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Original Article

Housing supply elasticity and government-owned land: evidence from Hong Kong

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Abstract

Housing supply elasticity is known to be related to three types of development constraints: topography, regulations, and scarcity of undeveloped land. This article shows that land ownership can also explain the spatial heterogeneity in supply elasticity if development costs differ between private and public land. Using data from Hong Kong (2003–2018), where government-owned land is common and has development advantages, this article confirms that the availability of government land contributes significantly to housing supply elasticity, in addition to the three constraints. This article sheds light on the potential of utilizing public land to increase housing supply.

Keywords: housing supply elasticity; spatial heterogeneity; development constraints; public land ownership; microgeography.

JEL classifications: R14, R31, R52

1. Introduction

Housing supply elasticity has received extensive attention because of its critical role in shaping not only the housing market but also labor supply, public finance, and urban development. Studies indicate that an inelastic housing supply is a significant driver of rapid housing price appreciation (Case and Shiller 2003; Glaeser, Gyourko, and Saks 2005), leading to the displacement of low-income households (Gyourko, Mayer, and Sinai 2013), spatial misallocation of labor (Hsieh and Moretti 2019), increased rent-seeking behavior (Diamond 2017), and reduced economic growth (Accetturo et al., 2020).

Central to these studies is what constrains the housing supply and makes it inelastic. Three types of land development constraints have been identified. They are 1 topographic terrains (Glaeser, Gyourko, and Saiz 2008; Saiz 2010; Wang, Chan, and Xu 2012), 2 development control, including zoning and building regulations (Brueckner and Singh 2020; Büchler and Ehrlich 2023; Glaeser, Gyourko, and Saks 2005), and 3 scarcity of undeveloped land (Ihlanfeldt and Mayock 2014; Hilber and Vermeulen 2016). In essence, these constraints increase the costs of acquiring and preparing land for development, thereby making new construction less responsive to rising demand (Baum-Snow 2023). However, previous studies have overlooked the potential influence of land ownership on development costs, an aspect that hinges on institutional frameworks.

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In this article, we investigate whether government-owned land can influence housing supply elasticity in Hong Kong (2003–2018) in addition to the three supply constraints mentioned above.[1] The practice of leasing public land for housing development, also known as public leaseholds, has been implemented in Hong Kong, as well as Singapore, China, Israel, the Netherlands, France, Sweden, and Finland (Bourassa and Hong 2003). Public land, as it is owned by the government, is not subject to fragmented titles that could impede development on private land. Moreover, as the government often serves as both land supplier and regulator, building on public land is expected to encounter fewer institutional barriers, unless the government is highly inefficient due to bureaucracy and rigidity (Werczberger and Borukhov 1999; Rubin and Felsenstein 2017). Therefore, we expect that the availability of government-owned land can facilitate housing supply in Hong Kong and contribute to housing supply elasticity.

Our empirical work comprises of three major steps. First, we examine baseline models that estimate the average supply elasticity before introducing any determinants. While the Two-Stage Least Squares (2SLS) method is well established in the literature, its primary challenge is to find an instrument variable that shifts housing demand but not supply (Baum-Snow 2023). We use the number of Mainland Chinese tourists going to Hong Kong (Tourist IV) as this demand shock, given the positive impact of tourism on the city's economic growth (IV relevance) and the legal restriction that prevents tourists from changing the labor conditions in the construction sectors (IV exclusion restriction). Our baseline estimate of 0.00916 indicates an extremely inelastic housing supply, highlighting the severe problem of housing unaffordability in Hong Kong (Task Force on Land Supply 2018). For robustness checks, labor Bartik-style IV, which is commonly used in the literature, provides similar estimates.

Second, we add the determinants of housing supply elasticity to the empirical models. Following the literature (Baum-Snow 2023), we have multiple measurements of the developable land share (DLS) in each neighborhood. Flat land, undeveloped land, and residential-zoned land are extracted as percentages of the neighborhood land areas. Similarly, government land reserves (GovLR) for future residential development, the focus of this research, are also identified on maps and counted as percentages of land share in each neighborhood. Each neighborhood's distance to the central business district (CBDdist) is also included as a determinant of housing supply elasticity (Baum-Snow and Han 2024). Evidence supports our proposition that the availability of government-owned land contributes significantly and positively to the housing supply elasticity of Hong Kong neighborhoods. In particular, one standard deviation rise in GovLR (1.256 percentage points) and CBDdist (6.308 km) is associated with increases in the neighborhood supply elasticity by 0.00564 and 0.00416, representing 62 and 45 per cent, respectively, above the baseline supply elasticity estimates.

Third, we calculate the housing supply elasticity of each neighborhood using the coefficients of the determinants. With these determinants, the average supply elasticity estimate of Hong Kong neighborhoods is 0.00987. This is close to the 0.00916 estimate from the baseline model. In terms of the regional average, the Hong Kong Islands are the most inelastic region, compared with the Kowloon Peninsula and the New Territories. This follows our expectations because the Hong Kong Islands are the most infilled regions and have much natural and historical conservation. Overall, our estimates of neighborhood supply elasticity range from 0.00041 to 0.02419. If we compare with the neighborhoods of major US cities—where supply elasticity estimates range from 0.0000165 to 0.8255 (Baum-Snow and Han 2024)—our estimates fall within this range but closer to the lower end.

This article contributes to the literature on the determinants of housing supply elasticity. As reviewed by Baum-Snow (2023), topography, regulations, the scarcity of undeveloped land, and distance to the city center are known to affect housing supply elasticity. We show, for the first time, that land ownership can be another factor shaping supply elasticity, as the development costs on public land often differ from those on private land. In addition, this article provides supply elasticity estimates at the neighborhood level. This contributes to the growing field of within-city heterogeneity in the housing market (Zhu et al. 2019; Fischer, Fuss, and Stehle 2021; Ren, Wong, and Chau 2023; Baum-Snow and Han 2024), which has been limited by the lack of supply elasticity estimates at a very local level (Gyourko 2009).

This article also adds to the literature on the economic impacts of land ownership, specifically the difference between public and private land. Kunce, Gerking, and Morgan (2002) estimate oil drilling

[1] Like Green, Malpezzi, and Mayo (2005), we only examine the short-term relationship between housing stocks and housing prices. Long-term supply elasticity is not studied because data of long series are unavailable in Hong Kong.

costs, which are found to be higher on federal land than on private land due to stringent law enforcement. Leonard and Parker (2021) argue that the extra costs on public land can be offset if land assembly costs of private land are considered. Studies on the impact of government-owned land on urban development, such as housing supply, have been limited since the rise of neoliberalism (Werczberger and Borukhov 1999). This article resumes this debate and provides evidence that public land can play a positive role in increasing housing supply elasticity.

Although this article focuses on Hong Kong, its findings are relevant to countries with public leaseholds, such as Singapore, China, Israel, the Netherlands, France, Sweden, and Finland (Bourassa and Hong 2003; van der Krabben and Jacobs 2013). Our findings may also have implications for countries with urban public land that are seldom used for housing construction, such as the US and Canada (Eidelman 2016; Sasu, Squires, and Javed 2022). Our positive evidence from Hong Kong may inspire policymakers to consider public land as a potential channel for improving housing supply and affordability.

The remainder of this article is organized as follows: Section 2 reviews the institutional background and summarizes the development advantages of government-owned land in Hong Kong. Section 3 describes the data, and Section 4 presents the models and empirical findings on housing supply elasticity. Section 5 concludes.

2. Public leaseholds in Hong Kong

Hong Kong has adopted a public leasehold system—the government leases land parcels to private entities for development, usually through auctions or tenders. The winning private entity, typically a developer, enters into a land lease with the government and agrees to develop the land according to the terms in the land lease (Lai, Ho, and Leung 2010). Thereafter, housing units, along with their share of the land parcels, are sold to individual home buyers. Hong Kong has a vibrant private market that facilitates leasehold rights transactions among private entities (Hong and Bourassa 2003). As private entities can develop, use, and sell these land rights, the government has full control of the land before it is leased. Thus, in this article, government-owned land or public land is defined as land yet to be leased to developers or individuals.

Housing can be constructed on land acquired from the government or private landowners. However, there are two reasons why developing private land in Hong Kong is usually more costly than developing government-owned land. First, the costs of assembling private land titles can be prohibitively high if the land has been subdivided into multiple ownerships (Adams, De Sousa, and Tiesdell 2010; Brooks and Lutz 2016; Lin, Huang, and Lin 2018). In contrast, government-owned land has a single owner, and acquiring it involves only one transaction with the government of Hong Kong, either through a standard tender or an open auction.

The second reason for the higher costs of developing private land in Hong Kong is that under the public leasehold system, the use of private land is restricted by land leases. If private landowners wish to develop or redevelop their land, they usually need to apply to the government for land lease modification, which often involves charging a land premium. This is a substantial amount, arguably equivalent to the land value gains from the modification. Appeals are common, and negotiations can lead to protracted delays in development (Nissim 2011). In contrast, developing public land does not require land lease modification. The government serves as both the land supplier and the land lease regulator. When the government puts public land on the market for developers to bid, land leases are prepared in accordance with the intended development. Therefore, developing public land avoids such barriers from land leases.[2]

The above analysis suggests that developing public land has cost advantages in Hong Kong because it does not require land assembly or land lease modification. In addition, facing skyrocketing housing prices, the Hong Kong government is under political pressure to increase housing supply and stabilize housing prices (Task Force on Land Supply 2018). Given this context, we expect that neighborhoods with more government-owned land should be more responsive to housing demand and contribute to higher housing supply elasticity in Hong Kong.

[2] Apart from title assembly and land lease modification, developing public and private land share similar procedures. There is no quota for how much land can be developed at a given time. The approval of building permits is based on compliance with building ordinances, such as being endorsed by the fire services and compatibility with sewage tunnel works (Lai, Ho, and Leung 2010).

3. Data

The data section has two parts: (1) the data used in our baseline models, which are sufficient to provide an average supply elasticity estimate without incorporating any neighborhood characteristics, and (2) the data used for measuring the supply elasticity determinants, which are then included in the main models.

3.1 Data for baseline model

3.1.1 Housing prices

We use housing transaction data and neighborhood boundaries from EPRC, a private company that collects information on property sales in Hong Kong. The EPRC classifies all residential buildings into sixty neighborhoods, whose boundaries are available on the company's website.[3] Four of the sixty neighborhoods have insufficient transactions for constructing the quarterly price indices. After merging these with adjacent neighborhoods, we are left with a total of fifty-six neighborhoods.[4]

The repeat sale method is used to construct housing price indices (Bailey, Muth, and Nourse 1963). In Equation (1), Y_{it} and Y_{is} are the transaction prices of housing unit i at times t and s, respectively. The hedonic attributes on the right side have been canceled out, and ε_{ts} is the error term. The τ_t and τ_s are the coefficients of the time dummies at time t and s, respectively, which are then converted into price indices.

$$\ln(Y_{it}) - \ln(Y_{is}) = \tau_t - \tau_s + \varepsilon_{ts} \tag{1}$$

Quarterly price indices are constructed using transaction data between 1995 and 2018. The index coverage is longer than our study period to avoid unstable coefficients in the early periods of the indices. Annual price changes between July 2003 and July 2018 are calculated by taking the log difference of the indices.

3.1.2 Housing stocks

Similar to price changes, we need a panel dataset of housing stocks. Data are not directly available but can be approximated given (1) the initial level of housing stock in 2003 and (2) the quantity of new supply each year.

First, we obtain the initial housing stocks in 2003 by combining two geo-datasets: the iG1000 maps and the Land Utilization Map (LUM). The iG1000 maps record buildings' projection areas and elevation levels. If a three-meter headroom is assumed, the total floor area of each building can be calculated: the projection area × (the top level−the base level) ÷ 3. Then, we have a geo-dataset showing the floor areas of all buildings, including residential buildings and others. Then, we use LUM 2003, which labels land occupied with residential buildings (not zoning) in 2003, to identify residential buildings.[5] The overlay of the two geo-datasets is illustrated in Supplementary Appendix Fig. S1—projection areas of all buildings are in gray, and the land occupied by residential buildings is in black. The initial residential floor areas of each neighborhood are known by keeping the floor areas of the overlaps.

Second, we calculate the quantity of construction each year. As permits have been commonly used in the supply elasticity literature (Malpezzi 1996; Glaeser, Gyourko, and Saiz 2008; Glaeser and Ward 2009), we obtain residential floor areas from construction permits. Compared with construction completion, using permit data requires a shorter time lag adjustment to match the reaction moment of housing price changes. After adding new construction to the initial housing stocks, we obtain the housing stock panel dataset.

3.1.3 Instruments

Three IVs are constructed for housing prices: Tourist IV, Labor-1 IV, and Labor-2 IV. Tourist IV is the main IV, and the other two are alternatives (refer to Section 4.1.2 for the IV justification). The focus here is on the data source for constructing the instruments.

As a Bartik-style IV, Tourist IV is the product of a contemporary national shock (the shift) and time-lagged local weights (the share). Here, the shift is the annual number of Mainland Chinese tourists

[3] EPRC district boundaries can be viewed at http://www.eprc.com.hk/DistrictBoundary/.
[4] We do not drop the four neighborhoods because we want to keep a full picture of the Hong Kong housing market.
[5] The LUM is published by the Hong Kong Planning Department each year. It is composed of satellite images and land use surveys to show the existing/actual land use status (not zoning). It has a resolution of 10 m.

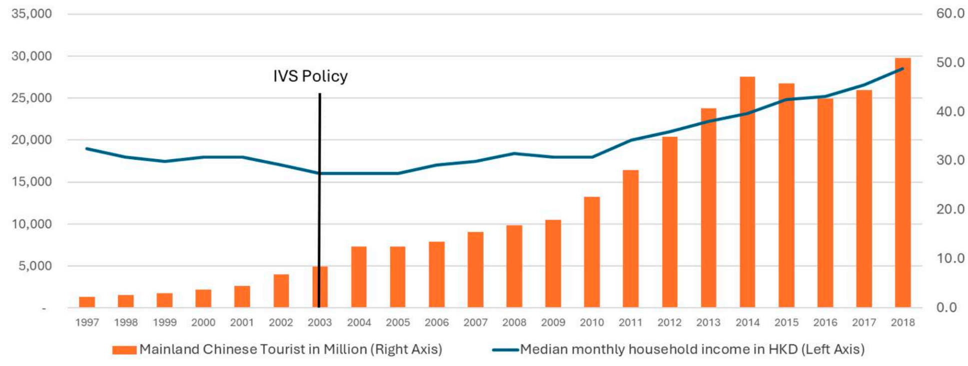

Figure 1. Mainland Chinese tourists and Hong Kong household median income.

Notes: Data are from the Census and Statistics Department of Hong Kong. The figure shows the persistent growth in the number of Mainland Chinese tourists (the bars correspond to the values on the right axis—millions) and the median of Hong Kong household monthly income (the line corresponds to the values on the left axis—HKD) during the study period (2003–2018).

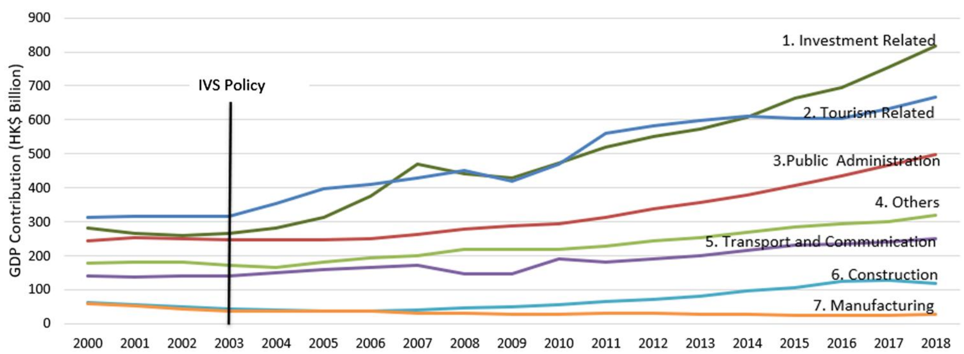

Figure 2. Hong Kong GDP contribution by industries.

Notes: Data are from the Census and Statistics Department of Hong Kong. The seven industry groups are the same as the employees' occupation groups in the 2001 census survey: (1) investment-related industries include finance and insurance, real estate, professional and business services; (2) tourist-related industries include import/export, wholesale and retail trades, accommodation and food services; (3) public administration includes public administration, social and personal services; (4) others are not specified; (5) transport and communication includes transportation, storage, postal and courier services, information and communications; (6) construction; and (7) manufacturing each represent one sector. It shows tourism-related industries' fast growth and strong contribution to the Hong Kong GDP during our study period (2003–2018).

between 2003 and 2018. Figure 1 shows a persistent upward trend of tourists during the sample period. The share is the initial percentage of the population working in tourism-related industries in the 2001 census, including wholesale, retail, import/export trades, restaurants, and hotels.[6] The product of the shift and share is then taken as the natural log and the first difference to instrument the log difference of housing prices in empirical models.

The two alternative instruments are Labor-1 IV and Labor-2 IV. They are Labor Bartik-style IV. Their shift is the GDP contribution of each industry from 2003 to 2018, and the share is the initial percentage of the population working in the corresponding industry in the 2001 census. Figure 2 shows the trends of the shift variables. These seven industry categories match the employees' occupation classifications in the 2001 census. The Labor-1 IV is the sum of the shift × share of all industries. However, as investment-related and construction sectors are easily related to housing supply, they could make the instrument endogenous and generate inconsistent results. Thus, these two industries are removed to create Labor-2 IV. Like the main instrument, alternative IVs are also in log difference in the empirical

[6] In census surveys, wholesale, retail, import/export trades, restaurants, and accommodations are one occupation category, and tourism is one item in the export.

models. As a preview, Labor-2 IV gives similar results to Tourist IV; Labor-1 IV gives a less satisfying result due to the potential endogenous problem mentioned above.

3.1.4 Supply shifter

In Saiz's (2010) seminal paper, the supply shifter is the change in national construction costs (shift) multiplied by a location-specific factor (share), which is the initial structure share of locations ($1-\frac{\text{initial land value}}{\text{initial housing price}}$). (Please refer to Section 4.1.1 for why we use a similar supply shifter to Saiz's.) Here, we focus on how to construct the variable. Our citywide construction cost changes are from the construction cost index published by the Commerce and Industry of Hong Kong. To obtain the initial structure shares of neighborhoods, we need to estimate the initial land value, which is explained below.

Unlike cities with periodic assessments of land values (Bostic, Longhofer, and Redfearn 2007), Hong Kong does not have such a practice. Instead, relative land values can be approximated using the hedonic regression in Equation (2). The $\ln(P_{ij})$ is the transaction price of unit i in location j in the natural log; L_j is the location dummies; S_i *and* S_i^2 are the unit size and quadratic term, respectively; F_i *and* F_i^2 are the unit floor and quadratic term, respectively; Y_i is the year of building completion; c is the constant; and ε_i is the residual. It excludes time dummies to obtain the average land values over the years. Equation (2) is run using transactions from 2000 to 2002, prior to the study period. Intuitively, land value is part of the hedonic value not captured by a building's attributes. Thus, the sum of the intercept (c) and location dummies (L_j) can represent the relative land values across neighborhoods. Similar procedures have been used in the literature (Wong, Yiu, and Chau 2012; Peng and Thibodeau 2013).

$$\ln(P_{ij}) = L_j + k_2 S_i + k_3 {S_i}^2 + k_4 F_i + k_5 {F_i}^2 + k_6 Y_i + c + \varepsilon_i \tag{2}$$

Then, we standardize the relative land value by assigning a value of 1 to a base location (Wong, Yiu, and Chau 2012) and further standardize the structure share of the base location to 50 per cent. In this way, the structure share across neighborhoods is between 39 and 64 per cent. We have cross-checked by looking at the ratio of construction costs per m^2 and the median transaction price per m^2 between 2000 and 2002. This alternative method provides an average structure share estimate of 49 per cent, which falls within the range of hedonic estimates mentioned above.[7] We admit that the hedonic method is not the best way to estimate land value. However, it satisfies the purpose of knowing the cross-sectional differences in each neighborhood's structure share prior to the study period.

3.1.5 Summary statistics

The summary statistics are presented in Table 1. The $\Delta\ln$ Q is the log difference of annual housing stocks. The $\Delta\ln P$ is the log difference of the price indices every four quarters. The Min and Max values of $\Delta\ln P$ seem astonishing. They are from two sequential periods in the Middle-Level-East neighborhood. Outlier transactions have been eliminated before constructing the quarterly repeat sales price indices. As high price volatility may represent certain neighborhood features, the seemingly astonishing price changes are kept rather than smoothed away.

The $\Delta\ln$ CC is the supply shifter in log difference, which is the citywide construction cost changes multiplied by the initial structure share of neighborhoods. The three instruments for $\Delta\ln P$ are also in log differences. They are $\Delta\ln$ Tourist IV, $\Delta\ln$ Labor-1 IV, and $\Delta\ln$ Labor-2 IV. So far, we have presented the data and variables used for the baseline models. The data used for measuring DLS, the supply elasticity determinants, are introduced next.

3.2 Data for supply elasticity determinants

3.2.1 Flat land

Following Saiz (2010), we count the percentage of flat land (land with slopes of less than 15 per cent) in each neighborhood after excluding inland waters. Two geo-datasets, the Digital Terrain Model (DTM)

[7] Construction costs of high-quality apartments in mid-2001 were approximately 17,442 HKD per m^2. It can be calculated from two sources: (1) construction costs of high-end apartments in Q4 of 2023 published by Arcadis, and (2) construction cost price index published by the Civil Engineering and Development Department to adjust the cost from 2023 to 2001. According to transaction records of EPRC, the median housing price was 35,735 HKD per m^2 between 2000 and 2002. Thus, a rough estimate of the initial structure share of Hong Kong is 17,442/35,735 = 49%. This is a cross-check for the hedonic estimates.

Table 1. Summary statistics for the baseline models.

Variables	Obs	Mean	SD	Min	Max
$\Delta\ln Q$	840	0.0023	0.0084	0	0.1401
$\Delta\ln P$	840	0.1145	0.1446	−0.962	0.9602
$\Delta\ln CC$	840	0.0166	0.068	−0.1233	0.1772
$\Delta\ln$ Tourist IV	840	0.0329	0.0314	−0.0273	0.1534
$\Delta\ln$ Labor-1 IV	840	0.0538	0.0332	−0.0414	0.1255
$\Delta\ln$ Labor-2 IV	840	0.0464	0.0323	−0.0459	0.1332

[a] *Notes:* $\Delta\ln Q$ is the annual housing stock change (dependent variable). $\Delta\ln P$ and $\Delta\ln CC$ are annual housing price changes and construction cost changes (supply shifter), respectively. The last three variables are instruments for the endogenous $\Delta\ln P$. These variables are sufficient to estimate the baseline models without any determinants of supply elasticity.

and Land Utilization Map (LUM), are processed in ArcGIS Pro to generate slope maps and exclude waters in the city. The DTM is published by the Lands Department of Hong Kong, and it is generated from multiple aerial photographs after excluding building heights to represent the terrain height only. The LUM is published by the Hong Kong Planning Department each year, and it is composed of satellite images and land use surveys to show the existing/actual land use status (not zoning) and waters. The spatial distribution of flat land in Hong Kong is visualized in Supplementary Appendix Fig. S2.

3.2.2 Undeveloped land

Following the literature, we extract undeveloped land from land use covers prior to the study period (Hilber and Vermeulen 2016; Baum-Snow and Han 2024). We use the land cover dataset LUM 2003, which shows the actual/existing land use status (not zoning) in 2003. Our definition of undeveloped land is the same as the "non-built-up land" used by the Hong Kong government (Legislative Council Secretariat of HKSAR 2018). The spatial distribution of undeveloped land in Hong Kong is shown in Supplementary Appendix Fig. S3.

3.2.3 Land zoned as residential

The Outline Zoning Plans (OZP) are the statutory town plans in Hong Kong. Land parcels with residential zoning are identified from OZP 2018, the earliest published version from the Hong Kong Planning Department.[8] From the rezoning records, we know the net changes in residential-zoned land between 2003 and 2018. Then, the net changes are deducted to calculate the percentage of residential-zoned land in each neighborhood in 2003, the initial stage of the study.

3.2.4 Government land reserves

For the government land reserves, our main data source is a comprehensive land survey published by the Hong Kong Development Bureau in mid-2012 in response to the public's concern about the frenetic housing prices in Hong Kong. We use geo-referencing and support vector machine (one image classification technique) in ArcGIS Pro to digitize the survey map, which is publicly available in PDF format only. Supplementary Appendix Figure S4 illustrates the data processing quality: even land of irregular shape or small size has been depicted. After digitization, each pixel has coordinates. Thus, the sizes and locations of these reserves are known. We combine this geo-dataset with rezoning plans for residential use from the Hong Kong Planning Department. These government-owned land parcels represent only developable (flat, undeveloped, and residential-zoned) land because land that is not feasible for residential development (e.g. military reserves or conservation) has been excluded from the government land survey outputs.[9]

Like other DLS measurements, the initial value of government land reserves is needed in empirical models. Thus, we add back government land sales between 2003 and 2012.[10] Data for this time

[8] Flats and houses are both permitted on land zoned for residential use. In Hong Kong, single-family and multi-family uses are not distinguished in land use zoning.

[9] This one-time survey was published as "Unleased and Unallocated Government Land Zoned 'Residential' or 'Commercial/Residential' (after deducting the types of land which are considered not suitable for development, not yet available for development or with low development potential)" by the Development Bureau of Hong Kong in mid-2012.

[10] We do not observe expansion (e.g. through reclamation) in the government's residential land reserves between 2000 and 2012. The government announced plans to expand the land reserves in its policy address in 2012. Reclamation in

Table 2. Summary statistics of supply elasticity determinants.

Variable	Obs	Mean	SD	Min	Max
Panel A: DLS measured by one constraint					
% Flat Land	56	41.728	22.427	7.885	90.127
% Undeveloped Land	56	46.317	23.747	7.98	88.98
% Residential Zoned Land	56	20.348	12.552	1.769	49.82
Panel B: DLS measured jointly by a few constraints					
% Flat and Undeveloped	56	10.587	8.279	1.607	42.48
% Flat and Zoned	56	11.519	7.877	0.313	31.956
% Undeveloped and Zoned	56	2.833	2.806	0.042	11.499
% Flat, Undeveloped, and Zoned	56	1.265	1.563	0.051	8.348
% GovLR	56	1.025	1.256	0	4.402
Panel C: Other determinants					
CBDdist (km)	56	7.892	6.308	0.284	26.274

Notes: Panel A presents developable land share (DLS) in neighborhoods measured with only one type of supply constraint. They represent, separately, the percentage of land that is flat (a slope of less than 15%), undeveloped (defined by the Hong Kong government), and zoned for residential use prior to the study. Panel B presents DLS when different supply constraints are jointly considered. For example, % Undeveloped and Zoned represents the percentage of undeveloped land with residential zoning. In real life, vacant land is not developable for housing unless it also has residential zoning. Our research focus is % GovLR, the share of the government-owned land in each neighborhood reserved for housing development. It jointly fulfills the prerequisites of land development mentioned above and keeps only the government-owned portion. Panel C shows the neighborhood's distance to CBD. Apart from CBDdist, other determinants in the table are in percentage points.

adjustment are land sales by the Lands Department of Hong Kong and the MTR Corporation (MTRC).[11] As the MTRC's annual reports are only available from 2000, we end up with the GovLR measurement in 2000.

3.2.5 *Summary statistics of determinants*

Panel A of Table 2 shows the summary statistics of the three types of supply constraints when measured separately, representing DLS from a single dimension. They are % Flat Land, % Undeveloped Land, and % Residential Zoned Land. On average, about 42 per cent of the land in Hong Kong neighborhoods is flat, while about 46 per cent remains undeveloped, and 20 per cent has residential zoning.

Panel B of Table 2 reports the DLS measured jointly using at least two types of supply constraints. For example, % Flat and Undeveloped is the percentage of land that is both flat and undeveloped in neighborhoods. Technically, these land parcels are identified by overlaying two geo-databases shown in Supplementary Appendix Figs S2 and S3.[12] Similarly, % Flat and Zoned and % Undeveloped and Zoned also restrict the definition of developable land using two criteria at the same time. When more constraints are added, there should be fewer qualified parcels. As expected, the means of DLS measurements from two dimensions are all smaller than the single-dimension measurements in Panel A. Likewise, % Flat, Undeveloped, and Zoned is the percentage of land that is flat, undeveloped, and zoned for residential use in each neighborhood. As it is jointly restricted by three types of supply constraints, its mean of 1.265 per cent is smaller than all two-dimension measurements mentioned above.

The last row of Panel B in Table 2 summarizes the share of GovLR in each neighborhood. It represents four layers of information. Compared to the three-dimension measurement, % GovLR further restricts flat, undeveloped, and residential-zoned land by keeping only the government-owned portion. The mean of % GovLR is 1.025 per cent, which is smaller than the mean of % Flat, Undeveloped, and Zoned by 0.24 percentage points. In terms of land areas, GovLR and Flat, Undeveloped, and Zoned land represent 622.88 and 1005.38 hectares of land in Hong Kong, respectively. This reflects a simple fact about the Hong Kong land market: most developable land for housing construction is in the hands of the government. Panel C of Table 2 shows neighborhoods' distance to the CBD, which is also an important determinant of neighborhood supply elasticity (Baum-Snow and Han 2024).

Lantau Island and title assembly in the north of the New Territories have been proposed, evaluated, and discussed. As both projects can take decades to complete, their land was not developable during our study period (2003–2018).

[11] There are three channels of government land sales in Hong Kong: the Lands Department of Hong Kong, the MTRC and the Urban Renewal Authority (URA). URA is not included here as it acquires land title from the market and does not own any land initially.

[12] The map of flat land and the map of undeveloped land are raster datasets with a pixel resolution of 10 meters (Supplementary Appendix Figs S2 and S3). The overlapped map shows 10 m × 10 m land parcels, which are then counted as percentages of the total areas of neighborhoods. Similarly, zoning plans are also at the parcel level, and aggregating the overlapped parcels into the neighborhoods as percentages happens only after the overlay.

4. Empirical models and results

The empirical analysis consists of three parts: (1) baseline models, which estimate the average supply elasticity without any determinants; (2) main models, which identify the determinants of supply elasticity along with their coefficients; (3) calculating neighborhood supply elasticity after the coefficients of the determinants are identified.

4.1 Baseline models and instrument variables

4.1.1 Baseline models

Before unpacking the determinants, we use baseline models to estimate the average supply elasticity and validate the instrument variables. Equation (3) is a generalized empirical model for estimating supply elasticity using panel data (Wooldridge 2009). The $\Delta\ln Q_{i,t}$ and $\Delta\ln P_{i,t}$ are observed changes in quantities and prices, which are simultaneously decided by demand and supply. Thus, $\Delta\ln P_{i,t}$ is endogenous and needs to be instrumented in 2SLS. The ΔX_{it} is exogenous supply shifters. Time-invariant variables and the constant term have been eliminated after the first difference, leaving the time fixed effect ϑ_t and error term $\mu_{i,t}$. By definition, the price elasticity of supply is $\frac{\Delta\ln Q_{i,t}}{\Delta\ln P_{i,t}}$, which is β_1 in Equation (3). To apply the equation to estimate housing supply elasticity, we will need to select the appropriate supply shifter, the time lags to adjust the late observed changes in housing stocks, and the instrument variables.

$$\Delta\ln Q_{i,t} = \beta_1\Delta\ln P_{i,t} + \beta_2\Delta X_{i,t} + \vartheta_t + \mu_{i,t} \tag{3}$$

First, we use construction costs as the supply shifter because construction costs are found to shift housing production (Baum-Snow 2023). In Saiz's (2010) seminal paper, which estimates the housing supply elasticity of metropolitan statistical areas (MSAs) in the USA, the supply shifter is the national construction cost changes multiplied by an MSA character: the initial structure share $(1 - \frac{\text{Initial land value}}{\text{Initial property price}})$. It captures the different levels of exposure of MSAs to national construction cost changes (Saiz 2010). Without loss of generality, assume that locations A and B have a structure share of 60 and 40 per cent, respectively. Given a sharp price drop in construction materials, e.g. the total development costs will reduce more in location A than in location B, assuming the land value is constant. If the expected selling price is unchanged, projects in location A will become more profitable than in location B. As a result, more construction activities will be attracted (the supply curve shifts more) to location A over location B, holding all else constant. Thus, locations with higher structure share are more sensitive to the changes in construction costs. Moreover, when the common changes in construction costs are multiplied by the initial structure share of each location, it becomes a Bartik-style variable, which has the advantage of minimizing endogeneity (Bartik 1991). Given these reasons, our article follows Saiz (2010) and uses the product of annual changes in Hong Kong construction costs and each neighborhood's initial structure share as the supply shifter, denoted as CC in Equation (4).

$$\Delta\ln Q_{i,t} = \beta_1\Delta\ln P_{i,t-m} + \beta_2\Delta\ln CC_{i,t-n} + \theta_t + \varepsilon_{i,t} \tag{4}$$

Next, we need to make time lag adjustments between the $\Delta\ln Q_{i,t}$ and $\Delta\ln P_{i,t}$ because of the late observed changes in housing stocks (e.g. project completion or building permits). Compared with construction completion, obtaining permits has shorter lags and is chosen to construct the annual housing stock changes. A time lag of m in $\Delta\ln P_{i,t-m}$ in Equation (4) is to adjust the timing of obtaining the permits at t to the moment of construction decision in response to price changes earlier at *t–m*. The $m = 1.5$ years account for designs, foundation work, and application processing time prior to the start of the superstructure of a standard residential project in Hong Kong.[13] Likewise, the supply shifter $\Delta\ln CC_{i,t-n}$ also needs to adjust for the time lag.[14] Supply elasticity β_1 can be identified with 2SLS given an valid instrument variable for $\Delta\ln P_{i,t-m}$, which will be discussed next.

[13] HKIS Guidance Notes suggest that the average time between acquiring the land and starting the superstructure work for a standard residential development is 18 months (The Hong Kong Institute of Surveyors 2016).

[14] We start by setting $n = m = 1.5$ and obtain unexpected positive signs for the coefficients of $\Delta\ln(CC_{i,t-n})$. We then try $n = 2.5$ and 3.5 years. The coefficients $\Delta\ln P{*}DLS$ are not much different, given $n = 1.5$, 2.5, or 3.5. Tables 3, 4, and 6 present the results given $n = 3.5$, whose coefficients of $\Delta\ln(CC_{i,t-n})$ are all negative as expected.

4.1.2 *Justification for instrument variables*

Equation (4) can be identified with 2SLS given an exogenous demand shifter (the instrument variable) that only shifts the demand but not the supply (Wooldridge 2009). Looking for this "pure" demand shifter is the main challenge in estimating supply elasticity (Baum-Snow 2023). In practice, the instrument variable also needs to vary over time for panel models because it is unlikely to have a strong correlation between level and change variables (Wooldridge 2009). Based on these criteria, this article proposes the number of Mainland Chinese tourists as the main instrument (Tourist IV). Background information is given below, followed by the justification for the IV relevance and exclusion restriction. Labor Bartik-style IVs are also introduced in the end as alternative instruments.

Hong Kong suffered a severe recession after the Asian Financial Crisis in 1997 and the outbreak of SARS in 2003. To boost the economy, the central government of China launched a bundle of preferential policies in 2003.[15] Among these, the Individual Visit Scheme (IVS Policy) allows individual tourists from mainland China to visit Hong Kong for seven days.[16] The IVS Policy started in four cities in 2003 and was extended to 49 major Chinese cities during our study period. It is a permanent (not short-term) policy for liberalizing the trading boundaries between Hong Kong and mainland China (Tourism Commission 2018).

Our argument for the IV relevance is that tourism and related industries contributed to the economic growth of Hong Kong, which then boosted the local housing demand during our study period. Figure 1 shows that the number of Mainland Chinese tourists escalates with a long-term (non-cyclical) trend, along with a steady growth in local household income. Intuitively, the money tourists spend in Hong Kong is the revenues or salaries of local residents. Figure 2 shows that the GDP contribution of tourism-related industries grows faster than most industries. Studies also confirm that tourism has a positive impact on Hong Kong's economic growth (Jin 2011; Sung et al., 2015; Odeleye, Akam, and Shah 2022).

We do not claim tourism as the key driver for shifting the housing demand in Hong Kong, which should be the outcome of a bundle of factors. However, tourism does contribute to the housing demand shift to some extent. Compared with other demand shifters (e.g. migration), this Tourist IV provides a source of exogenous variation.[17] Just from an econometric standpoint, the first-stage F statistic in Table 3 rejects the weak instrument hypothesis, supporting the IV relevance (Wooldridge 2009).

For the exclusion restriction, we argue that the number of Mainland Chinese tourists (1) is exogenous to Hong Kong housing markets and (2) does not shift the housing supply. The first condition is met because a tourist's decision to visit is primarily independent of the housing market in Hong Kong. A decision to visit mostly reflects one's disposable income and expected experience (e.g. sightseeing and food). For the second condition, we argue that Tourist IV can hardly shift the housing supply because Mainland Chinese tourists can stay in Hong Kong for only seven days, which is too short to affect housing construction (e.g. bringing in new labor, skills and technology). Additionally, we have thought about four possible channels of violating the exclusion restriction. These are discussed and ruled out as follows.

The number of Mainland Chinese tourists would be endogenous to the Hong Kong housing market if (1) their visa approvals had depended on the Hong Kong housing market, or if (2) many had come to Hong Kong to purchase residential properties. The first channel is ruled out because the tourist visas for Mainland Chinese are issued by the government authorities of the forty-nine Chinese cities, not the Hong Kong government (Tourism Commission 2018).[18] The local authorities of the forty-nine cities would have little motivation to consider the Hong Kong housing market. The second channel can be ruled out because only a negligible portion of Mainland Chinese tourists might come with investment motivation. Based on the data published by Fan et al. (2023) and the Hong Kong Yearbook, we estimate that about 0.001 per cent of Mainland Chinese tourists might purchase residential properties in Hong Kong.[19]

[15] Witnessed by the Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) signed on June 29, 2003.

[16] Hong Kong is a Special Administrative Region of China, which means Mainland Chinese need visas to visit Hong Kong. Before the IVS Policy, tourists from mainland China could only visit Hong Kong in groups with authorized travel agents. Since July 2003, individual tourists from mainland China can visit Hong Kong under the IVS Policy.

[17] Migration cannot be used as the IV because it not only shifts housing demand but also depends on housing supply and affordability (Hilber, Rouwendal, and Vermeulen 2020).

[18] For other visa types, such as working or study visas, both governments need to approve.

[19] Using data from 2001–2017, Fan et al. (2023) study Mainland Chinese buyers of Hong Kong residential properties. In their sample, 3.67 per cent of 687,598 transactions are identified as purchases of Mainland Chinese buyers. Among these,

Table 3. Baseline models and instruments.

Dependent variable = $\Delta \ln Q_{it}$				
VARIABLES	**(1) Tourist IV**	**(2) Labor-1 IV**	**(3) Labor-2 IV**	**(4) Tourist IV+Labor-2 IV**
$\Delta \ln P$	0.00916*	0.00773	0.00929*	0.00925*
	(0.00481)	(0.00483)	(0.00483)	(0.00480)
$\Delta \ln$ CC	−0.0510	−0.0457	−0.0515	−0.0513
	(0.0639)	(0.0645)	(0.0634)	(0.0635)
Obs	840	840	840	840
Instrument validity				
First-stage F statistics	133.6	150.3	151.3	78.94
P-value of Over Iden				0.90

Notes: The model is $\Delta \ln Q_{i,t} = \beta_1 \Delta \ln P_{i,t-m} + \beta_2 \Delta \ln CC_{i,t-n} + \theta_t + \varepsilon_{i,t}$. Our interest is the average supply elasticity estimate, which is β_1. The endogenous $\Delta \ln P$ is instrumented by Δln Tourist IV (column 1), Δln Labor-1 IV (column 2), and Δln Labor-2 IV (column 3). The first-stage F statistics reject weak instruments in all columns. The over-identification test is conducted for Tourist IV and Labor-2 IV (column 4), and its high P-value suggests no evidence to reject either instrument, at least from an econometric perspective. Time dummies θ_t are not reported. Robust standard errors are in parentheses.

*** $P < 0.01$.
** $P < 0.05$.
* $P < 0.1$.

Tourist IV would shift the housing supply not through housing price if (3) policies had changed (e.g. rezoning) in favor of building more commercial properties, or (4) if constructing commercial buildings had reduced residential construction. The third channel is negligible because only about 0.87 hectares of land was successfully rezoned to commercial during our sample period.[20] In addition, time dummies are included in all empirical models to control for citywide policy changes. The fourth channel is unlikely because we do not observe a negative correlation between residential and commercial construction. In fact, between 2003 and 2018, land actually used (not zoned) for residential and commercial properties increased by approximately 11 and 2 km^2 (site areas), respectively.[21]

To further reduce any concerns about violating the assumption of exclusion restriction, we construct Tourist IV as a Bartik-style IV. Its shift is the annual number of Mainland Chinese tourists, and its share is the percentage of the working population in tourism-related industries of each neighborhood in 2001. Tourist IV then takes the log difference to instrument the log difference of housing prices.

Labor Bartik-style IVs are constructed as alternative IVs because they have been well established in the literature (Saiz 2010; Paciorek 2013; Li, Shen, and Zhang 2023). Labor-1 IV is the sum of the GDP contribution of each industry multiplied by the initial share of the working population in the corresponding industry. Among all, investment-related industries (including real estate investment) and construction are likely to correlate with housing supply. Thus, these are excluded from constructing Labor-2 IV, as suggested by Baum-Snow and Han (2024).

4.1.3 *Results of baseline models*

Table 3 shows the results of baseline models (without any determinants) using different IVs. The results of the baseline models serve three purposes: (1) If specified correctly, the baseline model should provide a positive estimate of the average supply elasticity. (2) The estimate should be small in magnitude, given the simple fact that Hong Kong is extremely inelastic in housing supply. (3) The first-stage

about 83 per cent of the buyers had already lived in Hong Kong (not tourists). Mainland Chinese can live in Hong Kong for study, work, family connections, etc. Based on their data, we have a rough calculation: Mainland Chinese tourists could contribute around 4,290 housing transactions between 2001 and 2017, which is around 250 transactions per year. According to the Hong Kong Yearbook, there were about 24.44 million Mainland Chinese tourists per year during this same period, implying that only 0.001 per cent of Mainland Chinese tourists might have purchased residential properties in Hong Kong.

[20] Rezoning records are published by the Hong Kong Planning Department. Before being rezoned to “Commercial,” these land parcels were zoned for “Other Uses” or “Agriculture.”

[21] Data are from Land Utilisation Statistics, published by the Hong Kong Planning Department, which conducts land use surveys to represent the actual/existing land use status (not the land use zoning plans).

F statistics need to be greater than the threshold of 10 to reject the weak instrument. As a preview, the results in all columns satisfy the above criteria.

Column 1 of Table 3 shows the results from Tourist IV, the main instrument variable for identifying supply elasticity. Tourist IV is the log difference of the number of Mainland Chinese tourists per year (the "shift") multiplied by each neighborhood's initial share of the population working in tourism-related industries (the "share"). The estimated supply elasticity in column 1 is significantly positive, and its magnitude is as small as 0.00916. The first-stage F statistic is 133.6.

Columns 2 and 3 of Table 3 show the results using alternative IVs, the relevance of which is supported by their first-stage F statistics. Labor-1 IV (column 2) is a Bartik-style IV comprising all industries. In contrast, Labor-2 IV (column 3) excludes industries related to construction and real estate. Although the supply elasticity estimates are positive in both columns, they are significant only in column 3. This is expected because Labor-1 IV (column 2) contains industries related to construction and real estate, making it a less sound IV for identifying supply elasticity. Recall that a good IV needs to be a "pure" demand shock that is not correlated with supply. The average supply elasticity estimated from the good alternative IV is 0.00929 (column 3), which is close to the 0.00916 estimate from the main IV (column 1).

Column 4 of Table 3 presents the estimates using two instruments: Tourist IV (the main IV) and Labor-2 IV (the good alternative). Given two instruments and one endogenous variable, Wooldridge's over-identification test can detect whether at least one IV has violated the assumption of exclusion restriction. As the P-value of the over-identification test is as high as 90 per cent, we do not have evidence to reject either IV, at least statistically. The supply elasticity estimate using the two IVs together is 0.00925 (column 4), similar to the main estimate of 0.00916 (column 1). As alternative IVs provide similar results (columns 3 and 4), only Tourist IV is used later in the determinant tests.[22]

4.2 Supply elasticity determinants

4.2.1 Models with determinants

After validating the IVs in the baseline models, we are ready to test the determinants of housing supply elasticity. The potential determinants interact with housing prices in the empirical models (Baum-Snow and Han 2024), as shown in Equation (5). By definition, supply elasticity is $\frac{\Delta \ln Q_{it}}{\Delta \ln P_{it}} = \alpha_1 + \alpha_2 * DLS_i + \alpha_3 * CBDdist_i$, which can be calculated after the estimation.

$$\Delta \ln Q_{i,t} = \alpha_1 \Delta \ln P_{i,t-m} + \alpha_2 DLS_i * \Delta \ln P_{i,t-m} + \alpha_3 CBDdist_i * \Delta \ln P_{i,t-m} + \alpha_4 \Delta \ln CC_{i,t-n} + \theta_t + \varepsilon_{i,t} \tag{5}$$

The DLS represents multiple measurements of developable land share from four perspectives: geography, zoning, undeveloped status, and land ownership (public vs. private). As suggested by Baum-Snow and Han (2024), the distance to the city center (CBDdist) is also included as one determinant. Other variables are the same as in the baseline model. Again, the log difference of the prices is instrumented by the log difference of Tourist IV.

4.2.2 Results from geography, zoning and undeveloped land

In the literature, housing supply elasticity is known to be determined by supply constraints, including geography, zoning controls, and the availability of undeveloped land (Baum-Snow 2023). Intuitively, it costs less to construct new housing on these land parcels, holding other factors the same: (1) Flat land saves site formation costs. (2) Land with residential zoning can obtain building approval more easily than other zoning types. (3) Undeveloped land avoids revenue loss during construction.

Column 1 of Table 4 shows the results when the three determinants are considered separately (% Flat Land, % Undeveloped Land, and % Residential Zoned Land), as well as the distance to CBD (CBDdist). However, none of the determinants have significant coefficients. As we will show next, this seemingly surprising result is likely driven by multicollinearity.

In Table 5, the correlations between % Flat Land, % Undeveloped Land, % Residential Zoned Land, and CBDdist are all significant at the 5 per cent level.[23] The strong correlations among explanatory variables indicate multicollinearity. Reducing the number of variables by extracting the variations of multiple variables into one variable is a common solution (Wooldridge 2009). This motivates us to measure

[22] Using Labor-2 IV, we get similar results to those using Tourist IV in testing supply elasticity determinates. These results using Labor-2 IV are available in the Supplementary Appendix (Supplementary Appendix Tables S3 and S4).
[23] For the correlations of all determinants, please see Supplementary Appendix Table S1.

Table 4. Determinants from geography, zoning, and undeveloped land.

Dependent variable = $\Delta \ln Q_{it}$

Variables	(1)	(2)	(3)	(4)	(5)
$\Delta\ln P$	−0.00040	0.00802	0.00725	0.00163	0.00280
	(0.02198)	(0.00641)	(0.00539)	(0.00480)	(0.00509)
$\Delta\ln P$*% Flat Land	−0.00006				
	(0.00018)				
$\Delta\ln P$*% Undeveloped Land	0.00027				
	(0.00025)				
$\Delta\ln P$*% Residential Zoned Land	0.00017				
	(0.00030)				
$\Delta\ln P$*% Flat and Undeveloped		−0.00020			
		(0.00025)			
$\Delta\ln P$*% Flat and Zoned			−0.00009		
			(0.00035)		
$\Delta\ln P$*% Undeveloped and Zoned				0.00146*	
				(0.00078)	
$\Delta\ln P$*% Flat, Undeveloped and Zoned					0.00187*
					(0.00113)
$\Delta\ln P$* CBDdist	−0.00009	0.00064***	0.00056**	0.00052**	0.00055**
	(0.00046)	(0.00023)	(0.00028)	(0.00023)	(0.00023)
$\Delta\ln$ CC	−0.06817	−0.06641	−0.06523	−0.06316	−0.06032
	(0.06557)	(0.06454)	(0.06408)	(0.06441)	(0.06427)
Obs	840	840	840	840	840

Notes: The model is $\Delta\ln Q_{i,t} = \alpha_1 \Delta\ln P_{i,t-m} + \alpha_2 DLS_i * \Delta\ln P_{i,t-m} + \alpha_3 CBDdist_i * \Delta\ln P_{i,t-m} + \alpha_4 \Delta\ln CC_{i,t-n} + \theta_t + \varepsilon_{i,t}$. The endogenous $\Delta\ln P$ is instrumented by $\Delta\ln$ Tourist IV. Our interest is the coefficients of $DLS_i * \Delta\ln P_{it}$. The results in column 1 suffer from multicollinearity, as shown in Table 5. This motivates joint measurements of DLS in the rest of the table. Given an effective DLS measurement, α_2 should be significant and positive, contributing to supply elasticity. This table has filtered out % Undeveloped and Zoned (column 4) and % Flat, Undeveloped, and Zoned (column 5) to be included later to study the impact of GovLR. Time dummies θ_t are not reported. Robust standard errors are in parentheses.

*** $P < 0.01$.

** $P < 0.05$.

* $P < 0.1$.

Table 5. Correlations between supply elasticity determinants.

Variables	(1)	(2)	(3)	(4)
(1) % Flat Land	1.000			
(2) % Undeveloped Land	−0.759**	1.000		
(3) % Residential Zoned Land	0.371**	−0.644**	1.000	
(4) CBDdist (km)	−0.352**	0.703**	−0.447**	1.000

Notes: This table shows the high correlations between the four variables, evidencing multicollinearity when they are all included in one model (column 1 of Table 4).

** A significance at $P < 0.05$. For a full correlation table with all the determinates, please refer to Supplementary Appendix Table S1.

developable land jointly from multiple dimensions. In real life, a land parcel is not developable unless a few, if not all, prerequisites for development are met at the same time. For example, a piece of vacant land cannot be developed for housing unless it also has residential zoning.

By combining two dimensions of developable land, we have % Flat and Undeveloped (the share of flat and undeveloped land), % Flat and Zoned (the share of flat and residential-zoned land) and % Undeveloped and Zoned (the share of undeveloped and residential-zoned land). Then, DLS is further restricted by jointly satisfying three dimensions: % Flat, Undeveloped, and Zoned is the share of land that is flat, undeveloped, and zoned for residential. Their impacts on supply elasticity are shown in columns 2, 3, 4, and 5 of Table 4.

Column 4 of Table 4 shows that the % Undeveloped and Zoned land is significantly and positively related to housing supply elasticity. One percentage point increase in the share of undeveloped and residential-zoned land is associated with a rise in supply elasticity by 0.00146. Given the average estimate of 0.00916 from the baseline model, this is approximately a 16 per cent rise. However, similar impacts are not observed when flat land is considered as one of the two restrictions (columns 2 and 3 of Table 4). This reveals an interesting contrast to the findings of Saiz (2010), which show that the availability of flat land significantly determines the housing supply elasticity of MSAs in the US. This contradictory result regarding flat land is discussed below.

Hong Kong has mountainous topography and limited land areas (Task Force on Land Supply 2018). Given these disadvantages, building on slopes has been very common.[24] Compared with other supply constraints (e.g. zoning), overcoming slopes is a relatively easy option. On average, site formation costs are approximately 7 per cent of property prices in Hong Kong.[25] The ratio can be even lower in high-end neighborhoods. In contrast, overcoming zoning constraints (e.g. through rezoning) takes years and has a low chance of approval (Chau and Lai 2004). As slopes are not a major constraint for construction in Hong Kong, this explains the insignificant DLS in columns 2 and 3 of Table 4.

Finally, restricted by the three types of supply constraints, the % Flat, Undeveloped, and Zoned is significant and positive in column 5 of Table 4. One percentage point increase in flat, undeveloped, and residential-zoned land is associated with a 0.00187 increase in housing supply elasticity, a 20 per cent rise from the baseline estimate. Table 4 provides empirical evidence for the roles of geography, zoning, undeveloped status, and proximity to the CBD in shaping housing supply elasticity in Hong Kong. This exercise has filtered out two DLS measurements, % Undeveloped and Zoned (column 4) and % Flat, Undeveloped, and Zoned (column 5), to be included along with CBDdist as controlled determinants to study % GovLR, our research focus.

4.2.3 Results from GovLR

GovLR is the government land reserved for future residential development. As developing government-owned land in Hong Kong has cost advantages over private land (see Section 2), we expect a positive contribution of % GovLR to housing supply elasticity, which is confirmed by the results in columns 1 and 2 of Table 6. From column 2, one percentage point increase in % GovLR is associated with a 0.00449 increase in housing supply elasticity, or one standard deviation increase in % GovLR (1.256 percentage points) is associated with a 0.00564 rise in supply elasticity, a 62 per cnt rise from the baseline estimate. One kilometer away from the CBD contributes to supply elasticity by 0.00066, or one standard deviation away from the CBD (6.308 km) is associated with an increase in supply elasticity by 0.00416, a 45 per cent increase from the baseline estimate.

The % GovLR represents the availability of land satisfying the three prerequisites of housing construction (i.e. flat, undeveloped, and residential-zoned) and retains only the portion of government-owned land. If land ownership is a new determinant of supply elasticity, % GovLR should be significant and positive after controlling for other constraints. This is confirmed by the results in columns 3 and 4 of Table 6, where % Undeveloped and Zoned and % Flat, Undeveloped, and Zoned are controlled, respectively. In fact, the coefficients of % GovLR and CBDdist are stable in all columns of Table 6, suggesting their positive impacts on housing supply elasticity.

4.3 Neighborhood supply elasticity estimates

After obtaining the coefficients, we calculate neighborhood supply elasticity as $\alpha_1 + \alpha_2 * \%GovLR_i + \alpha_3 * CBDdist_i$ using the coefficients from column 2 of Table 6. Although it has fewer variables, GovLR has jointly considered four dimensions of developable land: flat, undeveloped, residential-zoned, and owned by the government. Similar to the findings of Saiz (2010), the coefficient of the independent term $\Delta \ln P$ is insignificant after sufficient supply constraints are added to the model. F test is used to test the joint significance of the coefficients of $\Delta \ln P$, $\Delta \ln P$*% GovLR and $\Delta \ln P$*CBDdist. Its Chi-square is 22.15, and the P-value is 0.0001, evidencing that they are jointly different from zero.

A summary of our supply elasticity estimates is given in Table 7.[26] The supply elasticity estimates ($\alpha_1 + \alpha_2 * \%GovLR_i + \alpha_3 * CBDdist_i$) are tested against zero using the delta method. The overall average estimate is 0.00987, which is significant at the 5 per cent level and close to our baseline estimate of

[24] For example, the main campus of the University of Hong Kong was constructed on hills over 100 years ago.

[25] Site formation costs, on average, count for 15 per cent of construction costs (Building Rehabilitation Platform 2023) and roughly 7 per cent of property prices (the share of construction costs in property prices is about 49 per cent on average—see footnote 7).

[26] During our sample period, the average housing size shrank in Hong Kong. For example, the average gross floor area of new development was around 80 and 60 m^2 in 2006 and 2018, respectively (Rider Levett Bucknall 2022). Thus, using housing units as housing stocks would give higher supply elasticity estimates than using floorspace.

Table 6. Government-owned land and housing supply elasticity.

Dependent variable = $\Delta \ln Q_{it}$				
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**
$\Delta \ln P$	0.00422	0.00009	−0.00156	−0.00050
	(0.00532)	(0.00554)	(0.00511)	(0.00537)
$\Delta \ln P$*% GovLR	0.00422***	0.00449***	0.00382**	0.00417**
	(0.00151)	(0.00150)	(0.00185)	(0.00178)
$\Delta \ln P$*% Undeveloped and Zoned			0.00089	
			(0.00095)	
$\Delta \ln P$*% Flat, Undeveloped and Zoned				0.00064
				(0.00135)
$\Delta \ln P$*CBDdist		0.00066***	0.00060***	0.00064***
		(0.00022)	(0.00023)	(0.00022)
$\Delta \ln$ CC	−0.04600	−0.06043	−0.06030	−0.05935
	(0.06324)	(0.06360)	(0.06372)	(0.06372)
Obs	840	840	840	840

Notes: The model is $\Delta \ln Q_{i,t} = \alpha_1 \Delta \ln P_{i,t-m} + \alpha_2 \% GovLR_i * \Delta \ln P_{i,t-m} + \alpha_3 CBDdist_i * \Delta \ln P_{i,t-m} + \alpha_4 DLS_i * \Delta \ln P_{i,t-m} + \ + \alpha_5 \Delta \ln CC_{i,t-n} + \theta_t + \varepsilon_{it}$. Our focus is on the coefficient of % $GovLR * \Delta \ln P$, which is expected to be significant and positive, contributing to supply elasticity. The % Undeveloped and Zoned and % Flat, Undeveloped, and Zoned are selected as controlled determinants, along with CBDdist, as suggested by the results of Table 4. The endogenous $\Delta \ln P$ is instrumented by $\Delta \ln$ Tourist IV. Time dummies are not reported. Robust standard errors are in parentheses.
*** $P < 0.01$.
** $P < 0.05$.
* $P < 0.1$.

Table 7. Summary of supply elasticity estimates by region.

	(1) **Average**	(2) **Min**	(3) **Max**
Hong Kong Island	0.00530	0.00041	0.01929***
Kowloon Peninsula	0.01044**	0.00327	0.02294***
New Territories	0.01592***	0.00641	0.02419***
Overall	0.00987**	0.00041	0.02419***

Notes: Supply elasticity of neighborhoods is calculated as $\frac{\partial \ln Q}{\partial \ln P} = (\alpha_1 + \alpha_2 * \% GovLR_i + \alpha_3 * CBDdist_i)$, using the results from column 2 of Table 6. They are tested against zero using the delta method. The average supply elasticity is estimated using the average values of % GovLR and CBDdist for each region. The Min and Max represent the ranges of estimates of each region. See Supplementary Appendix Table 2 for a full list of our supply elasticity estimates.
*** $P < 0.01$.
** $P < 0.05$.
* $P < 0.1$.

0.00916. The regional averages are 0.00530, 0.01044, and 0.01592 for the Hong Kong Islands, the Kowloon Peninsula, and the New Territories, respectively. Among these, only the Hong Kong Islands have supply elasticity not significantly different from zero. This follows our expectations that the Hong Kong Islands are extremely inelastic because of the infilled land and rich natural and historical conservation. The overall range of our supply elasticity estimates is between 0.00041 and 0.02419. This spatial heterogeneity is not trivial because it has differentiated housing price movements across the Hong Kong neighborhoods (Ren, Wong, and Chau 2023).

A full list of the estimates of housing supply elasticity for Hong Kong neighborhoods is presented in Supplementary Appendix Table 2. As expected, it is between zero and one for all neighborhoods. This confirms the conventional wisdom that Hong Kong is inelastic in housing supply, which partly explains why it has the most unaffordable housing prices in the world (Task Force on Land Supply 2018). The most inelastic neighborhood is Central (the traditional CBD district of Hong Kong), whereas the most elastic neighborhood is Ma On Shan in the suburbs.

In a recent study, Baum-Snow and Han (2024) estimate the supply elasticity for more than 60 thousand neighborhoods in the US, and their range is between 0.0000165 and 0.8255.[27] Our estimates for Hong Kong neighborhoods, which are between 0.00041 and 0.02419, fall in their range, but at the lower end. In a study by Gorback and Keys (2021), the housing supply elasticity of 90 core-based statistical areas (CBSAs) in the USA is between 0.0553 and 0.902. Compared with neighborhoods, CBSAs are more aggregated to smooth out the most inelastic estimates.

5. Conclusion

This article contributes to the literature by showing, for the first time, that government-owned land affects housing supply elasticity alongside geography, regulation, scarcity of undeveloped land, and proximity to the CBD. Our evidence is robust using the well-established 2SLS method and two instrument variables. In particular, we find that one standard deviation increase in % GovLR is associated with a 0.00564 rise in supply elasticity, or a 62 per cent rise above the baseline estimate; one standard deviation away from the CBD is related to an increase in supply elasticity by 0.00416, or a 45 per cent increase from the baseline estimate.

Although this article focuses on Hong Kong, the findings on the government-owned land and housing supply elasticity are relevant to other cities or countries. First, the practice of leasing public land for housing development is not unique in Hong Kong but is also adopted in Singapore, China, Israel, Netherlands, France, Sweden, and Finland (Bourassa and Hong 2003; van der Krabben and Jacobs 2013). Our findings can be generalized to these countries, although the magnitude of the impact can vary. Second, our findings may have implications for countries with urban public land that is seldom used for housing construction, including the US and Canada (Eidelman 2016; Sasu, Squires, and Javed 2022). While planning regulations have been the primary focus of policy discussion (Glaeser, Gyourko, and Saks 2005; Gyourko, Saiz, and Summers 2008), utilizing public land may be another approach to increasing housing supply. Limited projects have been undertaken in the most unaffordable cities, such as New York City (Stringer 2016). Our positive evidence from Hong Kong may encourage policymakers facing affordability crises to consider more strategic uses for their public land resources.

While this article shows the impact of government-owned land on housing supply elasticity, it does not explore the mechanisms behind this relationship, such as disentangling the effects between cost savings from land assembly and land lease conversion. Formalizing a theoretical model could better clarify why government-owned land might respond differently to housing price changes compared to private land, given the same positive demand shock. These questions, while beyond the scope of this article, represent valuable directions for future research.

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Supplementary data

Supplementary data are available at *Journal of Economic Geography* online.

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[27] We look at their estimates of new space supply elasticity, which are comparable to ours.

Data availability

The data underlying this article were provided by EPRC under licence. Data will be shared on request to the corresponding author with the permission of EPRC.

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