta_c}},$$

and the home region's composite price level, P_t, is given by

$$P_t = \left[\phi P_{H,t}^{1-\eta} + (1-\phi) P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}.$$

Household's total consumption spending can be expressed as follows:

$$\int_0^1 \left[P_{H,t}(j)C_{H,t}(j) + P_{F,t}(j)C_{F,t}(j)\right] dj = P_t C_t.$$

Similarly, foreign region's demand for foreign- and home-produced goods are

$$C_{F,t}^*(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\theta_c} C_{F,t}^*, \quad C_{H,t}^*(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\theta_c} C_{H,t}^*,$$

$$C_{F,t}^* = \phi^* \left(\frac{P_{F,t}}{P_t^*}\right)^{-\eta} C_t^*, \quad \text{and} \quad C_{H,t}^* = (1-\phi^*)\left(\frac{P_{H,t}}{P_t^*}\right)^{-\eta} C_t^*,$$

where the foreign region's composite price level, P_t^*, is given by

$$P_t^* = \left[\phi^* P_{F,t}^{1-\eta} + (1-\phi^*) P_{H,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}.$$

Housing stock and flow. Households' service flow of housing is proportional to their housing stock. Home region's housing stock evolves over time by

$$H_t = (1-\delta) H_{t-1} + I_t, \tag{D.29}$$

where I_t is the home region's new housing investment and δ is the depreciation rate of the housing stock. We assume separate housing markets in each region. The foreign region's housing stock evolves over time in a similar fashion.

Labor supply. To introduce wage stickiness in the output sector, we follow Schmitt-Grohe and Uribe (2007) in assuming that labor decisions are made by a central authority within the home household which supplies labor monopolistically to a continuum of labor markets indexed by $k \in [0, 1]$. In each labor market k, the central authority faces a demand for labor, N_t^k, given by

$$N_t^k = \left(\frac{W_t^k}{W_t}\right)^{-\tilde{\eta}} N_t^d,$$

where W_t^k denotes the nominal wage charged changed by the central authority in labor market k at period t, W_t is the home region's nominal wage index in the output sector, and N_t^d is the population-adjusted aggregate labor demand by firms. This labor variety demand function is later derived from the firm's problem. The central authority takes W_t and N_t^d as exogenous and sets W_t^k to satisfy labor demand. The sum of labor supply to each labor market must be equal to the household's total labor supply

$$N_t = \int_0^1 N_t^k dk.$$

Combined with the labor variety demand function, we get

$$N_t = N_t^d \int_0^1 \left(\frac{w_t^k}{w_t}\right)^{-\tilde{\eta}} dk, \tag{D.30}$$

where we alternatively use real wage variables: $w_t^k = W_t^k / P_t$ and $w_t = W_t / P_t$. In the construction sector, we assume that labor markets are perfectly competitive. The foreign region's labor decision is made in a similar fashion.

Budget constraint. We assume incomplete financial markets across regions in the sense that households only have access to risk-free nominal bonds. The real flow budget constraint of the home region household is given by

$$C_t + q_t I_t + \frac{B_{t+1}}{R_t} + \frac{\psi_b}{2} B_{t+1}^2 = \int_0^1 w_t^k \left(\frac{w_t^k}{w_t}\right)^{-\tilde{\eta}} N_t^d dk + w_{c,t} N_{c,t} + \frac{B_t}{\pi_t} + \frac{1}{n} T_t + \frac{1}{n} \Phi_t, \tag{D.31}$$

where q_t is the real price of a housing unit (Q_t / P_t), B_{t+1} is real bond holdings, R_t is the risk-free nominal interest rate between periods t and $t+1$, $\pi_t = P_t / P_{t-1}$ is the price inflation rate, $w_{c,t} = W_{c,t} / P_t$ is the real wage in the construction sector, T_t is the real transfer from the local government, and $\Phi_t = \int_0^1 \Phi_t(j) dj$ is the aggregate of home firms' real profits. Both the transfer and the firms' profits are distributed equally to the households based on the home population. For real bond holding B_{t+1}, we impose a convex portfolio holding cost of $\psi_b B_{t+1}^2 / 2$ that the local government rebates equally to the households.

We introduce wage stickiness by assuming that the central authority in the household cannot set the nominal wage optimally with probability $\tilde{\omega} \in [0, 1]$ of a random labor market in each period. When the household cannot set the nominal wage optimally in market k, we assume $W_t^k = W_{t-1}^k$.

The foreign region household's budget constraint is also written analogously with the respective foreign variables with the stochastic discount factor that is common across regions. Moreover, transfers and the firms' profits are distributed equally to the foreign households based on the foreign population share $1-n$.

Household choice. The home household chooses C_t, I_t, H_t, B_{t+1}, w_t^k, N_t, and $N_{c,t}$ so as to maximize the utility function (D.28) subject to (D.30), (D.31), the wage stickiness assumption, and a no-Ponzi constraint, taking as given the processes q_t, w_t, R_t, π_t, N_t^d, T_t, Φ_t, and the initial conditions B_0 and H_{-1}. The Lagrangian associated with the home household problem is

$$
\begin{aligned}
\mathcal{L} =&\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{U(C_t, H_t, N_t, N_{c,t}; \varphi_t) \\
&+ \xi_t \left[\int_0^1 w_t^k \left(\frac{w_t^k}{w_t} \right)^{-\tilde{\eta}} N_t^d dk + w_{c,t} N_{c,t} + \frac{B_t}{\pi_t} + \frac{1}{n} T_t + \frac{1}{n} \Phi_t \right. \\
&\left. - C_t - q_t I_t - \frac{B_{t+1}}{R_t} - \frac{\psi_b}{2} B_{t+1}^2 \right] \\
&+ \frac{\xi_t w_t}{\tilde{\mu}_t} \left[N_t - N_t^d \int_0^1 \left(\frac{w_t^k}{w_t} \right)^{-\tilde{\eta}} dk \right] \\
&+ \xi_t \nu_t \left[(1-\delta) H_{t-1} + I_t - H_t \right] \} .
\end{aligned}
$$

The optimal first-order conditions with respect to C_t, B_{t+1}, N_t, $N_{c,t}$, H_t, I_t, and w_t^k, in that order, are given by

$$U_C(t) = \xi_t, \tag{D.32}$$

$$\xi_t (R_t^{-1} + \psi_b B_{t+1}) = \beta \mathbb{E}_t \frac{\xi_{t+1}}{\pi_{t+1}}, \tag{D.33}$$

$$-U_N(t) = \frac{\xi_t w_t}{\tilde{\mu}_t}, \tag{D.34}$$

$$-U_{Nc}(t) = \xi_t w_{c,t}, \tag{D.35}$$

$$U_H(t) = \xi_t \nu_t - \beta(1-\delta) \mathbb{E}_t \xi_{t+1} \nu_{t+1}, \tag{D.36}$$

$$q_t = \nu_t, \tag{D.37}$$

$$w_t^k = \begin{cases} \tilde{w}_t, & \text{if wages are set optimally in } t \\ w_{t-1}^k / \pi_t, & \text{otherwise} \end{cases}, \tag{D.38}$$

where $\tilde{w}_t$ is the real wage in the $1-\tilde{\omega}$ labor markets where the central authority can set wages optimally in period t. In equilibrium, the real wage and labor supply are identical across varieties that are allowed to update, which we denote as $\tilde{w}_t$ and $\tilde{N}_t$ respectively. Plugging this into the labor demand curve, we get $\tilde{w}_t^{\tilde{\eta}}\tilde{N}_t = w_t^{\tilde{\eta}}N_t^d$. For labor variety k with s periods after the last optimization, its real wage w_{t+s}^k becomes

$$w_{t+s}^k = \tilde{w}_t \prod_{\tau=1}^{s} \pi_{t+\tau}^{-1}.$$

Separating out the Lagrangian associated with setting wages for optimizing central authorities,

$$\mathcal{L}^w = \mathbb{E}_t \sum_{s=0}^{\infty} (\tilde{\omega}\beta)^s \xi_{t+s} N_{t+s}^d w_{t+s}^{\tilde{\eta}} \prod_{\tau=1}^{s} \pi_{t+\tau}^{\tilde{\eta}} \left[\tilde{w}_t^{1-\tilde{\eta}} \prod_{\tau=1}^{s} \pi_{t+\tau}^{-1} - \frac{w_{t+s}}{\tilde{\mu}_{t+s}} \tilde{w}_t^{-\tilde{\eta}} \right].$$

The first-order condition with respect to $\tilde{w}_t$ is

$$0 = \mathbb{E}_t \sum_{s=0}^{\infty} (\tilde{\omega}\beta)^s \xi_{t+s} N_{t+s}^d w_{t+s}^{\tilde{\eta}} \prod_{\tau=1}^{s} \pi_{t+\tau}^{\tilde{\eta}} \left[\left(\frac{\tilde{\eta}-1}{\tilde{\eta}} \right) \tilde{w}_t \prod_{\tau=1}^{s} \pi_{t+\tau}^{-1} - \frac{w_{t+s}}{\tilde{\mu}_{t+s}} \right].$$

Then, the optimal $\tilde{w}_t$ is given by

$$\tilde{w}_t = \frac{\tilde{\eta}}{\tilde{\eta}-1} \frac{f_{H,t}^a}{f_{H,t}^b}, \tag{D.39}$$

where

$$\begin{aligned} f_{H,t}^a &= \mathbb{E}_t \sum_{s=0}^{\infty} (\tilde{\omega}\beta)^s \xi_{t+s} N_{t+s}^d w_{t+s}^{\tilde{\eta}} \left(\prod_{\tau=1}^{s} \pi_{t+\tau}^{\tilde{\eta}} \right) \frac{w_{t+s}}{\tilde{\mu}_{t+s}}, \\ f_{H,t}^b &= \mathbb{E}_t \sum_{s=0}^{\infty} (\tilde{\omega}\beta)^s \xi_{t+s} N_{t+s}^d w_{t+s}^{\tilde{\eta}} \left(\prod_{\tau=1}^{s} \pi_{t+\tau}^{\tilde{\eta}-1} \right). \end{aligned}$$

Note that we can write $f_{H,t}^a$ and $f_{H,t}^b$ in the following recursive forms:

$$f_{H,t}^a = \xi_t N_t^d w_t^{\tilde{\eta}} \frac{w_t}{\tilde{\mu}_t} + \tilde{\omega}\beta \mathbb{E}_t \pi_{t+1}^{\tilde{\eta}} f_{H,t+1}^a, \tag{D.40}$$

$$f_{H,t}^b = \xi_t N_t^d w_t^{\tilde{\eta}} + \tilde{\omega}\beta \mathbb{E}_t \pi_{t+1}^{\tilde{\eta}-1} f_{H,t+1}^b. \tag{D.41}$$

D.3.2 Developer

The home region's representative developer produces new housing units, I_t, using construction inputs produced in current and previous periods, $\{U_{t-p|t}\}_{p=0,1,\cdots,P}$, where the subscript $t-p|t$ refers to stage-p construction input produced in period $t-p$ for new housing in period t. The production function is:

$$I_t = \left(\sum_{p=0}^{P} U_{t-p|t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \ \theta > 0,$$

where the parameter θ governs the substitutability of the different stages of construction.

Stage-by-stage building of the lot takes place using the following construction technology:

$$U_{t|t+p} = Z_{c,t} \left(N_{c,t|t+p}\right)^{\alpha} \left(M_{t+p-P|t+p}\right)^{1-\alpha},$$

where $Z_{c,t}$ is an exogenous shock to construction productivity, $N_{c,t|t+p}$ is time-t construction labor input for new housing to be completed in period $t+p$, and $M_{t+p-P|t+p}$ is the housing permit approved in period $t+p-P$ for new housing that is expected to be completed in period $t+p$.

Taking the real house price $q_t(= Q_t/P_t)$ as well as the real input prices $q_{M,t}$ and $w_{c,t}(= W_{c,t}/P_t)$ as given, the representative developer solves the following profit-maximization problem:

$$\max_{\{I_t, N_{c,t}, M_{t|t+P}, \{U_{t|t+p}, N_{t|t+p}\}_{p=0}^{P}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{0|t} \left(q_t I_t - q_{M,t} M_{t|t+P} - w_{c,t} N_{c,t}\right),$$

$$\text{subject to} \quad U_{t|t+p} = Z_{c,t} N_{c,t|t+p}^{\alpha} \left(M_{t+p-P|t+p}\right)^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P,$$

$$N_{c,t} = \sum_{p=0}^{P} N_{c,t|t+p},$$

$$I_t = \left(\sum_{p=0}^{P} U_{t-p|p}^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}.$$

The foreign region's representative developer solves an analogous problem.

D.3.3 Goods producer

Home region. A monopolistically competitive firm in the home region produces the tradable j-variety output $Y_{H,t}(j)$ using the following production technology:

$$Y_{H,t}(j) = Z_{H,t} N_{H,t}(j),$$

where $Z_{H,t}$ is the common total factor productivity across varieties and $N_{H,t}(j)$ is the labor input. The demand for the variety that the firm is required to satisfy, $Y_{H,t}^{d}(j)$, is as follows:

$$Y_{H,t}^{d}(j) = nC_{H,t}(j) + (1-n)C_{H,t}^{*}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\theta_c} \left(nC_{H,t} + (1-n)\, C_{H,t}^{*}\right),$$

where the second equality is derived from the consumption variety demand functions. The period-t real profit is given by

$$\Phi_{H,t}(j) = \frac{P_{H,t}(j)}{P_t} Y_{H,t}(j) - \frac{W_t N_{H,t}(j)}{P_t}.$$

Prices are sticky in the sense that firms can adjust its price only with probability $1-\omega$ in each period. As such, the profit maximization problem of the firm that is allowed to adjust its price is given by

$$\max_{P_{H,t}^{\diamond}} \mathbb{E}_t \sum_{s=0}^{\infty} \omega^s \Lambda_{t|t+s} \left[\frac{P_{H,t}^{\diamond}}{P_{t+s}} Y_{H,t+s}(j) - \frac{W_{t+s} N_{H,t+s}(j)}{P_{t+s}}\right],$$

subject to

$$
\begin{aligned}
Y_{H,t+s}(j) &= Z_{H,t+s} N_{H,t+s}(j), \\
Y_{H,t+s}(j) &\geq \left(\frac{P_{H,t}^{\diamond}}{P_{H,t+s}} \right)^{-\theta_c} \left(nC_{H,t+s} + (1-n) C_{H,t+s}^{*} \right).
\end{aligned}
$$

The labor input used by the j-variety producing firm is assumed to be a CES aggregate of a continuum of labor services, $N_{H,t}^{k}(j)$ for $k \in [0,1]$, in the following manner:

$$
N_{H,t}(j) = \left(\int_0^1 (N_{H,t}^{k}(j))^{1-1/\tilde{\eta}} dk \right)^{1/(1-1/\tilde{\eta})},
$$

where $\tilde{\eta} > 1$ is the elasticity of substitution across labor services. In each period, the demand for each labor variety is derived by minimizing the total labor cost, $\int_0^1 W_t^k N_{H,t}^k(j) dk$, while satisfying the above CES aggregation, where W_t^k is the nominal wage to labor variety k in period t. This implies the following labor variety demand:

$$
N_{H,t}^{k}(j) = \left(\frac{W_t^k}{W_t} \right)^{-\tilde{\eta}} N_{H,t}(j),
$$

where

$$
W_t = \left(\int_0^1 (W_t^k)^{1-\tilde{\eta}} dk \right)^{\frac{1}{1-\tilde{\eta}}}.
$$

It follows that $W_t N_{H,t}(j) = \int_0^1 W_t^k N_{H,t}^k(j) dk$.

Foreign region. A monopolistically competitive firm in the foreign region has a similar problem. We summarize the profit maximization problem of the j-variety firm that is allowed to adjust its price as follows:

$$
\max_{P_{F,t}^{\diamond}} \mathbb{E}_t \sum_{s=0}^{\infty} \omega^s \Lambda_{t|t+s}^{*} \left[\frac{P_{F,t}^{\diamond}}{P_{t+s}^{*}} Y_{F,t+s}(j) - \frac{W_{t+s}^{*} N_{F,t+s}(j)}{P_{t+s}^{*}} \right],
$$

subject to

$$
\begin{aligned}
Y_{F,t+s}(j) &= Z_{F,t+s} N_{F,t+s}(j), \\
Y_{F,t+s}(j) &\geq \left(\frac{P_{F,t}^{\diamond}}{P_{F,t+s}} \right)^{-\theta_c} \left(nC_{F,t+s} + (1-n) C_{F,t+s}^{*} \right).
\end{aligned}
$$

The labor input used by the firm in the foreign region is assumed to be a CES aggregate analogous to firms in the home region.

D.3.4 Fiscal and monetary policy

The supply of housing permits in each region is determined by its local government, which in turn is elastic to the region's equilibrium house price. In detail, the home and foreign local governments issue their respective housing permits, M_t and M_t^*, according to

$$M_{t|t+P} = q_t^{\gamma} \quad \text{and} \quad M^*_{t|t+P^*} = (q_t^*)^{\gamma^*}.$$

The respective real cost of a housing permit is $q_{M,t}$ and $q^*_{M,t}$. Local governments also levy portfolio holding costs to households. Local governments follow a balanced budget in each period:

$$T_t = q_{M,t} M_{t|t+P} + n\frac{\psi_b}{2} B_{t+1}^2 \quad \text{and} \quad T_t^* = q^*_{M,t} M^*_{t|t+P^*} + (1-n)\frac{\psi_b}{2} B_{t+1}^{*2},$$

where T_t and T_t^* are real transfers to households of home and foreign local governments.

Both regions are in a monetary union. Monetary policy follows a standard Taylor rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{\tilde{\pi}_t}{\bar{\pi}}\right)^{\phi_\pi},$$

where $\tilde{\pi}_t = (\pi_t)^n (\pi_t^*)^{1-n}$ is the population-weighted aggregate inflation, $\bar{\pi}$ is the aggregate inflation target, and $\bar{R}$ is the subsequent nominal interest rate target. The parameter ϕ_π is the Taylor coefficient on the deviation of inflation from target.

D.3.5 Market clearing

Labor market. Taking into account that the output sector wage adjustments are identical at all labor markets when allowed to change optimally, the home household's aggregate labor demand (D.30) could be expressed as

$$\begin{aligned}
N_t &= N_t^d \int_0^1 \left(\frac{W_t^k}{W_t}\right)^{-\tilde{\eta}} dk \\
&= N_t^d \left[(1-\tilde{\omega})\left(\frac{\tilde{W}_t}{W_t}\right)^{-\tilde{\eta}} + (1-\tilde{\omega})\tilde{\omega}\left(\frac{\tilde{W}_{t-1}}{W_t}\right)^{-\tilde{\eta}} + (1-\tilde{\omega})\tilde{\omega}^2\left(\frac{\tilde{W}_{t-2}}{W_t}\right)^{-\tilde{\eta}} + \cdots\right] \\
&= (1-\tilde{\omega}) N_t^d \sum_{s=0}^{\infty}\left[\tilde{\omega}^s \left(\frac{\tilde{W}_{t-s}}{W_t}\right)^{-\tilde{\eta}}\right].
\end{aligned}$$

This expression could be written as

$$N_t = \tilde{\Xi}_t N_t^d, \tag{D.42}$$

where

$$\tilde{\Xi}_t = (1-\tilde{\omega})\left(\frac{\tilde{w}_t}{w_t}\right)^{-\tilde{\eta}} + \tilde{\omega}\pi_t^{\tilde{\eta}}\left(\frac{\tilde{w}_{t-1}}{w_t}\right)^{-\tilde{\eta}} \tilde{\Xi}_{t-1}. \tag{D.43}$$

Note that $\tilde{\Xi}_t$ is the wage dispersion term that could be shown as bounded below by one. The aggregate wage index is also written as

$$
\begin{aligned}
W_t^{1-\tilde{\eta}} &= \int_0^1 (W_t^k)^{1-\tilde{\eta}} dk \\
&= (1-\tilde{\omega})\tilde{W}_t^{1-\tilde{\eta}} + (1-\tilde{\omega})\tilde{\omega}\tilde{W}_{t-1}^{1-\tilde{\eta}} + (1-\tilde{\omega})\tilde{\omega}^2\tilde{W}_{t-2}^{1-\tilde{\eta}} + \cdots \\
&= (1-\tilde{\omega})\tilde{W}_t^{1-\tilde{\eta}} + \tilde{\omega}W_{t-1}^{1-\tilde{\eta}},
\end{aligned}
$$

which implies the following recursive form:

$$
w_t^{1-\tilde{\eta}} = (1-\tilde{\omega})\tilde{w}_t^{1-\tilde{\eta}} + \tilde{\omega}\pi_t^{\tilde{\eta}-1} w_{t-1}^{1-\tilde{\eta}}. \tag{D.44}
$$

Labor market clearing in the output sector implies that the aggregation of all labor demand across firms adjusted by the population should be equal to the per household aggregate labor demand:

$$
N_t^d = \frac{1}{n}\int_0^1 N_{H,t}(j)dj. \tag{D.45}
$$

Labor market in the construction sector also clears. Moreover, the foreign labor market in both the output and construction sectors clear in a similar fashion.

Goods market. Defining per household aggregate goods production in each region as $Y_{H,t}$ and $Y_{F,t}$, we get

$$
Y_{H,t} \equiv \frac{1}{n}\int_0^1 Y_{H,t}(j)\,dj = Z_{H,t}N_t^d, \text{ and } Y_{F,t} \equiv \frac{1}{1-n}\int_0^1 Y_{F,t}(j)\,dj = Z_{F,t}N_t^{d*}.
$$

Then, the aggregated goods market clearing conditions are

$$
Y_{H,t} = \frac{1}{n}\int_0^1 Y_{H,t}^d(j)\,dj = \frac{1}{n}\tilde{Y}_{H,t}\Xi_{H,t}, \text{ and } Y_{F,t} = \frac{1}{1-n}\int_0^1 Y_{F,t}^d(j)\,dj = \frac{1}{1-n}\tilde{Y}_{F,t}\Xi_{F,t},
$$

where

$$
\tilde{Y}_{H,t} \equiv nC_{H,t} + (1-n)\,C_{H,t}^* \quad \text{and} \quad \tilde{Y}_{F,t} \equiv nC_{F,t} + (1-n)\,C_{F,t}^*,
$$

and $\Xi_{H,t}$ and $\Xi_{F,t}$ are the respective price dispersion terms:

$$
\Xi_{H,t} = \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\theta_c} dj \quad \text{and} \quad \Xi_{F,t} = \int_0^1 \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\theta_c} dj.
$$

Bond market. The nominal bond market clearing condition is

$$
nP_tB_{t+1} + (1-n)P_t^*B_{t+1}^{*2} = 0.
$$

Resource constraint. Under a monetary union with a common nominal interest rate, we can also derive the aggregated resource constraint by combining households' budget constraints:

$$
\begin{aligned}
nP_tC_t + (1-n)\,P_t^*C_t^* =& nW_tN_t^d + \int_0^1 \left(P_{H,t}\left(j\right)Y_{H,t}\left(j\right) - W_tN_{H,t}\left(j\right)\right)dj \\
&+ (1-n)\,W_t^*N_t^{d*} + \int_0^1 \left(P_{F,t}\left(j\right)Y_{F,t}\left(j\right) - W_t^*N_{F,t}\left(j\right)\right)dj,
\end{aligned}
$$

which implies

$$
nC_t + (1-n)\,C_t^* = \tilde{Y}_{H,t}\frac{P_{H,t}}{P_t} + \tilde{Y}_{F,t}\frac{P_{F,t}}{P_t^*}.
$$

Lastly, we define (population-weighted) aggregate output as follows:

$$
Y_t = nY_{H,t} + (1-n)\,Y_{F,t}.
$$

D.3.6 Functional forms and calibration

Following Guren et al. (2020), we assume that consumption and leisure are substitutable in the style of Greenwood et al. (1988), which eliminates the wealth effects of labor supply. We also model the housing demand shock using a Stone-Geary formulation:

$$
U\left(C_t, H_t, N_t, N_{c,t}; \varphi_t\right) = \left(\frac{\left(C_t - \frac{\psi}{1+\nu}N_t^{1+\nu} - \frac{\psi_c}{1+\nu}N_{c,t}^{1+\nu}\right)^{\kappa}\left(H_t - \varphi_t\right)^{1-\kappa}}{1-\sigma}\right)^{1-\sigma}
$$

Under this assumption, the households' marginal utilities are defined as follows:

$$
\begin{aligned}
U_{c,t} &= \kappa\left(\left(\tilde{C}_t\right)^{\kappa}\left(\tilde{H}_t\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{C}_t} \\
U_{n,t} &= -\kappa\psi\left(\left(\tilde{C}_t\right)^{\kappa}\left(\tilde{H}_t\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{C}_t}N_t^{\nu} \\
U_{nc,t} &= -\kappa\psi_c\left(\left(\tilde{C}_t\right)^{\kappa}\left(\tilde{H}_t\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{C}_t}N_{c,t}^{\nu} \\
U_{h,t} &= (1-\kappa)\left(\left(\tilde{C}_t\right)^{\kappa}\left(\tilde{H}_t\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\tilde{H}_t}
\end{aligned}
$$

where

$$
\tilde{C}_t = C_t - \frac{\psi}{1+\eta}N_t^{1+\nu} - \frac{\psi_c}{1+\eta}N_{c,t}^{1+\nu} \text{ and } \tilde{H}_t = H_t - \varphi_t
$$

We pick parameter values based on long-run averages or from the literature. Table A.9 presents our calibration.

D.3.7 Model responses to shocks

We present the impulse response functions for house prices and housing investment with regards to a common housing demand shock in our two-region general equilibrium model. These examples show that the results for our local general equilibrium model extends to the two-region general equilibrium model. In all cases, we assume that the persistence parameter of the housing demand shock is 0.95.

In Figure A.6, we present the result when the home and foreign regions are only different in terms of the long-run elasticity parameters $\gamma > \gamma^*$. In the left panel, we observe that the partial equilibrium housing supply elasticity is the same in horizons lower than 12 quarters. Afterwards, housing supply elasticity is higher in the home region, consistent with its higher long-run elasticity. The second panel shows that house prices in the foreign region respond higher than in the home region, consistent with the result of the first panel. Note that even though the short-run elasticities are common across the two regions, house price responses in this case are likely to take into account supply elasticities beyond 12 quarters. The third panel shows the housing investment response in the two regions. Housing investment at an after 12 quarters is much higher in the home region compared to the foreign region. In this example, we observe that the long-run elasticity difference drives the difference in house prices both in business-cycle frequency and in the long run.

In Figure A.7, we conduct the same exercise under a different calibration. In this case, the home and foreign regions are only different in terms of TTD ($P < P^*$). In the left panel, we observe that the partial equilibrium housing supply elasticity is different at shorter horizons, but begins converging after 24 quarters. Note that the long-run housing supply elasticities are the same in both regions. The second panel shows that housing prices in the foreign region respond higher than in the home region, again consistent with the result of the first panel. Note that even though the long-run elasticities are common across the two regions, house price responses in this case are consistent with the supply elasticities in the short to medium run. The third panel shows the housing investment response in the two regions consistent with the difference in TTD. In this example, we observe that TTD alone can drive a sizable difference in the house price response, consistent with the implied gap in the short- to medium-run housing supply elasticities.

Figures A.8 and A.9 presents the responses when both the long-run elasticities and TTD are different in the two regions. Note that both the long-run elasticities and TTD are within the range of our sample counties, suggesting that our calibration exercise in these examples are sensible. A key takeaway is that TTD can work as both widening or reversing the price response difference between two regions. In the second case with reversal, housing supply elasticity is lower in the home region despite the higher long-run supply elasticity, as TTD is much higher at home. The model impulse responses in this case shows that house price responses become higher in the home region for about the first seven quarters, until house prices in the foreign region becomes higher consistent with its lower long-run elasticity. These examples suggest the need to take into account both the short- to long-run housing supply elasticities in accounting for house price responses to a common housing demand shock.

D.3.8 Details: Equilibrium conditions

We first define variables for relative prices and inflation:

$$\pi_t = \frac{P_{t+1}}{P_t},\ \pi_t^* = \frac{P_{t+1}^*}{P_t^*},\ X_t = \frac{P_t^*}{P_t},\ X_{H,t} = \frac{P_{H,t}}{P_t},\ X_{F,t} = \frac{P_{F,t}}{P_t^*},$$

$$\pi_{H,t} = \frac{X_{H,t}}{X_{H,t-1}}\pi_t,\ \pi_{F,t} = \frac{X_{F,t}}{X_{F,t-1}}\pi_t^*,\ p_{H,t}^{\diamond}\text{=}\frac{P_{H,t}^{\diamond}}{P_{H,t}},\ p_{F,t}^{\diamond}\text{=}\frac{P_{F,t}^{\diamond}}{P_{H,t}}$$

Variables

- (Home) Non-construction (7 variables): $\left\{C_{H,t}, C_{F,t}, C_t, \tilde{\mu}_t, N_t, N_t^d, \tilde{Y}_{H,t}\right\}$
- (Home) Construction ($7+3P$ variables):
$\left\{N_{c,t}, H_t, I_t, \{U_{t-p|t}\}_{p=0}^P, \{N_{c,t|t+p}\}_{p=0}^P, \{\mu_{t|t+p}\}_{p=0}^P, q_t, q_{M,t}, w_{c,t}, M_t\right\}$
- (Foreign) Non-construction (7 variables): $\left\{C_{H,t}^*, C_{F,t}^*, C_t^*, \tilde{\mu}_t^*, N_t^*, N_t^{d*}, \tilde{Y}_{F,t}\right\}$
- (Foreign) Construction ($7+3P^*$ variables):
$\left\{N_{c,t}^*, H_t^*, I_t^*, \{U_{t-p|t}^*\}_{p=0}^{P^*}, \{N_{c,t|t+p}^*\}_{p=0}^{P^*}, \{\mu_{t|t+p}^*\}_{p=0}^{P^*}, q_t^*, q_{M,t}^*, w_{c,t}^*, M_t^*\right\}$
- Nominal variables (17 variables):
$\left\{\pi_t, \pi_t^*, \pi_{H,t}, \pi_{F,t}, mc_{H,t}, mc_{F,t}, X_t, X_{H,t}, X_{F,t}, \Xi_{H,t}, \Xi_{F,t}, p_{H,t}^{\diamond}, p_{F,t}^{\diamond}, \tilde{Z}_{H,t}^a, \tilde{Z}_{H,t}^b, \tilde{Z}_{F,t}^a, \tilde{Z}_{H,t}^b\right\}$
- Wages (10 variables): $\left\{w_t, w_t^*, \tilde{w}_t, \tilde{w}_t^*, f_{H,t}^a, f_{H,t}^b, f_{F,t}^a, f_{F,t}^b, \tilde{\Xi}_t, \tilde{\Xi}_t^*\right\}$
- Aggregate variables (3 variables): $\{R_t, \tilde{\pi}_t, Y_t\}$
- Marginal utilities (8 variables): $\{U_{c,t}, U_{n,t}, U_{nc,t}, U_{h,t}, U_{c^*,t}, U_{n^*,t}, U_{nc^*,t}, U_{h^*,t}\}$

Notices that the number of variables excluding marginal utility variables is $58+3P+3P^*$, which is the same with the number of equations shown below (C.1)-(C.64).

- (Home) Home demand for home- and foreign-produced goods

$$C_{H,t} = \phi\left(X_{H,t}\right)^{-\eta} C_t \tag{D.46}$$
$$C_{F,t} = (1-\phi)\left(X_{F,t}X_t\right)^{-\eta} C_t \tag{D.47}$$

- (Home) Supply and demand for non-construction labor

$$-U_{n,t} = w_t \frac{U_{c,t}}{\tilde{\mu}_t} \tag{D.48}$$
$$N_t = N_t^d \tilde{\Xi}_t \tag{D.49}$$

- (Home) Wage dispersion

$$\tilde{\Xi}_t = (1-\tilde{\omega}) \left(\frac{\tilde{w}_t}{w_t} \right)^{-\tilde{\eta}} + \tilde{\omega} \pi_t^{\tilde{\eta}} \left(\frac{\tilde{w}_{t-1}}{w_t} \right)^{-\tilde{\eta}} \tilde{\Xi}_{t-1} \tag{D.50}$$

- (Home) Wage index

$$w_t^{1-\tilde{\eta}} = (1-\tilde{\omega}) \, \tilde{w}_t^{1-\tilde{\eta}} + \tilde{\omega} \left(\frac{w_{t-1}}{\pi_t} \right)^{1-\tilde{\eta}} \tag{D.51}$$

- (Home) Wage Phillips curve

$$\tilde{w}_t = \frac{\tilde{\eta}}{\tilde{\eta}-1} \frac{f_{H,t}^a}{f_{H,t}^b}, \tag{D.52}$$

$$f_{H,t}^a = N_t^d w_t^{\tilde{\eta}} \frac{w_t}{\tilde{\mu}_t} + \tilde{\omega} \beta \mathbb{E}_t \left[\frac{U_{c,t+1}}{U_{c,t}} \pi_{t+1}^{\tilde{\eta}} f_{H,t+1}^a \right] \tag{D.53}$$

$$f_{H,t}^b = N_t^d w_t^{\tilde{\eta}} + \tilde{\omega} \beta \mathbb{E}_t \left[\frac{U_{c,t+1}}{U_{c,t}} \pi_{t+1}^{\tilde{\eta}-1} f_{H,t+1}^b \right] \tag{D.54}$$

- (Home) Housing demand

$$\frac{U_{h,t}}{U_{c,t}} = q_t - \beta \, (1-\delta) \, \mathbb{E}_t \left[\frac{U_{c,t+1}}{U_{c,t}} q_{t+1} \right] \tag{D.55}$$

- (Home) Supply of construction labor

$$-U_{nc,t} = w_{c,t} U_{c,t} \tag{D.56}$$

- (Home) Housing accumulation

$$H_t = (1-\delta) \, H_{t-1} + I_t \tag{D.57}$$

- (Home) Housing construction function

$$I_t = \left(\sum_{p=0}^{P} U_{t-p|t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{D.58}$$

- (Home) Demand for p-period ahead construction labor

$$w_{c,t} = \alpha \mu_{t|t+p} \frac{U_{t|t+p}}{N_{c,t|t+p}} \quad \text{for } p = 0, 1, \cdots, P \tag{D.59}$$

- (Home) Demand for p-period ahead construction input

$$\mu_{t|t+p} = \mathbb{E}_t \left[\beta^p \frac{U_{c,t+p}}{U_{c,t}} q_{t+p} \left(\frac{I_{t+p}}{U_{t|t+p}} \right)^{\frac{1}{\theta}} \right] \quad \text{for } p = 0, 1, \cdots, P \tag{D.60}$$

- (Home) Demand for housing permit

$$q_{M,t} = (1-\alpha)\,\mathbb{E}_t \left[\beta^P \frac{U_{c,t+P}}{U_{c,t}} q_{t+P} \sum_{p=0}^{P} \left(\frac{I_{t+P}}{U_{t+p|t+P}} \right)^{\frac{1}{\theta}} \frac{U_{t+p|t+P}}{M_{t|t+P}} \right] \tag{D.61}$$

- (Home) Production of p-period ahead construction input

$$U_{t|t+p} = Z_{c,t} N_{c,t|t+p}^{\alpha} \left(M_{t+p-P|t+p} \right)^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P \tag{D.62}$$

- (Home) Demand for total construction labor

$$N_{c,t} = \sum_{p=0}^{P} N_{c,t|t+p} \tag{D.63}$$

- (Home) Housing permit supply

$$M_{t|t+P} = (q_t)^{\gamma} \tag{D.64}$$

- (Home) Supply and demand for non-construction output

$$\tilde{Y}_{H,t} = nC_{H,t} + (1-n)\,C^*_{H,t} \tag{D.65}$$

$$\tilde{Y}_{H,t}\Xi_{H,t} = nZ_{H,t}N_t^d \tag{D.66}$$

- (Home) Price dispersion

$$\Xi_{H,t} = (1-\omega)\left(p^{\diamond}_{H,t}\right)^{-\theta_c} + \omega\left(\pi_{H,t}\right)^{\theta_c}\Xi_{H,t-1} \tag{D.67}$$

- (Home) Aggregate price index

$$\left(\pi_{H,t}\right)^{1-\theta_c} = (1-\omega)\left(p^{\diamond}_{H,t}\right)^{1-\theta_c} + \omega \tag{D.68}$$

- (Home) Phillips curve

$$p^{\diamond}_{H,t} = \frac{\theta_c}{\theta_c - 1}\frac{\tilde{Z}^a_{H,t}}{\tilde{Z}^b_{H,t}} \tag{D.69}$$

$$\tilde{Z}^a_{H,t} = mc_{H,t}\tilde{Y}_{H,t} + \beta\omega\mathbb{E}_t\left[\frac{U_{c,t+1}}{U_{c,t}}\left(\pi_{H,t+1}\right)^{\theta_c}\tilde{Z}^a_{H,t+1}\right] \tag{D.70}$$

$$\tilde{Z}^b_{H,t} = X_{H,t}\tilde{Y}_{H,t} + \beta\omega\mathbb{E}_t\left[\frac{U_{c,t+1}}{U_{c,t}}\left(\pi_{H,t+1}\right)^{\theta_c-1}\tilde{Z}^b_{H,t+1}\right] \tag{D.71}$$

- (Home) Marginal cost

$$mc_{H,t} = \frac{w_t}{Z_{H,t}} \tag{D.72}$$

- (Foreign) Foreign demand for home- and foreign-produced good

$$C^*_{F,t} = \phi^* \left(X_{F,t}\right)^{-\eta} C^*_t \tag{D.73}$$

$$C^*_{H,t} = \left(1-\phi^*\right) \left(\frac{X_{H,t}}{X_t}\right)^{-\eta} C^*_t \tag{D.74}$$

- (Foreign) Supply and demand for non-construction labor

$$-U_{n^*,t} = w^*_t \frac{U_{c^*,t}}{\tilde{\mu}^*_t} \tag{D.75}$$

$$N^*_t = N^{d*}_t \tilde{\Xi}^*_t \tag{D.76}$$

- (Foreign) Wage dispersion

$$\tilde{\Xi}^*_t = \left(1-\tilde{\omega}\right) \left(\frac{\tilde{w}^*_t}{w^*_t}\right)^{-\tilde{\eta}} + \tilde{\omega}\pi^{\tilde{\eta}}_t \left(\frac{\tilde{w}^*_{t-1}}{w^*_t}\right)^{-\tilde{\eta}} \tilde{\Xi}^*_{t-1} \tag{D.77}$$

- (Foreign) Wage index

$$\left(w^*_t\right)^{1-\tilde{\eta}} = \left(1-\tilde{\omega}\right) \left(\tilde{w}^*_t\right)^{1-\tilde{\eta}} + \tilde{\omega} \left(\frac{w^*_{t-1}}{\pi^*_t}\right)^{1-\tilde{\eta}} \tag{D.78}$$

- (Foreign) Wage Phillips curve

$$\tilde{w}^*_t = \frac{\tilde{\eta}^*}{\tilde{\eta}^*-1} \frac{f^a_{F,t}}{f^b_{F,t}}, \tag{D.79}$$

$$f^a_{F,t} = N^{d*}_t \left(w^*_t\right)^{\tilde{\eta}} \frac{w^*_t}{\tilde{\mu}^*_t} + \tilde{\omega}\beta\mathbb{E}_t \left[\frac{U^*_{c,t+1}}{U_{c,t}} \left(\pi^*_{t+1}\right)^{\tilde{\eta}} f^a_{F,t+1}\right] \tag{D.80}$$

$$f^b_{F,t} = N^{d*}_t \left(w^*_t\right)^{\tilde{\eta}} + \tilde{\omega}\beta\mathbb{E}_t \left[\frac{U^*_{c,t+1}}{U_{c,t}} \left(\pi^*_{t+1}\right)^{\tilde{\eta}-1} f^b_{F,t+1}\right] \tag{D.81}$$

- (Foreign) Housing demand

$$\frac{U_{h^*,t}}{U_{c^*,t}} = q^*_t - \beta\left(1-\delta\right)\mathbb{E}_t \left[\frac{U_{c^*,t+1}}{U_{c^*,t}} q^*_{t+1}\right] \tag{D.82}$$

- (Foreign) Supply of construction labor

$$-U_{nc^*,t} = w^*_{c,t} U_{c^*,t} \tag{D.83}$$

- (Foreign) Housing accumulation

$$H_t^* = (1-\delta) H_{t-1}^* + I_t^* \tag{D.84}$$

- (Foreign) Housing construction function

$$I_t^* = \left(\sum_{p=0}^{P^*} \left(U_{t-p|t}^* \right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{D.85}$$

- (Foreign) Demand for p-period ahead construction labor

$$w_{c,t}^* = \alpha \mu_{t|t+p}^* \frac{U_{t|t+p}^*}{N_{c,t|t+p}^*} \text{ for } p = 0, 1, \cdots, P^* \tag{D.86}$$

- (Foreign) Demand for p-period ahead construction input

$$\mu_{t|t+p}^* = \mathbb{E}_t \left[\beta^p \frac{U_{c^*,t+p}}{U_{c^*,t}} q_{t+p}^* \left(\frac{I_{t+p}^*}{U_{t|t+p}^*} \right)^{\frac{1}{\theta}} \right] \text{ for } p = 0, 1, \cdots, P^* \tag{D.87}$$

- (Foreign) Demand for housing permit

$$q_{M,t}^* = (1-\alpha) \mathbb{E}_t \left[\beta^{P^*} \frac{U_{c^*,t+P^*}}{U_{c^*,t}} q_{t+P^*}^* \sum_{p=0}^{P^*} \left(\frac{I_{t+P^*}}{U_{t+p|t+P^*}^*} \right)^{\frac{1}{\theta}} \frac{U_{t+p|t+P^*}^*}{M_{t|t+P^*}^*} \right] \tag{D.88}$$

- (Foreign) Production of p-period ahead construction input

$$U_{t|t+p}^* = Z_{c,t}^* \left(N_{c,t|t+p}^* \right)^{\alpha} \left(M_{t+p-P^*|t+p}^* \right)^{1-\alpha} \text{ for } p = 0, 1, \cdots, P^* \tag{D.89}$$

- (Foreign) Demand of total construction labor

$$N_{c,t}^* = \sum_{p=0}^{P} N_{c,t|t+p}^* \tag{D.90}$$

- (Foreign) Housing permit supply

$$M_{t|t+P^*}^* = (q_t^*)^{\gamma^*} \tag{D.91}$$

- (Foreign) Supply and demand for non-construction output

$$\tilde{Y}_{F,t} = nC_{F,t} + (1-n) C_{F,t}^* \tag{D.92}$$

$$\tilde{Y}_{F,t} \Xi_{F,t} = (1-n) Z_{F,t} N_t^{d*} \tag{D.93}$$

- (Foreign) Price dispersion

$$\Xi_{F,t} = (1-\omega)\left(p^{\diamond}_{F,t}\right)^{-\theta_c} + \omega\left(\pi_{F,t}\right)^{\theta_c}\Xi_{F,t-1} \tag{D.94}$$

- (Foreign) Aggregate price index

$$\left(\pi_{F,t}\right)^{1-\theta_c} = (1-\omega)\left(p^{\diamond}_{F,t}\right)^{1-\theta_c} + \omega \tag{D.95}$$

- (Foreign) Phillips curve

$$p^{\diamond}_{F,t} = \frac{\theta_c}{\theta_c - 1}\frac{\tilde{Z}^a_{F,t}}{\tilde{Z}^b_{F,t}} \tag{D.96}$$

$$\tilde{Z}^a_{F,t} = mc_{F,t}\tilde{Y}_{F,t} + \beta\omega\mathbb{E}_t\left[\frac{U_{c^*,t+1}}{U_{c^*,t}}\left(\pi_{F,t+1}\right)^{\theta_c}\tilde{Z}^a_{F,t+1}\right] \tag{D.97}$$

$$\tilde{Z}^b_{F,t} = X_{F,t}\tilde{Y}_{F,t} + \beta\omega\mathbb{E}_t\left[\frac{U_{c^*,t+1}}{U_{c^*,t}}\left(\pi_{F,t+1}\right)^{\theta_c - 1}\tilde{Z}^b_{F,t+1}\right] \tag{D.98}$$

- (Foreign) Marginal cost

$$mc_{F,t} = \frac{w^*_t}{Z_{F,t}} \tag{D.99}$$

- Common stochastic discount factor (“Backus-Smith”)

$$\frac{U_{c^*,t}}{U_{c,t}} = X_t \tag{D.100}$$

- Euler equation and nominal interest rate

$$1 = \beta R_t \mathbb{E}_t\left[\frac{U_{c,t+1}}{U_{c,t}}\frac{1}{\pi_{t+1}}\right] \tag{D.101}$$

- Aggregate output

$$Y_t = nZ_{H,t}N^d_t + (1-n)\,Z_{F,t}N^{d*}_t \tag{D.102}$$

- Monetary policy

$$\frac{R_t}{\bar{R}} = \left(\frac{\tilde{\pi}_t}{\bar{\pi}}\right)^{\phi} \tag{D.103}$$

- Aggregate inflation

$$\tilde{\pi}_t = \left(\pi_t\right)^n\left(\pi^*_t\right)^{1-n} \tag{D.104}$$

- Resource constraint

$$nC_t + (1-n)\,C^*_t = \tilde{Y}_{H,t}X_{H,t} + \tilde{Y}_{F,t}X_{F,t} \tag{D.105}$$

- Relative price relationship

$$1 = \phi \left(X_{H,t}\right)^{1-\eta} + (1-\phi)\left(X_{F,t} X_t\right)^{1-\eta} \tag{D.106}$$

- Inflation relationship

$$\pi_t^* = \frac{X_t}{X_{t-1}} \pi_t \tag{D.107}$$

$$\pi_{H,t} = \frac{X_{H,t}}{X_{H,t-1}} \pi_t \tag{D.108}$$

$$\pi_{F,t} = \frac{X_{F,t}}{X_{F,t-1}} \pi_t^* \tag{D.109}$$

D.3.9 Details: Steady state

Baseline GHH preference for household utility.

$$\begin{aligned}
\bar{U}_c &= \kappa \left(\left(\bar{\tilde{C}}\right)^{\kappa}\left(\bar{\tilde{H}}\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\bar{\tilde{C}}}, \\
\bar{U}_n &= -\kappa\psi \left(\left(\bar{\tilde{C}}\right)^{\kappa}\left(\bar{\tilde{H}}\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\bar{\tilde{C}}}\bar{N}^{\nu}, \\
\bar{U}_{nc} &= -\kappa\psi_c \left(\left(\bar{\tilde{C}}\right)^{\kappa}\left(\bar{\tilde{H}}\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\bar{\tilde{C}}}\bar{N}_c^{\nu}, \\
\bar{U}_h &= (1-\kappa) \left(\left(\bar{\tilde{C}}\right)^{\kappa}\left(\bar{\tilde{H}}\right)^{1-\kappa}\right)^{1-\sigma}\frac{1}{\bar{\tilde{H}}},
\end{aligned}$$

where

$$\begin{aligned}
\bar{\tilde{C}} &= \bar{C} - \frac{\psi}{1+\nu}\bar{N}^{1+\nu} - \frac{\psi_c}{1+\nu}\bar{N}_c^{1+\nu}, \\
\bar{\tilde{H}} &= \bar{H}_t - \bar{\varphi}
\end{aligned}$$

- (Home) Home demand for home- and foreign-produced goods

$$\begin{aligned}
\bar{C}_H &= \phi\left(\bar{X}_H\right)^{-\eta}\bar{C} \\
\bar{C}_F &= (1-\phi)\left(\bar{X}_F \bar{X}\right)^{-\eta}\bar{C}
\end{aligned}$$

- (Home) Supply and demand for non-construction labor

$$\bar{\tilde{\mu}} = \frac{\tilde{\eta}}{\tilde{\eta}-1}$$

$$\begin{aligned}
-\bar{U}_n = \bar{w}\frac{\bar{U}_c}{\bar{\tilde{\mu}}} &\Leftrightarrow \psi = \frac{1}{\bar{\tilde{\mu}}}\frac{\bar{w}}{\bar{N}^{\nu}} \\
\bar{N} &= \bar{N}^d
\end{aligned}$$

- (Home) Wage dispersion

$$\bar{\tilde{\Xi}} = 1$$

- (Home) Wage index

$$\bar{w} = \bar{\tilde{w}}$$

- (Home) Wage Phillips curve

$$\bar{\tilde{w}} = \frac{\tilde{\eta}}{\tilde{\eta} - 1} \frac{\bar{f}_H^a}{\bar{f}_H^b},$$

$$\bar{f}_H^a = \frac{1}{1 - \tilde{\omega}\beta} \bar{N}^d \bar{w}^{1+\tilde{\eta}} \frac{1}{\bar{\tilde{\mu}}}$$

$$\bar{f}_H^b = \frac{1}{1 - \tilde{\omega}\beta} \bar{N}^d \bar{w}^{\tilde{\eta}}$$

- (Home) Housing demand

$$\left(\frac{1-\kappa}{\kappa}\right) \frac{\bar{\tilde{C}}}{\bar{\tilde{H}}} = \left(1 - \left(1 - \delta\right)\beta\right) \bar{q}$$

- (Home) Supply of construction labor

$$-\bar{U}_{nc} = \bar{w}_c \bar{U}_c$$

- (Home) Housing accumulation

$$\delta \bar{H} = \bar{I}$$

- (Home) Housing construction function

$$\bar{I} = \left(\sum_{p=0}^{P} \bar{U}_p^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}$$

- (Home) Demand for p-period ahead construction labor

$$\bar{w}_c = \alpha \bar{\mu}_p \frac{\bar{U}_p}{\bar{N}_{c,p}} \quad \text{for } p = 0, 1, \cdots, P$$

- (Home) Demand for p-period ahead construction input

$$\bar{\mu}_p = \beta^p \bar{q} \left(\frac{\bar{I}}{\bar{U}_p}\right)^{\frac{1}{\theta}} \quad \text{for } p = 0, 1, \cdots, P$$

- (Home) Demand for housing permit

$$
\begin{aligned}
\bar{q}_M &= (1-\alpha)\left[\sum_{p=0}^{P} \beta^p \bar{\mu}_{P-p} \frac{\bar{U}_{P-p}}{\bar{M}}\right] \\
&= (1-\alpha)\,\beta^P \bar{q} \frac{\bar{I}}{\bar{M}}
\end{aligned}
$$

- (Home) Production of p-period ahead construction input

$$\bar{U}_p = \bar{Z}_c \left(\bar{N}_{c,p}\right)^{\alpha} \left(\bar{M}\right)^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P$$

- (Home) Demand for total construction labor

$$\bar{N}_c = \sum_{p=0}^{P} \bar{N}_{c,p}$$

- (Home) Supply of housing permit

$$\bar{M} = (\bar{q})^{\gamma}$$

- (Home) Supply and demand for non-construction output

$$
\begin{aligned}
\bar{\tilde{Y}}_H &= n\bar{C}_H + (1-n)\,\bar{C}_H^* \\
\bar{\tilde{Y}}_H &= n\bar{Z}_H \bar{N}^d
\end{aligned}
$$

- (Home) Price dispersion of home-produced good

$$\bar{\Xi}_H = 1$$

- (Home) Aggregate price index

$$\overline{p^{\diamond}_H} = 1$$

- (Home) Phillips curve

$$
\begin{aligned}
\overline{p^{\diamond}_{H,t}} &= \frac{\theta_c}{\theta_c - 1} \frac{\bar{\tilde{Z}}_H^a}{\bar{\tilde{Z}}_H^b} \\
\bar{\tilde{Z}}_H^a &= \frac{1}{1-\omega\beta} \bar{mc}_H \bar{\tilde{Y}}_H \\
\bar{\tilde{Z}}_H^b &= \frac{1}{1-\omega\beta} \bar{X}_H \bar{\tilde{Y}}_H
\end{aligned}
$$

- (Home) Marginal cost

$$\bar{mc}_H = \frac{\bar{w}}{\bar{Z}_H}$$

- (Foreign) Foreign demand for home- and foreign-produced good

$$\bar{C}_F^* = \phi^* \left(\bar{X}_F\right)^{-\eta} \bar{C}^*$$
$$\bar{C}_H^* = (1-\phi^*) \left(\frac{\bar{X}_H}{\bar{X}}\right)^{-\eta} \bar{C}^*$$

- (Foreign) Supply and demand for non-construction labor

$$-\bar{U}_{n^*} = \bar{w}^* \frac{\bar{U}_{c^*}}{\bar{\tilde{\mu}}^*}$$
$$\bar{N}^* = \bar{N}^{d*}$$

- (Foreign) Wage dispersion

$$\bar{\tilde{\Xi}}^* = 1$$

- (Foreign) Wage index

$$\bar{w}^* = \bar{\tilde{w}}^*$$

- (Foreign) Wage Phillips curve

$$\bar{\tilde{w}}^* = \frac{\tilde{\eta}^*}{\tilde{\eta}^* - 1} \frac{\bar{f}_F^a}{\bar{f}_F^b},$$
$$\bar{f}_F^a = \frac{1}{1-\tilde{\omega}\beta} \bar{N}_t^{d*} \left(\bar{w}^*\right)^{1+\tilde{\eta}} \frac{1}{\bar{\tilde{\mu}}^*}$$
$$\bar{f}_F^b = \frac{1}{1-\tilde{\omega}\beta} \bar{N}^{d*} \left(\bar{w}^*\right)^{\tilde{\eta}}$$

$$\bar{\tilde{\mu}}^* = \frac{\tilde{\eta}^*}{\tilde{\eta}^* - 1}$$

- (Foreign) Housing demand

$$\left(\frac{1-\kappa}{\kappa}\right) \frac{\bar{\tilde{C}}^*}{\bar{\tilde{H}}^*} = \left(1 - (1-\delta)\,\beta\right) \bar{q}^*$$

- (Foreign) Supply of construction labor

$$-\bar{U}_{nc^*} = \bar{w}_c^* \bar{U}_{c^*}$$

- (Foreign) Housing accumulation

$$\delta \bar{H}^* = \bar{I}^*$$

- (Foreign) Housing construction function

$$\bar{I}^* = \left(\sum_{p=0}^{P^*} \left(\bar{U}_p^*\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}}$$

- (Foreign) Demand for p-period ahead construction labor

$$\bar{w}_c^* = \alpha \bar{\mu}_p^* \frac{\bar{U}_p^*}{\bar{N}_{c,p}^*} \text{ for } p = 0, 1, \cdots, P^*$$

- (Foreign) Demand for p-period ahead construction input

$$\bar{\mu}_p^* = \beta^p \bar{q}^* \left(\frac{\bar{I}^*}{\bar{U}_p^*}\right)^{\frac{1}{\theta}} \quad \text{for } p = 0, 1, \cdots, P^*$$

- (Foreign) Demand for housing permit

$$\begin{aligned}
\bar{q}_M^* &= (1-\alpha)\left[\sum_{p=0}^{P^*} \beta^p \bar{\mu}_{P^*-p}^* \frac{\bar{U}_{P^*-p}}{\bar{M}^*}\right] \\
&= (1-\alpha)\, \beta^{P^*} \bar{q}^* \frac{\bar{I}^*}{\bar{M}^*}
\end{aligned}$$

- (Foreign) Production of p-period ahead construction input

$$\bar{U}_p^* = \bar{Z}_c^* \left(\bar{N}_{c,p}^*\right)^{\alpha} \left(\bar{M}^*\right)^{1-\alpha} \quad \text{for } p = 0, 1, \cdots, P^*$$

- (Foreign) Demand for total construction labor

$$\bar{N}_c^* = \sum_{p=0}^{P^*} \bar{N}_{c,p}^*$$

- (Foreign) Supply of housing permit

$$\bar{M}^* = (\bar{q}^*)^{\gamma^*}$$

- (Foreign) Supply and demand for non-construction output

$$\begin{aligned}
\bar{\tilde{Y}}_F &= n\bar{C}_F + (1-n)\,\bar{C}_F^* \\
\bar{\tilde{Y}}_F &= (1-n)\,\bar{Z}_F \bar{N}^*
\end{aligned}$$

- (Foreign) Price dispersion of foreign-produced good

$$\bar{\Xi}_F = 1$$

- (Foreign) Aggregate price index

$$\bar{p}_F^{\diamond} = 1$$

- (Foreign) Phillips curve

$$\begin{aligned}
\bar{p}_F^{\diamond} &= \frac{\theta_c}{\theta_c - 1} \frac{\bar{\tilde{Z}}_F^a}{\bar{\tilde{Z}}_F^b} \\
\bar{\tilde{Z}}_F^a &= \frac{1}{1 - \omega\beta} \bar{mc}_F \bar{\tilde{Y}}_F \\
\bar{\tilde{Z}}_F^b &= \frac{1}{1 - \omega\beta} \bar{X}_F \bar{\tilde{Y}}_F
\end{aligned}$$

- (Foreign) Marginal cost

$$\bar{mc}_F = \frac{\bar{w}^*}{\bar{Z}_F}$$

- "Backus-Smith"

$$\frac{\bar{U}_{c^*}}{\bar{U}_c} = \bar{X}$$

- Euler equation and nominal interest rate

$$\bar{R} = \frac{1}{\beta}$$

- Aggregate output

$$\bar{Y} = n\bar{Z}_H \bar{N}^d + (1 - n)\, \bar{Z}_F \bar{N}^{d*}$$

- Resource constraint

$$n\bar{C} + (1 - n)\, \bar{C}^* = \bar{\tilde{Y}}_H \bar{X}_H + \bar{\tilde{Y}}_F \bar{X}_F$$

- Relative price relationship

$$1 = \phi \left(\bar{X}_H\right)^{1-\eta} + (1 - \phi) \left(\bar{X}_F \bar{X}\right)^{1-\eta}$$

- Inflation relationship

$$\bar{\pi}^* = \bar{\pi} = \bar{\pi}_H = \bar{\pi}_F$$

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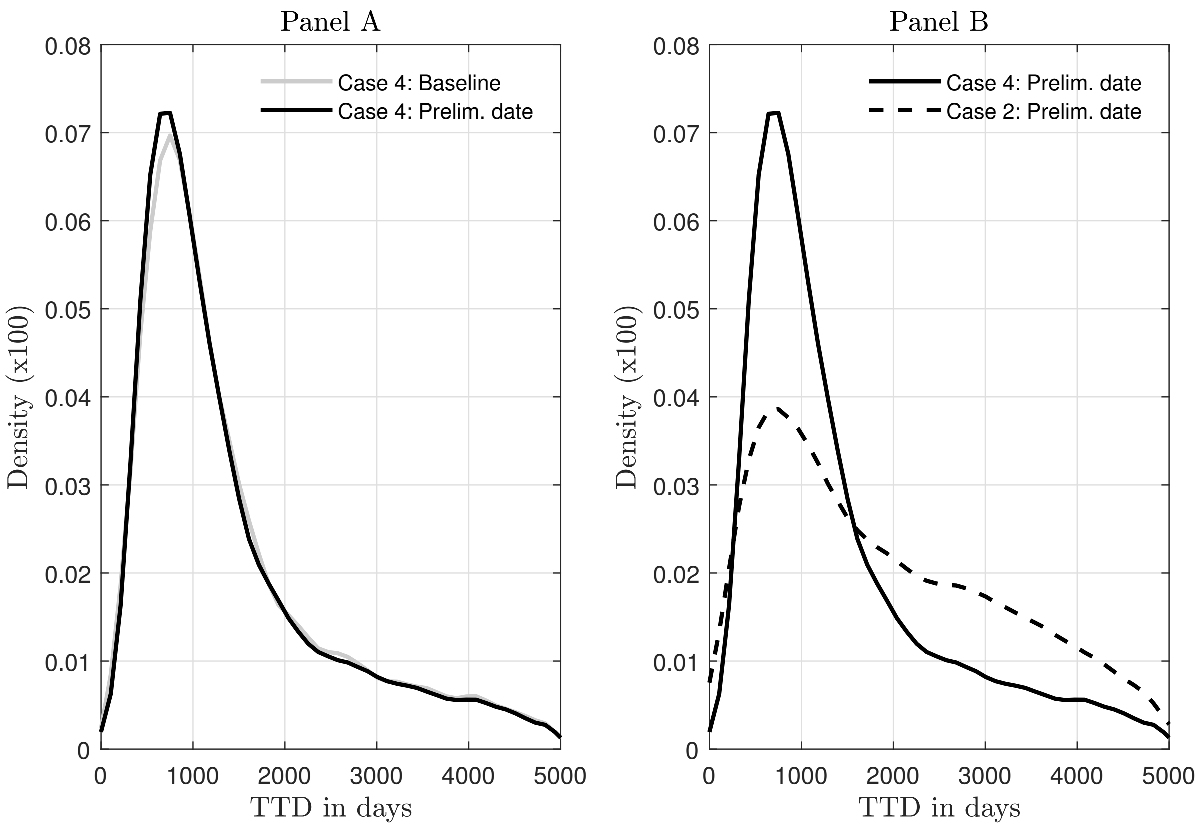

Figure A.1: TTD based on preliminary approval date

Note: The kernel density is plotted for a range of TTD data from 0 days to 5,000 days.

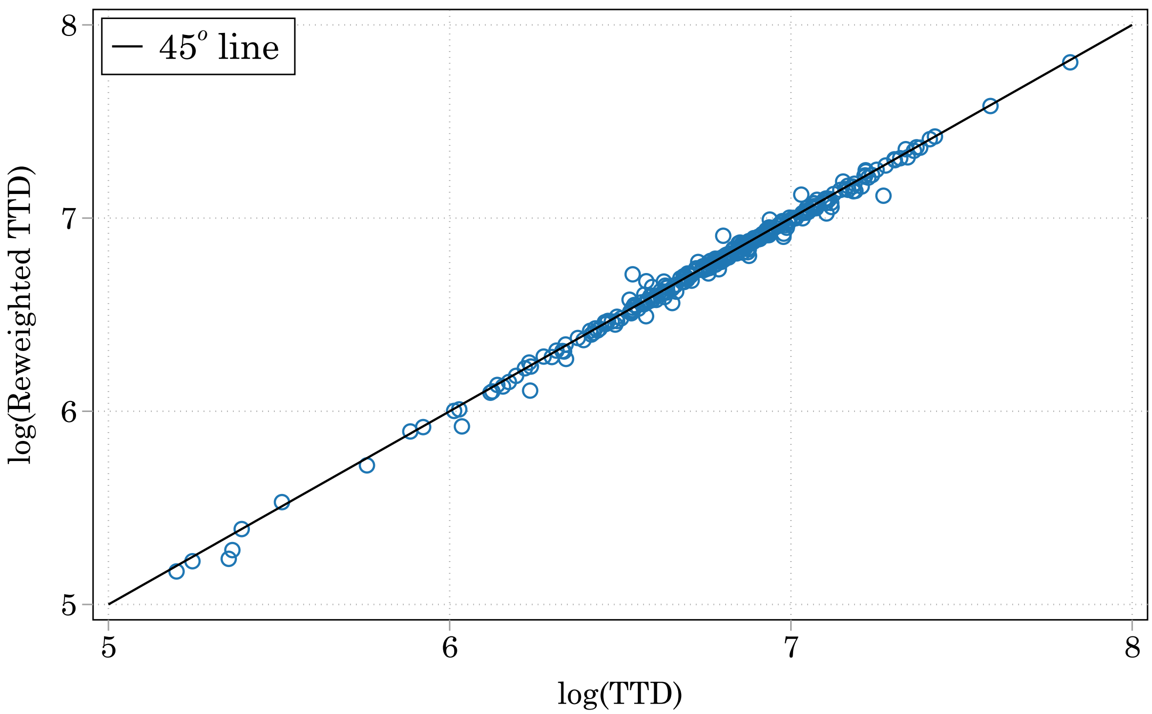

Figure A.2: Baseline and reweighted county-median TTD measures

Note: Each data represents a county's median TTD measure in logs. The figure compares baseline TTD with TTD constructed using inverse probability weights obtained from a probit model predicting inclusion in the TTD sample.

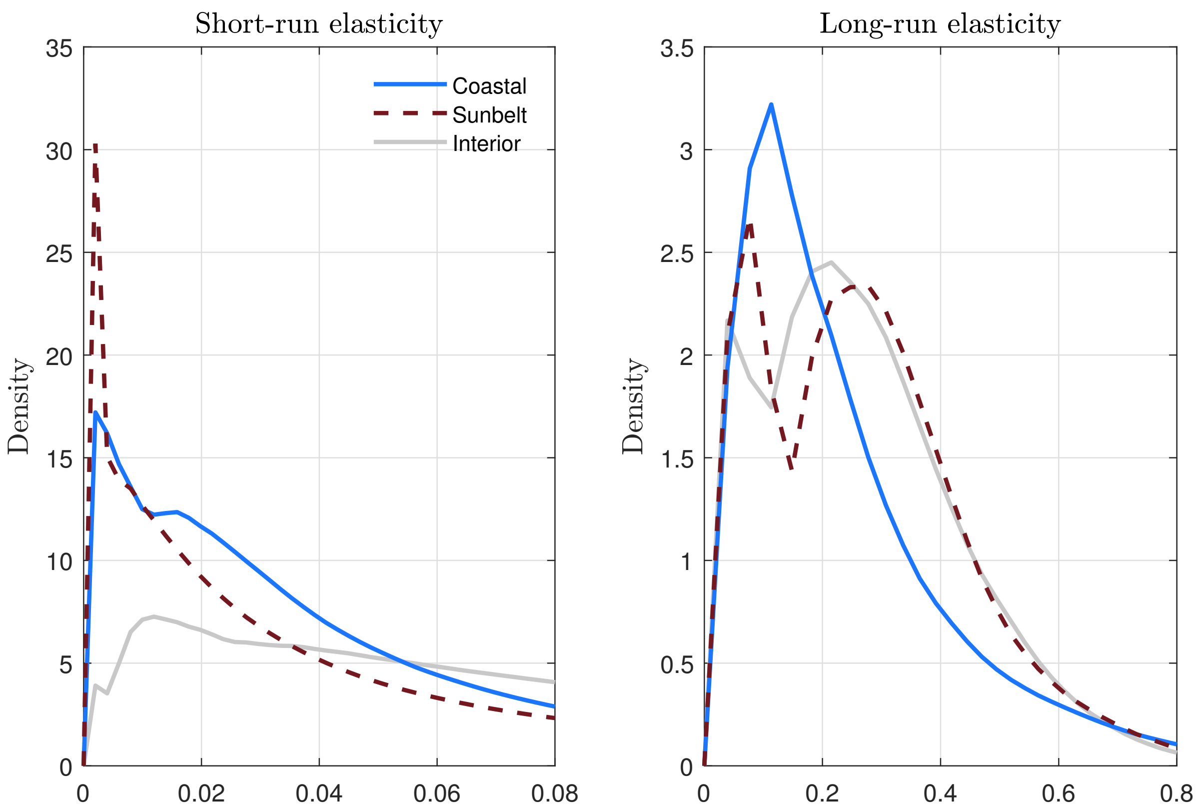

Figure A.3: Distribution of alternative housing supply elasticities by region

Note: The left panel shows the kernel density plots of the 3-year housing supply elasticities for the three regions, based on Baum-Snow and Han (2024) as the long-run elasticity. The right panel shows the kernel density plots of the Baum-Snow and Han (2024) housing supply elasticities for the three regions. The kernel densities for values above 0.08 in the left panel and above 0.8 in the right panel are not plotted for better visibility.

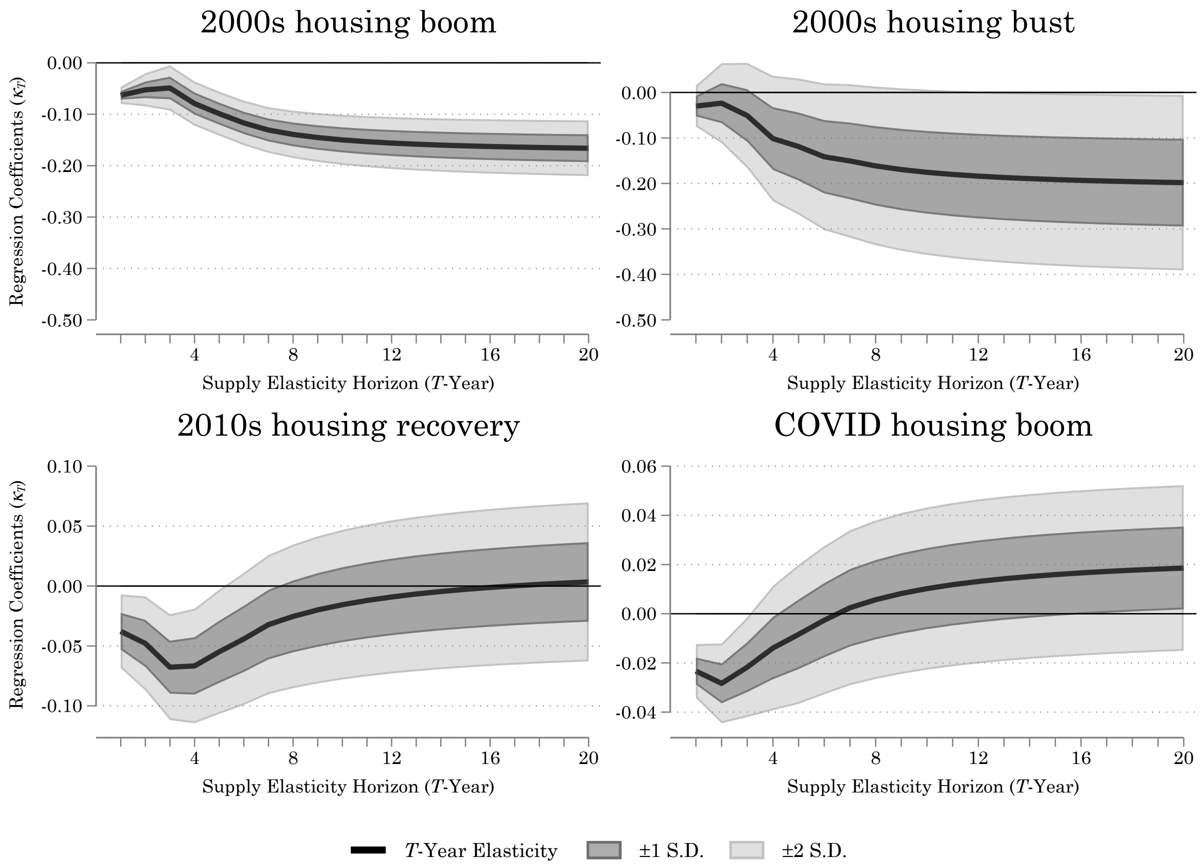

Figure A.4: Relative house price regression coefficients - including local controls

Note: Each figure shows the estimated coefficients for κ_T as a function of the standardized supply elasticity horizon T in equation (D.27). The confidence intervals for the 1 and 2 standard deviations of the estimates are shown as the dark gray and light gray areas, respectively. The four figures present the results using data for 2002–06 (top left panel), 2006–09 (top right panel), 2012–19 (bottom left panel), and 2019–22 (bottom right panel). Local control variables include the population share of college graduates, Bartik-type predicted industry employment growth, indicators for sand states and coastal states, the population share of immigrants, population density, and county-level real GDP growth. The regressions include controls for sand state and coastal state indicators.

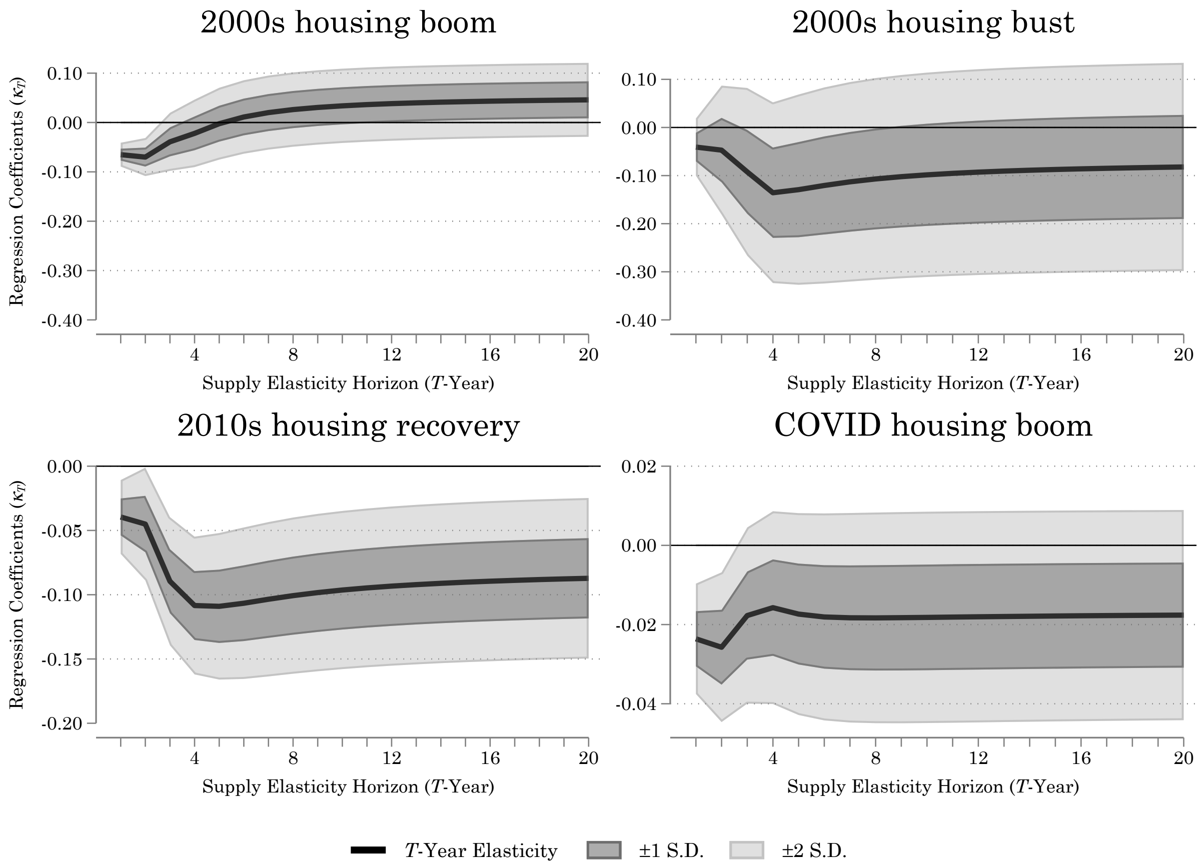

Figure A.5: Relative house price regression coefficients - using Baum-Snow and Han (2024) long-run supply elasticities

Note: Each figure shows the estimated coefficients for κ_T as a function of the standardized supply elasticity horizon T in equation (D.27). The confidence intervals for the 1 and 2 standard deviations of the estimates are shown as the dark gray and light gray areas, respectively. The four figures present the results using data for 2002–06 (top left panel), 2006–09 (top right panel), 2012–19 (bottom left panel), and 2019–22 (bottom right panel). We use Baum-Snow and Han (2024) supply elasticities for new construction housing units as the long-run supply elasticity to compute T-horizon supply elasticities.

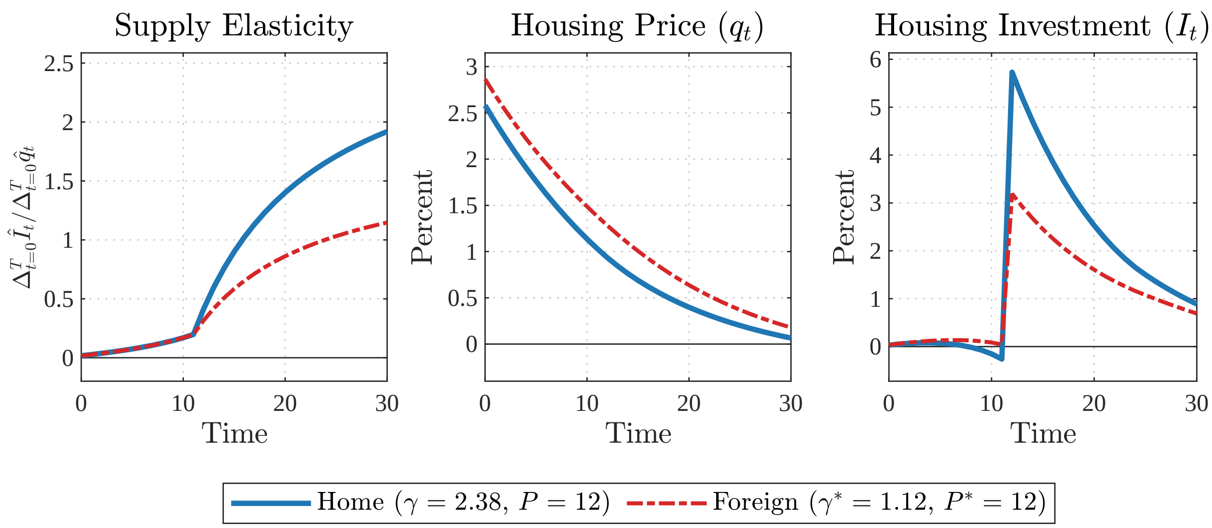

Figure A.6: Model Responses to Housing Demand Shocks in Each Region (Different γ)

Notes:

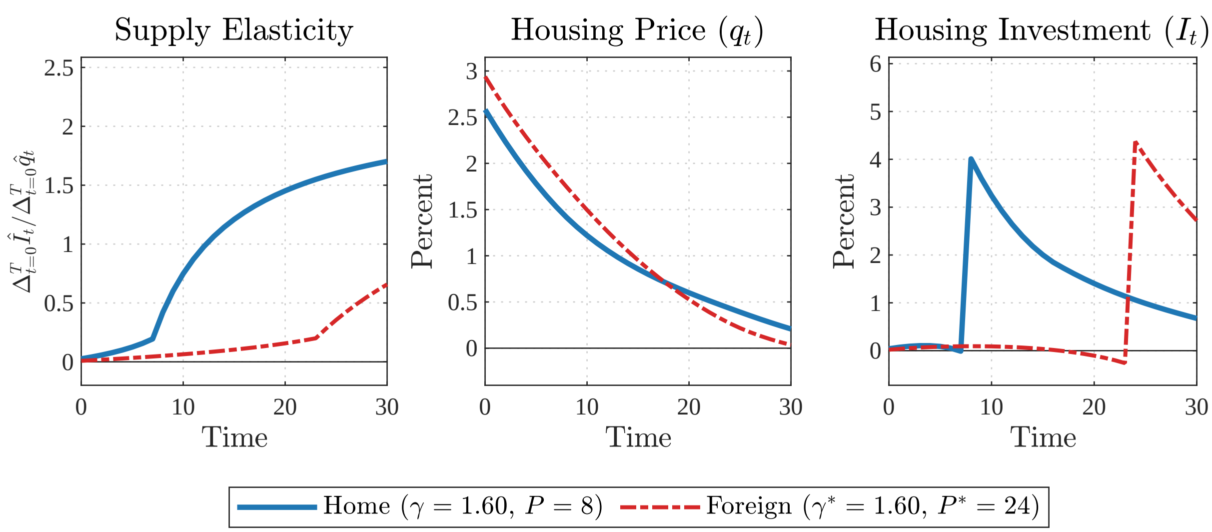

Figure A.7: Model Responses to Housing Demand Shocks in Each Region (Different P)

Notes:

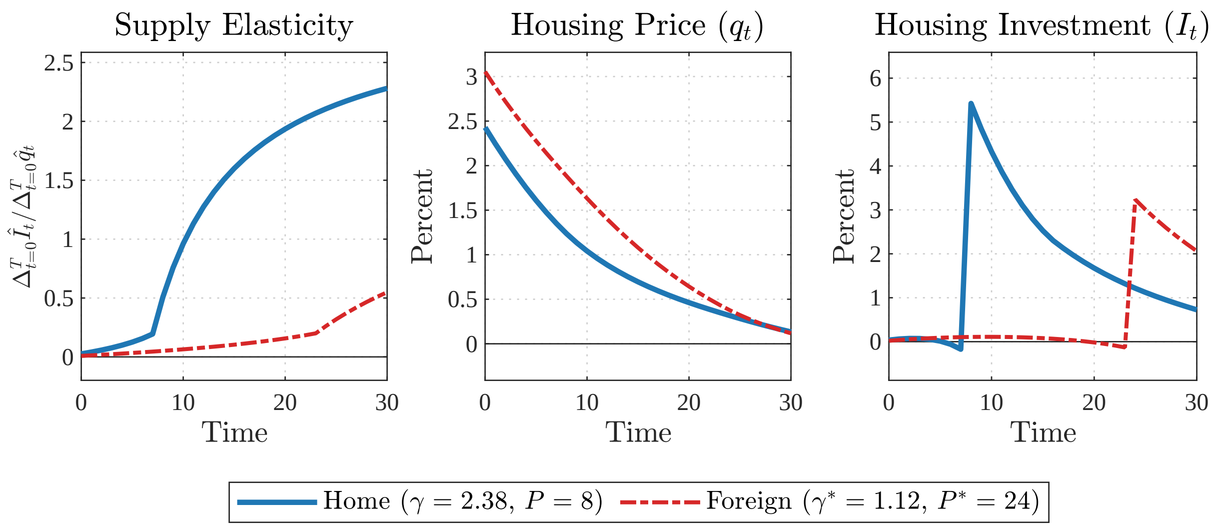

Figure A.8: Model Responses to Housing Demand Shocks in Each Region (Different γ and P 1)

Notes:

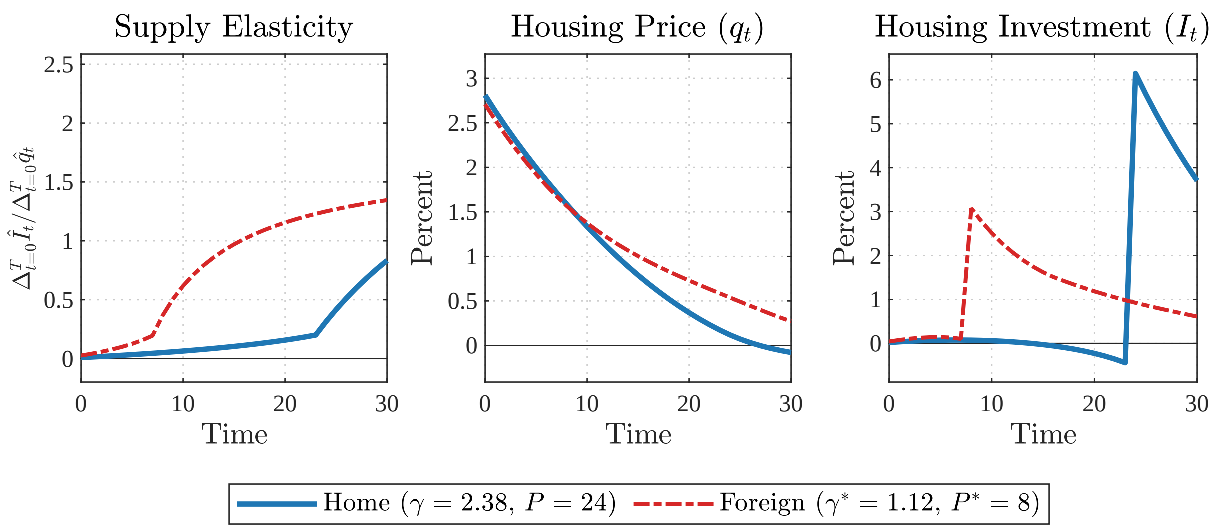

Figure A.9: Model Responses to Housing Demand Shocks in Each Region (Different γ and P 2)

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Table A.1: New housing completions by each year between 2003 and 2019

(unit: 1,000 housing)	Zonda	Census	Coverage
Total housing			
2003	555	1,677	33%
2004	820	1,835	45%
2005	835	1,929	43%
2006	902	1,989	45%
2007	754	1,514	50%
2008	495	1,127	44%
2009	348	796	44%
2010	319	654	49%
2011	264	585	45%
2012	301	641	47%
2013	419	763	55%
2014	344	883	39%
2015	372	965	39%
2016	417	1,061	39%
2017	465	1,152	40%
2018	496	1,190	42%
2019	504	1,260	40%
Single family housing			
2003	458	1,381	33%
2004	672	1,528	44%
2005	612	1,634	37%
2006	640	1,662	38%
2007	537	1,228	44%
2008	361	826	44%
2009	247	522	47%
2010	234	495	47%
2011	202	446	45%
2012	237	478	50%
2013	316	570	55%
2014	282	619	46%
2015	302	647	47%
2016	342	737	46%
2017	381	795	48%
2018	405	842	48%
2019	405	904	45%

Note: "Zonda" indicates total new housing completions for each year in our data set. "Census" indicates total new housing completions for each year in the Census Bureau's SOC. "Coverage" is the ratio between "Zonda" and "Census" in percentage.

Table A.2: Section TTD regression results: Local controls

Variables	(1)	(2)
Bartik		0.0817***
		(0.0311)
Immigrant		0.995
		(0.604)
College+		0.0533***
		(0.00654)
Log(population density)		0.0388***
		(0.00324)
Log(county gdp)		−0.0967***
		(0.0111)

Note: Additional details for Table 3 in the main text. Robust standard errors are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.3: Section TTD statistics (25 percent completion)

(unit: days)	Land TTD	Building TTD	Total TTD
Mean	577	515	1,092
Std. dev.	774	659	1,012
IQR	458	364	823
P10	91	91	274
P25	181	183	456
P50	275	275	731
P75	639	547	1,279
P90	1,278	1,096	2,466
Observations	104,923	104,923	104,923

Note: Each observation is a subdivision or a section of a subdivision when there are multiple sections in a subdivision. IQR stands for the interquartile range (P75−P25). Five different percentiles of each TTD distribution are shown, e.g. P50 referring to the median (50th percentile) of the distribution.

Table A.4: Section TTD regression results (25 percent completion)

Variables	(1)	(2)
Log(number of units)	0.128***	0.132***
	(0.00454)	(0.00458)
Log(lot size)	0.130***	0.142***
	(0.00488)	(0.00505)
Single family	–	–
Townhouse	0.168***	0.165***
	(0.0119)	(0.0122)
Condo	0.186***	0.218***
	(0.0406)	(0.0412)
Duplex	−0.0386	−0.0412
	(0.0309)	(0.0311)
Etc.	0.0472*	0.0548**
	(0.0263)	(0.0262)
Builder fixed effect	✓	✓
Year fixed effect	✓	✓
Local controls		✓
Constant	4.427***	4.317***
	(0.0522)	(0.0864)
Observations	104,923	104,923
R-squared	0.217	0.224

Note: The regression uses log(TTD) as the dependent variable. Local control variables include Bartik-type predicted industry employment growth, population share of immigrants, population share of college educated, population density, and county real GDP, all based on values from 1980. Year fixed effects are specified by the completion year of development. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.5: County-level TTD statistics (25 percent completion)

(unit: days)	Raw TTD	Reg. (1)	Reg. (2)
Mean	739	731	728
Std. dev.	301	260	260
IQR	363	326	338
P10	457	406	420
P25	549	558	559
P50	730	705	713
P75	912	885	897
P90	1,006	1,075	1,077
Observations	267	267	267

Note: Each observation is a county's median TTD. We use counties with at least 10 completed sections observed. IQR stands for the interquartile range (P75−P25). Five different percentiles of each TTD distribution are shown—for example, P50 referring to the median (50th percentile) of the distribution.

Table A.6: Balance table for TTD availability

Variables	Sample	Missing	t-statistic	p-value
Number of units	41.795	26.290	80.057	0.000
Lot size	14562.2	14944.5	-1.716	0.086
Single family share	0.872	0.906	-23.370	0.000
Townhouse share	0.097	0.072	18.551	0.000
Condo share	0.007	0.003	12.011	0.000
Duplex share	0.010	0.009	2.209	0.027
Bartik	1.592	1.580	21.195	0.000
Immigrant share	0.049	0.046	19.819	0.000
College+ share	0.190	0.191	-3.427	0.001
Population density	0.184	0.177	5.548	0.000
County GDP	44.588	44.510	0.936	0.349
Observations	104,426	80,488		

Note: "Sample" includes observations with non-missing TTD measures; "Missing" refers to observations without recorded TTD. The table reports group means and tests of equality in means using two-sample t-tests. All variables are measured at the project (section) level.

Table A.7: Frequency of section changing units from initial plan by threshold

	5 percent	10 percent	20 percent
Sample	0.324	0.289	0.251

Note: The column “5 percent” indicates the frequency of sections where the actual number of housing units is different from their initial plan by 5 percent or more.

Table A.8: Local GE Model: Calibration

	Value	Description	Source/Target
β	$0.98^{\frac{1}{4}}$	Subjective discount factor	2 percent annual real interest rate
σ	2.0	Inverse elasticity of intertemporal substitution	Guren et al. (2020)
ν	1.0	Inverse Frisch elasticity of labor supply	Guren et al. (2020)
ψ_n	1.0	Labor supply disutility parameter	Steady-state labor ($\bar{N}_n = 1$)
ψ	0.0009	Construction labor supply disutility parameter	Steady-state construction labor ($\bar{N} = 1$)
θ	0.334	TTD elasticity of substitution	Calibrated in main text
α	0.3852	Variable input elasticity of construction	Calibrated in main text
κ	0.75	Preference weight on effective consumption	Expenditure share on housing (CEX)
δ	$0.03^{\frac{1}{4}}$	Housing depreciation rate	Guren et al. (2020)
ψ_b	0.001	Scale of the portfolio holding cost	Guren et al. (2020)

Notes: This table shows model parameter values used for our local GE model simulation. See Section D.1.4 for details.

Table A.9: Two-Region GE Model: Calibration

	Value	Description	Source/Target
β	$0.98^{\frac{1}{4}}$	Time preference	Quarterly frequency
κ	0.58	Preference weight on effective consumption	Guren et al. (2020)
σ	2.0	Inverse of EIS	Guren et al. (2020)
ν	1.0	Inverse of Frisch elasticity	Guren et al. (2020)
ϕ	0.4	Degree of home bias in the home region	*Guren et al. (2020)*
ϕ^*	0.4	Degree of home bias in the foreign region	*Guren et al. (2020)*
η	2.0	ES between goods produced in home and foreign region	Assigned
θ	0.334	ES between different stages of housing production	See Section C.1
θ_c	5.0	ES across differentiated goods in each region	Iacoviello and Neri (2010)
ω	0.84	Degree of price stickiness	Iacoviello and Neri (2010)
$\tilde{\omega}$	0.91	Degree of wage stickiness	Iacoviello and Neri (2010)
$\tilde{\eta}$	5.0	ES across differentiated goods in each region	Iacoviello and Neri (2010)
δ_h	0.01	Housing depreciation rate	Iacoviello and Neri (2010)
α	0.385	Construction elasticity of labor	Guren et al. (2020)
ϕ_π	1.5	Inflation feedback in Taylor rule	Standard

Notes: This table shows model parameter values used for our baseline simulation. See Section D.3.6 for details.