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# Is housing supply meeting demand: the role of regulations

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**Abstract**

This paper explores how housing supply elasticities vary under different regulations regimes, and market conditions. I combine price data with local housing stock, local employment, and local building development for the 25 largest municipalities in Norway between 2003 and 2021. Using Bartik type employment as instrument, the paper measures supply elasticities for the 25 largest municipalities in Norway, focusing on two supply indicators: building work started and completed. These results reveal an average supply elasticity of 1.9 percent, with Oslo having a much lower elasticity of 0.4 percent. Apartments display higher elasticity compared to detached, attached, and row houses, thereby aligning with urban densification strategies in many cities.

**Keywords:** Housing supply, Government policy

**JEL codes:** R31; R38

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# 1 Introduction

The responsiveness of supply is essential in determining whether increasing demand results in higher prices or a larger number of housing units. When prices exceed construction costs and rise due to increased demand, developers in a competitive market will be motivated to build more homes. Thus, unresponsive supply stems from regulations on housing development or geographical obstacles, or both (Saiz, 2010). Unresponsive, or inelastic, supply has a wide range of consequences. Cities with inelastic supply tend to experience steeper price increases during housing bubbles, are more prone to such bubbles, and the bubbles tend to persist for longer periods (E. L. Glaeser et al., 2008). Inelastic housing supply leads to less development of new housing and higher house price growth (Saks, 2008). These elevated prices and growth rates affect wealth distribution, both across regions and between generations (Eggum & Røed Larsen, 2024; E. Glaeser & Gyourko, 2018). Additionally, inelastic supply significantly impacts employment growth, worker productivity, and national productivity (Accetturo et al., 2021; Ciccone, 2002; Hsieh & Moretti, 2019; Saks, 2008). In light of this context and the trend of increasing urbanization, it is key for policymakers to understand the elasticity of housing supply in different regional markets.

In this paper, I present a simple framework of housing supply and demand to illustrate supply dynamics under different regulation regimes and market conditions. I introduce three stylized examples: a growing market with lenient regulations, a growing market with strict regulations and a falling market. Subsequently, I use quarterly data on local prices, employment, building work started and building work completed for the 25 largest municipalities in Norway to measure supply elasticities. I start out with measuring the average supply elasticity for these municipalities using a Bartik instrument for employment to instrument for prices in the supply equation (Bartik, 1991).

I apply two measures of housing supply; building work started and building work completed, and estimate supply elasticities using both. Because construction projects often span several years, the relevant prices to be used in the estimations depend on which measure of supply is used. The number of units completed at time $t$ naturally reflects the number of units whose construction began in earlier periods. As a result, completions respond to house prices from previous years rather than contemporaneous prices. To account for this timing, I test alternative lag structures for prices in the elasticity estimations. I use a five-period lag for price in the supply equation when measuring supply with building work completed. For building work started, I assume that supply responds to contemporaneous prices. The estimated supply elasticities are not significantly different when measured using either building work started or building work completed, under both IV and OLS specifications for the latter. Additionally, I cannot reject that the lagged price is exogenous in the IV specification of building work completed. I proceed with measuring the supply elasticities of building work completed and lagged prices using OLS specification, as this offers greater flexibility to incorporate interaction terms. I expand the model with a measure of facilitation, using the Housing Construction Facilitation Rank developed by Benedictow et al. (2022), and estimate the supply elasticity associated with municipalities that display a low, medium, and high degree of facilitation of housing development. In addition, I include the square meters regulated for housing per capita as an indication of facilitation of housing development. I also measure the supply elasticity for Oslo, Kristiansand, and Stavanger, which resemble the three stylized markets presented in the empirical framework. In line with the model, I find that the supply elasticity in Oslo is well below average and that Kristiansand posits a higher elasticity. The estimated supply elasticity in Stavanger is also lower than the average; this suggests that demand, and thus the cost-adjusted price, fell to a point where development was not profitable in the time period studied.

Lastly, I estimate supply elasticities by building type. The population in the 25 largest municipalities in Norway grew by an average of 27 percent in the time period studied. The local authorities in many of these municipalities have upzoning as a policy goal, implying that they facilitate denser development and that the share of apartment construction is increasing.

I find an average supply elasticity of 1.9 percent on average for all the municipalities in the sample and a supply elasticity of 0.4 percent for Oslo. Additionally, when measuring supply elasticity by building type, I find that the supply of apartments has a higher supply elasticity compared to detached, attached, and row houses, which is in line with upzoning policies.

This article contributes to the literature on measuring supply elasticities (Baum-Snow & Han, 2024; Quigley & Raphael, 2005; Saiz, 2010). The findings of heterogeneous supply elasticities across municipalities are in line with those of Saiz (2010). Saiz (2010) measures supply elasticities ranging between between 0.5 and 5.4, while the range of supply elasticity I measure is between 0.4 and 0.7 in Oslo and 2.5 percent in Kristiansand. This article is also closely related to Baum-Snow and Han (2024), who find differences in supply elasticities across neighborhoods within a municipality. The results on variations in supply elasticities between housing types support the notion of neighborhood-level differences in supply elasticity. This is because neighborhoods are often characterized by different building type compositions and zoning regulations specific to each type.

The article also contributes to the literature by examining the timing of prices within the supply models. While previous studies in many cases use a panel where they observe changes in housing stock and house prices over a time span of a few years, I have access to data on a quarterly basis between 2003 and 2019. I compare the supply elasticities of building work started with respect to contemporaneous prices and of building work completed with respect to lagged prices and show that the results are very similar using the two supply measures. I also demonstrate that in the specification with building work completed and a lagged prices structure, I cannot reject that the lagged price is exogenous. Thus, the price elasticity of building work completed can be estimated with OLS, which is more flexible than the IV approach and allows for more interactions.

The article contributes to the literature with estimations on supply elasticities for different building types. This is also related to the literature on urban densification (Ahlfeldt & Barr, 2022). The findings show variation in supply elasticity across different housing types, with the elasticity of supply for apartments being higher than that for other types of housing. This aligns with the urban planning strategies of many of the municipalities, which focus on increasing housing density.

The paper is organized in the following manner: Section 2 presents the empirical framework applied, Section 3 presents the institutional setting and data, Section 4 presents the results. In Section 5, I do a back-of-the-envelope exercise and estimate the number of new housing units in Oslo if its supply elasticity matched the average of other large municipalities in Norway. Section 6 concludes.

## 2 Empirical framework

To illustrate the dynamics of housing markets under different conditions, I present a simple framework of supply and demand for new housing. I assume that landowners decide whether to develop their land based on the difference between house prices and construction costs. For simplicity, I assume a one-period setup, where landowners choose to develop their land as long as $p > c$. The supply of new housing, denoted as $h_s$, is represented by Equation 1:

$$h_s = a_s + \beta(p - c) \tag{1}$$

where $h_s$ is directly related to the price–cost gap, $(p - c)$, which implies that new housing is supplied only when prices exceed construction costs, making development profitable. Conversely, when prices fall below construction costs, no new construction takes place, so

$h_s >= 0$ . The parameter $\beta$ captures the sensitivity of new housing supply to this price-cost gap. The demand for new housing, $h_d$, is expressed by Equation 2:

$$h_d = a_d + \delta p + d \tag{2}$$

where $h_d$ also depends on price, $p$, and a demand shifter, $d$. $\delta$ has a negative sign, as a higher price reduces the demand for houses. The demand shifter, $d$, can represent variables such as local amenities, the current housing stock, employment opportunities, or demographic trends. Price is set in the intersection between supply and demand. By combining equations 1 and 2, we derive the reduced-form price equation:

$$p = \frac{(a_d - a_s) + d + \beta c}{\beta - \delta} \tag{3}$$

The price, $p$, depends on demand, $d$, and construction costs, $c$. The variables are in log form; thus $\beta$ can be interpreted as the supply elasticity and $\delta$ as the price elasticity of demand.

Inserting for $p$ in either Equation 1 or 2 yields the reduced-form of supply of new houses, $h$:

$$h = \frac{\delta}{\beta - \delta}(\beta c - a_s) + \frac{\beta}{\beta - \delta}(d + a_d) \tag{4}$$

To demonstrate how regulations and demand play a part in the model, three examples are presented below: a growing market with strict regulation, a growing market with lenient regulation, and a depressed market with falling demand[1].

[1] E. Glaeser and Gyourko (2018) illustrate how these three types of markets play out in a supply and demand figure, and present data on prices relative to building costs together with building work started for San Francisco, Atlanta, and Chicago as examples of the three markets.

The first case involves a growing market, with lenient regulations on housing development. Under this scenario, assuming constant returns to scale, the price elasticity, $\beta$, will approach infinity and landowners will produce houses until prices equal construction costs. This simplifies the reduced-form price equation, Equation 3, to

$$p' = c \tag{5}$$

The reduced-form for new housing supply equation, equation 4, reduces to

$$h' = \delta c + d \tag{6}$$

Thus, supply of new housing will depend on the demand.

In most cases there may be supply constraints. Additional costs due to geographical or regulatory constraints may lead to increasing marginal costs for landowners and developers. Saiz (2010) shows that the price sensitivity to demand shocks increase when developable land becomes more scarce. This means that we have an upward sloping supply curve with $\beta$ greater than 0 but not approaching infinity. More stringent regulations imply a lower price elasticity, $\beta$.

Second, to illustrate a growing market with sufficiently strict regulations and binding supply constraints, we assume that housing development is primarily determined by regulations and permits rather than being driven by the relationship between house prices and total construction costs. In this scenario, new housing development is determined by $h^p$, which represents the supply of housing determined by the number of permits issued or regulatory constraints. Consequently, the general supply equation, Equation 1, is updated in the following manner:

$$h''_s = h^p \tag{7}$$

Setting the new supply equation, Equation 7, equal to the demand equation, Equation 2, and solving for the price yields:

$$p'' = \frac{-a_d - d + h^p}{\delta} \tag{8}$$

Inserting for $p''$ in the demand equation yields the reduced-form for the housing stock:

$$h'' = h^p \tag{9}$$

In this fully regulated market, developers do not respond to price differences between house prices and construction costs and the supply elasticity is zero, $\beta = 0$. Instead, housing development is driven by the availability of permits. Consequently, the reduced-form housing stock, Equation 9, remains identical to the supply equation, Equation 7. As Equation 8 shows, the prices in this market are not dependent on construction costs.

In the third case, a depressed market with a decreasing demand for housing, the demand for housing falls below the existing housing stock, with prices dropping below total costs $p < c$. Consequently, no new housing is developed. In this scenario, the supply equation from the general model, Equation 1, equals zero and housing supply is equal to the existing housing stock:

$$h_s''' = 0 \tag{10}$$

Setting demand, Equation 2, and supply, Equation 10, equal to each other yields the following reduced-form price equation:

$$p''' = \frac{-a_d - d}{\delta} \tag{11}$$

Inserting for $p'''$ in the demand equation, Equation 2, yields

$$h''' = 0 \tag{12}$$

In this market, prices are not dependent on construction costs either, $\beta = 0$ and $h_s = 0$, and there is no new development. The total housing supply equals the existing housing stock.

Although the examples above are stylized, they offer some insight into how markets respond to shifts in the supply and demand functions. None of the largest municipalities in Norway have experienced a decline in population. In fact, all the largest municipalities in Norway are witnessing significant population growth. If we were to find an instance of example 3, a depressed market, among the municipalities studied, it could be Stavanger. The regional crisis following the decline in oil prices in 2013–2014 may have temporarily driven housing demand down to the level of existing stock. Oslo, with its growing market, strict regulations, and house prices well above replacement costs, may resemble example 1, where construction depends on permits. This would suggest that rising construction costs would not affect house prices, but rather affect land values. Kristiansand is often cited as an example of a municipality that has consistently promoted and supported housing development over time, thereby making it the closest example we have to example 2. The city has lenient regulations and a growing market. In Benedictow et al. (2022), Kristiansand was ranked as number 1 in the total Housing Construction Facilitation Ranking of the 20 largest municipalities in Norway and Oslo at the bottom 20, which supports the choice of these two municipalities as examples.

**Empirical implementation**

In the empirical implementation, supply of new housing units is represented by the following equation:

$$h^n_{m,t} = \alpha_1 + \beta p^c_{m,t-l} + t_q + M_m + \epsilon \tag{13}$$

where $h^n_{mt}$ is the log supply of new housing in municipality, $m$, at time $t$. I presume $h^n \geq 0$. Both housing supply and price measures are in log form: thus, $\beta$ can be interpreted as the price elasticity of supply. $p^c_{m,t-l}$ is the log construction cost adjusted price index at time $t-l$, where $l$ is a lag. The main variables used to measure new housing supply, $h^n_{m,t}$, is building work started and building work completed. I assume that building work *started* is influenced by the price developments in the current period. To model the supply of new housing, where building work *completed* is the primary variable of interest, we need to account for the fact that the completion of housing units depends on the price development when the building work started. Therefore, the supply of new housing (building work completed) is modeled as a function of lagged house prices. I test for different lags in prices in Equation 13, both for building work started and building work completed. The results are presented in Table B.2. and Table B.3 in Appendix B. I do not have access to construction costs at the regional level and, thus, all prices are deflated with the same construction cost index. $t_h$ represents period fixed effects (quarterly), $M_m$ municipality represents fixed effects, and $\epsilon$ is the error term.

To test the hypothesis that regulation reduces supply elasticity, I extend the model by incorporating measures of how municipalities regulate or facilitate housing development in the model, represented by $X_m$ in Equation 14. First, I include the Housing Construction Facilitation Ranking (HCFR) constructed by Samfunnsøkonomisk Analyse (SØA) for the Co-operative Housing Federation of Norway (NBBL). I divide the municipalities into three groups based on their rating on the HCFR and include an interaction with the lower and medium facilitated group, thereby leaving the group classified as highly facilitated to be the base group. The HCFR is described in Section 3. Second, I include the area regulated for housing per capita as an indication of regulatory stringency, where a larger area regulated for housing per resident suggests more lenient regulations and a smaller area indicates stricter regulatory constraints. Third, I include an interaction with the three cities — Kristiansand, Oslo, and Stavanger — which are the closest to resembling the three stylized examples of a growing market with lenient regulations, growing market with strict regulations, and a declining market, respectively. Equation 13 is expanded with the regulation indicators and cities, denoted by $X_m$.

$$h^n_{m,t} = \alpha_1 + (\beta + b * X_m)p^c_{m,t-l} + \psi t_h + \varphi M_m + \epsilon \tag{14}$$

The regulation indicators and cities, $X_m$, are interacted with the price in turn. Accordingly, the supply elasticity is $\beta$ for the base group and $\beta + b * X_m$ for the other groups.

## 2.1 Bartik-type instrument construction

As price and quantity are jointly determined by the interaction between supply and demand, simply running Equation 13 with an OLS regression is likely to produce biased price elasticity estimates, $\beta$. The key challenge to identify unbiased $\beta$'s is to find an exogenous factor that shifts local demand for housing, without affecting supply factors as productivity in construction, construction costs, or land availability for example. I apply the 2SLS method and use a Bartik-type instrument of employment to instrument for price changes in the supply equation, as done by Baum-Snow and Han (2024), and Quigley and Raphael (2005).

The reduced-form for the cost-adjusted price is obtained by subtracting the log construction cost from both sides of Equation 3: $p - c = p^c = \frac{a_d - a_s}{\beta - \delta} + \frac{\delta}{\beta - \delta}c + \frac{d}{\beta - \delta}$. Equation 15 is the first stage and the empirical equivalent:

$$p^c_{mt} = \kappa + \upsilon_1 l_t + \upsilon_2 l_{t-1} + \upsilon_2 l_{t-2} + +\upsilon_2 l_{t-3} + M_m + y_q + \zeta \tag{15}$$

Employment in the current and lagged periods represent the demand shifters and $\frac{d}{\beta-\delta}$ is approximated by $\upsilon_1 l_t + \upsilon_2 l_{t-1} + \upsilon_2 l_{t-2} + \upsilon_2 l_{t-3}$. As I do not have access to construction costs at a regional level, the potential differences in construction costs, $c$, between municipalities are captured by the municipality fixed effects, $M_m$, and cost development over time is captured by the time fixed effects, $y_q$. The first stage results are presented in Tables B.4 and B.5 in Appendix B and reveal that both the level and growth of Bartik employment have an effect on the cost-adjusted prices.

The identification strategy is a two-step strategy; Bartik employment is used instead of actual employment in Equation 15 to instrument for price in Equation 13. The reason Bartik employment is used instead of employment is to ensure that supply shocks — such as changes in construction productivity, costs, or land size — do not affect the instrument. Bartik employment is independent of supply conditions, as it uses industry shares in the beginning of the period and growth rates for the national industry employment. Additionally, employment in the construction industry is excluded from the aggregate, which is also a measure to ensure that supply-side factors do not affect the instrument.

To construct the Bartik instrument, I use employment shares at two-digit NACE in 2002 in each municipality as the base. The industry employment levels per municipality are then developed through the use of national growth rates in employment at the corresponding industries from National Accounts. Lastly, these industry measures of employment are summed up to the aggregate Bartik-type employment per municipality. Bartik employment instrument per municipality is displayed with actual employment in Figure B.1.in Appendix B.

To ensure that Bartik employment explains the observed employment, observed employment is regressed on Bartik employment, municipality fixed effects, and time fixed effects. The results are presented in Table A.1 in Appendix A. Goldsmith-Pinkham et al. (2020) recommends several empirical tests to assess what drives the variation in the Bartik instrument;

whether it is variation in the initial industry shares or variation in growth rates and what industries (instruments) are dominant in the aggregate Bartik instrument. The empirical tests are presented in Appendix A. The tests show that it is the variation in the initial shares that drive the variation in the instrument, and that the industries Health and social work, Public administration, Education, Wholesale and retail trade, repair of motor vehicles, and Transport that are dominant in the instrument. I assess the first three industries, Health and social work, Public administration, and Education, to be unrelated to potential supply shocks in housing development. Parts of Wholesale and retail trade and repair of motored vehicles and Transport may be affected by supply shocks in the construction industry or housing development. However, my assumption is that employment in these industries are less likely to be affected by supply side shocks than their sales and turnover. Overall, I assess the Rotemberg weights to support the assumption of exogeneity and that Bartik employment is independent of $\epsilon$ in Equation 13.

# 3 Institutional settings and data

### Institutional settings

In Norway, the municipalities hold responsibility for planning, zoning, and regulating building construction. The time span from vacant land, or a site designated for redevelopment, to completed housing units may be a long one. The first step is to regulate the land for housing development, which implies that the municipality must formally designate the land as suitable for residential use. Once the land is regulated for housing, detailed zoning plans for the land is presented and there is a consultation process before the zoning plans can be approved. Private interests may also propose changes in the zoning plans. The next step in the building process is that the developer applies for general permission, which outlines the external parameters of the construction project. Typically, the developers have to sell approximately 50–60 percent of the housing units to be constructed to obtain a building loan. After receiving general permission and securing financing (such as building loans), the developer applies for project start-up permission. Once granted, the actual construction can begin. The building process typically lasts between 12 and 24 months, depending on the type and size of the building. Once the housing unit is complete, the developer applies for provisional permission to use and then a certificate of completion. This process, while detailed, ensures that housing developments adhere to local regulations, community standards, and safety codes; however, it can also result in lengthy timeframes between project initiation and completion. The time municipalities spend on each step of the process is crucial for the ease and cost of housing development. The initial step—regulating land for housing—can be particularly time-consuming and may lead to significant capital costs for landowners.

Samfunnsøkonomisk Analyse (SØA) has developed a Housing Construction Facilitation Rank (HCFR) for The Co-operative Housing Federation of Norway (NBBL) for all major municipalities in Norway. The HCFR ranks the municipalities on how well they facilitate housing development (Benedictow et al., 2022), providing insight into which municipalities are better equipped to meet housing demand and stimulate construction. The ranking comprises several indicators, which are grouped into two main subcategories: facilitation and construction. The construction ranking includes both buildings completed and prices and, thus, is not suitable to include in the model. However, the facilitation ranking (FR) attempts to measure how effectively municipalities promote and support housing development. It focuses on factors that influence how quickly and efficiently new housing can be developed, which directly affects how supply responds to changes in demand. The facilitation ranking is based on four indicators for time for processing building applications, three indicators for costs associated with applying infrastructure investments, one indicator for digitalization of building applications, and three indicators of other types of building facilitation[2]. The

[2]Share of approved applications, share of private planning proposals, and land reserves for housing

facilitation ranking for the 25 largest municipalities is presented in Table 1.

By incorporating the FR into the model, it helps explain how well municipalities can respond to increased housing demand, with higher-ranked municipalities expected to exhibit a more elastic housing supply in response to rising prices.

**Table 1** Housing Construction Facilitation Rank: Facilitation ranking (FR).

| | Municipality | Ranking 2020 | | Ranking 2020 | |
|---|---|---|---|---|---|
| High facilitation: | Bodø | 1 | | Drammen | 14 |
| | Sandnes | 2 | | Oslo | 15 |
| | Arendal | 3 | | Moss | 16 |
| | Lørenskog | 4 | Low facilitation: | Lillestrøm | 17 |
| | Sandefjord | 5 | | Trondheim | 18 |
| | Bergen | 6 | | Tromsø | 19 |
| | Skien | 7 | | Ålesund | 20 |
| | Kristiansand | 8 | | Sarpsborg | 21 |
| Medium facilitation: | Stavanger | 9 | | Larvik | 22 |
| | Asker | 10 | | Fredrikstad | 23 |
| | Indre Østfold | 11 | | Tønsberg | 24 |
| | Bærum | 12 | | Nordre Follo | 25 |
| | Ullensaker | 13 | | | |

Source: The Co-operative Housing Federation of Norway, NBBL.
Notes: The table reports the ranking of the the 25 largest municipalities in Norway on the Housing construction facilitation rank (HCFR) sub rank: Facilitation, obtained from NBBL. The decreasing score implies that the municipality assessed as the top facilitator of housing development is ranked as number 1. The high, medium, and low facilitation division is done by dividing the municipalities into three groups by their respective HCFR.

### Data

The dataset consists of quarterly data from 2003 to 2019, encompassing the 25 largest municipalities in Norway. The data used is described in Table 2 and the municipalities included are presented in Table 1.

Statistics Norway provides quarterly data on new housing units under building work completed and building work started, by building type and municipality. Building work started is tied to the issuance of a building permit, while building work completed is determined

development compared to historical population growth.

**Table 2** Data

| Source | Variable |
|---|---|
| Statistics Norway | Building work started |
| | Building work completed |
| | Employment by industry and municipality 2002 |
| | Employment by industry National Accounts |
| | Population 2002 |
| | Area regulated land for housing 2011 |
| | Construction cost index for residential buildings |
| Eiendomsverdi/Eiendom Norge | Price indexes |
| Eiendomsverdi | Transactions 20 largest municipalities |
| Norsk Boligbyggelag (NBBL)/ Samfunnsøkonomisk Analyse | Housing Construction Facilitation Rank |

Notes: The table displays the data and sources used. The data is for the municipality level and is collected for the 25 largest municipalities in Norway, except for the transaction data, which only is available for the 20 largest municipalities.

either by the granting of temporary permission to use or the formal certificate of building accomplishment. The time lag between building work started and building work completed will depend on the size of the project and the building type, and there are no available statistics on this time lag. Large (and small) apartments projects will naturally take more time to build than row, detached, and attached houses. The Co-operative Housing Federation of Norway (NBBL) reports typical building durations of 12–18 months for row, detached, and attached houses and 18 months for an apartment project with approximately 50 units, 24 months for larger apartment projects, and 12–24 months for apartment projects in subsequent steps (where some ground work is already done). This corresponds with the lags used in the model in which building work completed is the supply measure.

I rely on two sources for data on house prices. For the overall price development at the municipal level, I use price indexes from Eiendom Norge. The accumulated change in the construction cost-adjusted price index and the accumulated change in housing stock is shown in Figure 1. In most municipalities, real house prices have grown at a faster rate than the increase in housing stock.

**Figure 1** Accumulated change in real house prices and housing stock.


Source: Ambita, Eiendom Norge, Statistics Norway
Notes: The figure depicts the accumulated percentage change in cost-adjusted price (left axis), and accumulated percentage change in housing stock (right axis).

The data used for house prices per building type is transaction data from the 20 largest municipalities in Norway between 2003 and 2019, obtained from Eiendomsverdi. The dataset includes sell price, square meters, land area, and building type from 2003 to 2021[3]. Quarterly prices per municipality and building type are estimated using the hedonic model displayed in Equation 16 for each muncipality and for each building type:

$$p_i = \varrho + \gamma_1 sqm_i + \gamma_2 sqm_i^2 + age_d + zip_c + q_h + \nu \tag{16}$$

where $p_i$ is the log price per square meter for transaction $i$, $sqm_i$ is the demeaned square meter, $q_h$ is a time fixed effect (quarter and year), $age_d$ is a control for the age decile the

[3]The data are trimmed at the 0.1 and 99.5 percentiles for interior areas. For price and price per square meter, the data are trimmed by 0.5 and 99.5 percentile set per municipality per year.

building in transaction $i$ is in, and $zip$ controls for the zip code fixed effects. The average size in the sample is 97 square meters and the base age decile is the first decile. The regression is run with the command *areg* in Stata where the zip code is absorbed. Thus, $\widehat{\varrho_{mb}}$ can be interpreted as the log square meter price of a newer housing unit of 97 square meters in the base period for municipality $m$ and building type $b$ in the average zip code in the municipality. Subsequently, I predict the price, $\widehat{p_{qmb}}$ of an average sized home for each building type, $b$, for each quarter, $q$, in each municipality, $m$, in the following manner:

$$\widehat{p_{qmb}} = \widehat{\varrho_{mb}} + \widehat{q_{qmb}} \tag{17}$$

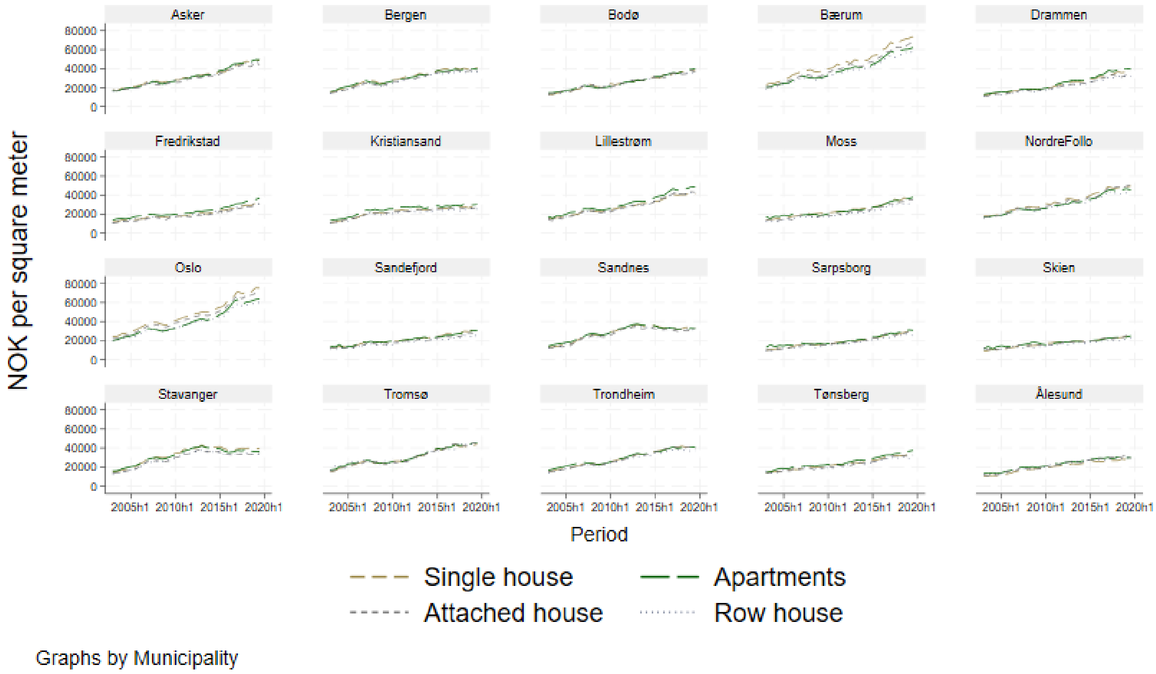
The average of the square meter prices predicted for each building type based on the hedonic model is used in the model that estimates the supply elasticities per building type and is displayed in Figure 2. As evident from the figure, both the price *level* and price *growth* is quite similar across building types within a municipality, while there is heterogeneity both in levels and growth between the municipalities. A comparison of the development in the estimated prices per building type and the price index from Eiendom Norge is presented in Figure B.4. in Appendix B.

Employment per municipality per two-digit NACE from 2002 and national employment at the industry level from 2003 to 2019 is obtained from Statistics Norway. Employment growth by municipality is displayed in Figure B.1 in Appendix B. All but one of the municipalities have experienced employment growth over the period studied.

The summary statistics of housing stock, transaction prices, and employment for the 25 largest municipalities is presented in Table 3.

To calculate the square meters land regulated for housing development per capita for each municipality, I use data for population in 2002 and data on the area regulated for housing development. The area regulated for the construction of homes is published by Statistics

**Figure 2** Price per square meter per building type.




Source: Eiendomsverdi
Notes: The figure depicts the average of the predicted price per square meter per building type. The predicted price is estimated with the hedonic model described in Equations 16 and 17.

**Table 3** Summary statistics

| Variable | Min | Median | Mean | Max |
|---|---|---|---|---|
| Housing stock 2003 | 12,399 | 25,049 | 41,505 | 278,116 |
| Pct. growth in housing stock 2003-2019 | 15.9 | 25.9 | 26.3 | 45.7 |
| Price/sqm single family home 2003 | 9,092.3 | 13,945.2 | 14,563.1 | 24,463.9 |
| Pct. growth in price/sqm single family home 2003-2019 | 133.2 | 169.7 | 171.9 | 217.0 |
| Employment 2003 | 14,041 | 28,068 | 51,379 | 388,968 |
| Pct. growth in employment 2003-2019 | -2.2 | 24.7 | 24.4 | 63.5 |

Source: Ambita, Eiendom Norge, Eiendomsverdi, Statistics Norway
Notes: The table presents the summary statistics for the 25 largest municipalities in Norway.

Norway on an annual basis from 2011. Due to the minimal changes in regulated areas over the years, it is reasonable to assume that the figures for 2011 provide a reliable estimate for the beginning of the estimation period.

# 4 Results

## 4.1 Supply elasticities

Table 4 presents results for the price elasticities of supply, when supply is measured as building work started. As the price is endogenous, the estimations are made using Bartik employment to instrument for price. The models run with OLS specifications are presented in Table B.1. in Appendix B and the results align closely with the IV results in Table 4. The tests for different lags in price is presented in Table B.2., also in Appendix B[4]. I assume that building work started is dependent on contemporaneous prices.

**Table 4** Building work started. IV specification. Quarterly data

| | Model 1a | | Model 2a | | Model 3a | | Model 4a | |
|---|---|---|---|---|---|---|---|---|
| Price index | 1.855 | ** | 3.300 | *** | 3.945 | *** | 2.338 | *** |
| | (0.732) | | (1.134) | | (1.073) | | (0.797) | |
| 1/3 lowest facilitation X Price index | | | -0.475 | | | | | |
| | | | (0.570) | | | | | |
| 1/3 medium facilitation X Price index | | | -2.058 | *** | | | | |
| | | | (0.615) | | | | | |
| Regulated area per capita X Price index | | | | | 2.578 | *** | | |
| | | | | | (0.825) | | | |
| Oslo X Price | | | | | | | -1.916 | *** |
| | | | | | | | (0.514) | |
| Number of observations | 1623 | | 1558 | | 1623 | | 1623 | |
| F-stat | 41.24 | | 9.07 | | 11.78 | | 18.20 | |

Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work started and the price instrumented is contemporaneous ($lags = 0$). The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

The average supply elasticity is presented in the first column and is estimated to be 1.86 percent, which implies that when prices increase by 1 percent, building work started increase

[4]The price coefficient is of similar size and statistically significant with 0 and 1 lags. With 2 and 3 lags, the price coefficient loses statistical significance.

by 1.86 percent on average for the municipalities in the sample. In the second column in Table 4, Model 2, the municipalities are divided into three groups based on their ranking in the HCFR: high, medium, and low facilitation. The municipalities included in each group are presented in Table 1. The high facilitation group, consisting of the third of the municipalities with the highest ranking, serves as the base group and has an average supply elasticity of 3.3 percent. The medium facilitation municipalities are associated with 2.06 percentage points lower supply elasticity than the high facilitation municipalities. Oslo is classified in the medium facilitation group and is likely to contribute to this coefficient. For the lowest facilitation group of municipalities, the coefficient is negative but not statistically significant. Thus, the lowest third facilitation group of municipalities has an average supply elasticity that is not statistically significantly different from the high facilitation group. Note that the F-statistic is below 10, which implies that we should interpret the results with caution.

In the third column, Model 3, the log of area regulated for housing per capita is included in the model. Area regulated for housing per capita is demeaned, thereby implying that the coefficient for Price index displays the estimated result for supply elasticity for the municipalities with the average log regulated area per capita. The interaction term Regulated area per capita X Price is measured to be 2.58, which implies that when log regulated area over population increases by 1, that is, a doubling in the regulated area per capita, the supply elasticity is 2.58 percentage points higher. Area regulated for housing per capita can serve as an indicator of regulatory stringency, where a larger area allocated for development per resident indicates more lenient regulations and a smaller area suggests stricter regulatory constraints.

In the models that include the measures of regulation of facilitation, it is worth noting that these may be endogenous. Fischel (2002), introduced the "homevoter hypothesis" claiming that residents vote to hinder new supply of housing as a means to maximize the value of their own homes. Thus, regulations may be correlated with house prices, geographical hindrances, and historical land values, as found by Saiz (2010). Saiz (2010), instruments his measure for regulation, the Wharton Regulation Index (WRI) with public expenditures on "protective inspection" and on the share of nontraditional Christian denominations. The coefficient estimates for the WRI falls in IV specification compared to when it is treated as exogenous in the OLS specification. Thus, treating the regulation indicator as exogenous might overestimate the effect on supply.

In the fourth column, the price index is interacted with a dummy for Oslo. The coefficient for Oslo is measured to be -1.92, meaning that the supply elasticity in Oslo is 1.92 percentage points lower than the average of the other large municipalities in Norway. Thus, the estimated supply elasticity for Oslo is measured to be 0.42.

I compare the elasticities of building work started and building work completed. Table 5 reports the estimation results using building work completed as the supply measure. As construction of homes takes time and units completed in time $t$ depends on the number of units started in previous periods, it is reasonable that building work completed depends on lagged prices. The tests for different lags in price in the model is presented in Table B.3. in Appendix B[5]. I use a five-quarter lag for price in the supply equation when measuring supply with building work completed. This is in line with what is reported by The Co-operative Housing Federation of Norway of a building time period of 12–18 months[6]. The models using building works completed as the supply measure are run with both IV and OLS; both are presented in Table 5. The Wooldridge (1995) test for endogeneity is performed for the IV specification, and the test results are reported in the rows at the bottom of the table. The null hypothesis of the endogeneity test is that the instrumented variables are exogenous, and this cannot be rejected in any of the models as is evident by the p-values reported. The estimated results both from estimating the models using IV and OLS are very similar to the

[5]The models run on building work completed are tested with four to seven lags in price. The lagged prices are statistically significant in all models and vary between 1.56 and 2.3.

[6]Information received via personal communication, May 2024.

**Table 5** Building work completed. IV and OLS specification. Quarterly data

| | (1b) IV | (1c) OLS | (2b) IV | (2c) OLS | (3b) IV | (3c) OLS | (4b) IV | (4c) OLS |
|---|---|---|---|---|---|---|---|---|
| Price index | 2.188 *** | 1.971 *** | 2.647 *** | 2.614 *** | 4.197 *** | 2.236 *** | 2.466 *** | 2.180 *** |
| | (0.716) | (0.253) | (0.939) | (0.396) | (1.097) | (0.256) | (0.762) | (0.260) |
| 1/3 lowest facilitation X Price index | | | -0.712 | -0.397 | | | | |
| | | | (0.495) | (0.440) | | | | |
| 1/3 medium facilitation X Price index | | | -1.038 ** | -1.235 *** | | | | |
| | | | (0.507) | (0.418) | | | | |
| Regulated area per cap X Price | | | | | 2.680 *** | 1.211 ** | | |
| | | | | | (0.893) | (0.477) | | |
| Oslo X Price | | | | | | | -1.409 *** | -1.633 *** |
| | | | | | | | (0.489) | (0.439) |
| Adjusted R-squared | | 0.59 | | 0.59 | | 0.59 | | 0.59 |
| Number of observations | 1497 | 1497 | 1437 | 1437 | 1497 | 1497 | 1497 | 1497 |
| F-stat | 45.11 | | 10.70 | | 12.78 | | 20.85 | |
| Wooldridge (1995) Test endogeneity: | | | | | | | | |
| Robust score chi2, p.val: | 0.75 | | 0.24 | | 0.15 | | 0.48 | |
| Robust regression F, p.val: | 0.75 | | 0.25 | | 0.16 | | 0.45 | |

Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway by OLS and IV specification where cost-adjusted price is instrumented by Bartik-type employment. The data is at quarterly basis. The supply measure is building work completed and the instrumented price is lagged with five periods ($lag = 5$). All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

estimation results using building works started in Table 4. The average supply elasticity of building work completed is measured to be 2.19 and 1.97 in the IV and OLS specifications, respectively, compared to the supply elasticity of 1.86 for building work started, as reported in Table 4.

In Models 2b and 2c in Table 5, including an interaction with the HCFR, the municipalities with the third highest rank are measured to have an average supply elasticity of 2.6 in both the IV and OLS specifications. The municipalities with the 1/3 medium ranking are associated with 1 and 1.2 percent lower supply elasticity in the IV and OLS specifications, respectively. This is a slightly lower effect than that estimated in Model 2 in Table 4. The coefficient of the interaction between price and 1/3 of the municipalities with the lowest facilitation has a negative sign but is not statistically significant in these models either. For Model 2b, the instruments do not pass the Hansen J test of exogenous instruments; thus the results should be interpreted with caution.

For Models 3b and 3c, including an interaction with the area regulated for housing per capita, there are larger differences between the results in the IV and OLS specification. The supply elasticity for a municipality with the average area developed for housing per capita is measured to be 4.2 in the IV specification and 2.25 in the OLS specification. The coefficient for the interaction between regulated area developed for housing per capita is also different — estimated to be 2.68 and 1.21 for the IV and OLS specifications, respectively. The interaction between the area regulated for housing development per capita and price is associated with an increase in the supply elasticity, with 54 percent in the OLS specification and 64 percent in the IV specification.

In Models 4b and 4c, the average supply elasticity excluding Oslo is measured to be 2.47 and 2.18 in the IV and OLS specifications, respectively. The interaction between price and Oslo is measured to be -1.4 and -1.63 in the IV and OLS specifications, thus, the supply elasticity for Oslo is measured to be 1.06 in the IV specification and 0.55 in the

OLS specification, which are both slightly higher than the supply elasticity of building work started in Oslo, measured to be 0.4, presented in Table 4.

Table B.5 in Appendix B presents results for where an interaction with Oslo is included in Models 2c and 3c with OLS specification. In the model in which HCFR is included, both Oslo and the 1/3 medium facilitation ranking is negative and statistically significant. In Model 3d, both the regulated area for housing per capita and Oslo variables are interacted with price. As is evident, Oslo still has a negative statistically significant interaction term, while the regulated area per capita interaction is no longer statistically significant. Thus, it appears that Oslo was driving the effect of this stringency effect in Model 3 as the city with the least area regulated for housing per capita in the sample.

The estimation results on supply elasticities are rather robust to the supply measure used and whether the estimation is done using OLS or IV specification. Quarterly data was used for the estimations. As a robustness exercise, the estimations were also done on biannual data where the number of units for building work started and units for building work completed are summed up from quarterly to halfyearly data to mitigate potential measurement errors stemming from registration dates of building work started and building work completed and seasonality. The results are presented in Tables B.8 and B.9. The findings obtained from quarterly and bi-annual data are consistent with each other. However, the measured supply elasticities using bi-annual data is somewhat lower, ranging between 1.5 and 1.75 on average for all municipalities, compared to Model 1a–c where the average ranges between 1.86 and 2.19 when estimating using quarterly data.

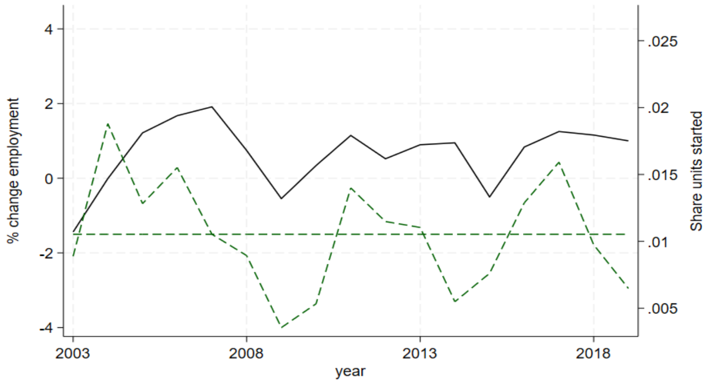
Overall, the estimated supply elasticities of building work started and building work completed are very similar. Additionally, the results from the OLS and IV specifications for modeling supply elasticity of building work completed align closely, and I cannot reject exogeneity of the lagged prices. I proceed with estimating supply the elasticity of building work completed using the OLS specification in the next chapters, as it allows for more flexibility in including additional interaction terms.

### 4.2 A comparison of three cities

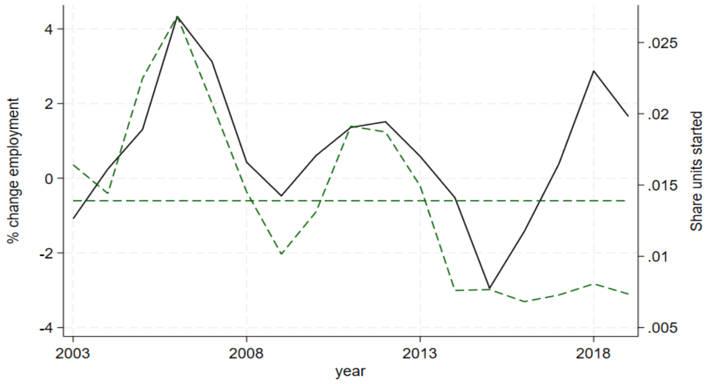
As mentioned, Kristiansand, Oslo, and Stavanger are assessed to resemble the stylized examples presented in Section 2. In Benedictow et al. (2022), Kristiansand is ranked at the top and Oslo at the bottom for the 20 largest municipalities when measuring the HCFR including both the construction and facilitation indexes. Barth et al. (2026), also refer to Kristiansand as an example of a city with lenient regulations and Oslo as an example of strict regulation. Furthermore, their results on Housing Tobin's Q and land prices in these two cities support this notion. Figure 3 displays building work started relative to housing stock together with employment growth for the three cities. Kristiansand represents a growing market with lenient regulations on housing development. With the exception of a few years, the city experienced rising local employment as shown in Figure 3. At the same time, cost-adjusted prices fell from 2013, as can be seen in Figure 1, while the level of building work started continued to fluctuate around 1.5 percent of the housing stock, as illustrated in Figure 3. Oslo is an example of an increasing market with strong supply hindrances; the city has increasing population, increasing local employment, and increasing cost-adjusted prices. Nevertheless, the city displays a relatively low share of building work started as share of housing stock with no apparent upward trend, which is evident from Figure 3. Stavanger is the closest we have to a market, that at least for a period after the oil price fall in 2014, resembles a falling market; local employment fell for a short period, cost-adjusted prices fell by 25 percent between 2013 and 2019, building work plummeted from 2014, and did not pick up during the estimation period, as can be seen in panel b in Figure 3.

**Figure 3** Change in employment and building work started over housing stock.

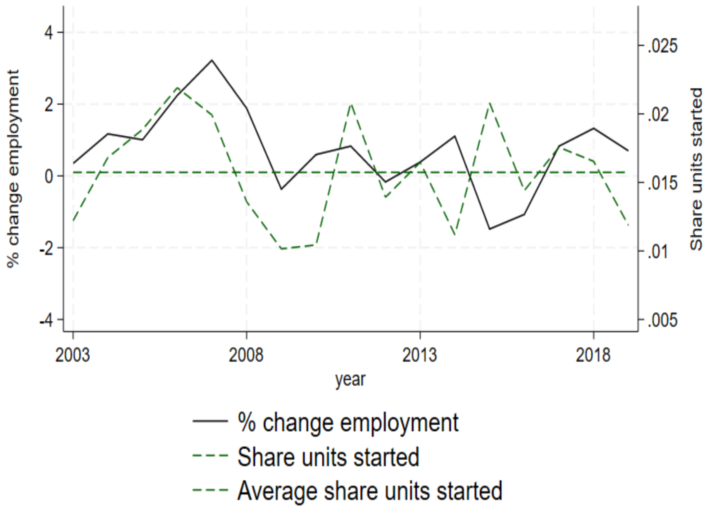
**(a)** Oslo




**(b)** Stavanger




**(c)** Kristiansand




Source: Statistics Norway

Notes: The figures display the annual percentage change in employment on the left hand axis. On the right hand axis, the number of units started as share of the total housing stock is displayed.

**Table 6** Building work completed. OLS specification.

| | Model 5 | |
|---|---|---|
| Price index | 2.486 | *** |
| | (0.284) | |
| Kristiansand X Price | -0.562 | |
| | (0.456) | |
| Oslo X Price | -1.798 | *** |
| | (0.447) | |
| Stavanger X Price | -1.562 | *** |
| | (0.526) | |
| Adjusted R-squared | 0.59 | |
| Number of observations | 1497 | |

Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway using OLS specification. The supply measure is building work completed and the price is lagged with five periods ($lag = 5$). The model includes municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

Table 6 presents results from the OLS specifications when using building work completed as a supply measure and an interaction for Kristiansand, Oslo, and Stavanger. The interaction between Kristiansand and price is not statistically significant, which implies that the price elasticity in Kristiansand is not significantly different than the average of the remaining municipalities, which was measured to be 2.49 percent. Both Oslo and Stavanger are measured to display significantly lower elasticities than the average, 1.8 and 1.6 percentage points lower, respectively.

As Oslo displays increasing cost-adjusted prices over the time period and no significant increase in the share of building work started, this indicates that the low supply elasticity is due to supply hindrances. This is in line with the example in Section 2 of a growing market with strict regulations where change in housing stock depends more on permits rather than price changes. In housing markets with strict regulation on development, price development is independent of construction costs, as shown in Section 2. Instead, prices are driven by demand, and any wedge between prices and construction costs is capitalized into land values or captured as developer profits. Barth et al. (2026) documents this mechanism, showing a positive association between stringent regulations and higher land prices in Oslo. In the empirical framework, I assume that the landowners are observed in one period and that they will choose to develop their area of land whenever $p > c$. In reality, landowners may make that decision over several periods of time. Murphy (2018) demonstrates that in markets with strict regulations, landowners may delay the development of their plots, basing their decisions on expectations of future price increases. This strategic behavior can further reduce supply elasticities by limiting the responsiveness of new developments to current price changes.

Stavanger paints a different picture. The city is closely tied to the oil industry, and was severely impacted by the decline in oil prices in 2014. Cost-adjusted prices fell with 25 percent between 2013 and 2019, see Figure 1, building work plummeted in 2014 and did not pick up again during the time studied, as illustrated in Figure 3. Although local employment and, thus, demand has increased since 2013, building work started has not followed this trend. Total housing supply is asymmetric; housing supply can increase but is restricted downward by housing stock. Thus, during the period after 2014, demand for housing may have fallen below the housing stock and although demand is increasing again, it may take some time before it catches up to the housing stock. Barth et al. (2026), show that the land prices in Stavanger were high and close to the level of that of Oslo prior to 2014. Although land prices have declined somewhat, they remain high compared to cities like Kristiansand. From a developer's perspective, this implies that the total cost of development, including land costs, in Stavanger exceeds those in Kristiansand.

### 4.3 Supply elasticities by building type

All the municipalities experienced population growth during the estimation period. Many local authorities have adopted upzoning as a policy goal, aiming to promote denser development. This makes it particularly interesting to examine whether such measures influence the estimated supply elasticities for different types of buildings.

Table 7 presents the results of estimating supply elasticities per building type. As outlined in Section 3, the data source for prices per building type is transaction data for the 20 largest municipalities in Norway, while the price data for the total housing stock in each municipality is price indexes for the 25 largest municipalities provided by Eiendom Norge. Since the number of municipalities is reduced when estimating supply elasticities by building type, the average supply elasticity for the 20 largest municipalities, using the price index as an independent variable is presented in column 1 in Table 7 as a reference. The estimated average price elasticity is 1.39, which is lower than the estimate for the 25 largest municipalities, presented in Model 1c of Table 5 which was estimated to be 1.97.

Model 7 includes a dummy variable for each building type, with detached houses as the base category, while Model (8) includes interactions between building type and price, also with detached houses as the base building type.

The overall results, both from Tables 7 and 8, indicate that the supply of apartments is more responsive to price than the other building types. These results appear to be in line with the municipalities' densification policies. In Model 7, all the home types are restricted to the same price elasticity, which are measured to be 0.7 percent. The dummy variable for apartments in Model 7 is also positive and statistically significant, which indicates that, although the estimated price elasticity is fixed at 0.7 for all house types in this model, the intercept is higher for apartments; this implies that more apartments are built, independent of price. In Model 8, the building type is interacted with price and supply elasticity is allowed to vary across house types. The estimated coefficient on Price is 0.3, implying a supply elasticity of 0.3 for detached houses, which serve as the baseline building type. Note though that the coefficient is only statistically significant at the 10 percent level. The estimated coefficient for apartments interacted with price is 1.1, which suggests that the supply elasticity for apartments is 1.1 percent higher than that for single family houses. The coefficient of the interaction between price and row houses is positive but not statistically significant, meaning that the price elasticity on row houses is not statistically significantly different from the price elasticity of single family homes. Attached houses interacted with price is measured to be 0.5 and is statistically significant, thereby indicating that attached houses are slightly more responsive to price than single family homes.

In Table 8, Models (1)–(4) are run separately for each building type. The price elasticity of apartments is measured to be 1.64 and statistically significant, thereby implying that if the cost-adjusted price increases with 1 percent, the supply of apartments increases by 1.64 percent. The price coefficient is statistically significant in the model for row houses as well, which is measured to be 0.6 percent. The price coefficients for the other building types are not statistically significant. These results also support the notion of more dense building in the municipalities in the sample. In Table B.7 in Appendix B, Table 5 is replicated with

OLS specification, including apartments only. The HCFR categories do not have statistically significant effects. Oslo displays a lower supply elasticity than the average for apartments as well.

**Table 7** Building work completed by building type. OLS specification.

| | Model 1d | | Model 7 | | Model 8 | |
|---|---|---|---|---|---|---|
| Price index | 1.385 | *** | | | | |
| | (0.258) | | | | | |
| Price | | | 0.721 | *** | 0.310 | * |
| | | | (0.141) | | (0.160) | |
| Apartments X Price | | | | | 1.101 | *** |
| | | | | | (0.233) | |
| Row house X Price | | | | | 0.220 | |
| | | | | | (0.203) | |
| Attached X Price | | | | | 0.499 | *** |
| | | | | | (0.166) | |
| Building: | | | | | | |
| Apartment | | | 2.545 | *** | 2.100 | *** |
| | | | (0.103) | | (0.141) | |
| Row house | | | -0.350 | *** | -0.491 | *** |
| | | | (0.125) | | (0.151) | |
| Attached | | | -0.429 | *** | -0.689 | *** |
| | | | (0.100) | | (0.135) | |
| Intercept | -0.252 | | 3.573 | *** | 3.785 | *** |
| | (1.296) | | (0.136) | | (0.144) | |
| Number of observations | 1259 | | 4513 | | 4513 | |
| Adjusted R-squared | 0.62 | | 0.63 | | 0.63 | |

Notes: The table presents results from estimating Equation 13 for the 20 largest municipalities in Norway using OLS specification. The supply measure is building work completed and the cost-adjusted price is lagged with five periods ($lag = 5$). The reason for the different number of observations is that Model 1d is run with the cost-adjusted price index for all housing types and total building work completed, while Models 7 and 8 are run with all building types. The price in Models 7 and 8 is a deviation from the mean price per building type. Model 7 includes a dummy per building type, with detached houses as the base. Model 8 includes interactions between building type and price, with detached houses as base building type. All models include municipality and time fixed effects. Models 7 and 8 include municipality by building type fixed effect. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table 8** Building work completed by building type. OLS specification.

| | Single | | Apartments | | Row | | Attached | |
|---|---|---|---|---|---|---|---|---|
| Price | 0.028 | | 1.640 | *** | 0.598 | ** | 0.391 | |
| | (0.184) | | (0.349) | | (0.304) | | (0.260) | |
| Intercept | 3.723 | *** | 3.310 | *** | 1.260 | *** | 1.713 | *** |
| | (0.124) | | (0.406) | | (0.259) | | (0.257) | |
| Number of observations | 1257 | | 1033 | | 1066 | | 1157 | |
| Adjusted R-squared | 0.54 | | 0.52 | | 0.31 | | 0.38 | |

Notes: The table presents results from estimating Equation 13 for the 20 largest municipalities in Norway using OLS specification. The supply measure is building work completed and the cost-adjusted price is lagged with five periods ($lag = 5$). The price is a deviation from the mean price per building type. The models are run separately for each building type. The reason for the different number of observations for the number of housing units completed is 0 in certain quarters. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

## 5 Counterfactual analysis: Oslo with a different supply regime

As a back-of-the-envelope exercise, I estimate the number of units completed in Oslo if its supply elasticity matched the average of other large municipalities in Norway. The estimation is based on Equation 13, estimated using OLS, where Oslo is interacted with price. The coefficients are listed in column 8 in Table 5. Oslo is the base municipality and consequently the intercept can be interpreted as the log number of units completed in Oslo in the base period. Thus, the number of units completed in Oslo can be expressed by the following relationship:

$$h^n_{osl,t} = \widehat{\alpha_1} + 2.18 p^c_{m,t-5} - 1.63 p^c_{osl,t-5} + \widehat{t_q} + \widehat{\epsilon} \tag{18}$$

where $h^n_{osl,t}$ is the log of building work completed and $p^c_{m,t-5}$ is the log price index in municipality $m$ lagged five periods. If Oslo changed its regulatory policies and obtained the same supply elasticity as the average of the other large municipalities in Norway, the number of units completed could be expressed by the following equation:

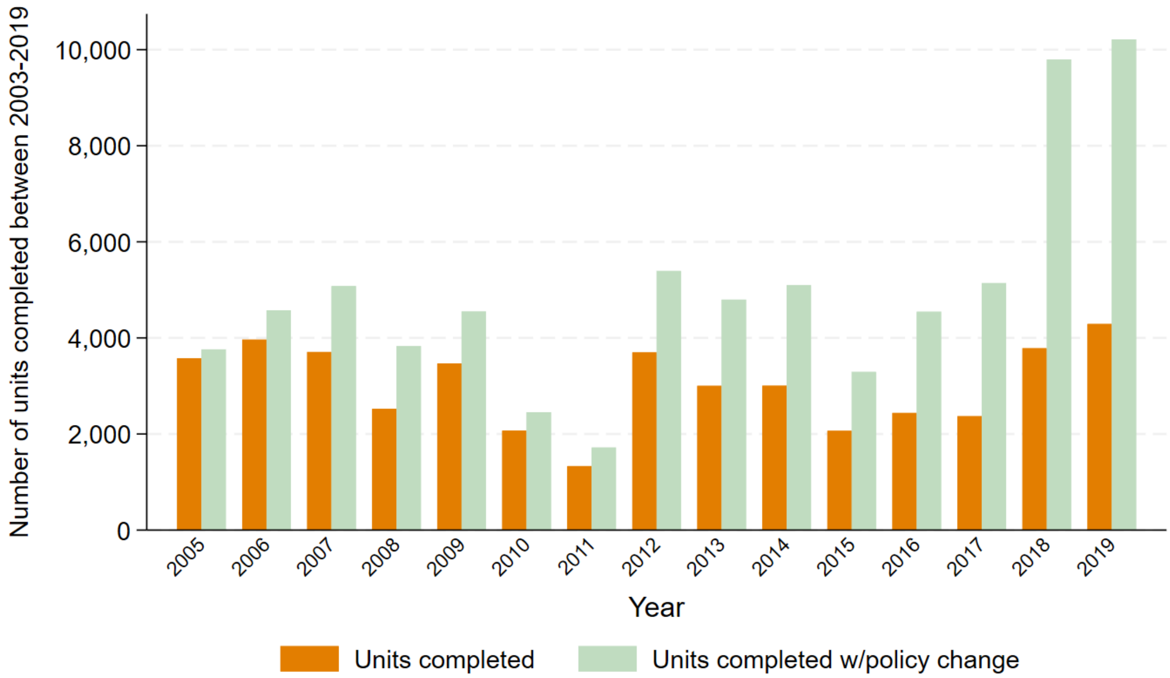
$$h^n_{oslalt,t} = \widehat{\alpha_1} + 2.18 p^c_{m,t-5} + \widehat{t_q} + \widehat{\epsilon} \tag{19}$$

Thus, the difference between units completed in with the counterfactual supply elasticity and the the actual supply elasticity can be expressed in the following manner:

$$h^n_{oslalt,t} - h^n_{osl,t} = 1.63 p^c_{osl,t-5} \tag{20}$$

The alternative number of completed units estimated with Equation 19 is displayed in Figure 4 alongside the actual number of completed units. As illustrated, if the price elasticity were equal to the national average for Norway, Oslo would have seen far more completed units than what has actually been observed. The accumulated change measured using Equation 20 is displayed in Figure 5.

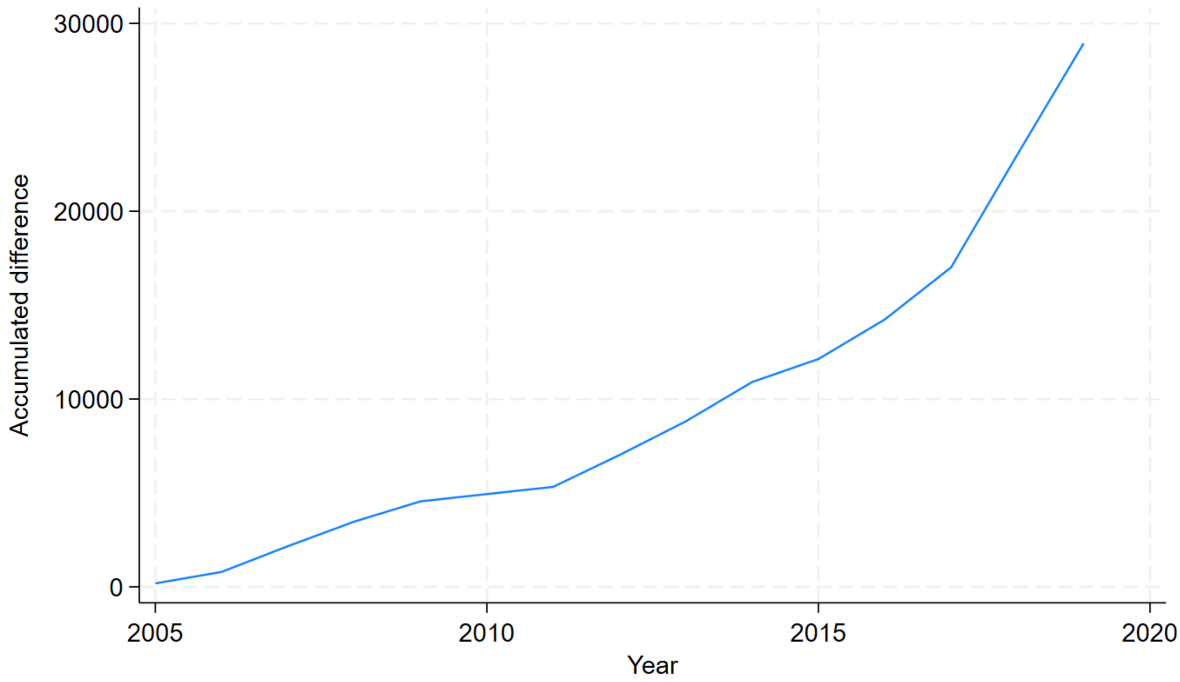
**Figure 4** Number of housing units completed by year, alternative measure, and actual building work completed. (Base year: 2005 base year)




Notes: The figure displays both the actual units completed and the alternative in which Oslo posits the same supply elasticity as the average of the other large municipalities measured by Equation 19.

The estimated alternative number of building work completed is dependent on the choice of the base period used in the estimation. This is due to the change of base period in the price index and the number of units completed in that period, which serve as the starting point for the estimations. It is difficult to assess a period in which the market was in balance and delivered the "correct" amount of housing completed to use as base period. However, as depicted in Figure 2, a comparison of price-level trajectories across municipalities reveals that prices in Oslo were closer to those in other municipalities at the beginning of the estimation period than they were later. The increasing gap in price levels between Oslo and the other

**Figure 5** Accumulated difference in the number of units alternative and actual building work completed. (Base year: 2005 base year)




Notes: The figure displays the accumulated difference between alternative and actual building work completed, with 2005 as the base year, as estimated by Equation 20.

municipalities suggests a growing demand in the municipality that is not being matched by a corresponding increase in supply over the time period. This observation supports the decision to select a base period from the earlier portion of the estimation period.

Figure B.5 in Appendix B illustrates the total number of units completed over the time period 2003—2019 by the year of policy change, that is, the year which is set as the base period and elasticity in Oslo is set as the average of the other municipalities. As evident, the total number of units over the time period would have been almost 30 000 more if the regulatory policies resulted in the average supply elasticity in Norway from 2005. However, note that the calculations are done with the actual house prices. If the number of new housing units had been higher in this period, the prices would most probably not have increased as much as they have.

# 6 Concluding remarks

In this paper, I have outlined a framework that shows how supply constraints and market conditions influence housing supply. Next, I apply empirical data to the model, incorporating three key measures that reflect how municipalities regulate or facilitate housing development. First, I included the Housing Construction Facilitation Ranking (HCFR), dividing municipalities into three groups based on their rating: low, medium, and high facilitation. Second, I added the area regulated for housing per capita as an indicator of regulatory stringency, where a larger area suggests lenient regulations and a smaller area indicates stricter constraints. Lastly, I interacted the model with three cities, Kristiansand, Oslo, and Stavanger, representing stylized examples of a growing market with lenient regulations, a growing market with strict regulations, and a declining market, respectively. I found that the municipalities grouped in the high facilitation group exhibited a significantly higher supply elasticity than medium facilitation group. The area regulated for housing per capita was also associated with a positive effect on supply elasticities; however, when including an interaction for Oslo, this effect disappeared.

Further, I found that Oslo has a significantly lower supply elasticity than the average, measured to be between 0.4 percent and 0.7 percent, depending on the model used. This aligns with the theory that in growing markets with strict regulations, housing supply is more influenced by permitting processes and less responsive to price changes. The findings also supported the hypothesis that the high price increase and level in Oslo is due to the insufficient response on the supply side. The supply elasticity in Stavanger was also measured to be significantly lower than the average; a market that experienced a fall in local employment, house prices and building work after the fall in oil price in 2014. This low elasticity was interpreted as insufficient demand and the falling cost-adjusted prices not being sufficiently high for it to be profitable to develop housing. Kristiansand, an example of a growing market with lenient regulations, has a higher supply elasticity than the average when measured with all the municipalities.

Additionally, supply elasticities per building type is estimated. In line with the the densification strategies of many of the largest municipalities in Norway, the supply elasticities for apartments is higher than for the other building types.

Lastly, I performed a back-of-the-envelope calculation to estimate the number of housing units that would have been completed in Oslo if its supply elasticity matched the average of other large municipalities in Norway. Since the average supply elasticity in these municipalities is higher than that in Oslo, this counterfactual measure is inherently greater than the observed level.

In conclusion, Oslo's low supply elasticity contributes to the growing disparity in house prices between Oslo and other municipalities. This dynamic leads to a redistribution of wealth, benefiting homeowners in Oslo while disadvantaging those who does not own a home in this city. House prices in Oslo have also grown at a faster pace than construction costs. Barth et al. (2026) showed that landowners are the primary beneficiaries of the gap between house prices and the minimum profitable production costs. Additionally, the high house prices in Oslo are likely to hinder worker mobility to the city. Given that value added per worker is higher in Oslo than in the other counties, reduced worker mobility could negatively impact overall economic growth.

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## Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author has used Chat GPT in order to improve language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

# A Appendix A: Bartik instrument validity

Bartik employment is used instead of employment to instrument for price. A first requirment to do this is that Bartik employment predicts employment. Table A.1 presents the results for when total employment for each municipality is regressed on Bartik employment, and we can see that Bartik employment is a good predictor of employment. An increase in Bartik employment of 1 percent is associated with an increase in employment of 0.91 percent.

**Table A.1.** Employment on Bartik employment

| | employment | |
|---|---|---|
| Bartik-type employment | 0.911 | *** |
| | (0.087) | |
| Intercept | 1.166 | |
| | (1.118) | |
| Number of observations | 1700 | |
| Adjusted R-squared | 0.998 | |

Notes: The table displays the results of regressing employment on Bartik employment. The regression includes municipality and time (quarter by year) fixed effects. Significance levels: *** p<0.01, ** p<0.05, * p<0.1

The standard identifying assumptions for instrument variables must be satisfied; the Bartik instrument must both be relevant and uncorrelated with the structural error term in the price equation. The first stage results for Bartik employment as an instrument for price in Equations 13 and 14 is presented in Appendix B and shows that Bartik employment has a statistically significant effect on the cost-adjusted price. The F-statistics are presented in Tables 4 and 5 and are above 10, except for those in Model 2a in Table 4. To reduce the probability of Bartik employment being correlated with the error term in the supply equation, Equation 13, through factors like shocks to construction productivity or costs, I exclude the construction industry from the instrument.

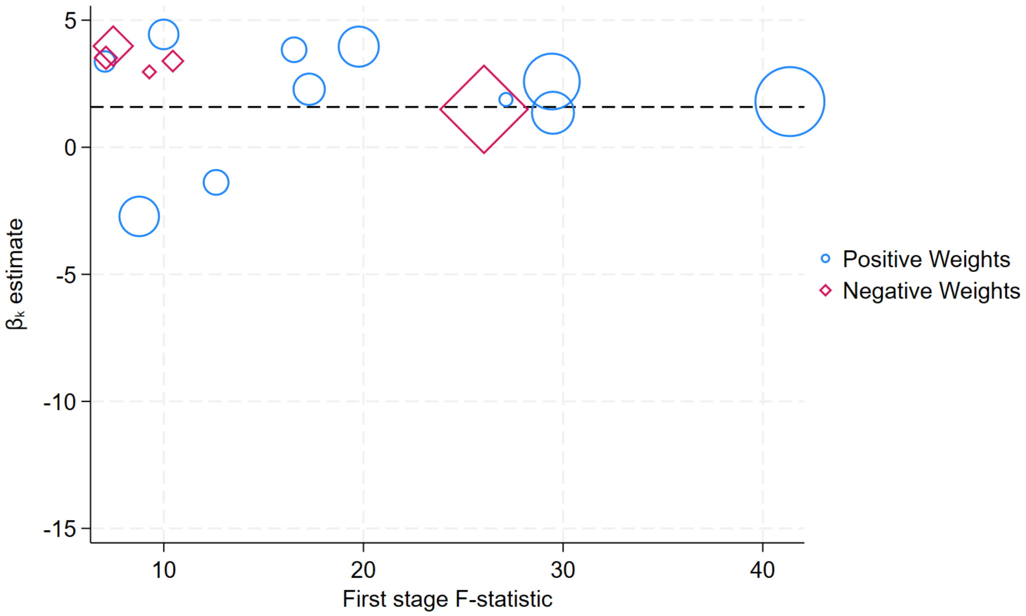
To further assess the instrument validity, I follow the recommended empirical tests suggested by Goldsmith-Pinkham et al. (2020), and use their published replication package to produce the reported results below. Constructing the Bartik employment is the first step in the two step identification strategy, where Bartik employment is used instead of employment in Equation 15. As noted by Goldsmith-Pinkham et al. (2020), the insights from their paper remain applicable even when the instrument is employed in the reduced form, and it is still relevant to compute the Rotemberg weights. I use these weights to explore the variation in Bartik employment.

The Bartik instrument is an aggregate of the included industry shares multiplied by their respective national employment growth. Thus, each industry can be viewed as an instrument, which is then aggregated to the overall Bartik instrument, and the variation in the instrument depends on a combination of the initial industry shares and the national employment growth in the industries. The Rotemberg weights measure which components are dominant in the variation in the overall instrument. Following the recommendations of Goldsmith-Pinkham et al. (2020), I compute the Rotemberg weights for the estimated Bartik instrument, presented in Table A.2. The Rotemberg weights are summarized in Panel A and represented by $\alpha$ in the rest of the table. The panel displays the average correlations for the industries $k$ between the Rotemberg weights, $\alpha_k$, the national growth rates, $g_k$, the Bartik coefficient in the price equation, $\beta_k$ and the variance in the industry shares, $Var(z_k)$. As seen in Panel A, the variance in the industry share contribute more to the Rotemberg weights than the growth rates, and explain approximately 14 percent of the variance in $\alpha_k$ ($0.372^2$).

The summed Bartik instrument consists of 29 industries (instruments). Panel B shows the top five industries with the highest Rotemberg weights. These industries, Health and social work, Public administration, Education, Wholesale and retail trade, repair of motor vehicles, and Transport, account for most of the weight in the estimator. I assess the three first industries, Health and social work, Public administration, Education to be completely unrelated to the construction industry and potential supply shocks in housing development. Parts of Wholesale and retail trade and Repair of motor vehicles and transport may be related to the construction industry and development of housing. However, my conjecture is that employment in these industries are more unlikely to be affected by supply shocks than their sales and turnover.

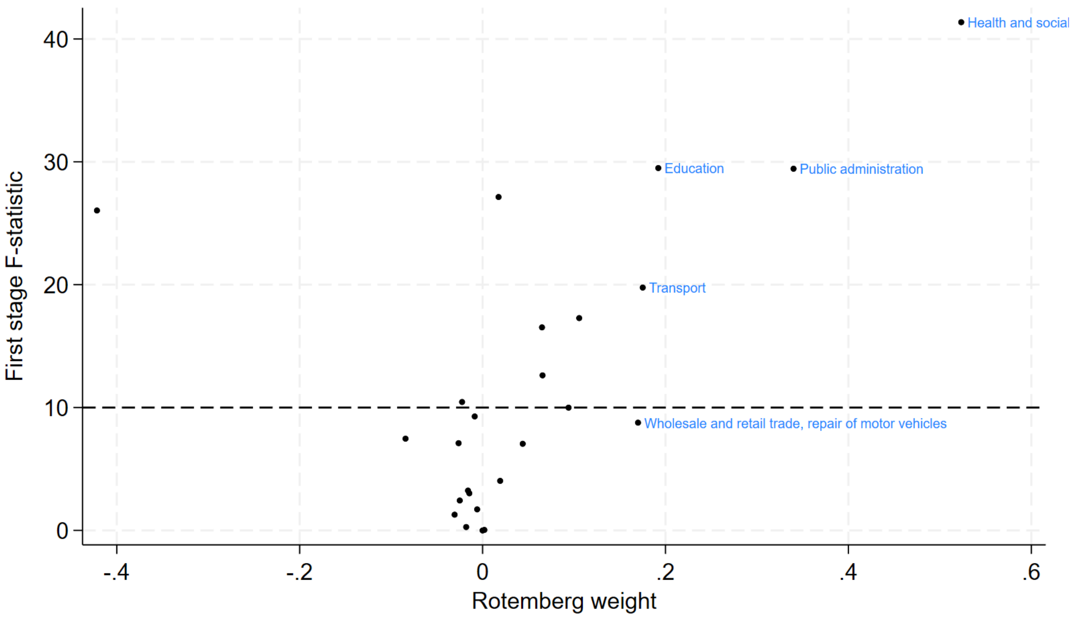
Figure A.1 plots the first-stage F-statistics with the corresponding $\beta_k$ for each instrument/industry $k$. Figure A.2 displays the Rotemberg weights with the corresponding F-statistics.

**Figure A.1.** Heterogeneity of $\beta_k$




Notes: The figure plots the first stage F-statistics on the x-axis and the corresponding $\beta_k$ on the y-axis for each instrument $k$. The size of the points are scaled with the corresponding Rotemberg weight. The figure was created using the code from the replication package from Goldsmith-Pinkham et al. (2020).

**Figure A.2.** First stage F-statistics and Rotemberg weights.




Notes: The figure plots the Rotemberg weight on the x-axis and the corresponding F-statistics on the y-axis. The five industries with the largest Rotemberg weight are denoted with industry name. The figure is produced using the code from the replication package from Goldsmith-Pinkham et al. (2020).

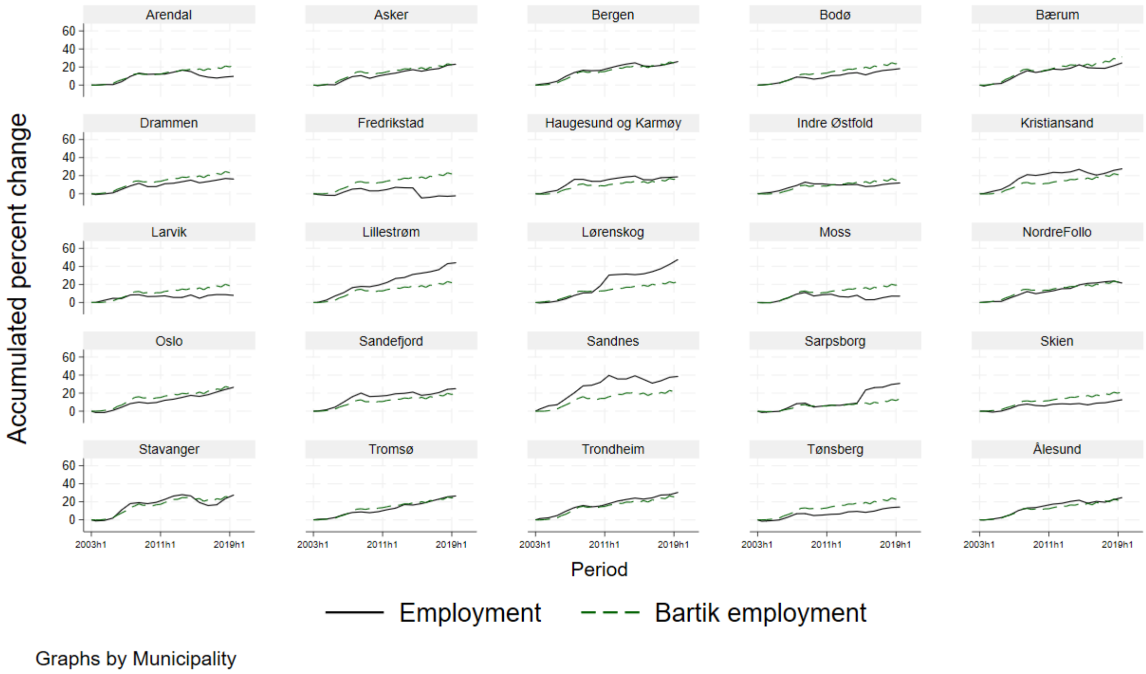
**Table A.2.** Summary of Rotemberg weights

| **Panel A: Correlations of Industry Aggregates** | | | | | |
|---|---|---|---|---|---|
| | $\alpha_k$ | $g_k$ | $\beta_k$ | $F_k$ | Var($z_k$) |
| $\alpha_k$ | 1 | | | | |
| $g_k$ | 0.049 | 1 | | | |
| $\beta_k$ | 0.055 | 0.989 | 1 | | |
| $F_k$ | 0.492 | 0.213 | 0.223 | 1 | |
| Var($z_k$) | 0.372 | 0.223 | 0.222 | 0.513 | 1 |
| **Panel B: Top 5 Rotemberg weight industries** | | | | | |
| | $\hat{\alpha}_k$ | $g_k$ | $\hat{\beta}_k$ | 95 % CI | Ind Share |
| Health and social work | 0.523 | 0.072 | 1.798 | (0.60,3.40) | 19.460 |
| Public administration | 0.340 | 0.057 | 2.588 | (1.10,5.20) | 7.454 |
| Education | 0.192 | 0.087 | 1.359 | (-0.30,2.80) | 8.143 |
| Wholesale and retail trade, repair of motor vehicles | 0.170 | -0.056 | -2.721 | N/A | 17.917 |
| Transport | 0.175 | -0.050 | 3.960 | (2.60,6.70) | 5.564 |

The table is produced using the code from the replication package from Goldsmith-Pinkham et al. (2020).

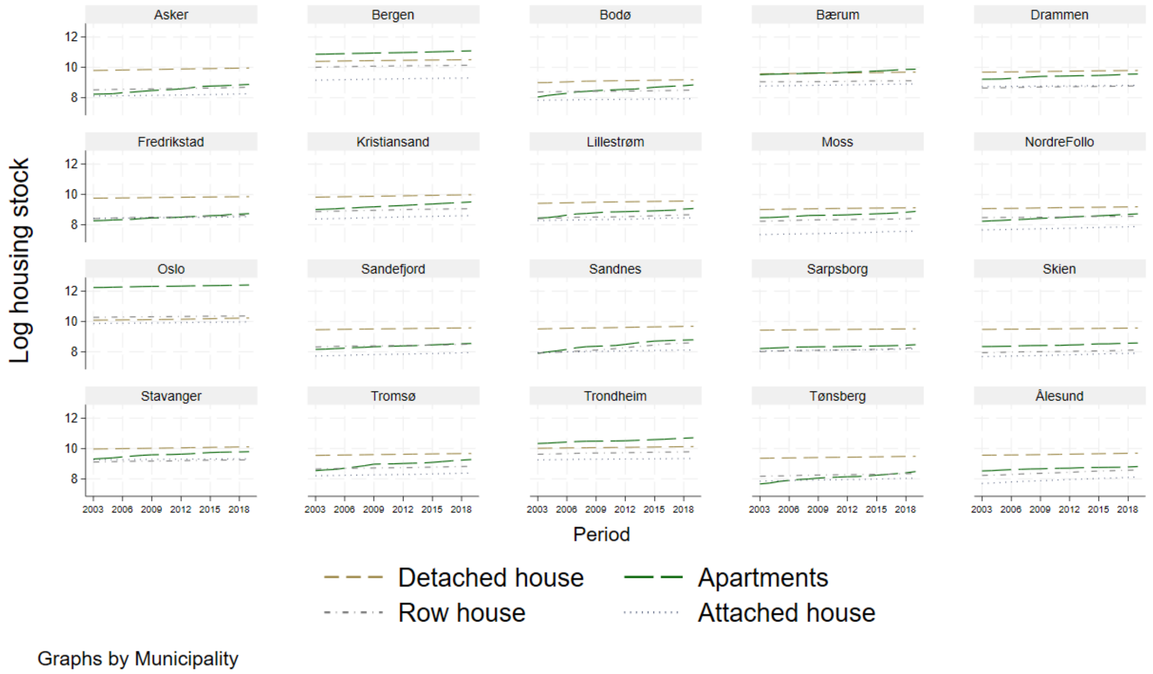
# B Appendix B: Additional tables and figures

**Figure B.1.** Accumulated change in Bartik employment instrument.




Source: Statistics Norway
Notes: The figure illustrates the accumulated change in the Bartik employment instrument by municpality for the time period 2003–2021.

**Figure B.2.** Log housing stock by muncipality. 2003-2019.




Source: Ambita

**Table B.1.** Building work started. OLS specification.

| | Model 1' | | Model 2' | | Model 3' | | Model 4' | |
|---|---|---|---|---|---|---|---|---|
| Price index | 1.760 | *** | 2.714 | *** | 1.931 | *** | 1.931 | *** |
| | (0.249) | | (0.453) | | (0.256) | | (0.263) | |
| 1/3 medium facilitation X Price index | | | -1.740 | *** | | | | |
| | | | (0.471) | | | | | |
| 1/3 lowest facilitation X Price index | | | -0.275 | | | | | |
| | | | (0.499) | | | | | |
| Regulated area per capita X Price | | | | | 0.917 | ** | | |
| | | | | | (0.454) | | | |
| Oslo X Bartik empl | | | | | | | -1.341 | *** |
| | | | | | | | (0.406) | |
| Adjusted R-squared | 0.52 | | 0.53 | | 0.52 | | 0.52 | |
| Number of observations | 1623 | | 1558 | | 1623 | | 1623 | |

Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway with OLS specification. The supply measure is building work started and the cost-adjusted price is contemporaneous ($lags = 0$). All models include municipality- and time- fixed effects. Robust standard error are given in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Figure B.3.** Building work completed. Share by building type and municipality. 2003–2019.


Source: Statistics Norway

**Figure B.4.** Development of the Price index from Eiendom Norge and estimated prices per building type.

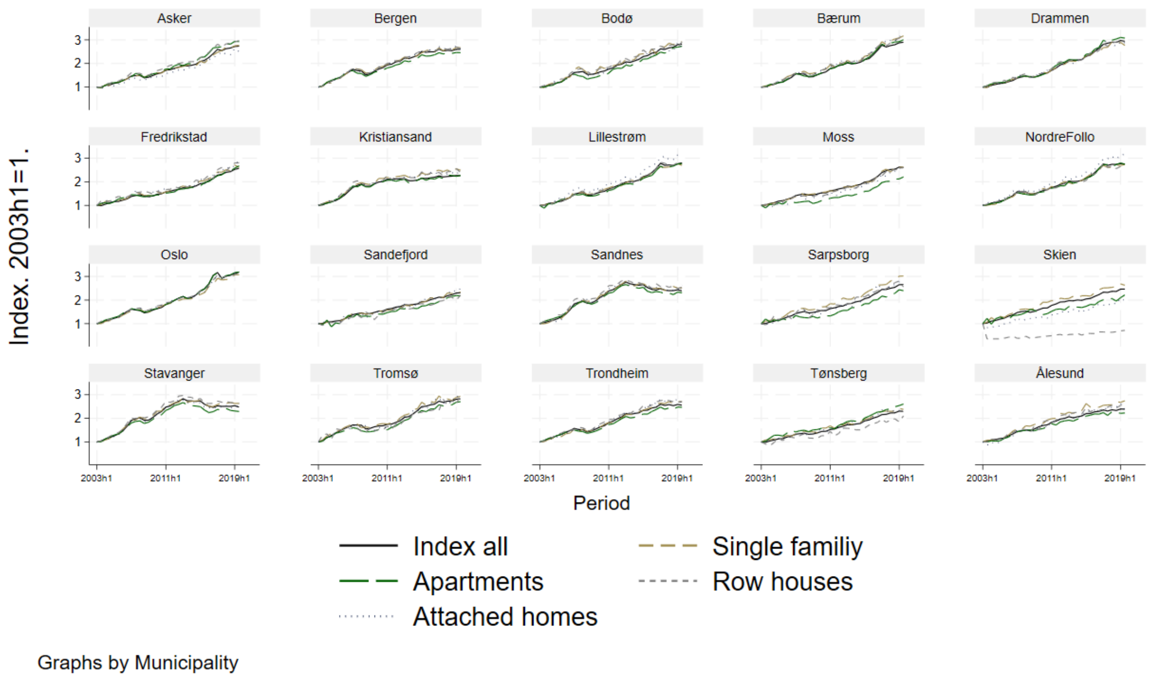


**Table B.2.** Building works started. IV specification. Lagged prices.

| | (1) lig | (2) lig | (3) lig | (4) lig |
|---|---|---|---|---|
| Price index, lags=0 | 1.855** | | | |
| | (0.732) | | | |
| Price index, lags=1 | | 1.783** | | |
| | | (0.724) | | |
| Price index, lags=2 | | | 1.199 | |
| | | | (0.730) | |
| Price index, lags=3 | | | | 0.990 |
| | | | | (0.731) |
| Sample Size | 1623 | 1598 | 1573 | 1548 |
| F-stat | 41.24 | 42.40 | 43.30 | 44.36 |

Notes: The table presents results of estimating Equation 13 for the 25 largest municipalities in Norway where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work started and the price instrumented is lagged by the number of periods denoted in the table. The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * $p<0.1$, ** $p<0.05$, *** $p<0.01$

**Table B.3.** Building works completed. IV specification. Lagged prices.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | lff | lff | lff | lff |
| Price index, lags=4 | 2.301*** | | | |
| | (0.717) | | | |
| Price index, lags=5 | | 2.188*** | | |
| | | (0.716) | | |
| Price index, lags=6 | | | 1.562** | |
| | | | (0.721) | |
| Price index, lags=7 | | | | 1.701** |
| | | | | (0.739) |
| Sample Size | 1522 | 1497 | 1472 | 1447 |
| F-stat | 45.25 | 45.11 | 44.85 | 44.16 |

Notes: The table presents results of estimating Equation 13 for the 25 largest municipalities in Norway where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work completed and the price instrumented is lagged by the number of periods denoted in the table. The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.4.** First stage building work started.

| | (1) lag0lrph | (2) lag0lrph | (3) lag0lrph_lavf253 | (4) lag0lrph_medf253 | (5) lag0lrph | (6) lag0denslrph | (7) lag0lrph_k16 | (8) lag0lrph |
|---|---|---|---|---|---|---|---|---|
| lag0lbsyss | 3.139*** | 3.157*** | -0.572 | 1.067 | 2.774*** | 0.216 | 0.249 | 3.020*** |
| | (0.864) | (1.064) | (0.537) | (0.669) | (0.863) | (0.293) | (0.181) | (0.873) |
| lag1lbsyss | 0.280 | 0.155 | 1.220 | 0.858 | 0.269 | 0.254 | 0.0958 | 0.219 |
| | (1.159) | (1.409) | (0.776) | (0.948) | (1.159) | (0.434) | (0.305) | (1.171) |
| lag2lbsyss | 0.559 | 0.553 | -1.052 | -0.650 | 0.899 | -0.0881 | -0.189 | 0.693 |
| | (1.184) | (1.433) | (0.792) | (0.946) | (1.176) | (0.433) | (0.341) | (1.194) |
| lag3lbsyss | -1.799** | -2.271** | -0.138 | -1.050* | -1.908** | -0.0941 | -0.153 | -1.870** |
| | (0.860) | (1.053) | (0.535) | (0.627) | (0.859) | (0.296) | (0.224) | (0.865) |
| lag0lbsyss_lavf253 | | -0.173 | 2.892*** | -0.0115 | | | | |
| | | (0.486) | (0.313) | (0.159) | | | | |
| lag1lbsyss_lavf253 | | 0.289 | -1.964*** | -0.0382 | | | | |
| | | (0.660) | (0.398) | (0.196) | | | | |
| lag2lbsyss_lavf253 | | -0.395 | 2.004*** | 0.0124 | | | | |
| | | (0.693) | (0.437) | (0.226) | | | | |
| lag3lbsyss_lavf253 | | 0.412 | -1.379*** | 0.0287 | | | | |
| | | (0.511) | (0.335) | (0.175) | | | | |
| lag0lbsyss_medf253 | | 0.270 | 0.0278 | 3.221*** | | | | |
| | | (0.558) | (0.189) | (0.421) | | | | |
| lag1lbsyss_medf253 | | 0.0412 | -0.0942 | -2.107*** | | | | |
| | | (0.770) | (0.232) | (0.584) | | | | |
| lag2lbsyss_medf253 | | 0.0808 | 0.107 | 2.364*** | | | | |
| | | (0.807) | (0.266) | (0.638) | | | | |
| lag3lbsyss_medf253 | | 0.0636 | 0.00627 | -1.616*** | | | | |
| | | (0.587) | (0.205) | (0.459) | | | | |
| lag0denslbsyss | | | | | 1.560** | 3.299*** | | |
| | | | | | (0.760) | (0.632) | | |
| lag1denslbsyss | | | | | -1.279 | -2.207*** | | |
| | | | | | (1.072) | (0.830) | | |
| lag2denslbsyss | | | | | 1.307 | 2.334** | | |
| | | | | | (1.164) | (0.940) | | |
| lag3denslbsyss | | | | | -1.401* | -1.819*** | | |
| | | | | | (0.832) | (0.696) | | |
| lag0lbsyss_k16 | | | | | | | 3.748** | 0.586 |
| | | | | | | | (1.477) | (0.999) |
| lag1lbsyss_k16 | | | | | | | -2.103 | -0.106 |
| | | | | | | | (1.854) | (1.291) |
| lag2lbsyss_k16 | | | | | | | 2.394 | 0.262 |
| | | | | | | | (2.109) | (1.422) |
| lag3lbsyss_k16 | | | | | | | -1.989 | -0.317 |
| | | | | | | | (1.607) | (1.079) |
| _cons | -20.99*** | -15.00*** | -6.670*** | -2.540** | -16.91*** | -5.103*** | -0.0393 | -16.88*** |
| | (2.033) | (2.032) | (1.219) | (1.268) | (2.080) | (0.483) | (0.141) | (1.828) |
| Adj. R-squared | 0.814 | 0.826 | 1.000 | 1.000 | 0.814 | 1.000 | 1.000 | 0.815 |
| Sample Size | 1623 | 1558 | 1558 | 1558 | 1623 | 1623 | 1623 | 1623 |

Notes: The table presents first-stage results corresponding to Table 4, where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work started and the price instrumented is contemporaneous ($lags = 0$). The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.5.** First stage building work completed.

| | (1) lag5lrph | (2) lag5lrph | (3) lag5lrph_lavf253 | (4) lag5lrph_medf253 | (5) lag5lrph | (6) lag5denslrph | (7) lag5lrph_k16 | (8) lag5lrph |
|---|---|---|---|---|---|---|---|---|
| lag5lbsyss | 4.174*** | 4.623*** | -0.467 | 1.729*** | 3.718*** | 0.490* | 0.257 | 4.082*** |
| | (0.778) | (0.966) | (0.562) | (0.608) | (0.777) | (0.282) | (0.200) | (0.783) |
| lag6lbsyss | 0.00960 | -0.236 | 1.199 | 0.458 | 0.114 | 0.0708 | 0.0956 | -0.0347 |
| | (1.070) | (1.316) | (0.821) | (0.947) | (1.061) | (0.441) | (0.334) | (1.081) |
| lag7lbsyss | 0.483 | 1.160 | -0.840 | -0.369 | 0.483 | -0.0614 | -0.181 | 0.716 |
| | (1.095) | (1.344) | (0.828) | (0.965) | (1.079) | (0.437) | (0.364) | (1.102) |
| lag8lbsyss | -2.480*** | -3.713*** | -0.341 | -1.537** | -2.410*** | -0.213 | -0.176 | -2.653*** |
| | (0.793) | (0.977) | (0.556) | (0.624) | (0.787) | (0.290) | (0.232) | (0.795) |
| lag5lbsyss_lavf253 | | -0.385 | 2.893*** | -0.0304 | | | | |
| | | (0.469) | (0.317) | (0.169) | | | | |
| lag6lbsyss_lavf253 | | 0.165 | -1.938*** | -0.0138 | | | | |
| | | (0.655) | (0.422) | (0.222) | | | | |
| lag7lbsyss_lavf253 | | -0.658 | 1.863*** | -0.0162 | | | | |
| | | (0.695) | (0.467) | (0.256) | | | | |
| lag8lbsyss_lavf253 | | 0.849* | -1.295*** | 0.0495 | | | | |
| | | (0.500) | (0.347) | (0.191) | | | | |
| lag5lbsyss_medf253 | | -0.0304 | -0.00532 | 3.254*** | | | | |
| | | (0.529) | (0.196) | (0.414) | | | | |
| lag6lbsyss_medf253 | | -0.0268 | -0.0563 | -2.103*** | | | | |
| | | (0.753) | (0.258) | (0.594) | | | | |
| lag7lbsyss_medf253 | | -0.280 | 0.0609 | 2.210*** | | | | |
| | | (0.796) | (0.294) | (0.661) | | | | |
| lag8lbsyss_medf253 | | 0.623 | 0.0431 | -1.538*** | | | | |
| | | (0.562) | (0.218) | (0.461) | | | | |
| lag5denslbsyss | | | | | 1.720** | 3.376*** | | |
| | | | | | (0.735) | (0.651) | | |
| lag6denslbsyss | | | | | -1.111 | -2.194** | | |
| | | | | | (1.051) | (0.914) | | |
| lag7denslbsyss | | | | | 1.442 | 2.253** | | |
| | | | | | (1.159) | (1.033) | | |
| lag8denslbsyss | | | | | -1.683** | -1.833** | | |
| | | | | | (0.818) | (0.740) | | |
| lag5lbsyss_k16 | | | | | | | 3.764** | 0.387 |
| | | | | | | | (1.545) | (1.009) |
| lag6lbsyss_k16 | | | | | | | -2.217 | -0.200 |
| | | | | | | | (2.116) | (1.429) |
| lag7lbsyss_k16 | | | | | | | 2.233 | 0.0977 |
| | | | | | | | (2.405) | (1.589) |
| lag8lbsyss_k16 | | | | | | | -1.825 | 0.0135 |
| | | | | | | | (1.767) | (1.158) |
| _cons | -20.28*** | -14.14*** | -6.327*** | -2.900** | -15.84*** | -5.080*** | 0.0374 | -17.36*** |
| | (1.908) | (1.855) | (1.149) | (1.207) | (1.945) | (0.500) | (0.157) | (1.774) |
| Adj. R-squared | 0.842 | 0.849 | 1.000 | 1.000 | 0.843 | 1.000 | 1.000 | 0.842 |
| Sample Size | 1497 | 1437 | 1437 | 1437 | 1497 | 1497 | 1497 | 1497 |

Notes: The table presents first stage results corresponding to the IV specifications in Table 5, where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work completed and the price instrumented lagged with five periods ($lags = 5$). The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.6.** Building work completed. OLS specification.

| | Model 2d | | Model 3d | |
|---|---|---|---|---|
| Price index | 2.641 | *** | 2.193 | *** |
| | (0.396) | | (0.255) | |
| 1/3 medium facilitation X Price index | -1.015 | ** | | |
| | (0.436) | | | |
| 1/3 lowest facilitation X Price index | -0.397 | | | |
| | (0.440) | | | |
| Regulated rea per capita X Price | | | 0.098 | |
| | | | (0.791) | |
| Oslo X Price | -1.102 | ** | -1.563 | ** |
| | (0.478) | | (0.759) | |
| Adjusted R-squared | 0.59 | | 0.59 | |
| Number of observations | 1437 | | 1497 | |

Notes: The table presents results of estimating Equation 13 for apartments for the 25 largest municipalities in Norway with OLS specification. The supply measure is building work completed and the price is lagged with five periods ($lag = 5$). The data is on a quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.7.** Apartments. Building work completed. OLS specification.

| | (1) lff | (2) lff | (3) lff | (4) lff |
|---|---|---|---|---|
| Price | 1.640*** | 1.773*** | 1.801*** | 1.768*** |
| | (0.349) | (0.481) | (0.363) | (0.361) |
| 1/3 lowest facilitation X Price | | 0.629 | | |
| | | (0.586) | | |
| 1/3 medium facilitation X Price | | -0.342 | | |
| | | (0.523) | | |
| Regulated area per capita X Price | | | -1.075* | |
| | | | (0.601) | |
| Oslo X Price | | | | -1.153** |
| | | | | (0.486) |
| Adj. R-squared | 0.525 | 0.526 | 0.526 | 0.526 |
| Sample Size | 1033 | 1033 | 1033 | 1033 |

Notes: The table presents results of estimating Equation 13 for apartments for the 20 largest municipalities in Norway with OLS specification. The supply measure is building work completed and the price is lagged with five periods ($lag = 5$). The data is on quarterly basis. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.8.** Building work started. IV specification. Bi-annual data.

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Price index | 1.468 | * | 2.416 | ** | 3.593 | *** | 1.919 | ** |
| | (0.761) | | (1.177) | | (1.178) | | (0.827) | |
| 1/3 lowest facilitation X Price index | | | -0.318 | | | | | |
| | | | (0.582) | | | | | |
| 1/3 medium facilitation X Price index | | | -1.238 | ** | | | | |
| | | | (0.623) | | | | | |
| Regulated area per capita X Price | | | | | -2.693 | *** | | |
| | | | | | (0.881) | | | |
| Oslo X Price index | | | | | | | -1.705 | *** |
| | | | | | | | (0.516) | |
| Number of observations | 825 | | 792 | | 825 | | 825 | |
| F-stat | 42.18 | | 9.25 | | 11.18 | | 18.54 | |

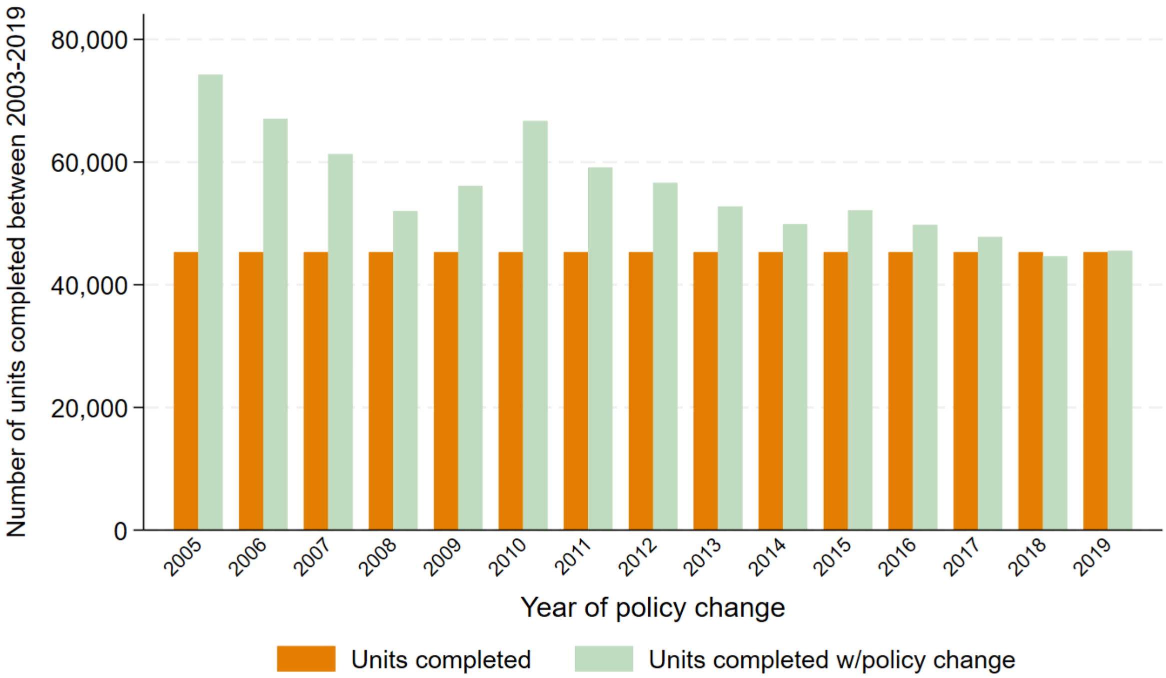
Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work started and the price instrumented is contemporaneous ($lags = 0$). The table is equivalent as Table 4, only with biannual data instead of quarterly. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Table B.9.** Building works completed. IV and OLS specification; biannual data.

| | (1) IV | (2) OLS | (3) IV | (4) OLS | (5) IV | (6) OLS | (7) IV | (8) OLS |
|---|---|---|---|---|---|---|---|---|
| Price index | 1.598 ** | 1.750 *** | 2.418 ** | 2.195 *** | 3.660 *** | 2.103 *** | 1.820 ** | 1.928 *** |
| | (0.760) | (0.274) | (0.959) | (0.379) | (1.258) | (0.282) | (0.805) | (0.280) |
| 1/3 lowest facilitation X Price index | | | -0.489 | -0.350 | | | | |
| | | | (0.528) | (0.399) | | | | |
| 1/3 medium facilitation X Price index | | | -1.251 ** | -0.900 ** | | | | |
| | | | (0.521) | (0.409) | | | | |
| Regulated area per capita X Price | | | | | -2.597 ** | -1.342 *** | | |
| | | | | | (1.032) | (0.457) | | |
| Oslo X Price | | | | | | | -1.091 ** | -1.385 *** |
| | | | | | | | (0.474) | (0.425) |
| Number of observations | 750 | 775 | 720 | 744 | 750 | 775 | 750 | 775 |
| Adjusted R-squared | | 0.69 | | 0.70 | | 0.69 | | 0.70 |
| F-stat | 45.37 | | 10.74 | | 11.59 | | 20.97 | |
| Wooldridge (1995) Test endogeneity: | | | | | | | | |
| Robust score chi2, p.val: | 0.77 | | 0.95 | | 0.29 | | 0.79 | |
| Robust regression F, p.val: | 0.76 | | 0.94 | | 0.27 | | 0.78 | |

Notes: The table presents results from estimating Equation 13 for the 25 largest municipalities in Norway where the cost-adjusted price is instrumented by Bartik-type employment. The supply measure is building work completed and the price instrumented is lagged with three periods ($lag = 3$). The table is equivalent to Table 5, only with biannual data instead of quarterly. All models include municipality and time fixed effects. Robust standard errors are given in parentheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01

**Figure B.5** Total units completed between 2003 and 2019, by year of policy change




Notes: The figure displays both the actual number units completed over the estimation period 2003—2019 and the counterfactual number of units completed between 2003 and 2019. The year denoted on the x-axis represents the year of the policy change, that is, the base year. The number of units completed before this year is set to the actual number of completed units and number of units completed from this year is estimated using Equation 19.

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