Valuation of Long-Term Property Rights under Political Uncertainty*

Zhiguo He, Maggie Hu, Zhenping Wang, Vincent Yao

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Abstract

We identify exposure to political uncertainty by exploiting a unique variation around land lease extension protection beyond 2047 in Hong Kong's housing market due to the historical arrangements under the "One Country, Two Systems" design. Relative to properties that have been promised an extension protection, those with legally unprotected leases granted by the current government are sold at a substantial discount of around 8%, and those with colonial leases suffer an additional discount of about 8%. Our model with the estimated structural parameters, which suggest an additional 20% ground rent after 2047, matches well these empirical discounts across long-term lease horizons. The discount is higher when people's confidence declines and where residents feel more uncertain of the city's future.

Keywords: Long-term contracting, Housing, Land lease, Asset pricing, Gordon growth model, Reneging risk.

JEL Classification: G11, G12, G18, R30

*He: Booth School of Business, University of Chicago and NBER, zhiguo.he@chicagobooth.edu; Hu: School of Hotel and Tourism Management, Chinese University of Hong Kong, maggiehu@cuhk.edu.hk; Wang: State of Wisconsin Investment Board, zhenping.wang@swib.state.wi.us; Yao: J. Mack Robinson College of Business, Georgia State University, wyao2@gsu.edu. Zhiguo He acknowledges financial support by the John E. Jeuck Endowment at the University of Chicago Booth School of Business. We thank Scott Baker, Kwong Wing Chau, Lennon Choy, Bryan Kelly, Wenlan Qian, Johannes Stroebel, Shang-jin Wei, David M. Webb, Jason Wu, Constantine Yannelis, Bernard Yeung, and seminar participants at various institutions and conferences for helpful insights and discussions.

1. Introduction

It has been widely recognized that political uncertainty plays a significant role in asset valuations as well as economic activity (for example, Pástor and Veronesi, 2013; Baker et al., 2016). While most of the existing evidence on the connection between political uncertainty and asset pricing is from financial markets in developed economies typically associated with established and stable political environments, one would expect this universal economic force to prevail the most in emerging market economies, especially those struggling with protracted indeterminacy in their political systems complicated by colonial history.

We fill this gap by studying Hong Kong's property market and identifying a causal link between its ongoing political uncertainty and long-term property rights, reflected by housing prices. Although Hong Kong's economy has evaded classification as clearly developed or emerging, our setting offers several advantages to study this topic.[1] First, caught in the middle of the conflict between China and the western world, Hong Kong has become a political battleground for the fate of the unprecedented political experiment "One Country, Two Systems," especially since the social unrest there that began in 2019. Second, all land in Hong Kong is contracted through leaseholds, in which land tenure is granted by the government for a fixed term; they are subject to extension at the end of their terms possibly by a different government, exposing property rights to substantial political risk. Third, the political outlook of Hong Kong, for historical reasons, features an impending uncertainty that will resolve on a predetermined future date (July 1st, 2047) when the current authority in power—Hong Kong Special Administrative Region (HKSAR)—ceases to exist. Fourth, Hong Kong is known for its notoriously expensive housing market, hence any noticeable difference in the housing market due to political uncertainty can be meaningful for welfare.

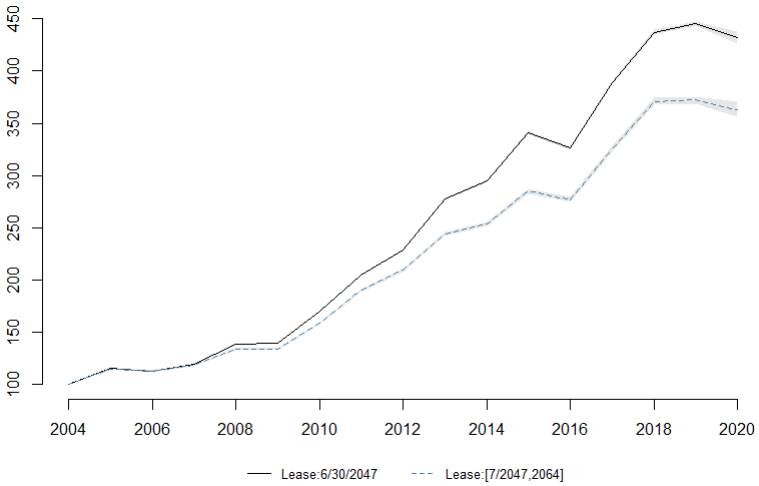
We identify the impact of political uncertainty on long-term property rights by studying housing prices; and throughout this paper, political uncertainty concerns the expected change of certain economic policies employed by the future Hong Kong government. That is to say, we study the directional economic policy change in Hong Kong (due to political reasons), which is the first moment as opposed to the second moment.[2]

The main empirical challenge in exploring the relationship between political uncertainty

[1] Morgan Stanley Capital International (MSCI) classifies Hong Kong as a developed market because of its world-renowned financial market (https://www.msci.com/market-classification), while the United Nations still lists Hong Kong as an emerging economy in 2019 (https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2019_BOOK-web.pdf).

[2] Arguably, the directional policy change plays a more dominant role in shaping the economic and business environment in Hong Kong today. Previous papers that have studied the impact of directional change of specific policies include but are not limited to Handley and Limão (2017) who show the effect of reduced trade policy uncertainty on China's export growth to the Unites States when China obtained permanent most favored nation status after it became a member of the World Trade Organization (WTO), and Bianconi et al. (2020) who study how such reduced trade policy uncertainty affects stock returns.

Figure 1. Hone Kong Home Price Indices across Two Groups of Leases



This figure plots the home price indices estimated using the repeat sales methods (Bailey et al., 1963; Case and Shiller, 1989) based on residential housing transactions with land leases expiring on June 30$^{\text{th}}$, 2047, and after that date, respectively, in Hong Kong from 2004 to 2020.

and valuation of long-term properties is the difficulty in isolating exogenous variation in the political uncertainty, which often moves with fundamental economic conditions. We overcome the challenge by exploiting the heterogeneity among land lease extension protections that are linked to the expiry of the HKSAR in 2047. By historical design, the "One Country, Two System" expires on July 1st, 2047, giving rise to the greatest political uncertainty regarding any lease extension after that point. Thus, we find the starkest difference comparing land leases expiring on June 30th, 2047, that have been promised a 50-year extension protection, to those expiring immediately after that date, hence left legally unprotected.

Using the repeat sales methods, we show as important motivating evidence that home price trajectories of these two groups (i.e., those with land leases expiring on June 30$^{\text{th}}$, 2047, versus those with leases expiring after that date) appear to diverge over time, potentially driven by the worsening political outlook in Hong Kong over the past two decades. Figure 1 plots the home price indices we estimate based on housing transactions with the two different land leases, showing that the two groups trended similarly from 2004 to 2010 but have since become increasingly divergent. From 2004 to 2019, houses with land leases expiring after June 30$^{\text{th}}$, 2047 have appreciated by 264% (17.6% annualized rate), but 82 percentage points (5.5 percentage points based on annualized rate) less than those with leases expiring on that date.

Our empirical analysis, which mainly adopts a reduced-form approach, is guided by a structural asset pricing framework where we incorporate different land lease extension policies facing the political uncertainty after 2047 into housing valuation. In a Gordon growth model, there is a "natural" rent as well as a *ground rent* mandated by the government for leasing the land. The ground rent can be viewed as a "tax" paid by the property owner and equals a

percentage of the property's rateable (rental) value that is assessed annually by the government based on market rents. The percentage used to calculate the ground rent, i.e., ground rent rate, is subject to change upon the next lease extension in the future, rather than kept constant at 3% per today's practice.[3] This uncertainty in the future ground rent schedule is linked to the political fate of Hong Kong.

Our model captures the key idea that the greatest political uncertainty in Hong Kong's housing market occurs at a predetermined future date—July 1st, 2047—when the Basic Law and the HKSAR are set to expire. For example, at some year n before 2047, the HKSAR makes a 50-year extension decision, which could be in effect beyond 2047 (up to $n+50$). If this decision will be respected by the new government in Hong Kong after 2047, the lease extension protection predicts that house prices should increase as their lease expiration years approach 2047, followed by a discrete downward jump right after 2047. Thus, our model implies a "periodic" housing price pattern with a discrete downward jump at the HKSAR expiry date, and further posits a price discount schedule that smoothly decays with the expiration years of the lease after 2047.

We provide strong empirical support for our hypothesis implied by the model using the property transactions in Hong Kong and hedonic regressions. Relative to the control group whose leases are set to expire on June 30th, 2047, and expect to receive an extension to 2097, properties with leases expiring immediately after that date are sold at a 14.1% discount. The estimated price discount relative to the control group decays as the expiration year moves further away from 2047, and the prices of those set to expire after 2097 are similar to the control group. The results are robust when we use a more exogenous control subgroup whose lease terms were historically determined following the Second Convention of Peking in 1898 as well as using alternative specifications. Our placebo test using rental transaction data confirms that the estimates are not driven by any unobservables that would affect the consumption values of properties.

We also find properties with colonial British leases are sold at significantly greater discount—about another 8%—than other leases expiring in similar years, suggesting that homeowners assess a reneging risk in these legacy leases due to the expectation that the future government will still be under China's rule and thus more aligned with the HKSAR than the colonial British government.[4] We hence extend our baseline model by incorporating a reneging risk in the colonial British leases, allowing for differential reneging intensities before and after

[3]Suppose that a homeowner could collect an annual rent of HKD 100,000 in the market (regardless of whether the house is actually being rented). Given a 3% of the ground rent rate, this homeowner needs to pay the government HKD 3,000 per year; and this payment goes up to HKD 25,000 per year if the ground rent rate increases to 25%.

[4]"Colonial British leases" refer to leases that were auctioned by the British government before the Sino-British Joint Declaration (JD) signed in 1984 and were never regranted thereafter. More detailed definitions are are explained in Section 2.3 and footnote 11.

2047. Also, homeowners of colonial British leases may face an extra land premium charge, in addition to ground rent, to extend when those leases are reneged on or expire.

The above-mentioned reduced-form discount estimates inform us about the deep structural parameters of the full-blown model with reneging risk, which is estimated using the standard generalized method of moments (GMM). The resulting estimation implies that after the HKSAR ceases to exist in 2047, homeowners expect to pay an additional 20% of the net rental value in addition to current ground rent charges on the noncolonial leases at extension; homeowners expect no reneging risk on colonial British leases before 2047 but expect those leases to be reneged on every 59 years after 2047, while colonial British leases face extra land premium charges at about 7% and 21% of house value before and after 2047 at extension, respectively. We note that 20% additional ground rent is relatively lower than the required extension cost in the U.K. and Singapore.

We emphasize the key role of differential treatment by the new regime (in power after 2047) with respect to land leases that will have already been promised by HKSAR versus those that will not have been promised; the "periodic" pattern revealed by the data should disappear if the market believes that it is impossible for the new Hong Kong government post-2047 to honor the remaining part of the 50-year protection promised by the HKSAR. Indeed, when we modify our model to incorporate reneging risk in noncolonial leases before 2047, the estimation results reveal that homeowners expect no such risk for noncolonial leases. In addition, this modified model has very similar objective value with our baseline model, indicating no extra explanatory power given to additional model freedom.

We establish the link between the relative valuation discount embedded in land leases and the political uncertainty faced by Hong Kong, by showing the discount comoves over time with citywide confidence in Hong Kong's future. To further provide plausible economic mechanisms, we construct two local political sentiment measures that are time-varying district-level characteristics unique to Hong Kong: the percentage of pro-democracy seats from district council elections, and the percentage of migrants from mainland China. We show that these two measures, which reflect both causes and consequences in a complicated political economy equilibrium in Hong Kong, trace the significant role of sentiments in political uncertainty on the estimated price discount in the remote future.

Our last piece of evidence comes from comparing mainland and local buyers and sellers, identified through buyer and seller names in the transaction data. We find that mainland buyers tend to be more optimistic than local buyers, and mainland sellers tend to be more pessimistic than local sellers concerning political uncertainty in the far future. The individual beliefs of different buyers and sellers only diverge in more recent years as political uncertainty regarding Hong Kong's future has intensified.

Literature Review We study the housing market in Hong Kong, which has received little attention from academic researchers (with the notable exception of Bhattacharya et al. (2020) and Fan et al. (2021)). In related work, Giglio et al. (2015) estimate the price discount of leaseholds with maturities ranging from 99 to 999 years relative to perpetual ownership contracts in freeholds using U.K. and Singapore housing transactions. Both their and our papers belong to a large literature on exploring the effect of long-run factors on asset valuation.[5]

However, in contrast to the focus on the "very long-run discount rate" in Giglio et al. (2015), our paper aims to identify exposure to political uncertainty via both time-varying and location-specific political sentiments based on different land leases regarding extension protection. While our setting in Hong Kong's housing market also contains land leases that have been largely influenced by the same British system, there are also leases granted by the HKSAR that are exposed to a different degree of political uncertainty. Moreover, our treatment of land leases differs from the control group primarily in their having extension protection beyond 2047, not the original terms as in Giglio et al. (2015).

The literature on property rights is an active field that can date back to Coase (1960). There is ample evidence that property rights institutions have a first-order effect on long-term economic growth, investment, financial development, management of natural resources, and household welfare (Besley, 1995; Besley and Burgess, 2000; Acemoglu and Johnson, 2005; Field, 2007; Goldstein and Udry, 2008; Galiani and Schargrodsky, 2010; Abdulai et al., 2011). Relately, La Porta et al. (1997, 1998, 2008) show empirically that legal rules protecting investors vary systematically among legal origins in cross-country contexts, and the differences are a strong predictor of financial development. We emphasize the role of political uncertainty where long-term property rights granted by the previous government might be subject to the discretion of next government.

In a number of papers, Pástor and Veronesi analyze the effect of political uncertainty on financial assets and find that political uncertainty is priced in stock prices (Pástor and Veronesi, 2012), risk premium (Pástor and Veronesi, 2013), and equity options prices (Kelly et al., 2016).[6] Instead, we highlight how political uncertainty affects a major asset class on households' balance sheets in the context of Hong Kong.[7] Since most of the above-mentioned papers focus on financial markets in countries with developed economies and established and

[5] Another of their papers, (Giglio et al., 2021) studies the appropriate long-run discount rate for investments in climate change abatement using housing assets.

[6] Hassan et al. (2019) construct a new measure of political risk at the firm level and document that political decision-making can incur social costs by creating idiosyncratic political risk for individual firms and reducing corporate investment, and Hansen (2014) develops analytical methods to investigate the implications of the pricing of long-term uncertainty.

[7] In the context of the land market in mainland China, Chen and Kung (2019) study political rents by estimating the price differentials between the princeling firms (connected to Politburo members) and other firms without such connections for land parcels of similar quality. Their paper is tightly linked to the study of political economy and corruption (Fisman, 2001), while ours is not.

stable political environments, our paper is perhaps more relevant for studying "political uncertainty," in that Hong Kong is an economy that has been struggling with protracted indeterminacy in its political system, but at the same time possesses a well-functioning property market so that researchers can measure the economic effects of political uncertainty. Finally, we clarify that in our framework, it is the first moment of the policy change (i.e., the expected ground rent increase by the future Hong Kong government), as opposed to the second moment, that plays the key role.

The remainder of the paper is structured as follows. We explain the institutional details of housing markets in Hong Kong in Section 2. In Section 3, we lay out the theoretical framework using a Gordon growth model of housing assets with different land leases to incorporate the effect of political uncertainty on asset pricing. We describe the data sources and empirical design in Section 4, and conduct our main baseline analysis. We present the full model that accommodates reneging risk and estimate this model via GMM. In Section 6, we study the empirical relation between political uncertainty and price discounts by exploiting variations in citywide, district-level, and individual transaction–level measures of sentiments in political uncertainty. Section 7 concludes.

2. Hong Kong's Housing Markets: History and Present

In this section we discuss the relevant institutional details of housing markets in Hong Kong, highlighting the historical changes of leaseholds over the past several decades.

2.1. A Brief History of Hong Kong

Hong Kong has been loosely incorporated into the Chinese empire since the Qin Dynasty (221–206 BC). The British Empire took possession of Hong Kong Island in 1841 during the First Opium War with Qing China, and Kowloon in 1860 after winning the Second Opium War. The British further forced the Second Convention of Peking (1898) on the weakened Qing Dynasty, stipulating that China must lease the New Territories to Britain for 99 years until June 30$^{\text{th}}$, 1997; this stipulation became the legal basis of the handover of Hong Kong in its entirety, including Hong Kong Island, Kowloon and New Territories, to China in 1997.

In the early 1980s, the negotiations began between the two governments, leading to the Sino-British Joint Declaration (JD) signed on December 19$^{\text{th}}$, 1984, and ratified on May 27$^{\text{th}}$, 1985. The JD lays the groundwork for the transfer of sovereignty over Hong Kong from the United Kingdom to the People's Republic of China (PRC) based on the "One Country, Two Systems" principle proposed by the late Chinese leader Deng Xiaoping. The Basic Law was enacted under the Constitution of China to implement the JD in 1990 and came into effect

on July 1st, 1997, as the de facto constitution of the HKSAR, under which Hong Kong enjoys a high degree of autonomy and will retain its capitalist society for at least fifty years, until July 1st, 2047.

Since the handover in July 1997, Hong Kong has experienced significant changes in all aspects of society. While the Basic Law guarantees a high degree of autonomy, concerns over the possibility of Beijing's interference in Hong Kong's affairs, especially civil and political rights, have been present since the handover and have intensified recently (e.g., the 2014 Umbrella Revolution or Occupy Central movement and the 2019 social unrest; see Cantoni et al. (2019)). After the 2004 Legislative Council (LegCo) election, political parties and politicians from different political ideologies formed two broad political alignments: the pro-establishment camp, which is perceived to be more supportive of the HKSAR and the Chinese government; and the pro-democracy camp, which is identified as the opposition camp, with one of its main goals being to achieve universal suffrage as laid out in the Basic Law.

2.2. The Economy and Housing Market in Hong Kong

As China has surged to the second largest economy in the world, Hong Kong's economy has become increasingly more dependent on the mainland over the years. Sky-high property prices have diminished the prospect of young adults being able to afford their own homes; and it is believed that the housing market boom is fueled by mainland property investors.[8] The wealth gap has widened significantly to record levels, and all these factors have contributed to the population's general discontent with Hong Kong's governance (Taylor, 2019; The Economist, 2019).

We choose to study the effect of political uncertainty through the lens of the housing market in Hong Kong for two reasons. First, the housing market consists of very long-term assets and liabilities, with the typical mortgage term being 30 years. Thus, the price of a property, as a present value of expected net cash flows in the future, including those beyond the current land lease term, can be exposed to risk due to a change in political uncertainty.

Second, housing is the dominant source of household wealth, even more so in Hong Kong given its rapid home price appreciation over the past two decades. Demographia (2019) rates housing in Hong Kong as the most unaffordable among all 309 worldwide cities based on the price to income ratio. Thus if households respond to the changes in political uncertainty in asset markets, housing would be the most important decision choice by magnitude.

[8]For example, www.cnbc.com/2018/09/07/china-investors-set-to-investment-more-in-overseas-property-investment.html.

2.3. Land Tenure System and Land Policy in Hong Kong

Although almost all land in Hong Kong was owned by the British government during the colony era and is now owned by the PRC, the chief executive of Hong Kong has the authority to: (1) grant government leases or (2) licences for individuals or corporations to occupy state land for ownership over a limited period of time (namely, leasehold). The chief executive is also allowed to invoke the Land Resumption Ordinance to order the requisition of any land for public purposes—i.e., reneging on the original land contract.

The provisions in (1) include the chief executive's power to extend the nonrenewable leases at its expiration date. The HKSAR Lands Department seeks to provide clarity, consistency, and certainty in the land lease terms;[9] however, "certainty" here is apparently limited by the inherent political uncertainty faced by the "One Country, Two Systems" principle and the HKSAR. This is exactly the focus of our paper.

Leaseholds Granted Prior to 1984 Table A.1 summarizes different types of land leases.[10] The earliest land leases in Hong Kong date back to 1843 with a term of 999 years, labeled as Type 1. From 1843 to 1898, the British government auctioned "75" year leases or "99" year leases (Type 2), which could be regranted at expiration by paying an additional land premium and adjusted ground rent. Throughout the text, we use renew/renewal, extend/extension, and regrant interchangeably. From 1899 to 1985, the British government had widely implemented "75 + 75" or "99 + 99" year leases, with a single right of renewal ("+") for another 75 or 99 years period after the initial term. All these leases are located in Hong Kong Island and Old Kowloon, which are classified as Type 3 in Table A.1.

Leaseholds Granted or Regranted After 1984 The 1984 JD states that new leases could be granted during the transition period (between JD and June 30$^{\text{th}}$, 1997) for terms expiring no later than June 30$^{\text{th}}$, 2047. As a result, all new leases granted during the transition period are set to expire on June 30$^{\text{th}}$, 2047, with terms ranging from 50 to 62 years. They form Type 5 leases in Table A.1. In contrast, Type 4 leases are nonrenewable leases expiring during the transition period; according to the JD, they were automatically extended to June 30$^{\text{th}}$, 2047. Finally, after the handover in 1997 the HKSAR granted new land leases; they are Type 6 in Table A.1 and expire 50 years after the initial land auction date.

[9] Some land leases in Hong Kong have a renewal option in the original contract (i.e., renewable leases) while others have no such renewal option (i.e., nonrenewable leases). Once a land owner has exercised a renewal option, the lease also becomes a nonrenewable lease. See Table A.1 for details. More details on the land policies can be found at https://www.landsd.gov.hk /tc/service/landpolicy.htm.

[10] Webb (2010), in his online reports, explains the historical context of lease tenures since 1841. In identifying land leases, we begin with Webb's collection and validate every detail with our own data and other sources including official texts of JD, the Basic Law, and Hong Kong government websites.

Interestingly, the 1984 JD did not explicitly address the right to extend historical leases after 1997. The HKSAR, upon its establishment, announced on July 15th, 1997, that nonrenewable leases may, upon expiry and at the sole discretion of the HKSAR, be extended for another term of 50 years without an additional premium; see Section 2.4 for details. For example, leases expiring on June 30th, 2047, would be automatically extended to 2097.

Variation in Land Policies The government has three tools at its disposal when considering land lease extensions. The first is whether to extend nonrenewable leases upon their expiry. As an example, for a 75-year nonrenewable lease auctioned in 1850 and a 75+75 lease auctioned in 1900, the government has the full discretion to decide whether and how to extend them at their expiration dates, 1925 and 2050 (after a renewal option had been exercised in 1975), respectively.

The second tool is recalculating the ground rent for the new term at extension. This rate was determined to be 3% (percentage charge) multiplied by the rateable value, which is an estimate of the annual rent assessed by the government annually based on open market rents for similar properties in the locality. This is applied to Type 4–6 leases and some Type 2 leases in Table A.1. However, colonial British leaseholders (Type 1 and 3, and some Type 2 leases) only need to pay 3% of the rateable evaluated at the beginning of the leases (named nominal ground rent), fixed throughout the entire lease period.[11] Such fixed ground or nominal rent was common practice before the JD.

The third tool is to determine land premium required at extension of nonrenewable leases. In 1946, the colonial British government announced that unless land was needed for public purposes, it would offer extension by charging the full and fair land lease value (Webb, 2010). During the transition period as well as after the handover, per JD and the HKSAR announcement on July 15th, 1997, respectively, the payment of an additional land premium has not been required for lease extension. However, this policy of zero additional premium may be subject to change, a scenario that we incorporate in our modeling later.

2.4. The Legitimacy of Leasehold Extensions Beyond 2047

Thus far, HKSAR practices have been to i) extend nonrenewable leases requiring an annual ground rent of 3% of rateable value that is adjusted in step with its market value, and ii) set

[11] "Colonial British leases" refer to the existing leases in our data that were auctioned by the British government before the JD and were never regranted as nonrenewable leases after the JD. For example, a 75-year lease auctioned in 1843 had its first extension in 1918 and second extension in 1993. After its extension in 1993, which was after the JD, it is no longer a "colonial British lease." On the other hand, a 75-year lease auctioned in 1984, which will expire in 2059, is considered a colonial British lease. Also, for a 75+75 lease auctioned in 1915, it would have exercised its renewal option in 1990 (regranted as renewable lease), and it will expire in 2065. Thus, this lease is a "colonial British lease".

the ground rent for the colonial British leases at 3% of rateable value that is fixed throughout the term as specified in the original contracts; neither has an additional land premium. These practices aim to provide as much clarity as possible about the land policy and to minimize any possible disruption to the housing market. Nevertheless, several uncertainties of the extension policy remain: i) whether the government will extend land leases in the future; ii) if so, whether the government will require an additional land premium and/or increase the ground rent to above the current 3% level.

The policy uncertainty regarding the land lease extension policy in Hong Kong has always existed. More specifically, because the arrangements under the "One Country, Two Systems" design are set to expire in 2047, this makes all the land leases that have been extended by the HKSAR beyond its own expiration date a focal point.

To address this concern, on July 15$^{\text{th}}$, 1997, HKSAR affirmed its constitutional authority to grant land leases beyond July 1$^{\text{st}}$, 2047, on the following grounds:[12] (1) under Article 7, HKSAR is entrusted to manage and grant land leases without being limited to a duration of 50 years; (2) under Article 120, all leases granted or extended before 1997 and all rights in relation to such leases shall continue to be protected under the Basic Law; (3) under Article 123, leases expiring after 1997 without right of extension shall be dealt with by the HKSAR, thus not imposing any restriction on the HKSAR's power to grant leases beyond 2047; and finally, (4) there is no provision in the Basic Law that restricts the otherwise unlimited power of HKSAR to grant land leases beyond 2047. In this view, the HKSAR can legitimately extend leases beyond July 1$^{\text{st}}$, 2047.. We will come back to this issue in Section 3.3 after presenting our theoretical framework in the next section.

3. Housing Asset Valuation with Political Uncertainty

We lay out the theoretical framework in this section, with a stylized example in Section 3.2 illustrating the role of political uncertainty in housing valuation with different extension dates. By establishing a link between the observed housing transaction prices and the (expected) future ground rent as well as reneging risk, the model allows us to back out the implied structural parameters using the price discounts estimated from transaction data in Section 5.

3.1. Model Setup

Consider an infinite-horizon Gordon growth model in which a housing asset generates a "natural" gross rent (or gross rental income) $\hat{R}_t$, for $t \in [0, \infty)$; for ease of illustration our model is cast under the risk-neutral measure (we discuss the role of risk premium later). We normalize

[12] See https://www.landsd.gov.hk/en/resources/land-info-stat/land-tenure-system-land-policy.html.

the time-0 housing natural rent $\hat{R}_0$ to $\frac{1}{1-\omega}$, where ω is the percentage of repairing costs and taxes in the gross rent; ω includes the ground rent mentioned in Section 2.3, which is 3% of $\hat{R}_t$. Given a constant discount rate r and a constant growth rate g, we have that

$$\hat{R}_t = \frac{e^{gt}}{1-\omega}.$$

Before the lease expires, a homeowner's net cash flow from the property can be expressed as

$$R_t = \hat{R}_t\,(1-\omega) = e^{gt}. \tag{1}$$

However, the current house value not only depends on the ground rent today, but also the expected ground rent in the future when the lease is up for extension after the current term expires. Denote the nearest land lease expiration date by L; when it expires at time $L > t$, the government may extend the lease for another T years by charging an additional ground rent (on top of the 3% of the rateable).

In general, we define the additional ground rent rate as $f_s^{(\tau)}$ imposed by the government on land leases upon extension at a future time s by

$$f_s^{(\tau)} \equiv f(s;\tau) \in [0,1]. \tag{2}$$

We highlight that $f_s^{(\tau)}$ depends also on a fixed time in the future $\tau > t$ and is linked to the political fate of Hong Kong, which is determined by the complicated political struggle between all parties in Hong Kong, the HKSAR, and Beijing.[13] This predetermined future time τ is the date on which the policy uncertainty resolves to a large extent, in the case of Hong Kong, July 1st, 2047; we will provide a more detailed explanation in Section 3.2. Also note that the entire profile of $f_s^{(\tau)}$ can be fairly flexible, and under the risk-neutral measure it suffices to consider a deterministic schedule.

For a given extension date L, the additional ground rent in Eq. (2) applies to the following T-year interval $t \in [L, L+T]$. As a result, for any future time $s > L$, the homeowner's cash flow is

$$R_s = \hat{R}_s(1-\omega)(1-f^{(\tau)}_{L+T\cdot N(s)}) = e^{gs}\left(1-f^{(\tau)}_{L+T\cdot N(s)}\right), \tag{3}$$

where $N(s) \equiv \lfloor \frac{s-L}{T} \rfloor$ and $\lfloor \frac{s-L}{T} \rfloor$ denotes the greatest integer that is smaller than $\frac{s-L}{T}$. Before the extension (i.e., for $s \in [t, L]$), there is no additional ground rent, and hence $R_s = e^{gs}$. The

[13] Here, $f_s^{(\tau)}$ captures both additional ground rent and land premium to be paid by the lessee (the 'owner') to the government in return for the right to occupy the land for another term. The government may charge additional ground rent by increasing the current 3% to a higher percentage. Land premium is an up-front payment due at the time of extension while ground rent is payable annually from the date of extension as a percentage of the rateable.

underlying assumption is that the current government will honor the lease contract covering $[N(s), N(s)+T]$, even though this contract was granted by the previous government (HKSAR). We will discuss this important assumption in Section 3.3.

One can calculate the house price P_t at time t to be

$$P_t = \mathbb{E}_t \left[\int_t^\infty e^{-r(s-t)} e^{gs} \left(1 - \mathbf{1}_{s>L} \cdot f^{(\tau)}_{L+T\cdot N(s)} \right) ds \right]. \tag{4}$$

3.2. An Illustrating Example

As an illustration, we set $t = 0$ in this subsection. For the purpose of parsimony, given the additional ground rent at extension $\gamma \in [0, 1]$, we consider a simple schedule of additional ground rent to be:

$$f^{(\tau)}_s = \gamma \mathbf{1}_{\{s \geq \tau\}}. \tag{5}$$

The predetermined time τ is right after the deadline of the current HKSAR land policy under which the government will extend the lease for another T years without charging any additional ground rent; recall the discussion in Section 2.3. In the context of our paper, the HKSAR will extend land leases for another 50 years ($T = 50$) without additional ground rent if they expire before June 30$^{\text{th}}$, 2047, but will require additional ground rent for those set to expire after July 1$^{\text{st}}$, 2047.

The simplified schedule in Eq. (5) captures the key idea that the greatest political uncertainty in Hong Kong's housing market occurs at a predetermined future date τ (i.e., July 1$^{\text{st}}$, 2047) when the Basic Law and HKSAR expire, after which the expected additional ground rent γ will be imposed. In one stark interpretation, $1 - \gamma$ can be viewed as the probability that the post-2047 Hong Kong government will maintain the current practice by extending the land lease every 50 years at 3% of the rateable; γ would be the probability of the post-2047 Hong Kong government taking back the land completely (or charging a ground rent/premium sufficient to eliminate the ownership value completely) when leases are due for extension. In other words, γ can be considered as expected additional ground rent charged at the lease expiration date, in addition to 3% of the rateable.

Now consider a house with land lease expiring at L with its value denoted by $P(L; \tau)$. Denote $\kappa \equiv r - g$, and we have

$$P(L; \tau) = \int_0^L e^{-\kappa s} ds + \int_L^\infty e^{-\kappa s} \left(1 - f^{(\tau)}_{L+T\cdot N(s)} \right) ds. \tag{6}$$

If $L < \tau$ and $L + T \geq \tau$, the homeowner can extend the land lease to $L + T$ before the

uncertainty resolution date τ, implying that

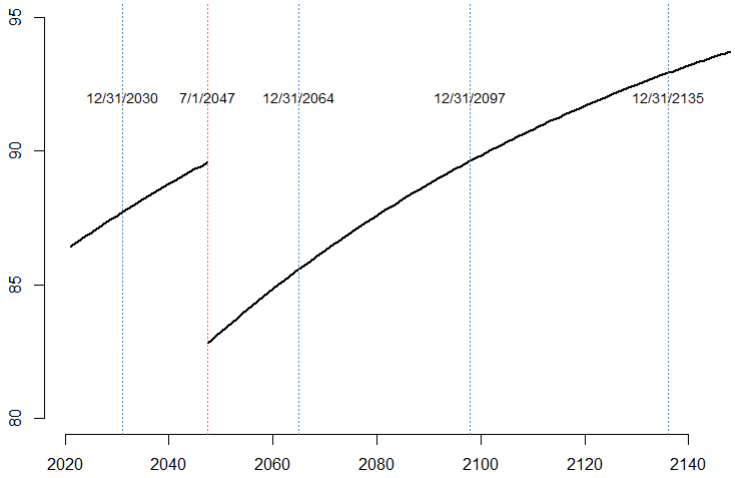
$$P(L;\tau) = \int_0^{L+T} e^{-\kappa s} ds + \int_{L+T}^{\infty} e^{-\kappa s}(1-\gamma)\, ds = \frac{1-\gamma e^{-\kappa(L+T)}}{\kappa}. \tag{7}$$

In contrast, if $L \geq \tau$, then the house value is

$$P(L;\tau) = \int_0^{L} e^{-\kappa s} ds + \int_{L}^{\infty} e^{-\kappa s}(1-\gamma)\, ds = \frac{1-\gamma e^{-\kappa L}}{\kappa}. \tag{8}$$

Figure 2 plots the model-implied house value $P(L;\tau)$ as a function of the lease expiration date L. As explained, τ corresponds to July 1$^{\text{st}}$, 2047, indicated by a red dashed line (vertical). In Figure 2, we also plot the cutoff years in blue dotted lines (vertical) at several boundaries of leasehold groups defined in Section 4.

Figure 2. Model Implied Price Discounts



This figure plots the model implied house value as a function of lease expiration date L. The political uncertainty will be largely resolved on 7/1/2047, when a new Hong Kong government replaces the current HKSAR. Vertical lines indicate several lease expiration dates.

We see that $P(L;\tau)$ first increases with the lease expiration date L, dips at $L = \tau$, and then slowly grows back at $L = \tau + T$ with almost the same height as the previous cycle but slightly greater due to the standard discount effect. This periodic pattern in valuation can be best illustrated by investigating the lease group with $L = \tau - \epsilon$ (say, land leases expiring on June 30$^{\text{th}}$, 2047) and the lease group with $L = \tau + T$ (e.g., land leases expiring on June 30$^{\text{th}}$, 2097): the former group can be successfully extended right before τ and hence enjoy the standard ground rent 3% for another $T = 50$ years, which exactly matches the ground rent schedule faced by the latter lease group.

3.3. What Drives the Value Discount due to Political Uncertainty?

It is worth pausing to highlight the key assumptions of our model. Although the HKSAR government is expected to expire in 2047 and this expiration is the underlying source of political uncertainty regarding the land lease extension policy after 2047, we assume that the extension decisions made by HKSAR before 2047 at year n—but in effect beyond 2047 (up to $n + 50$)—will be respected by the new government in Hong Kong. Therefore, in the model, land leases that expire right before 2047 face no discount in the next 50 years but those expiring right after do, driving the discrete drop at $L = \tau$ in Figure 2.

Exactly on this point, Section 2.4 explains the legitimacy of the HKSAR extending land leases that are set to expire before 2047 to beyond 2047. For instance, the last point in the formal affirmation issued by the HKSAR on July 15$^{\text{th}}$, 1997, states, "there is no provision in the Basic Law to restrict the otherwise unlimited power of the HKSAR to grant land leases beyond 2047." This policy announcement appeared to have implicit approval from Beijing, and the legitimacy of the HKSAR to extend land leases offers an important protection of long-term property rights for a particular group of land leases beyond the HKSAR's own term. Indeed, this precedent of policy continuity is reflected in the previous negotiations between the United Kingdom, China, and Hong Kong.

Of course, we do not know whether these leases granted by HKSAR will be fully honored under the scenario of the collapse of "One Country, Two Systems" experiment. What we want to stress, before we move on to the next section, is that the possibility of this dire political scenario does not invalidate our analysis. First, our key prediction of a significant price discount at $L = \tau$ only requires a differential treatment by the new regime (in power after 2047) with respect to the land leases that have already been promised by HKSAR versus those that have not. This differential treatment, which would exist even under the most extreme scenario, reflects the guiding principle of "policy continuity" that has been present throughout Hong Kong's history, as well as in Beijing's practices in China's economic reform including its land policy.[14]

Second, we have yet to discuss the leases granted by the colonial British government before 1997. Our empirical results later suggest that there exists a wedge between colonial leases and leases granted or regranted after the JD, with the former sold at a greater price discount.

[14]Historical precedents in Hong Kong came from the Land Leases Annex (Annex III) in the JD, which was signed during a period of political uncertainty and market turbulence. The annex guarantees that all leased lands granted by the British Hong Kong government expiring after June 30$^{\text{th}}$, 1997, and all rights in relation to such leases, shall continue to be recognized and protected under the law of HKSAR. The practice in mainland China concerns the extension of 20- or 30-year land leases in Qingdao, Shenzhen, and Wenzhou, which resulted in a policy set by the Ministry of Land that homeowners would not have to pay an extension fee to continue using their residences after the shorter lease expires (Hsu, 2017). For background information on China's land policy and its housing market, and their connections with local government financing problems in China, see Fang et al. (2016) and Chen et al. (2020), among others.

We extend our model to incorporate the reneging risk in Section 5.

Finally, and perhaps most importantly, the underlying assumption that these noncolonial HKSAR leases will be honored is strongly supported by our empirical finding of a significant price discount associated with properties whose leases expire right after July 1st, 2047, suggesting investors expect Beijing to honor the long-term property right arrangements promised by the HKSAR. In fact, Section 5 extends the baseline model to allow for potential reneging risk in both colonial and noncolonial leases, and finds a negligible estimate on the latter.

4. Empirical Design and Main Results

In this section, we first introduce main data sources along with our sample design and descriptive statistics. We then explain our main empirical design, guided by the theory developed in Section 3. Lastly, we present the baseline analysis together with a battery of robustness tests.

4.1. Data Sources

This paper uses three major sources of data, two of which are acquired from the same data vendor, while the third is publicly available.

Residential Transactions and Amenities In Hong Kong, all property transactions have to be registered with the Land Registry. We obtain all residential property transactions in Hong Kong from EPRC Ltd., which has purchased all electronic transaction data from the Land Registry. Our EPRC data covers the period from January 1992 to February 2020 and contains a comprehensive set of information on housing characteristics and transaction details in Hong Kong: for instance, address, building construction year and month, district name or code, floor and unit numbers, property characteristics (e.g., swimming pool, club house), transaction information (sale date and transaction prices), whether the transaction is a first- or second-hand market transaction, and names of buyers and sellers.[15]

We use the land lease expiration year (e.g., 2047) in the transaction data, to identify different lease groups. As explained above, the land lease groups are necessary for us to link property value and policy uncertainty in Hong Kong. We also geocoded all the buildings in our sample and calculated their distance to nearby amenities using their latitudes and longitudes. The amenities include the Mass Transit Railway (MTR), bus stops, hospitals, schools (K–12), universities, and the coastline. Proximity to any of these nearby amenities is an important determinant of the fundamental value of the estate.

[15] Bhattacharya et al. (2020) study the spillover effect of "haunted" houses, those associated with a murder, suicide, or other unnatural death, on the prices of nearby houses using the same transaction data used in this paper.

Land Sales In the EPRC data, only the year of land lease expiration is provided, without information on the date of expiration. Since it is important for us to separate leases expiring before and after July 1st, 2047, we obtain the land auction data from the Land Registry website and match the land transaction price and auction date to the housing transaction data using the land lot number.

Hong Kong Quinquennial Census Data and Local Elections To obtain demographic characteristics of the residents, we use the 1% Quinquennial Population Census data from 2001, 2006, 2011, and 2016. Each of the census data sets contains rich information on quarters (apartments), households, and persons with district of residence disclosed. We capture several important district-level characteristics. In addition, to measure the political sentiment at the district level, we collect the percentage of pro-democracy seats from Hong Kong district council elections in 1999, 2003, 2007, 2011, 2015 and 2019.

4.2. Data Sample

We apply several filters to construct the final sample of transactions. First, according to the housing statistics published by the Transport and Housing Bureau of HKSAR, 54% of the population in Hong Kong lives in private housing units as of 2019, while the rest of the population lives in public housing, including public rental housing and government-subsidized sale flats. We focus on private housing in Hong Kong only, a sector where transaction prices are fully driven by market forces, and hence exclude all the government housing projects.

We require observations to have no missing values for land lease expiration year, transaction price and date, and floor number. This excludes transactions before 1998 due to missing data on several unit characteristics in early years. We also exclude houses, townhomes, and non–arm's length transactions (e.g., deeds of gift, assignments, changes of name and subagreements), and transactions in Island district (the smallest district). Lastly, we trim the top and bottom 1% extreme values in unit and total transaction price. Our final sample contains 551,790 residential housing transactions sold from January 1998 to February 2020.

Table 1 reports the summary statistics of all the variables used in our analysis. First, the average sale price of the units is HKD 2,801,066 (logged value of 2.80 = 1.03) in total and HKD 5,541 per square feet. Using an exchange rate of 0.13 HKD to USD, they are valued at USD 363,552 in total and USD 719 per square feet. The total price varies widely, ranging from HKD 663,650 to HKD 16.78 million. Hong Kong is known for its small living quarters with net living area ranging from 258 to 1,157 sq feet, with an average of 528. The average age of buildings at the time of sale is 16 years. The building completion year is well populated from 1959 to 2018 with more than half of the transactions involving those built after 1992.

The number of bedrooms and living rooms are both 2 on average. In our sample, most units have a bay window, which reduces the net living area. We also calculate market turnover at the individual land lease by year level as the ratio of the number of transactions in a given year to the number of unique properties that have ever transacted in our data. The average turnover rate is 7.9% in our sample period.

Table 1: Summary Statistics

Variable	N	Mean	SD	Min	1st	5th	Median	95th	99th	Max
Log(Price)	551,790	1.03	0.65	-0.41	-0.24	0.00	0.99	2.13	2.53	2.82
Log(Unit Price)	551,790	8.62	0.54	7.44	7.57	7.78	8.57	9.56	9.77	9.90
Net Living Area Area	551,790	528.57	163.80	258	277	306	504	852	1,043	1,157
Floor	551,790	18	12	0	1	3	16	41	56	80
No of Bedrooms	526,155	2	1	0	0	0	2	3	3	4
No of Living Rooms	530,719	2	1	0	0	0	2	2	2	4
Bay Window Size	551,790	20.32	15.37	0	0	0	22	44	54	250
Building Age	551,790	16.01	9.03	2	2	3	15	32	38	40
Building Completion Year	551,790	1992	8.98	1959	1972	1978	1992	2006	2012	2018
Distance To MRT	551,790	702	886	8	24	59	423	2,462	4,708	10,633
Distance To Bus Stop	551,790	314	276	8	12	48	258	711	1,312	3,365
Distance To Hospital	551,790	1,644	1,268	80	251	394	1,359	3,978	6,565	10,589
Distance To School	551,790	138	196	0	5	22	101	303	946	2,526
Distance To University	551,790	3,564	2,466	85	309	611	3,022	8,348	10,311	10,311
Distance To Coastal Line	551,790	1,358	1,635	17	31	72	732	5,441	7,338	8,227
Turnover	551,790	0.079	0.043	0.000	0.006	0.024	0.072	0.156	0.209	0.517

The table presents summary statistics of all the variables used in the analysis. Our sample contains all second-hand housing transactions in Hong Kong from 1998 to February 2020 with the following exclusions: transactions with missing date, total price, unit price, net living area size, building unique ID, lease expiration date, latitude or longitude, and floor number; complexes that belong to public housing projects; houses or townhouses; transactions in Island district, which consists several islands that are not part of Kowloon peninsula or Hong Kong Island. Turnover is calculated as the number of transactions over the number of units for each land lot and transaction year.

4.3. Empirical Design

The variation in exposure to political uncertainty is identified by grouping various land leases as explained in Section 2.3 based on expiration year.

Control Lease Group We first identify all leases set to expire on June 30th, 2047, as our control lease group, which, according to the current HKSAR policy, will be automatically extended to 2097 and hence are subject to the least degree of political uncertainty in our model as laid out in Section 3. We take the following steps to identify our control group.

As explained in Section 2.3, there are four types of land leases that are set to expire in 2047. First, according to the JD, which became effective on May 27th, 1985, all existing nonrenewable leases that were going to expire before June 30th, 1997, were automatically extended to June 30th, 2047. These leases primarily cover land in New Kowloon and the New Territories (Type 4 in Table A.1) and a small portion of such leases cover land in Hong Kong

Island and Old Kowloon (Type 2 in Table A.1). Second, any land leases auctioned between May 27th, 1985, and June 30th, 1997, are set to expire on June 30th, 2047 (Type 5). These two groups of land leases form our control group.

In contrast, the other two types of leases are not part of our control group. Any land that happened to be auctioned in the year of 1897 with a "75 + 75" year lease (part of Type 2 in Table A.1) will also expire in 2047, but only in the second half of the year according to the historical auction data.[16] Finally, any land auctioned by the newly established HKSAR between July 1st–December 31st, 1997, will expire between July 1st–December 31st, 2047, which constitutes part of Type 6 in Table A.1.[17]

Treatment Lease Groups Our treatment leases include three broad categories. The first category contains all the leases set to expire before 2047 ("pre-2047" leases), which will also be automatically extended until up to 2096 and thus are also subject to a similar degree of political uncertainty as the control group. To test the sharp predictions delivered by our model as shown in Figure 2, we further decompose the pre-2047 leases into three subgroups: viz. 2029–2033, 2034–2039, and 2040–2046 (Type 2 in Table A.1).

On the other hand, leases set to expire after July 1st, 2047, but before 2097 have relatively high exposure to the ongoing and expected political uncertainty since neither the Basic Law, nor policies set forth by HKSAR have clarified the future of these leases beyond 2047. These post-2047 leases are further decomposed into four subgroups: viz. July 1st 2047–2049, 2050–2052, 2053–2064, and 2065–2097. According to our theory, the first post-2047 lease subgroup should be the most exposed to political uncertainty; the exposure diminishes as the lease expiration year moves further away. In later analyses we also combine the earliest three subgroups (July 1st 2047–2049, 2050–2052, 2053–2064) together and call them the main treatment group.

The third group consists of leases that are set to expire after 2097, so we call this group "distant" leases. There are two subgroups of distant leases (2098–2135 and 2842–2959); the latter contains the 999-year leaseholds that were granted before the 1960s. Figure OA.2 plots the number of transactions by individual lease expiration year and by lease group. It shows that while there may not be enough transactions for an individual expiration year,

[16] We collected all such land auction information from the *Hong Kong Government Gazette* (https://lib.hku.hk/hkgro/index.jsp) and verified that the land leases of matched properties in our data were all auctioned in the second half of 1897 and thus are set to expire during the second half of 2047.

[17] We identify such land by collecting land auction data from the Land Registry website, which has recorded all Hong Kong government land auctions since April 1985. The land auction data include the unique land lot number with land transaction price and date. There were twelve land lots auctioned between July 1st–December 31st, 1997, eight of which could be found in the EPRC data by matching the land lot number. Thus, properties with those eight land lots will expire between July 1st and December 31th, 2047. The other four unmatched land lots could have been developed as nonresidential properties or could be held by developers as real options. In Hong Kong, given the volatile housing market, it is common for developers to wait for a few years or even decades before developing the land into building properties.

the lease groups are constructed such that they all have sufficient observations to be used in the empirical analysis. Panel C plots the number of leases for the control group and main treatment group across all districts, showing that all districts except the Islands are well populated with both lease groups.

In Table OA.2, we report the number of transactions, number of estates, and number of districts, respectively, by the lease groups and sale year. It shows that all leasehold groups are well represented across sale year cohorts using number of transactions, estates, or districts. The largest lease group, those expiring on June 30$^{\text{th}}$, 2047, account for 66% of the sample.

Empirical Specification Our empirical specification sets the lease group June 30$^{\text{th}}$, 2047, as the main control group, which includes all transactions with land leases expiring on June 30$^{\text{th}}$, 2047. In the baseline specification, we estimate the price discounts of all other leasehold groups relative to the main control lease group in the following hedonic specification (Rosen, 1974):

$$\ln(P_{i,t}) \quad = \quad \sum_{n=1}^{N} \beta_n \cdot Lease_n + \eta \cdot X_{i,t} + \alpha_{d\times m(t)} + \varepsilon_{i,t}, \tag{9}$$

where $P_{i,t}$ is the total or unit sale price of house i at time t; $X_{i,t}$ is a full set of housing characteristics, including the number of bedrooms and living rooms, bay window, bay size, floor area, age of the building, direction facing, swimming pool, club house, and neighborhood amenities (e.g., distance to MTR), all used as categorical variables (e.g., dummies for one, two, or three bedrooms) to capture potential nonlinear effects; $\alpha_{d\times m(t)}$ represents the district $\times$ year-month fixed effects.

Our model in Section 3 predicts that the control group has the least exposure to ongoing political uncertainty, owing to the promised 50-year extension policy from HKSAR. Thus, we expect all estimated $\hat{\beta}_n$ in Eq. (9) to be negative. In contrast, properties in the post-2047 lease groups have the highest exposure to political uncertainty and should bear the largest discount, corresponding to the sudden drop at $L = \tau$ in Figure 2.

The 50-year extension policy also applies to other pre-2047 lease groups and thus effectively mitigates their exposure to political uncertainty. However, our theory predicts that the value of 50-year extension protection is greater for the leases with expiration years closer to 2047 and thus $\hat{\beta}_n$ on these lease groups is anticipated to be negative, but to a lesser extent. Lastly, our theory posits a price discount schedule that decays with their expiration years, implying that transactions in the distant groups either sell at a small discount, if at all, relative to the control group.

4.4. Baseline Analysis

Table OA.1 presents summary statistics based on the control and main treatment lease group separately. On average, the unit (total) price of the units in the control group is 51% (44%) lower than those in the main treatment lease group. All structural characteristics and amenities except the number of bedrooms are significantly different for the two lease groups, likely driven by their locations. Hence, in Figure OA.1, we plot the residuals of the property attributes of the two lease groups, obtained from the regression of each hedonic characteristic on the district by year fixed effects. We find little differences in the structural characteristics and neighborhood amenities between the groups, except that buildings in the control group are older — an issue addressed in our robustness tests. We control all of these characteristics in our regressions.

Table 2: Baseline Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Log (Unit Price)				Log (Total Price)			
I(2030 ≤ Lease ≤ 2033)	-0.057	-0.054	-0.076	-0.071	-0.043	-0.043	-0.065	-0.058
	[0.043]	[0.045]	[0.046]	[0.045]	[0.046]	[0.046]	[0.050]	[0.049]
I(2034 ≤ Lease ≤ 2039)	-0.038	0.002	-0.022	-0.040	-0.042	0.001	-0.027	-0.044
	[0.039]	[0.038]	[0.036]	[0.038]	[0.042]	[0.041]	[0.040]	[0.042]
I(2040 ≤ Lease ≤ 2046)	-0.024	-0.009	-0.006	-0.022	-0.013	0.001	0.008	-0.011
	[0.057]	[0.056]	[0.057]	[0.058]	[0.060]	[0.058]	[0.060]	[0.060]
I(7/1/2047 ≤ Lease ≤ 2049)	-0.141***	-0.124***	-0.125***	-0.138***	-0.149***	-0.128***	-0.132***	-0.146***
	[0.028]	[0.026]	[0.029]	[0.029]	[0.029]	[0.027]	[0.030]	[0.030]
I(2050 ≤ Lease ≤ 2052)	-0.127***	-0.121***	-0.126***	-0.128***	-0.127***	-0.120***	-0.124***	-0.128***
	[0.028]	[0.027]	[0.028]	[0.028]	[0.030]	[0.028]	[0.030]	[0.030]
I(2053 ≤ Lease ≤ 2064)	-0.127***	-0.090***	-0.117***	-0.126***	-0.130***	-0.090***	-0.118***	-0.129***
	[0.032]	[0.028]	[0.034]	[0.032]	[0.033]	[0.029]	[0.035]	[0.033]
I(2065 ≤ Lease ≤ 2097)	-0.105***	-0.090***	-0.098***	-0.110***	-0.107**	-0.091**	-0.101**	-0.112***
	[0.035]	[0.033]	[0.036]	[0.034]	[0.043]	[0.040]	[0.044]	[0.042]
I(2098 ≤ Lease ≤ 2135)	-0.022	-0.014	-0.002	-0.023	-0.029	-0.019	-0.009	-0.030
	[0.039]	[0.035]	[0.039]	[0.038]	[0.040]	[0.036]	[0.041]	[0.040]
I(2842 ≤ Lease ≤ 2959)	-0.052	-0.034	-0.037	-0.054	-0.054	-0.034	-0.039	-0.057
	[0.035]	[0.034]	[0.037]	[0.035]	[0.038]	[0.036]	[0.040]	[0.038]
Turnover				0.170				0.103
				[0.113]				[0.120]
Property Attributes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Property Attributes × Year	No	Yes	No	No	No	Yes	No	No
District × Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	551,790	551,790	525,730	551,790	551,790	551,790	525,730	551,790
Adj R^2	0.9288	0.9405	0.9316	0.9289	0.9421	0.9509	0.9440	0.9421

This table presents the baseline hedonic housing price regression results using the entire sample of housing transaction records in Hong Kong from 1998 to February 2020. The dependent variable is the logorithm of unit price in Columns (1)–(4) and the logorithm of total price (in million HKD) in Columns (5)–(8). Control variables in Columns (1) and (5) include a full set of property and building characteristics specificed in Eq. (9). Columns (2) and (6) control for the interactions of property characteristics with year. In Columns (3) and (7), we exclude the observations with missing bedrooms and living rooms. Columns (4) and (8) include additional control of turnover. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

Table 2 presents the results, with dependent variables of the logarithm of unit price in Columns (1)–(4) and the logarithm of total price in Columns (5)–(8). Our baseline specification is reported in Columns (1) and (5) where we control for property attributes and district by year-month fixed effects. In Columns (2) and (6), we control for property attributes by year and district by year fixed effects to allow for time-varying (annually) coefficients on individual property attributes in addition to the district-level home price trends. In Columns (3) and (7), we estimate the baseline specification, but based on a restrictive sample that excludes properties missing data on number of bedrooms and living rooms.

Results in Columns (1) and (5) suggest that relative to the control group whose leases are to expire at June 30$^{\text{th}}$, 2047, properties with leases expiring immediately after July 1$^{\text{st}}$, 2047, are sold at a 14.1% discount using unit price or 14.9% in terms of total price, both significant at the 1% level. The other three post-2047 lease groups—those set to expire in 2050–2052, 2053–2064, and 2065–2097—sell at statistically significant discounts as well of 12.7%, 12.7%, and 10.5% using unit price, and of 12.7%, 13.0%, and 10.7% using total price, respectively. Estimates from alternative specifications reported in other columns are quite similar to our baseline results but with slightly smaller magnitude. For instance, in Columns (2) and (6), for our main treatment group with leases expiring July 1$^{\text{st}}$, 2047–2049, properties are sold at a discount of about 12.4% (12.8%) using unit (total) price. Consistent with our model prediction, discounts decay for land leases that expire in the remote future.

In Columns (4) and (8) of Table 2, we include market turnover rate as an additional control to the baseline specification. Market turnover rate, which captures "market liquidity" of the properties under different leases, might be an endogenous outcome driven by political uncertainty and hence we report these results separately. However, estimates are also very similar when we control for market turnover rate, suggesting on that turnover is not a significant factor explaining the price discount.

Properties in the lease groups set to expire before 2047 are sold similarly to those in the control group with estimates of price differentials not statistically different from 0. However, in terms of magnitude, their discounts relative to the control group shrink smoothly when lease expiration year approaches 2047 for pre-2047 or is further from 2047 for the post-2047 lease groups. The broad empirical pattern matches that in Figure 2, confirming that properties with pre-2047 leases face a small and similar degree of political uncertainty as laid out in the model.

Finally, the coefficients on the "distant" lease groups are negative—but always insignificant—in each of the specifications. For example, the coefficient on 999-year leases (the 2842–2959 group) is 5.2% (5.4%) for unit (total) price. These large point estimates of price discount, though insignificant, warrant some discussion as they are likely driven by two distinct features. First, they are all legacy leases granted by the colonial British government, subject to a

reneging risk discussed in Section 5. Second, the group contains 999-year leases which, unlike other leases, do not specify any land use in the original contracts, and thus are more likely to fall out of compliance with contemporary zoning codes. Anecdotally, the government will modify these leases to a 50-year term upon redevelopment.[18]

Based on the baseline estimates in Column (4), we can calculate the aggregate effect on all properties with leases expiring after July 1st, 2047, but before 2097. Without the estimated price discount, properties in these lease groups would have been sold at 13.6% discount (= 12.0% / (1 − 12.0%) based on the weighted average discount 12.0%). Based on their average sale price of HKD 4.78 million and total sales of HKD 119 billion in 2019, lost property sales revenue for Hong Kong homeowners is estimated to be HKD 652,000 per property and HKD 16.2 billion in total, equivalent to 0.6% of Hong Kong's GDP in 2019. The estimated cost of political uncertainty, however, does not necessarily imply net welfare loss because the scope of this paper is limited and other parties may benefit from the lower property price.

4.5. Robustness Tests

A More Exogenous Control Group Is it possible that our control lease group, with land leases expiring on June 30th, 2047, is endogenously affected by political uncertainty regarding the future of "One Country, Two Systems" in Hong Kong? We leverage a rich institutional feature to address this concern.

Our main control group can be further divided into three subgroups: control a) corresponds to Type 5 land leases in Table A.1, whose leases were granted after the JD; control b) could be traced to Type 2 leases, whose leases were granted before the JD and are located on Hong Kong Island and in Old Kowloon; and finally, control c) constitutes Type 4 leases, whose leases were granted before the JD and are located in New Kowloon and the New Territories districts. Each group was formed due to different historical reasons. The origin of control c) dates back to the Second Convention of Peking in 1898, when leases were set to expire on June 27th, 1997, but were extended to June 30th, 2047, according to the JD, and thus are the most exogenous control group. In contrast, control a) can be potentially endogenous to market conditions in the post-JD period. For example, it is possible that land granted in the post-JD period was more likely to go to developers who had closer relationships with or have more confidence in mainland China compared to other periods.

Table OA.3 reports the results using only control c) as the control lease group. We include indicators for controls a) and b) as additional explanatory variables. First, we find that coefficients on all the treatment lease groups change little from the baseline results. Second,

[18]For example, Pokfulam Gardens, a large development of six 28-story high-rises, is built on a lot with a 75-year lease granted in 1931. When it was regranted in 2006, the government changed the lease to 50 years.

coefficients on control groups a) and b) are close to zero and statistically insignificant. This suggests that the endogeneity concern in the control group is not valid.

Alternative Specifications Another potential concern with the baseline analysis is that transaction heterogeneity between the control and treatment groups might affect our findings. We conduct a slew of robustness tests using alternative specifications.

Table 3 Column (1) reports the baseline hedonic regression based on the sample that contains transactions in the control and main treatment lease groups. Properties with leases expiring in July 1st, 2047 to 2064 sell at a statistically significant discount of 13.3% using the unit price, corresponding to the average effect on the three disaggregated lease groups in Table 2. Column (2) includes property attributes interacted with district to control for any differences in structural characteristics that may vary by the location and thus are potentially correlated with the differences between the lease groups. The estimate is almost identical to Column (1). Column (3) controls for subdistrict by time instead of district by time to compare the lease groups located in a much finer market. The estimated discount is 11.1%, smaller than the baseline estimate yet still very significant both statistically and economically.

Column (4) reports the baseline regression but using only transactions that have transacted more than once. We find that properties in the main treatment group sell at statistically significant discount of 10.7%. Column (5) uses a subsample constructed using the propensity score matching (PSM) methodology based on location, time, and housing characteristics that we use in Eq. (9), which shows a similar discount of 11.9% for unit price. Finally, Column (6) estimates our main specification employing a generalization of the PSM (i.e., entropy balance weighting), which involves a reweighting scheme that is more flexible than nearest-neighbor matching (Hainmueller, 2012). It suggests that properties in the main treatment group are sold at a discount of 15.6%, even greater than the baseline estimates.

A Placebo Test Based on Rental Value We also study the effect of political uncertainty regarding land leases on rents, as a placebo outcome, in the treatment lease groups based on a sample of rental transactions from November 2018 to February 2020 obtained from one large brokerage platform in Hong Kong. Unlike homeowners, renters who care more about housing amenities should be indifferent to uncertainty in the remote future. To the extent that rents capture the consumption value of the property, this helps alleviate concerns over unobserved structural heterogeneity among different lease groups. Column (1) in Table 4 presents the analysis. It shows that coefficients on the main treatment group are not statistically significant and magnitudes are virtually zero, suggesting that the consumption values of properties in the main treatment and control groups are very similar.

Table 3: Robustness Tests

Sample	All	All	All	Repeated Sales	PSM-Matched	Entropy Balancing
	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	Log (Unite Price)					
I(7/1/2047 ≤ Lease ≤ 2064)	-0.133*** [0.022]	-0.135*** [0.025]	-0.111*** [0.020]	-0.107*** [0.021]	-0.119*** [0.021]	-0.156*** [0.023]
Property Attributes	Yes	No	Yes	Yes	Yes	Yes
Property Attributes × District	No	Yes	No	No	No	No
District × Month FE	Yes	Yes	No	Yes	Yes	Yes
Subdistrict × Month FE	No	No	Yes	No	No	No
N	456,330	456,330	456,330	246,022	46,874	456,330
Adj R^2	0.9362	0.9705	0.9464	0.9387	0.9511	0.9258

This table presents the hedonic regression results of our main treatment lease group (7/1/2047, 2064). The dependent variable is the log of unit price. The main explanatory variable is the main treatment lease group dummy. Column (1) follows the specification in Eq. (9); Column (2) controls for property attributes interacted by district; Column (3) controls for subdistrict by month fixed effects. These three columns use all transactions in the control group and main treatment group. Column (4) is based on repeated sales that have been transacted at least twice. Column (5) is based on the PSM-matched sample using all property characteristics and the nearest neighbor. Column (6) performs the weighted regression using the entropy reweighting scheme (Hainmueller, 2012). Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

Endogenous Investment: New versus Old Buildings Homeowners may choose to spend less on maintenance, precisely due to expected uncertainty after 2047, which would be also reflected as lower price for the treatment groups. This implies that estimates in Table 2 may be overestimated, partially reflecting the effect of under-maintenance driven by political uncertainty.

To address the concern, we add the interaction terms of lease groups with an indicator of new buildings, defined as those built in the past 5 years. Presumably, the effect of endogenous investment matters more for older buildings that require substantial maintenance services. Results are reported in Table 4. Column (2) uses unit rent and Columns (3) and (4) use unit price as the dependent variable; Column (3) is based on entire sample while Column (4) is based on the housing transactions matched with the rental sample. These results show most coefficients on the interaction terms are not statistically significant. More importantly, the estimated discounts for the treatment lease groups are very similar to Table 2, suggesting the (potential) lack of maintenance does not affect our estimates.

5. Model Extension and Estimation

In this section, we study the price differential of land leases granted by the HKSAR relative to those by the British Hong Kong government. This strong empirical pattern present in our data suggests a potential "reneging" risk embedded in the leases originally granted by the

Table 4: Placebo Test and Effect of Maintenance

Sample	For Rent		All	Matched
	(1)	(2)	(3)	(4)
Dep Var	Log (Unit Rent)		Log (Unit Price)	
I(2030 ≤ Lease ≤ 2046)	-0.054*	-0.041	-0.043	-0.053
	[0.028]	[0.034]	[0.031]	[0.042]
× New Buildings		0.005	-0.049*	0.052
		[0.067]	[0.028]	[0.075]
I(7/1/2047 ≤ Lease ≤ 2049)	-0.007	-0.006	-0.143***	-0.185***
	[0.022]	[0.023]	[0.029]	[0.030]
× New Buildings		0.021	0.027	0.076
		[0.051]	[0.026]	[0.064]
I(2050 ≤ Lease ≤ 2052)	-0.017	-0.016	-0.134***	-0.184***
	[0.018]	[0.019]	[0.028]	[0.033]
× New Buildings			0.039*	0.057
			[0.021]	[0.049]
I(2053 ≤ Lease ≤ 2064)	0.017	0.014	-0.136***	-0.099**
	[0.022]	[0.029]	[0.031]	[0.038]
× New Buildings		0.043*	0.046*	0.021
		[0.024]	[0.027]	[0.021]
I(Lease ≥ 2065)	-0.034	-0.047**	-0.056*	0.002
	[0.020]	[0.022]	[0.032]	[0.035]
× New Buildings		0.085	-0.018	-0.182**
		[0.055]	[0.049]	[0.068]
Property Attributes	Yes	Yes	Yes	Yes
District × Month FE	Yes	Yes	Yes	Yes
N	9,171	9,171	551,790	18,029
Adj R^2	0.8042	0.8047	0.9286	0.7217

This table presents the hedonic regression result using a sample of housing rental or sales transaction records from November 2018 to February 2020. The rental (for rent) sample is obtained from the website of Centaline Property, and the transaction sample is matched to the rental sample based on the estate and time. Columns (3) and (4) follow the baseline specification in Table 2. Since similar variables are not available for the rental sample, we use the estate-level average or mode (if categorical) in Columns (1) and (2). We control for district by year-month fixed effects in all the regressions. s.e. are clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

colonial government. We then extend our baseline model to capture this feature, which is estimated to inform us about the magnitude of our underlying model parameters in light of estimated land lease discounts.

5.1. British Hong Kong versus HKSAR Leases

The reneging risk refers to a scenario under which the future government may renege on the land leases granted by previous governments after 2047. This is likely because neither the JD, nor the Basic Law prescribe any arrangements beyond 2047 and thus the future government will not be legally bound to honor the existing leases. Under existing laws, the government can invoke the Land Resumption Ordinance to order the requisition of any land for public

purposes.[19] We argue that leases granted under the British Hong Kong would be subject to greater reneging risk than those granted by the HKSAR since the future government will be still under China's rule even in the worst-case scenario.

To empirically investigate this reneging risk, we identify land leases that were granted by the HKSAR, whose expiration years range from 2047 to 2064 in our data.[20] In Table 5, we further interact our treatment group, 2047–2064, with an indicator as to whether the lease was granted under the HKSAR (after July 1st, 1997), which captures the relative price differential between British Hong Kong and HKSAR leases within the lease group 2047–2064. We find that, within the same expiration years, properties with land leases granted by the HKSAR government are traded at a premium at 7–8 percentage points (about half of the base effect) in various specifications relative to colonial British leases. This is consistent with how market participants might perceive the Hong Kong government reneging on land leases issued by the colonial British government to be at least possible.

5.2. Full Model and Estimation

We first extend our model with the possibility of reneging on colonial British leases, and adjust the formula to take into account the difference between rateable and nominal ground rents (see discussion in 2.3). We then explain how we estimate our model parameters and discuss the results and implications. In this way, we use the reduced-form discount estimates from Section 4.4 and Section 5.1 to inform us about the magnitudes of structural parameters of the model.

Reneging Risk Motivated by the evidence in Table 5, we extend our baseline model by incorporating a reneging risk applied to colonial British leases.[21] The land lease will be extended to another 50-year HKSAR lease at its expiration date, or reneged on before that; we call the latter a *reneging event*, which we will explain shortly. In both scenarios, the homeowner will be charged with a one-time additional land premium as a fraction of the house market value denoted by $\delta^{pre} \geq 0$ (if expiring or reneging at $t < \tau$) or $\delta^{post} \geq 0$ (if expiring or reneging at $t \geq \tau$), where $\tau = 7/1/2047$. Then the homeowner receives a new

[19]The ordinance has been used 13 times since the handover in 1997 to turn the city's idle land into public housing. It was used successfully for the Yan Tin Estate in Tuen Mun district in northwestern Hong Kong, which was constructed in 2018 and now provides 42,687 units for 13,500 residents, 10 years after government reclaimed the land.

[20]We collect all land publicly auctioned by HKSAR and match it with property transactions using the land lot number in our data; we also collect all the buildings initiated by the Urban Renewal Authority of Hong Kong, which issues new HKSAR leases for the land they redevelop. The most remote HKSAR lease expiration year in our data is 2064 because i) we only include second-hand transactions, and ii) there is some delay in developing land into properties.

[21]See the definition in footnote 11.

Table 5: Leases Granted by British Hong Kong versus HKSAR

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	Log (Unit Price)			Log (Total Price)		
I(2030 ≤ Lease ≤ 2033)	-0.042	-0.043	-0.062	-0.028	-0.032	-0.051
	[0.043]	[0.044]	[0.046]	[0.046]	[0.045]	[0.050]
I(2034 ≤ Lease ≤ 2039)	-0.039	0.001	-0.021	-0.042	0.001	-0.027
	[0.038]	[0.038]	[0.037]	[0.042]	[0.041]	[0.041]
I(2040 ≤ Lease ≤ 2046)	-0.030	-0.015	-0.012	-0.019	-0.005	0.003
	[0.058]	[0.057]	[0.059]	[0.060]	[0.059]	[0.061]
I(7/1/2047 ≤ Lease ≤ 2049)	-0.168***	-0.148***	-0.150***	-0.176***	-0.152***	-0.158***
	[0.029]	[0.026]	[0.030]	[0.030]	[0.027]	[0.031]
I(2050 ≤ Lease ≤ 2052)	-0.150***	-0.141***	-0.147***	-0.151***	-0.141***	-0.146***
	[0.030]	[0.028]	[0.030]	[0.032]	[0.029]	[0.032]
I(2053 ≤ Lease ≤ 2064)	-0.135***	-0.097***	-0.125***	-0.138***	-0.097***	-0.126***
	[0.032]	[0.027]	[0.033]	[0.033]	[0.028]	[0.035]
I(2065 ≤ Lease ≤ 2097)	-0.099***	-0.085***	-0.092***	-0.101**	-0.086**	-0.095**
	[0.035]	[0.033]	[0.036]	[0.043]	[0.040]	[0.044]
I(2098 ≤ Lease ≤ 2135)	-0.020	-0.012	0.000	-0.027	-0.018	-0.007
	[0.038]	[0.035]	[0.039]	[0.040]	[0.037]	[0.041]
I(2842 ≤ Lease ≤ 2959)	-0.049	-0.032	-0.034	-0.051	-0.032	-0.036
	[0.035]	[0.034]	[0.037]	[0.038]	[0.036]	[0.040]
I(7/1/2047 ≤ Lease ≤ 2064)	0.085***	0.074***	0.073***	0.088***	0.075***	0.074***
× I(HKSAR Leases)	[0.027]	[0.025]	[0.027]	[0.028]	[0.026]	[0.028]
Property Attributes	Yes	No	Yes	Yes	No	Yes
Property Attributes × Year	No	Yes	No	No	Yes	No
District × Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	551,790	551,790	525,730	551,790	551,790	525,730
Adj R^2	0.9294	0.9409	0.9321	0.9425	0.9511	0.9443

This table presents the baseline hedonic regression results. The dependent variable is the log of unit price in Columns (1)–(3) and the log of total price in Columns (4)–(6). The specifications are similar to those in Table 2 except that we include an dummy for the leases granted by the HKSAR as additional explanatory variable. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

50-year lease contract facing the extra ground rent schedule given in Eq. (2).

We model this reneging shock as a Poisson event that is *i.i.d.* across all leases in the second category, with different reneging intensity before and after τ, denoted by $\lambda^{pre} > 0$ and $\lambda^{post} > 0$. Recall that Annex III in the JD (see footnote 14) guarantees all land leases granted by the British Hong Kong government shall be protected by the HKSAR; but the HKSAR only exists through June 30$^{\text{th}}$, 2047, not even considering the anecdotal reports mentioned above (see footnote 19). Our assumption ensures parsimony while capturing the potentially different reneging intensity before and after July 1$^{\text{st}}$, 2047, and essentially lets the real housing transaction data reveal to us the perceived reneging risk for British colonial leases.

Thus, the value of a house with a colonial British lease can be calculated as

$$P(L;\tau,Brit) = \mathbb{E}\left[\int_0^{L\wedge\mathcal{T}} e^{-\kappa s}ds + e^{-\kappa(L\wedge\mathcal{T})}\cdot(1-\delta^{pre}\mathbf{1}_{s<\tau}-\delta^{post}\mathbf{1}_{s\geq\tau})\cdot P(L\wedge\mathcal{T}+50;HK)\right]. \tag{10}$$

Here, $\mathcal{T}$ denotes the reneging event with intensity $\lambda^{pre}\mathbf{1}_{s<\tau}+\lambda^{post}\mathbf{1}_{s\geq\tau}$, and $P\left(L\wedge\mathcal{T}+50;HK\right)$ is the value of a standardized Hong Kong land lease expiring on $L\wedge\mathcal{T}\equiv\min(L,\mathcal{T})$ and paying $f^{\tau}_{L\wedge\mathcal{T}}$ to extend another 50 year-term standing at $L\wedge\mathcal{T}$, as given in Section 3.1.

Finally, note that the reneging intensity λ and the one-time land premium charge δ at the time of extension are separately identified because λ will affect all contracts that are expiring in the future, while δ will differentially affect leases expiring in the near term more.

Ground Rent: Rateable vs Nominal For ease of exposition, in Section 3.1 we assumed the annual ground rent to be 3% of rateable, the market-based annual rent reevaluated every year. However, there is an exception in practice: colonial British leases only pay a nominal ground rent equal to 3% of gross rent evaluated at the beginning of the leases and fixed throughout the term (see Section 2.3). In our data, all treatment groups except those auctioned by the HKSAR government after July 1st, 1997, belong to the colonial British category. We hence modify Eq. (10) in the Appendix OA.1.1 to accommodate the nominal ground rent setting.

Estimation Method and Results We have estimated the price discount of discrete treatment lease groups using a reduced-form method. However, these estimates are in terms of housing value and we need to convert them to the policy parameters used by the Hong Kong government. We hence conduct an estimation exercise based on the structural model developed in Section 3, using the standard GMM method. This allows us to back out the additional ground rent γ as well as the magnitude of reneging risk implied by the regressions.

As the only predetermined parameter, $\kappa=r-g=2\%\times(1-28\%)=1.44\%$ is set based on recent housing statistics in Hong Kong. Here, 2% is the average gross rent yield (annual gross rent/housing value) and 28% is the benchmark expense ratio,[22] as κ essentially captures the houseowners' net rent yield (annual net rent/housing value). Section 5.4 considers different values of κ for robustness.

Denote the set of remaining parameters by $\Theta\equiv\{\gamma,\lambda^{pre},\lambda^{post},\delta^{pre},\delta^{post}\}$ and $\beta_n\left(\Theta\right)$ is then the model-implied average discount for each leasehold group $n\in\{1,2,...,N\}$ as follows:

$$\beta_n(\Theta)=\frac{\sum_{L_i\in n}\{\ln P_{t_i}(L_i;\Theta)-\ln P_{t_i}(L=\tau;\Theta)\}}{\#\text{ of transactions in group }n},\tag{11}$$

where i indexes each housing transaction in our data, L_i denotes its land lease expiration date,

[22]Information on gross rent yields is obtained from the government report https://www.legco.gov.hk/research-publications/chinese/2021issh09-private-domestic-rental-market-in-hong-kong-20201210-c.pdf. The expense ratio of 28% includes 3% ground rent, 5% rates, and 20% repair cost set by the government https://www.gov.hk/en/residents/taxes/property/deduction/statutory.htm.

and t_i denotes its transaction date.[23] In other words, conditional on a set of parameters Θ, the expression

$$\ln P_{t_i}(L_i;\Theta) - \ln P_{t_i}(L=\tau;\Theta)$$

gives the model-implied price discount relative to the control lease group for transaction i in lease group n, and the term $\beta_n(\Theta)$ is the average model-implied discount for all transactions in the leasehold group n.

We consider $\beta_n(\Theta)$ as N moment conditions and estimate Θ using a 2-step GMM (Hansen, 1982). We have twelve moment conditions corresponding to each treatment group. Each moment equals to $\hat{\beta}_n$, which is the empirically estimated discount for lease group n in Table 2. Column (1) of Table 6 reports the estimation results from the 2-step GMM procedure, with standard errors reported in parentheses. Note that our estimation is subject to the constraint that all parameters are nonnegative, by invoking the underlying economic interpretations of these structural parameters; as we will see, the nonnegativity constraint may bind for certain parameters.

Figure 3 plots each lease groups' discount relative to the control group from the regression (light blue and light orange) and the model estimation (dark blue and dark orange), respectively. The overall model fit is quite good, shown as the close price discounts between model and regression for all lease groups except two lease groups (viz. 2098–2135 and 2842–2959) for which the model overpredicts and underpredicts the price discount, respectively.

5.3. Economic Magnitudes

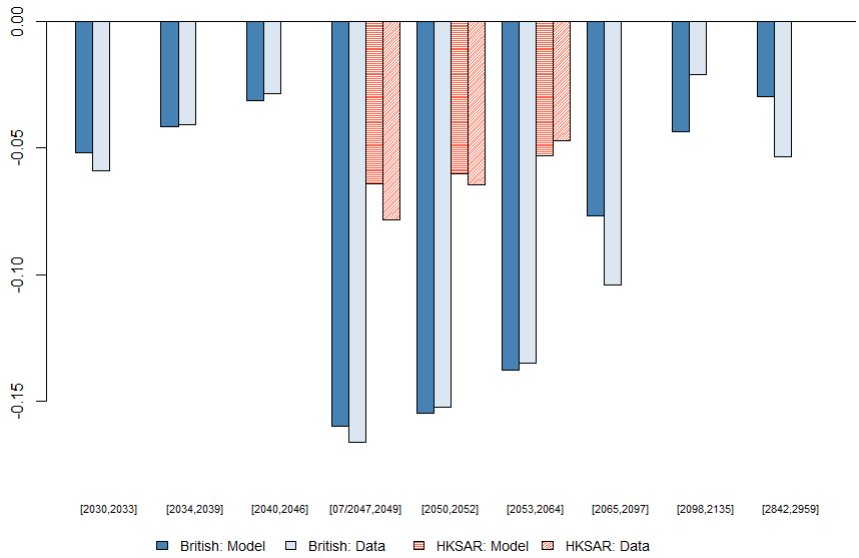
We now discuss the economic magnitude of estimated parameters implied by the observed land leases discounts in Hong Kong.

Economic Magnitude of $\hat{\gamma}$ Column (1) of Table 6 reports that the estimate of $\hat{\gamma} = 20.3\%$ (significant at 1% level), implying that after 2047 Hong Kong homeowners expect to pay about 20% higher ground rents to extend their land leases.

There are three points worth stressing. First, this seemingly large expected additional ground rent in the remote future takes into account all political uncertainty in the future (from the perspective of the first two decades of the 21$^{\text{st}}$ century), with the most imminent uncertainty in mid-2047. Second, $\hat{\gamma}$, which is uncovered from housing prices, typically differs from the expectation under physical measure. Since an increase in ground rent is likely associated with worse economic conditions (so a higher marginal value of wealth), the expected

[23] Since the EPRC only records the lease expiration year (but no actual date), we assume L_i to be the last day (December 31$^{\text{st}}$) of the leasehold year except for leaseholds that belong to the control group, for which we set their expiring dates to be June 30$^{\text{th}}$, 2047.

Figure 3. Model Estimation



This figure presents the model-implied discounts and those estimated from hedonic regressions (Table 5) across twelve lease groups. The resulting parameters from the estimation are $\kappa = r - g = 1.44\%$ and $\lambda^{pre} = 0.00\%$, $\lambda^{post} = 1.68\%$, $\delta^{pre} = 6.86\%$, $\delta^{post} = 21.22\%$, $\gamma = 20.32\%$.

ground rent under physical measure is likely to be lower than $\hat{\gamma} = 20.3\%$ (under risk-neutral measure). Third, although an "endogenous investment" mechanism may lead to an overestimated $\hat{\gamma}$, Section 4.5 has largely ruled out the significance of this channel.

Is a 20% additional ground rent burden plausible? To answer this question, we compare the estimate with the United Kingdom and Singapore, which have similar leasehold land tenure systems as Hong Kong, as well as the U.S., which uses a freehold land system. In the U.K., one has to pay the full market value (of land + structure) over the extended lease terms to the landowner, which is essentially 100% of net rent. Singapore followed the same policy as the U.K. until 2008, after which only the market value of land has been required to extend the lease while the building value is waived. Thus, 11–20% of net rent expected in Hong Kong is still considerably more affordable than expenses in the U.K. and Singapore.[24]

Economic Magnitude of Reneging Risk Regarding the parameters on reneging risk in colonial British leases, Table 6 reports $\hat{\lambda}^{pre} = 0$, implying that for colonial leases that expire before June 30$^{\text{th}}$, 2047, their homeowners should not worry about the lease being reneged on earlier before their lease contract ends. However, they expect to pay a one-time $\hat{\delta}^{pre} = 6.9\%$

[24]The freehold system in the U.S. does not require extension but homeowners need to pay property tax annually. Assuming a typical property unit in Hong Kong with a gross rent yield of 2% and a 20% expense ratio, the current 8% of annual gross rent (ground rent + rates) plus an additional 20% (15%) of net rent yields an expected property tax rate of 22.4% (18.8%) the gross rent in total. The number is comparable to property tax rates in U.S. cities: for example, the corresponding rate as a ratio to gross rent is 18.5% in New York City and 32% in Chicago.

land premium. For leases expiring after July 1st, 2047, the colonial British leases will suffer a reneging risk $\hat{\lambda}^{post} = 1.7\%$, suggesting that they are expected to be reneged on every 59 years after July 1st, 2047; and homeowners need to pay a one-time land premium $\hat{\delta}^{post} = 21.2\%$ upon receiving a 50-year HKSAR-style extension contract (together with a new ground rent $\hat{\gamma} = 20.3\%$). To put these estimates into perspective, consider a hypothetical 50-year colonial British lease and an otherwise identical 50-year HKSAR lease. Relative to the latter, the house with the former is traded at an effective price discount of 9.8% on January 1st, 2021.[25]

Section 2.4 discussed the current land lease extension policy and potential uncertainty in the future. The original terms of colonial British leases are protected by Article 120 of the Basic Law, legally up to June 30th, 2047. This implies $\lambda^{pre} = 0$, a prediction that is confirmed by our estimates ($\hat{\lambda}^{pre} = 0$, with a standard error of 0.004),[26] though future Hong Kong government may renegotiate the colonial leases ($\hat{\lambda}^{post} = 1.7\%$, with a standard error of 0.003).

Regarding our estimates of the one-time renewal premium δ, it is important to recognize that although the HKSAR's current policy is to extend any expiring leases for another 50 years with no additional land premium, the HKSAR has the full discretion to increase the charge[27], which is captured by δ^{pre} and δ^{post} in our model. Based on our estimates, homeowners with colonial leases expiring before June 30th, 2047, though expecting no reneging risk, will need to pay a one-time land premium of $\hat{\delta}^{pre} = 6.9\%$ to extend their leases. In other words, homeowners expect the current land policy (i.e., no one-time land premium charges) to no longer hold for colonial land leases even before June 30th, 2047.

Reneging Risk for HKSAR Leases What if the political situation worsens so much, that Beijing might renege not only on colonial leases but also on noncolonial ones granted by the HKSAR before June 30th, 2047, hence violating the land policy coded in the Basic Law? To accommodate this potentially dire political scenario, we consider the possibility of all land leases being reneged on before July 1st, 2047. Essentially, this model extension allows for reneging risk, again modeled as a Poisson event with intensity λ^{pre}, on both colonial and noncolonial leases. Further, to accommodate the differential treatment between colonial and noncolonial leases, we allow for a HKSAR lease–specific land premium δ^{pre}_{HK} for noncolonial leases expire or are reneged on before June 30th, 2047.[28]

[25] If the lease term is 100 years, then the implied discount will be 9.5% considering that the British lease pays nominal rent fixed at 2021 instead of 3% of rateable. Both of these leases expire after 2047 (2075 for the 50-year lease and 2121 for the 100-year lease, more precisely).

[26] Because the estimated $\hat{\lambda}^{pre} = 0$ sits at the lower bound of $\lambda^{pre} \geq 0$, $\hat{\lambda}^{pre}$ follows a half-normal distribution asymptotically (Hansen (2021)).

[27] The exact language used on the government website is "The extension of such leases is wholly at the discretion of the HKSAR." See https://www.landsd.gov.hk/en/resources/land-info-stat/land-tenure-system-land-policy.html.

[28] The common reneging intensity λ^{pre} is motivated by the possibility of "a political catastrophe," which applies to both land leases; though, colonial and noncolonial contracts might be exposed to this "catastrophic

The key empirical pattern documented in Section 4.4 does not support a significant reneging risk before June 30$^{\text{th}}$, 2047, for *both* leases. Intuitively, this is inconsistent with the existence of a substantial discount (about 14%) for the main treatment group (colonial leases) relative to the control group (noncolonial leases), revealed by observed house prices. Indeed, our estimation in Column (2) of Table 6 confirms this intuition. We find that the estimated $\hat{\lambda}^{pre}$ remains at 0 (with a standard error of 0.019), suggesting that homeowners expect that the HKSAR will honor the land policy coded in the Basic Law until June 30$^{\text{th}}$, 2047. In addition, the estimated extra premium charge for noncolonial leases $\hat{\delta}^{pre}_{HK}$ is only about 2.8%, which is rather small compared to that of colonial leases.

5.4. Model Estimates under Alternative Discount Rates

Our baseline parameter estimation in Section 5.2 is based on a discount rate of $\kappa = r - g = 1.44\%$, which is determined (externally) by the prevalent statistics in recent Hong Kong's housing market. Columns (3) to (6) of Table 6 present the estimation results for different κ's, which correspond to different gross rent yields as $\kappa = (1 - \text{expense ratio}) \times \text{gross rent yield}$. Note that this discount rate allows for a wide interpretation and can capture various economic forces, including but not limited to risk premia in the aggregate market and individual beliefs regarding political uncertainty in the future. We observe that as the discount rate doubles the current level (i.e., gross rent yield = 4%), $\hat{\lambda}^{post}$ increases from 1.7% to 2.4%, and all homeowners expect to pay higher additional ground rent to extend their land leases after June 30$^{\text{th}}$, 2047, up to 23.4% from 20.3%.

6. Political Uncertainty and Price Discounts

In this section, we exploit sentiment measures at citywide, district, and individual levels and explore their relations with the estimated price discounts.

6.1. Citywide Sentiments in Political Uncertainty

We first relate the estimated price discount in properties with leases expiring after 2047 to citywide public sentiment in Hong Kong's political outlook. Political uncertainty regarding the fate of Hong Kong has been hovering over society since the 1984 JD, but its severity and gravity have evolved over time and have often manifested more significantly when public sentiment rises. Our paper argues that the severity of political uncertainty should drive the price discounts of different land leases.

event" differently due to different land renewal premium charges.

Table 6: Parameter Estimations

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	Extension	Baseline: Alternative κ			
Gross Rental Yield	2.00%	2.00%	1.00%	3.00%	4.00%	5.00%
κ	1.44%	1.44%	0.72%	2.16%	2.88%	3.60%
λ^{Pre}	0.000	0.000	0.000	0.000	0.000	0.003
	[0.004]	[0.019]	[0.003]	[0.004]	[0.003]	[0.003]
λ^{Post}	0.017***	0.020***	0.015***	0.020***	0.024***	0.024***
	[0.003]	[0.003]	[0.002]	[0.004]	[0.005]	[0.005]
δ^{Pre}_{HK}		0.028***				
		[0.056]				
δ^{Pre}	0.069***	0.090***	0.045***	0.097***	0.131***	0.154***
	[0.008]	[0.033]	[0.005]	[0.011]	[0.015]	[0.018]
δ^{Post}	0.212***	0.225***	0.130***	0.317***	0.463***	0.718***
	[0.021]	[0.110]	[0.012]	[0.027]	[0.031]	[0.053]
γ	0.203***	0.246***	0.267***	0.206***	0.234***	0.283***
	[0.008]	[0.207]	[0.008]	[0.0084]	[0.010]	[0.012]
N	551,790	551,790	551,790	551,790	551,790	551,790

This table reports the 2-step GMM estimation results for our base model and extension model as shown in Columns (1) and (2). Columns (3) to (6) show the estimation results under alternative discount rates. The discount rate κ equals to $1 - 0.28 = 0.72$ multiplying the corresponding Gross rental yield. Standard errors are reported in [ ]; * denotes significance levels (***=1%, **=5%, *=10%).

Figure 4 plots the net confidence in Hong Kong's future, a popular measure of public sentiment toward political risk based on a survey conducted at the University of Hong Kong, as well as the estimated price discount over time. It shows that Hong Kong people's confidence in their own future began to decline in 2007, became negative after the "Occupy Central" movement in 2014 and has remained negative since then. Consistent with the view that the discounts of the treatment group are driven by the political uncertainty faced by Hong Kong, the price differentials are not statistically significant from zero until after 2003 amid rising anxiety about the anti-subversion law as well as the advent of severe acute respiratory syndrome (SARS). Since then, the price differential has become significant and negative, and this trend has been exacerbated over time. It has settled at 20% since 2015. The trends in the two series are almost perfectly aligned with each other. As people's confidence in Hong Kong's future declines, the relative price discount associated with political uncertainty in the housing market climbs, hinting at a connection between the estimated price discount and public sentiment in political uncertainty since 2007.

6.2. Local Sentiments and Housing Discounts

We now explore time-varying socioeconomic characteristics at the district level to capture different local sentiments in political uncertainty and their relations with the estimated price

Figure 4. Price Discounts over Time

The figure plots price discounts over time for the main treatment group of leases expiring between [7/1/2047] and 2064.

discounts.

Local Political Sentiment Measures Our socioeconomic characteristics at the district level come from the census data as well as district council elections.[29] We focus on two district-level characteristics unique to Hong Kong: percent of pro-democracy seats, and percent of residents who were born in mainland China (hereafter, mainland migrants). The average percent of pro-democracy seats is 30%, but with a wide range from 4 to 100 percent. Mainland migrants include renters as well as homeowners, roughly split 57/43 between them; together, they account for 31% of the Hong Kong population.

Local councilors get to choose five seats on the LegCo (70 seats) and 117 seats on the 1,200-member panel that selects the city's chief executive. Local elections have become even more important since 2014 when the Occupy Central movement failed to achieve its political goals and more people switched to elections as a way to express their political opinion. The percentage of pro-democracy seats from district council elections captures local sentiments in Hong Kong's political future, given that this has been the dominant topic in the elections. Panel (A) of Figure OA.4 shows that after suffering some defeats in previous elections, the

[29]The census survey is conducted by the Census and Statistics Department of the HKSAR every five years, while the district council is elected every four years. For each census year (2001, 2006, 2011, 2016), we match the census variables to all the transactions since the prior census year (e.g., transactions in 2012 and later are matched with 2016 census variables). From each local election (1999, 2003, 2007, 2011, 2015, 2019), we match the percentage of pro-democracy seats for each district to all the transactions from two years before the election year through two years after (e.g., transactions in 2018–2020 are matched with 2019 pro-democracy seats). Panel A of Table 7 reports the summary statistics of district characteristics based on the merged data.

pro-democracy camp in conjunction with localist groups in 2019 gained control of 17 of the 18 district councils, a victory by the largest margin in the history of Hong Kong. It also illustrates the significant cross-sectional variation in the percent of pro-democracy seats across districts within the same elections.

The percentage of mainland migrants provides a measure of local sentiments against cultural influences from mainland China that has less to do with political encroachments. Since the handover, a large influx of tourists and migrants from the mainland had been blamed anecdotally by some locals for their lost Hong Kong identity. There has been growing anxiety that Hong Kong will no longer belong to Hong Kongers. Panel (B) of Figure OA.4 shows that the percentage of mainland migrants was high across all districts in the early censuses, but has decreased slightly in the latest census. While they are spread across the city, they have been most concentrated in the districts of Kowloon, an area of Hong Kong that is attached to the Chinese mainland.[30]

We now take the percentage of pro-democracy seats and the percentage of mainland migrants as our two primary measures of local sentiments and explore their relations with the price discount associated with political uncertainty. Table 7 includes the interaction of the main treatment lease group and the percentage of pro-democracy seats, as well as the percentage of mainland migrants. Coefficients on the interaction terms give the incremental effect of district-level variations, and they are all significant at the 1% level. We find a negative coefficient in Column (2) on the interaction, suggesting that in addition to the −14.6% price discount, a one SD increase in pro-democracy seats in the local district (i.e., 18%) is associated with an additional discount of 5.2 percentage points (or 36% increase of base effect) for the treatment group. Similarly, results in Column (3) suggest that on top of the −13.1% average price discount, a one SD increase of mainland migrants in the local district (i.e., 6%) is associated with 8.2 percentage points (or 63% increase of base effect) in additional price discount. Column (4) includes interactions with both measures in a horse-race setting and finds similar estimates as in Columns (2) and (3).

In Columns (5)–(6), we replace the percentage measures with indicators showing whether the district is above the median value of each variable (within each cohort year), respectively. They show that properties in the treatment group located in districts with a high proportion of pro-democracy seats see an additional 8.6% (77% of the base discount) increase in the price discount on top of the 11.2% base discount, and properties in the treatment group located in the districts with high percent of mainland migrants see an additional 10.6% (118% of the base discount) increase in the price discount on top of 9.0% base discount. Taken together,

[30]Panel A of Table OA.4 reports summary statistics of the district characteristics, and Panel B reports the correlations among the district characteristics. The two local sentiment measures are positively correlated with each other (with $\rho = 0.34$). Panel C presents similar analysis as Table 7, but includes interaction terms of the HKSAR leases dummy with the two district variables.

Table 7: Local Political Sentiments and Price Discount

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	Log (Unit Price)					
I(7/1/2047 $\leq$ *lease* $\leq$ 2064)	-0.132***	-0.146***	-0.131***	-0.127***	-0.112***	-0.090***
	[0.021]	[0.020]	[0.021]	[0.021]	[0.023]	[0.025]
× % of Pro-Democracy Seats		-0.052***		-0.049***		
		[0.012]		[0.012]		
× % of Mainland Migrants			-0.082***	-0.077***		
			[0.024]	[0.024]		
× I(High % Pro-Democracy Seats)					-0.086***	
					[0.021]	
× I(High % Mainland Migrants)						-0.106***
						[0.025]
× Median Age		-0.014	-0.039***	-0.016	-0.023	-0.047***
		[0.015]	[0.014]	[0.014]	[0.015]	[0.014]
×Median Income		-0.012	-0.044	-0.036	-0.010	-0.054*
		[0.028]	[0.031]	[0.029]	[0.028]	[0.031]
× % of College Above		0.017	0.029	0.032	0.013	0.046
		[0.031]	[0.030]	[0.030]	[0.030]	[0.031]
× % of Home Owners		0.028	0.004	-0.005	0.035	0.021
		[0.024]	[0.027]	[0.025]	[0.024]	[0.024]
Property Attributes	Yes	Yes	Yes	Yes	Yes	Yes
District × Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	551,790	551,790	551,790	551,790	551,790	551,790
Adj R^2	0.9288	0.9301	0.9300	0.9305	0.9300	0.9301

This table presents the district-level variation of price discounts for our main treatment lease group. The dependent variable is the log of unit price. We calculate the terms % of Pro-Democracy Seats using district voting data and % of Mainland Migrants based on Census data. The variables I(High % of Pro-Democracy Seats) and I(High % of Mainland Migrants) are defined as indicators for values above the median of the district cross section. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

these results confirm that the two series provide valid measures of local sentiment in political uncertainty and that the housing price discount due to future political uncertainty increases where we see increases in local sentiment.

Figure OA.5 plots the evolution of political uncertainty effects across districts with different sentiments. Regardless of which measure we use, price discounts in districts with greater local political sentiment are almost always more negative than those in districts with less sentiment. But in districts with greater local sentiment, we observe a significant price discount even before 2005. A significant price discount did not emerge in the districts with less sentiment until after 2005 when citywide sentiments increased. The comparison suggests that estimated price discounts for transactions in the treatment group do capture the price of political uncertainty, which is manifested through the change in public sentiment in political uncertainty, whether local or citywide.

Plausible Social and Economic Mechanisms There are several plausible mechanisms through which the local sentiment measures can have a significant effect on the price discount in the treatment lease group. The pro-democrats also generally embrace liberal values such as rule of law, human rights, and civil liberties. Thus, residents in places where pro-democratic camps won more seats should be more sensitive to the future of "One Country, Two Systems,". Moreover, since the elections have been widely viewed as a de facto referendum on the ongoing pro-democracy protest out of the fear and panic of losing a "high degree of autonomy," residents in districts with a high percentage of pro-democracy seats may feel more uncertain over Hong Kong's future. Thus, percentage of pro-democracy seats has a direct effect on the estimated price discount associated with political uncertainty in the remote future.

Moving on to the percentage of mainland migrants in a district, we believe this captures Hong Kongers' rising antagonistic sentiments toward cultural influences from the mainland. Hong Kongers over time have grown increasingly fearful of losing their own identity, and the resulting tension and anxiety are particularly high where there are a lot of tourists and mainland migrants. Such anxiety stems partly from their eroding social position, but more importantly it is induced by mainland China's overwhelming political and economic dominance over the HKSAR. As a result, in places where more mainland residents are present and where the cultural differences between Hong Kongers and mainlanders are on full display, local residents tend to see their lives as more affected by the mainland, and ultimately have become more pessimistic about the future of "One Country, Two Systems."

6.3. The Effect of Individual Beliefs

We now explore the perspectives of buyers and sellers from the mainland China, identified through the buyer and seller names in the transaction data (Fan et al., 2021). Our premise is that mainland buyers (sellers) may have different private valuations regarding the political uncertainty embedded in the treatment leases as opposed to local buyers (sellers). Because of their experience in China, mainland buyers tend to be more optimistic than local buyers about the future of "One Country, Two Systems," and hence less sensitive to the political uncertainty. On the other hand, mainlanders who have lived in Hong Kong but decided to sell their houses might be those who are more pessimistic about Hong Kong's future and hence more sensitive to the political uncertainty.

We restrict the estimation sample to transactions in which buyers/sellers are identified as either a mainlander or Hong Konger, and report the results in Table OA.5. The monotonicity of transaction prices across different buyer-seller pairs documented in Column (1) suggest that mainland buyers tend to be more optimistic than local buyers and mainland sellers tend to be more pessimistic than local sellers concerning the political uncertainty in the far future.

Columns (2) and (3) together suggest that the individual beliefs only diverge in more recent years as political uncertainty regarding Hong Kong's future has intensified.

7. Conclusion

We find that political uncertainty is priced in the property market where the value of the housing assets depends on the continuity of land ownership in the far future. The treatment of different extension policies translates to a 14% discount for the treatment group, and is rooted in historical arrangements that are set to expire in 2047, giving rise to the largest political uncertainty regarding any lease extension beyond that point.

The estimates imply that after 2047, homeowners expect to pay an additional 20% of the net rental value at extension; they expect no reneging risk on colonial British leases before 2047 but expect those leases to be reneged on every 59 years after 2047, while colonial British leases face extra land premium charges at about 7% and 21% of house value before and after 2047 at extension, respectively.

Our results provide important empirical evidence that political uncertainty could be costly to the valuation of long-term property rights. It is worth noting that after this paper was made available online, the HKSAR government added a notice to its website that says, "the Government is fully aware of the challenge of coping with a large number of leases that will expire in 2047," and "will make reference to past experience in legislation and work out suitable arrangements to cater for the significant volume of lease extension cases at an appropriate juncture."

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Table A.1: Summary of Lease Types

Auction Date	Lease Type	Land Proceeds
Before JD ($\leq$ 4/1/1985)	Hong Kong Island & Old Kowloon: (1) 999 years lease (auctioned from 1843 to 1898 and expiring from 2842 to 2897). It pays nominal ground rent. (2) 75 years lease (auctioned from 1843 to 1898, expiring from 1918 to 1973 if no extension, expiring from 1993 to 2048 after first extension, expiring on 6/30/2047 after second extension. 99 years lease (rare, auctioned from 1843 to 1898, expiring from 1942 to 1997 if no extension, expiring from 2041 to 2083 after first extension. Both types will be extended to 6/30/2047 instead of another 75 or 99 years after the JD.) Most of them in our sample pay nominal ground rent, except that those extended after the JD and set to expire on 6/30/2047 are required to pay 3% of rateable as ground rent since the handover. (3) 75+75 years lease (auctioned from 1899 to 1985 and expiring from 2049 to 2135); 99+99 years lease (rare, auctioned from 1899 to 1985 and expiring from 2097 to 2183). "+" indicates that a one-time renewal option is included in the covenants which allows the lease owner to renew the lease for another 75 or 99 years after the first 75 or 99 years. It pays nominal ground rent evaluated at the auction date for the first 75 or 99 years and the ground rent is reevaluated at the renew date for the second 75 or 99 years. New Kowloon & New Territories: (4) Nonrenewable lease expires in 6/27/1997 due to historical reason. According to Joint Declaration, these leases will be automatically renewed to 6/30/2047. Thus, they will expire in 2047 in our data.	
Transition (4/1/1985–6/30/1997)	(5) Non-renewable lease expiring on 6/30/2047. It pays 3% of rateable as ground rent since 7/1/1997.	Split between UK & HKSAR
Post Handover ($\geq$ 7/1/1997)	(6) Non-renewable lease expiring in (auction date + 50 years). It pays 3% of rateable as ground rent since 7/1/1997.	HKSAR

This table presents a summary of different land leases in the history of Hong Kong. The JD was signed on Dec 19, 1984 and went effective on May 27, 1985. However, according to our data, lease was set to expire in 2047 even if the land was auctioned from April 1, 1985 to May 26, 1985. So we use April 1, 1985 as the starting date for this policy. For Type (2), when this type of leases ends, it could be extended for another 75 or 99 years by paying premium and updated rent if the government did not need the land for public proposes. If 75 years lease was sold in 1897 and got extended once in 1972, then they will set to expire in 2047 in our data. It is important to separate leases before or after 6/30/2047 in our paper. Thus, we collect 75–year leases sold in 1897 from Hong Kong Government Gazette. We do not find any 75–year lease sold before 6/30/1897. We find two 75–year leases sold between 7/1/1897 and 12/31/1897, and we classify them as leases expiring in the second half year of 2047. Furthermore, if a 99–year lease was sold in 1849 and got extended once in 1948, then they will expire in 2047 in our data. We do not find any 99–year lease sold in 1849 according to Hong Kong Government Gazette. "Nominal ground rent" refers to 3% of annual rent evaluated at the beginning of the lease (if no extension) or at the most recent lease extension date, fixed throughout the entire term. On the contrary, "3% of rateable" refers to 3% of annual rent re-evaluated every year.

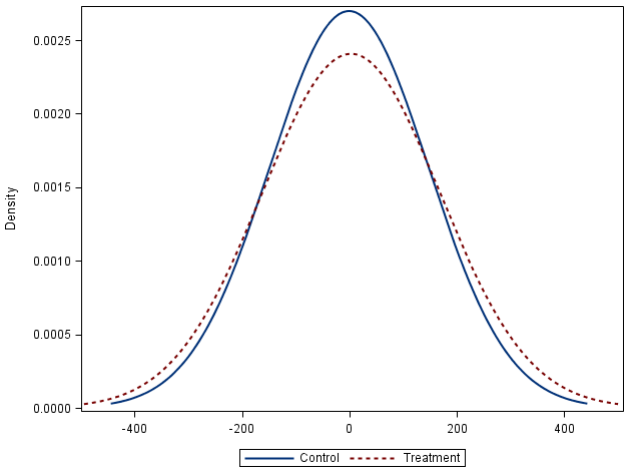
For Online Publication

Valuation of Long-Term Property Rights under Political Uncertainty

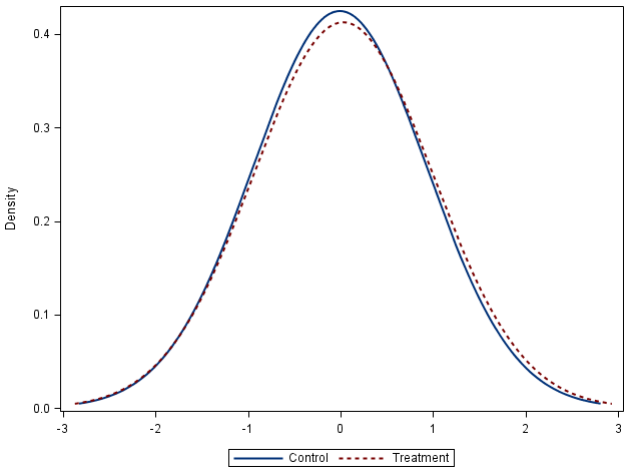
by He, Hu, Wang and Yao

Figure OA.1. Distribution of Residuals

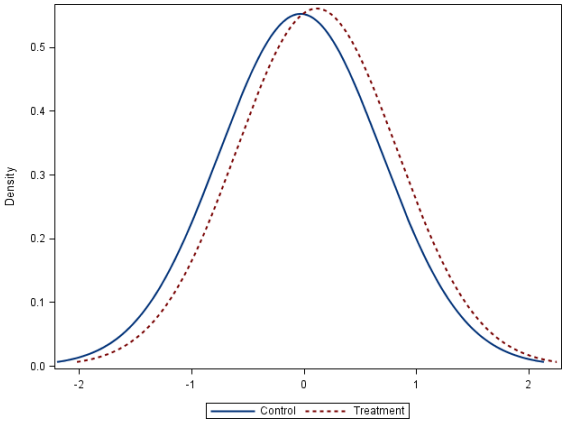
(A) Net Living Area



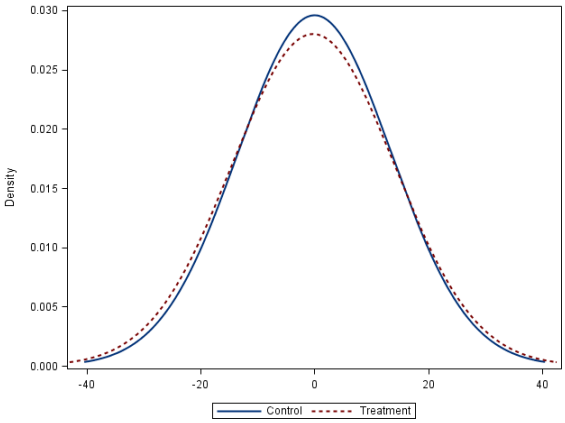
(B) No of Bedrooms



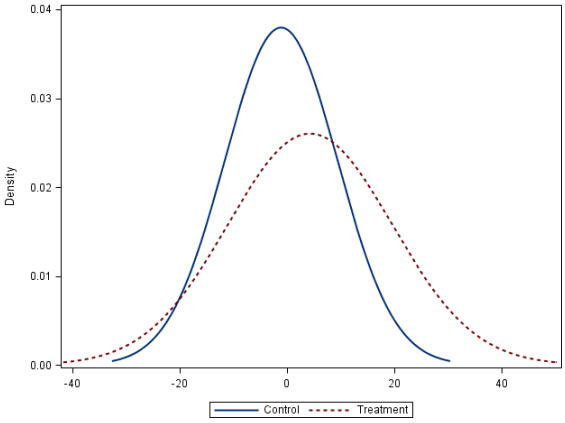
(C) No of Living Rooms



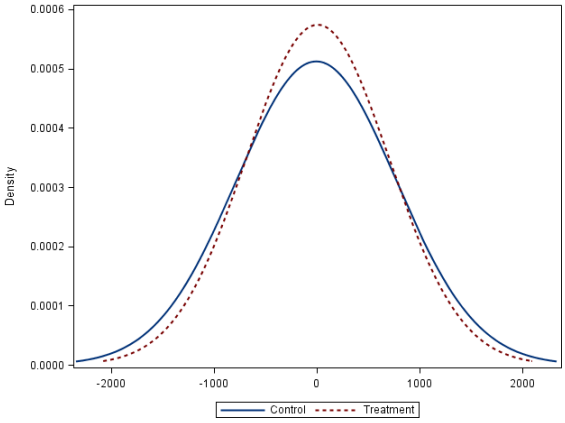
(D) Bay Window Size



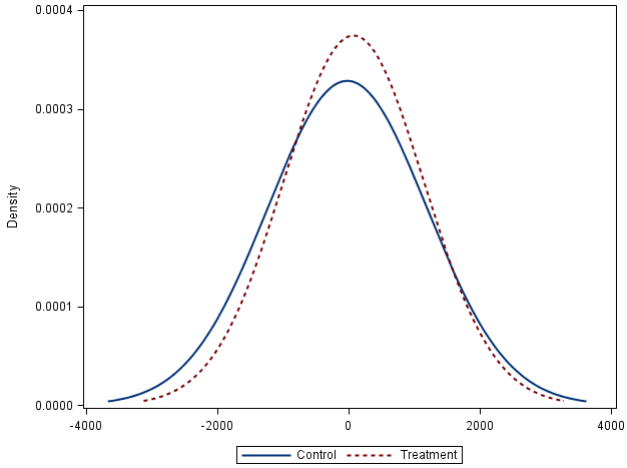
(E) Distance to MRT stations



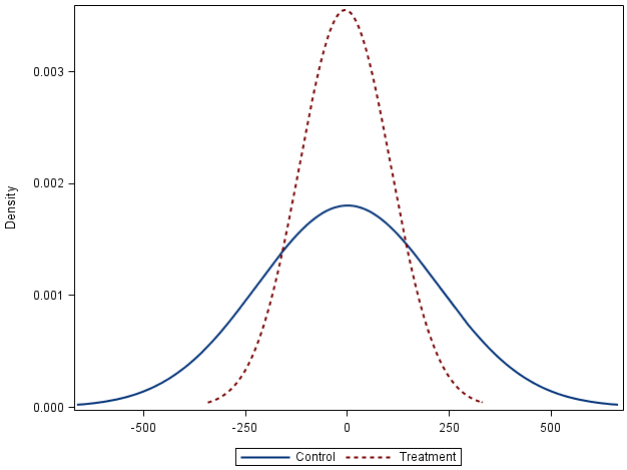
(F) Distance to Bus Stops



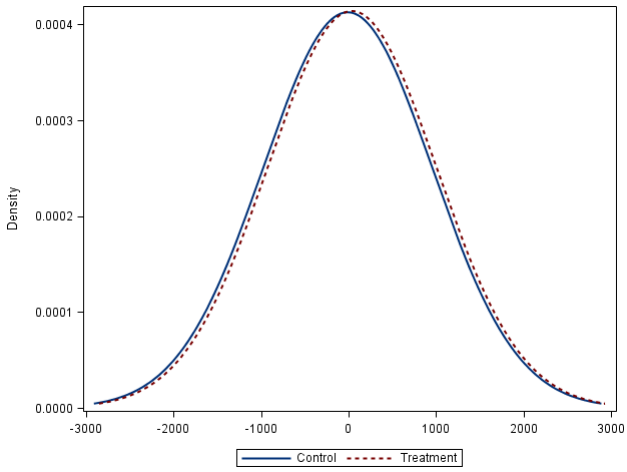
(G) Distance to School



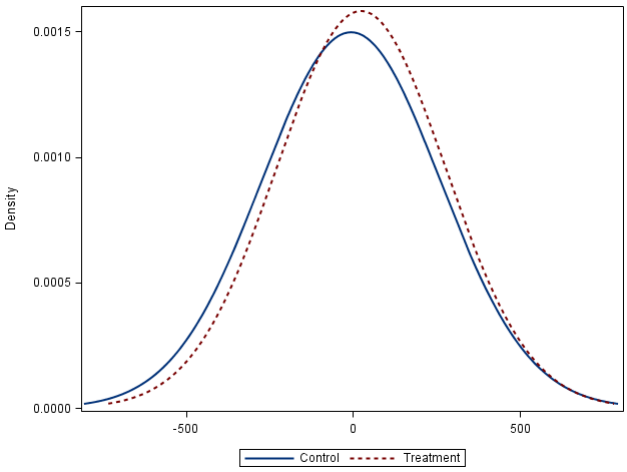
(H) Distance to University



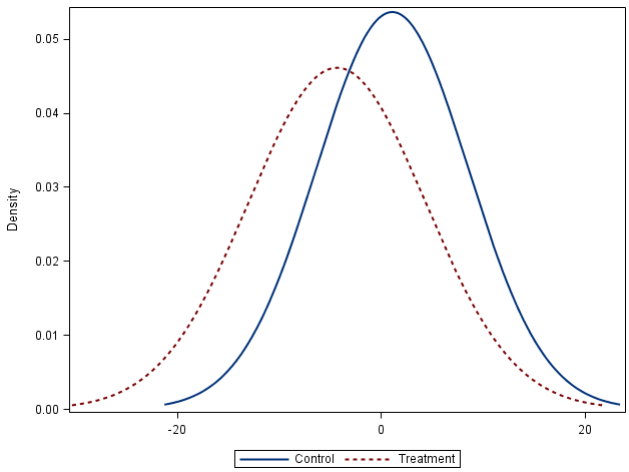
(I) Distance to Coastal Line



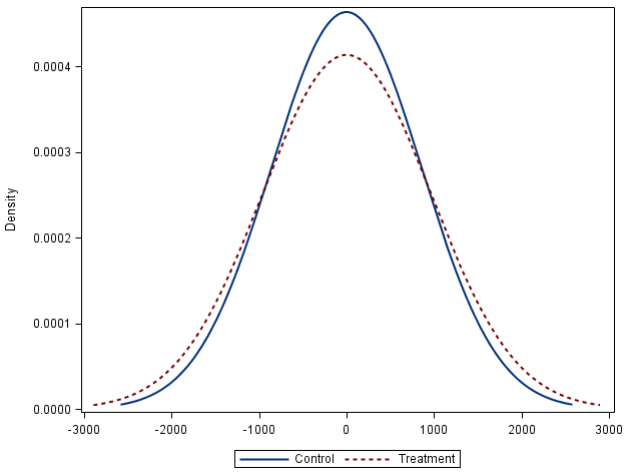
(J) Distance to Hospital



(K) Building Age



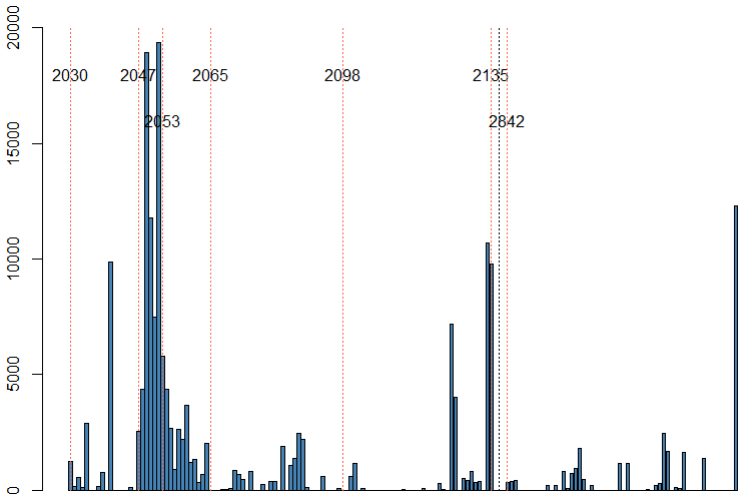
(L) Turnover



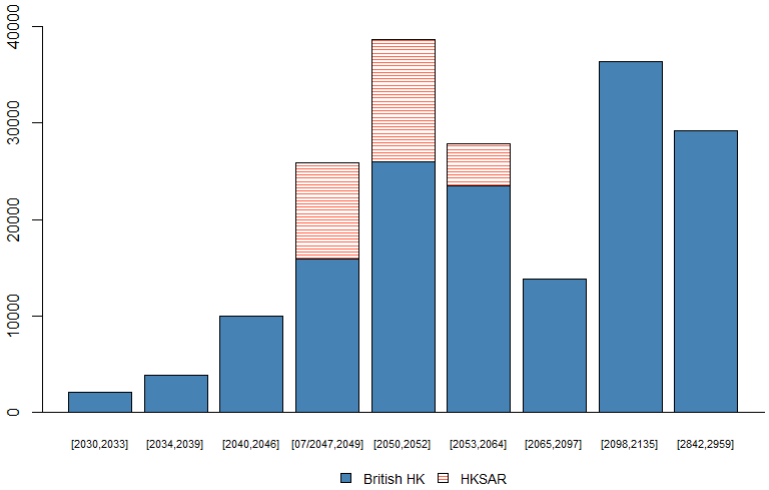
This figure plots the residuals from regressing each property characteristic on the district fixed effects for our control lease group [6/30/2047] and main treatment group [7/1/2047, 2064].

Figure OA.2. Distribution of Transactions by Lease Groups

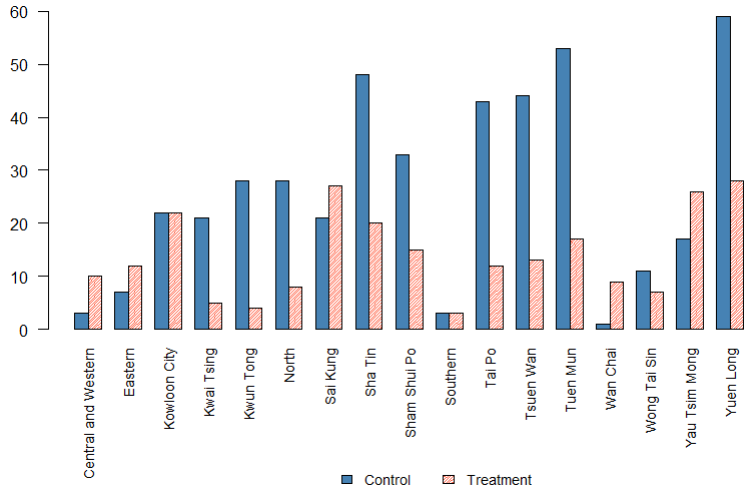
Panel A: Number of Transactions By Expiration Year



Panel B: Number of Transactions by Lease Group

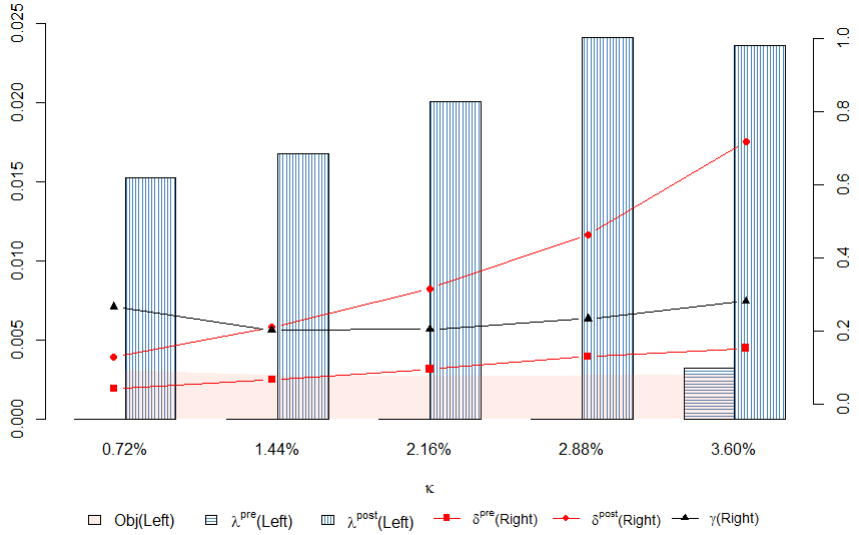


Panel C: Number of Leases by District



This figure plots the number of housing transactions by individual lease expiration year (except leases expiring on 6/30/2047). Panel A presents the number of transactions by lease expiration year from 2030 to 2135, and from 2842 to 2959. Panel B presents the number of transactions by lease groups and lease types (colonial British leases or HKSAR leases). Panel C plots the number of leases for control group and main treatment group by each district.

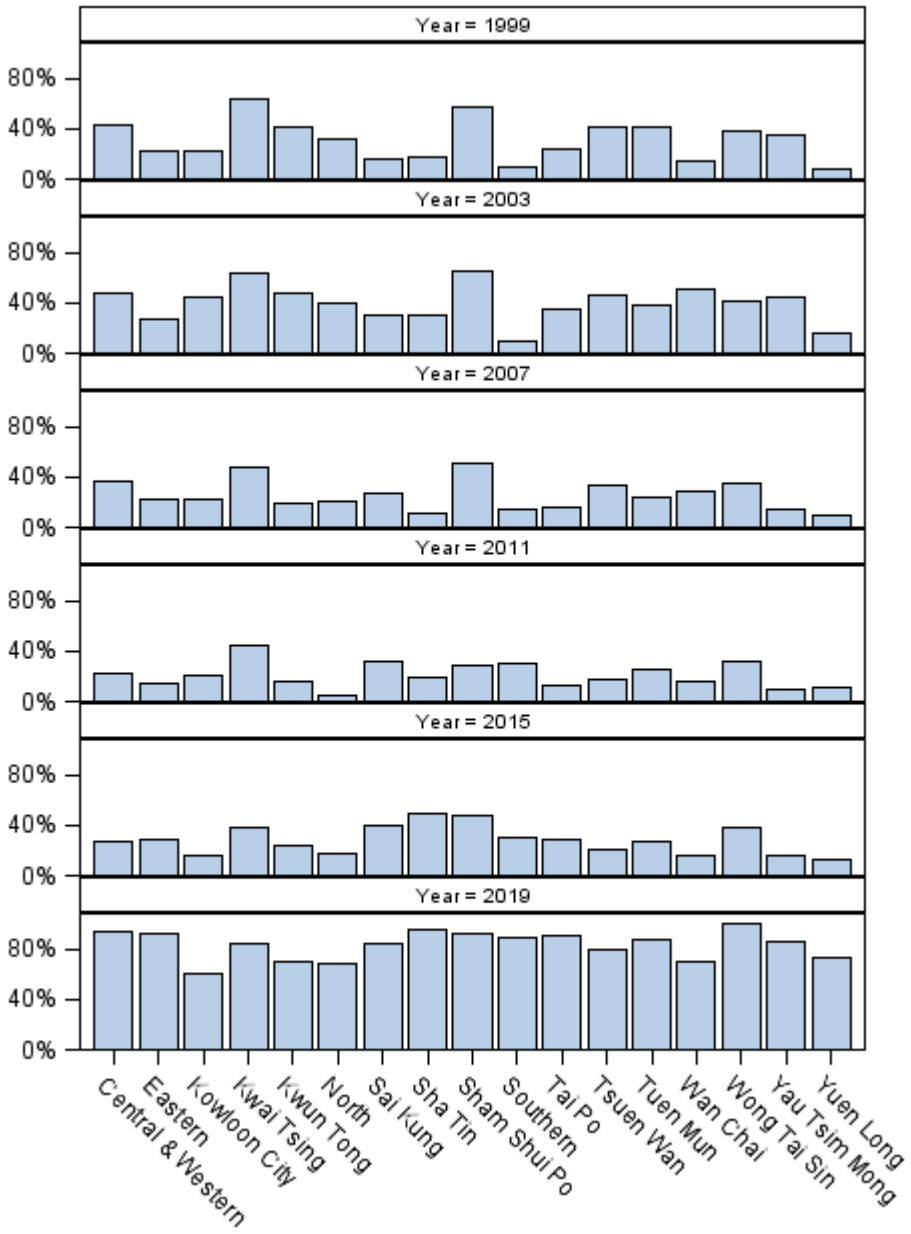
Figure OA.3. Model Estimates Under Alternative Discount Rates



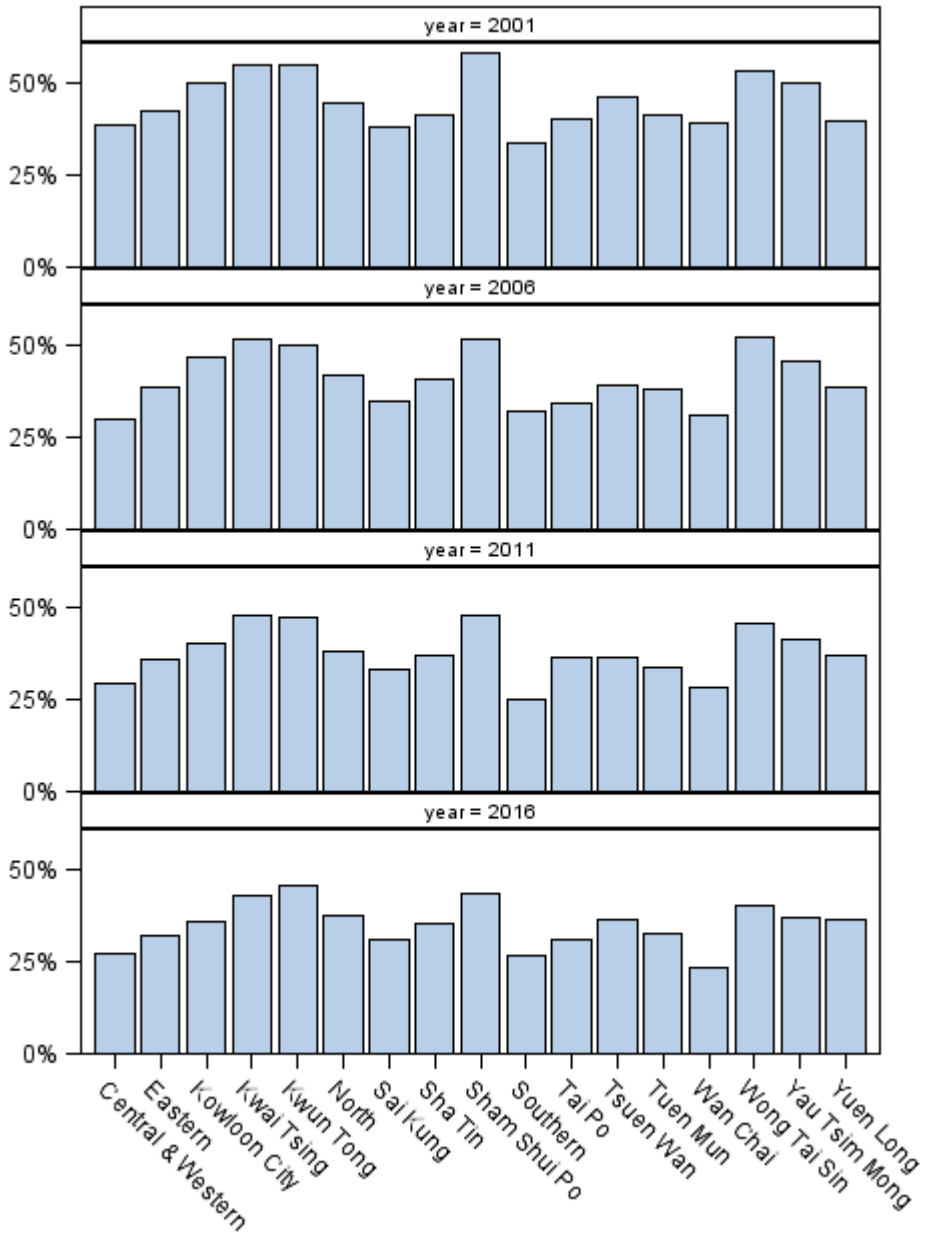
This figure presents the 2-step GMM estimation results of our base model given different discount rate $\kappa = r - g$. We vary the gross rental yield from 1% to 5%, and the corresponding discount rate κ as shown in the x-axis equals to $1 - 28\% = 0.72$ multiplying the gross rental yield. Obj, λ^{pre}, and λ^{post} are plotted against the left scale, while δ^{pre}, δ^{post}, and γ are plotted against the right scale.

Figure OA.4. District Characteristics Over Time

Panel A: % of Pro-Democracy Seats



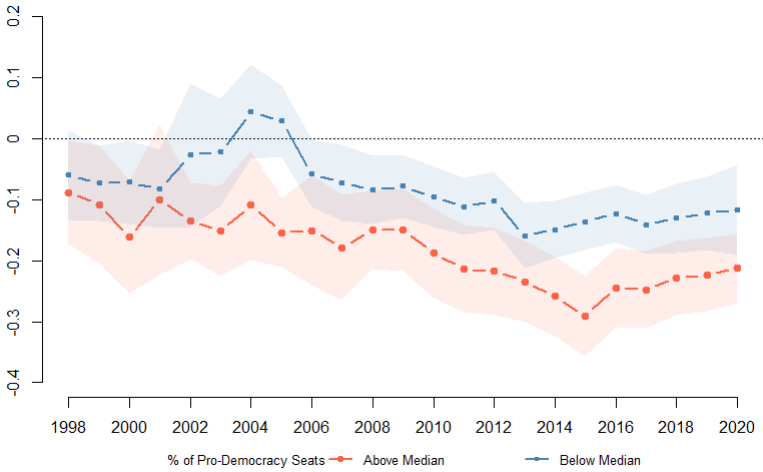
Panel B: % of Mainland Migrants



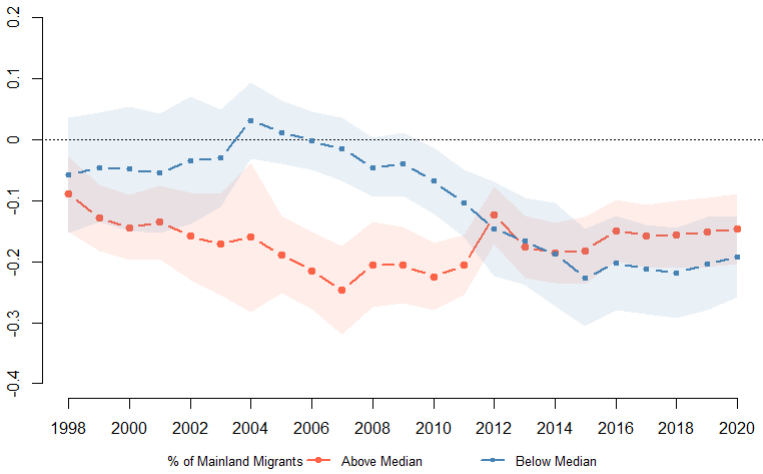
Panel A plots % of Pro-Democracy Seats by voting year and districts. Panel B plots % of Mainland Migrants by census year and districts.

Figure OA.5. Estimates Over Time

Panel A: Districts with High Versus Low % of Pro-Democracy Seats



Panel B: Districts with High Versus Low % of Mainland Migrants



Panel A plots the price discounts over time for two groups: main treatment groups which have the percentage of Pro-Democracy Seats above median, main treatment groups which have the percentage of Pro-Democracy Seats below median. Panel B plots the price discounts over time for two groups: main treatment groups which have the percentage of Mainland Migrants above median, main treatment groups which have the percentage of Mainland Migrants below median.

Table OA.1: Summary Statistics By Split Samples

	Control Lease Group			Main Treatment Lease			Control -
Variable	N	Mean	SD	N	Mean	SD	Treatment
Log(Price)	363,923	0.89	0.62	92,407	1.40	0.63	-0.51***
Log(Unit Price)	363,923	8.51	0.53	92,407	8.95	0.51	-0.44***
Net Living Area Area	363,923	513.90	157.00	92,407	551.50	162.10	-37.67***
Floor	363,923	16.98	10.97	92,407	24.07	15.90	-7.08***
No of Bedrooms	363,923	2.06	0.98	92,407	2.06	0.98	0.00
No of Living Rooms	363,923	1.61	0.77	92,407	1.75	0.71	-0.14***
Bay Window Size	363,923	22.62	15.25	92,407	22.81	13.55	-0.19***
Building Age	363,923	16.44	8.41	92,407	9.46	8.02	6.98***
Building Completion Year	363,923	1991	7.31	92,407	2002	9	-11***
Distance To MRT	363,923	799	945	92,407	692	900	107***
Distance To Bus Stop	363,923	313	292	92,407	352	278	-39***
Distance To Hospital	363,923	1,689	1,382	92,407	1,549	1,181	140***
Distance To School	363,923	150	230	92,407	128	108	22***
Distance To University	363,923	4,010	2,539	92,407	3,349	2,365	661***
Distance To Coastal Line	363,923	1,608	1,742	92,407	1,254	1,634	354***
Turnover	363,923	0.079	0.043	92,407	0.082	0.050	-0.003***

The table presents number of observations, mean and standard deviation of property characteristics for the control group (lease = 6/30/2047) and main treatment group (lease $\in$ [7/1/2047, 12/31/2064]) separately. The last column presents the mean difference of these two groups and the t-test significance. Turnover is calculated as the number of transactions over the number of units for each land (identified by land lot number) and transaction year.

Table OA.2: Distributions by Lease Group and Year

	Sale Year				All
Lease Group	1998-2005	2006-2010	2011-2015	2016-Feb 2020	Years
Panel A: Number of Transactions					
2030 to 2033	678	960	315	157	2,110
2034 to 2039	1,621	1,404	631	222	3,878
2040 to 2046	4,569	3,131	1,502	805	10,007
6/30/2047	120,869	134,766	72,002	36,286	363,923
7/1/2047 to 2049	1,746	7,573	4,094	2,489	15,902
2050 to 2052	1,120	9,886	9,457	5,577	26,040
2053 to 2064	3,550	4,975	6,997	7,963	23,485
2065 to 2097	4,177	5,465	2,825	1,354	13,821
2098 to 2135	15,368	12,251	5,800	3,019	36,438
2842 to 2959	12,656	10,458	4,443	1,649	29,206
HKSAR Leases	1,534	12,098	7,925	5,423	26,980
Panel B: Number of Estates					
2030 to 2033	4	4	5	6	6
2034 to 2039	4	4	4	2	4
2040 to 2046	3	3	2	2	3
6/30/2047	353	353	342	328	376
7/1/2047 to 2049	18	24	24	22	26
2050 to 2052	14	37	36	33	38
2053 to 2064	22	30	48	61	71
2065 to 2097	40	34	28	23	43
2098 to 2135	43	41	33	28	46
2842 to 2959	64	59	55	44	66
HKSAR Leases	18	40	54	79	84
Panel C: Number of Districts					
2030 to 2033	3	3	3	3	3
2034 to 2039	3	3	3	2	3
2040 to 2046	3	3	2	2	3
6/30/2047	17	17	17	16	17
7/1/2047 to 2049	8	12	12	12	12
2050 to 2052	9	16	16	16	16
2053 to 2064	6	13	16	15	16
2065 to 2097	5	6	6	5	6
2098 to 2135	5	5	5	5	5
2842 to 2959	6	6	6	6	6
HKSAR Leases	10	11	14	15	15

This table presents number of transactions (Panel A), number of estates (Panel B), and number of districts (Panel C) by these lease subgroups and sale year groups.

Table OA.3: A More Exogenous Control Group

	(1)	(2)	(3)	(4)
Dep Var	Log (Unit Price)		Log (Total Price)	
I(2030 ≤ Lease ≤ 2033)	-0.064	-0.061	-0.052	-0.044
	[0.047]	[0.052]	[0.051]	[0.056]
I(2034 ≤ Lease ≤ 2039)	-0.033	-0.032	-0.038	-0.033
	[0.039]	[0.043]	[0.043]	[0.046]
I(2040 ≤ Lease ≤ 2046)	-0.004	-0.002	0.006	0.012
	[0.058]	[0.061]	[0.061]	[0.065]
I(Lease = 6/30/2047 & After JD)	0.025	0.025	0.024	0.025
	[0.019]	[0.019]	[0.020]	[0.020]
I(Lease = 6/30/2047 & Before JD and in HKL+KIL)		0.005		0.014
		[0.037]		[0.040]
I(7/1/2047 ≤ Lease ≤ 2049)	-0.134***	-0.132***	-0.141***	-0.137***
	[0.028]	[0.032]	[0.030]	[0.033]
I(2050 ≤ Lease ≤ 2052)	-0.123***	-0.122***	-0.123***	-0.120***
	[0.028]	[0.030]	[0.030]	[0.031]
I(2053 ≤ Lease ≤ 2064)	-0.124***	-0.122***	-0.126***	-0.122***
	[0.032]	[0.035]	[0.034]	[0.036]
I(2065 ≤ Lease ≤ 2097)	-0.106***	-0.104***	-0.108**	-0.102**
	[0.035]	[0.040]	[0.042]	[0.046]
I(2098 ≤ Lease ≤ 2135)	-0.018	-0.016	-0.025	-0.020
	[0.038]	[0.043]	[0.040]	[0.044]
I(2842 ≤ Lease ≤ 2959)	-0.052	-0.050	-0.054	-0.049
	[0.036]	[0.040]	[0.038]	[0.042]
Property Attributes	Yes	Yes	Yes	Yes
District × Month	Yes	Yes	Yes	Yes
N	551,790	551,790	551,790	551,790
Adj R^2	0.9289	0.9289	0.9422	0.9422

This table presents the hedonic regression results using the baseline sample. We separate the control group into three subgroups: the first set denoted by indicator I(lease = 6/30/2047 & After JD); the second set denoted by indicator I(lease = 6/30/2047 & Before JD and in (HKL,KIL)); the last set, granted before the JD and located in New Kowloon and New Territories, is used as the control group. The specification in Columns (1) and (2) is the same as Column (1) in Table 2 and that in Columns (3) and (4) is the same as Column (4) in Table 2. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

Table OA.4: Local Political Sentiments and Price Discount

Panel A: Summary Statistics

Variable	N	Mean	SD	Min	1st	5th	Median	95th	99th	Max
% of Pro-Democracy Seats	551,790	0.30	0.18	0.04	0.04	0.10	0.26	0.70	0.92	1.00
% of Mainland Migrants	551,790	0.39	0.06	0.24	0.25	0.31	0.37	0.50	0.55	0.58
Median Age	551,790	40.42	2.59	34	34	35	41	44	45	45
Median Income	551,790	12,422	2,111	9,000	9,200	10,000	12,500	16,300	16,500	16,800
% of College or Above	551,790	0.17	0.06	0.05	0.06	0.08	0.16	0.26	0.32	0.38
% of Home Owners	551,790	0.51	0.08	0.29	0.29	0.32	0.54	0.61	0.62	0.62

Panel B: Correlation

	% of Pro-Democracy Seats	% of Mainland Migrants	Median Age	Median Income	% of College or Above	% of Home Owners
% of Pro-Democracy Seats	1.00					
% of Mainland Migrants	0.34	1.00				
Median Age	0.00	-0.40	1.00			
Median Income	0.33	0.16	0.26	1.00		
% of College or Above	0.01	-0.45	0.84	0.09	1.00	
% of Home Owners	-0.28	-0.67	0.51	-0.24	0.64	1.00

Panel C: Adding Interaction with HKSAR Leases

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	Log (Unit Price)					
I(7/1/2047 $\leq$ *lease* $\leq$ 2064)	-0.153***	-0.156***	-0.145***	-0.148***	-0.114***	-0.113***
	[0.022]	[0.021]	[0.021]	[0.021]	[0.024]	[0.028]
× % of Pro-Democracy Seats		-0.057***		-0.054***		
		[0.013]		[0.013]		
× % of Mainland Migrants			-0.064***	-0.057***		
			[0.022]	[0.022]		
× I(High % Pro-Democracy Seats)					-0.093***	
					[0.026]	
× I(High % Mainland Migrants)						-0.073**
						[0.028]
× HKSAR Leases	0.084***	0.077***	0.085***	0.078***	0.077***	0.106***
	[0.026]	[0.024]	[0.027]	[0.026]	[0.026]	[0.036]
× % of Pro-Democracy Seats		-0.001		0.004		
		[0.019]		[0.020]		
× % of Mainland Migrants			-0.016	-0.014		
			[0.038]	[0.038]		
× I(High % Pro-Democracy Seats)					-0.002	
					[0.037]	
× I(High % Mainland Migrants)						-0.042
						[0.043]
Property Attributes	Yes	Yes	Yes	Yes	Yes	Yes
District × Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	551,790	551,790	551,790	551,790	551,790	551,790
Adj R^2	0.9294	0.9304	0.9301	0.9309	0.9301	0.9300

This table presents the district-level variation of price discounts for our main treatment lease group. Panel A reports the summary statistics of raw values. Panel B reports the correlations of standardized values. Panel C presents similar analysis as Table 7 with additional interaction terms of the HKSAR leases dummy with the two district variables. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

Table OA.5: Mainlander Transactions and Price Discount

Sample	All	< 2006	> 2006
	(1)	(2)	(3)
Dep Var	Log (Unit Price)		
I(7/1/2047 $\leq$ *lease* $\leq$ 2064)	-0.117***	-0.072***	-0.116***
	[0.021]	[0.023]	[0.020]
× I(Mainland Buyer) × I(Local Seller)	0.014*	-0.016	0.014*
	[0.008]	[0.019]	[0.008]
× I(Mainland Buyer) × I(Mainland Seller)	0.002	-0.010	0.004
	[0.012]	[0.036]	[0.012]
× I(Local Buyer) × I(Mainland Seller)	-0.016**	0.023	-0.015**
	[0.008]	[0.024]	[0.007]
I(Mainland Buyer) × I(Local Seller)	0.016***	0.001	0.020***
	[0.003]	[0.005]	[0.004]
I(Mainland Buyer) × I(Mainland Seller)	-0.015*	-0.009	-0.015*
	[0.008]	[0.020]	[0.008]
I(Local Buyer) × I(Mainland Seller)	0.004*	0.003	0.004
	[0.003]	[0.005]	[0.003]
Property Attributes	Yes	Yes	Yes
District × Month FE	Yes	Yes	Yes
N	457,575	145,759	311,816
Adj R^2	0.9343	0.8379	0.9238

This table presents the pricing difference of mainland buyers and mainland sellers. The sample includes the housing transaction records in Hong Kong from 1998 to February 2020. The dependent variable is the log of unit price. The buyer and seller dummy variables are defined using the assignee (assignor) names. The regression controls are the same with Column (1) in Table 2 with additional controls including the interaction term of main treatment indicator with Median Age, Median Income, % of College Above, and % of Home Owners. Standard errors are two-way clustered by estate and year-month; * denotes significance levels (***=1%, **=5%, *=10%).

OA.1.1. Valuation of Colonial Leases with Nominal Ground Rent

In Section 3.1 the net cash flow $R_s = e^{gs}$ is under the setting of current baseline ground rent, with is 3% of rateable, i.e., annual rent reevaluated every year. To take the nominal rent into account, we show that Eq. (10) needs to be modified as:

$$P(L;\tau,Brit) = \mathbb{E}\left[\int_0^{L\wedge\mathcal{T}} (C_1 e^{-\kappa s} - C_2)ds + e^{-\kappa(L\wedge\mathcal{T})} \cdot (1 - \delta^{pre}\mathbf{1}_{s<\tau} - \delta^{post}\mathbf{1}_{s\geq\tau}) \cdot P(L\wedge\mathcal{T}+50;HK)\right].$$

More specifically, we adjust the net cash flow before $L \wedge \mathcal{T}$ using C_1 and C_2, where $C_1 = \frac{1-\omega+0.03}{1-\omega}$, and $C_2 = \frac{0.03\times e^{gT_B}}{1-\omega}$, where ω is the percentage of repairing costs and taxes in the gross rent. Here, T_B is the auctioned date for a lease that has never been extended, or the most recent extension date for a lease that has been extended before. Essentially, these leases pay a ground rent as 3% of annual rent evaluated at T_B, instead of 3% of the rateable.