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ABSTRACT

Superstition in the Housing Market*

We provide the first solid evidence that Chinese superstitious beliefs can have significant effects on house prices in a North American market with a large immigrant population. Using real estate data on close to 117,000 house sales, we find that houses with address number ending in four are sold at a 2.2% discount and those ending in eight are sold at a 2.5% premium in comparison to houses with other addresses. These price effects are found either in neighborhoods with a higher than average percentage of Chinese residents, consistent with cultural preferences, or in repeated transactions, consistent with speculative behavior.

JEL Classification: D03, J15, R2, Z1

Keywords: superstition, lucky Chinese numbers, housing markets efficiency, immigration

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I. Introduction

In this paper, we explore the price effects of auspicious and inauspicious Chinese numbers in house addresses on transaction sales in a North American market. We focus on the Greater Vancouver area, also called the Lower Mainland of British Columbia. This metropolitan area comprises a sizeable but overall minority share of immigrants of Chinese ethnicity who tend to concentrate in several ethnic enclaves. Because the superstitious beliefs are not as widespread as in some Asian markets, we can exploit differences in the concentration of ethnic Chinese residents across neighborhoods to identify the effect of the auspicious and inauspicious numbers and claim that they are driven by Chinese superstitious beliefs or "cultural cues". As the cultural number preferences have become well-known outside of the Chinese community, we can also study potential speculative behavior by investigating price effects of the fateful numbers in repeated sales across Chinese and non-Chinese neighborhoods. The argument for the presence of some speculative behavior is buttressed by the size of the observed effects being in line with transaction costs limiting arbitrage opportunities. This paper thus contributes to an emerging literature on the economic impact of superstitious or "false" beliefs, as well as to the literature on the impact of immigration on housing markets.

Studying the potential role and impact of superstitious or false beliefs in the economy and in society is relatively new in economics. False beliefs have long been considered a sign of irrationality in economics and thus at odds with *homo economicus*. Sociologist Gerald Bronner argues that social media now allows people with fringe beliefs (such the feared apocalypse of December 21st, 2012) to congregate and build a community of believers that is hardly disciplined by the scientific community or the relevant elite.[1] When false beliefs are allowed to flourish, this creates profit opportunities for unscrupulous agents. Akerlof and Shiller (2012) in "Phishing for Phools" argue that opportunities to exploit buyers' "emotional or cognitive weaknesses" have increased as some features of the competitive market envisaged by Adam Smith are absent in internet trading and fly by night operations.[2] Is the discipline provided by a competitive market sufficient to keep the consequences of irrationality in check or is regulation in order? When the

[1] There are still numerous web sites advertising survival skills summer camp for the post-apocalypse world.

[2] Buyers and sellers are never in a position to build a trust relationship. Indeed, an important feature of trust building on successful internet sites is through consumer reports on sellers.

public interest is at stake, a solid case for intervention to dispel false beliefs can be made.[3] In cases of private losses or gains, the case is not as clear. In this paper, we consider the impact of numbers considered "lucky" and "unlucky" by a large community in the context of largely one-shot transactions, finding evidence that, in the long run, competitive markets do indeed limit the price effects of superstitious beliefs. Nevertheless, if you are holding real estate in a neighborhood that has experienced an influx of Asian immigrants in recent decades, results indicate you may be facing unanticipated gains or losses because of the numbers in your home address.

Our results also speak to the role of immigrants' cultural beliefs in the process of integration to the host country. Popular anti-immigrant sentiments often emerge not only when natives feel threatened in their economic position (Mayda, 2006), but perhaps more importantly when their cultural values are threatened by newcomers (Dustmann and Preston, 2007). This begs the question of how public policies should respond to the irrational beliefs (or cultural sensibilities) of newcomers while respecting the traditional values of the host population. Which social norms should prevail? In the case at hand, should city-by laws allow homeowners to change house numbers that become inauspicious following the arrival of the Chinese immigrants to protect them for unexpected losses? Ni (2011) reports that the city of Arcadia in the San Gabriel Valley east of Los Angeles has gone back and forth on this issue.[4] Twenty-two years ago, following a dramatic rise in Chinese homeownership, the city allowed people to change inauspicious numbers for a fee. It abandoned the program in 2006 because of complications, but is considering reintroducing it to bolster a slow real estate market.

When the Beijing Summer Olympics opened at 08:08:08 pm on the 8th day of the 8th month of 2008, it was shown to the world that the Chinese take the auspiciousness of the number "8" seriously. In Las Vegas, where superstitious beliefs are rampant, many large casino-hotels (such as MGM, Wynn and Palms Place) omit floor numbers 4, 14, 24, 34 and 40 to 49 because

[3] The case of false beliefs concerning a link between vaccination and autism that spread through the internet is one where fraud in the inceptive scientific paper (Wakefield et al., 1998) was finally brought to light, but where beliefs at odds with the scientific evidence persist to this day. The Food and Drug Administration is the prime example of the need to regulate "snake oil" (Akerlof and Shiller, 2009), although "shark fins" seem to escape its purview. .

[4] The San Gabriel Valley has an estimated population of 2 million, about a quarter of whom are Asian American according to census data. In the city of Arcadia, Asians, predominantly Chinese made up nearly 60% of the population in 2010.

the number "4" is considered unlucky in the Chinese tradition.[5] This *tetraphobia* comes from the fact that the pronunciation of the word for four (四: sì) is very similar to the word for death (死: sǐ) in Mandarin, Cantonese, and several Chinese dialects. Conversely, the word for eight (八: bā) is phonetically similar to the word for prosperity or wealth (发: fā).[6] Jed Kolko (2012), chief economist at Trulia.com, a comprehensive real estate internet site in the United States, reports that in Asian-majority neighborhoods, such as Inner Sunset in San Francisco, Monterey Park in Los Angeles, and Flushing in Queens, NY, the number "8" is the last non-zero digit of the asking price in 20% of their home listings in comparison to just 4% of home listings in non-Asian neighborhoods. He also reports that this percentage goes up to 37% among homes listed for over one million dollars in Asian-majority neighborhoods.[7]

Vancouver, B.C., has a long history of Chinese immigration dating back to the construction of the Canadian Pacific Railway in the 19th century. Chinese immigration flows were curtailed with the imposition of a head tax in 1885, and banned formally in 1923. While there was a continuous trickle of Chinese refugees thereafter, the relaxation of ethnic restrictions in Canadian immigration regulations in the 1970s saw a substantial increase in the number of immigrants from China. It was, however, the impending return of Hong Kong to the People's Republic of China in 1997 that resulted in a dramatic increase of Chinese immigrants as it sent a new wave of immigrants from Hong Kong in the 1980s and 1990s. Indeed, between 1986 and 1996, the percentage of Greater Vancouver residents of Chinese ancestry doubled from 8% to 16%. Since then, Vancouver has continued to see a substantial number of immigrants from mainland China, many of them admitted as Business Class Applicants. In June 2006, the percentage of residents of Chinese ethnicity was estimated to be 19%. This large influx of immigrants resulted in the development of several Chinese ethnic enclaves.[8] Our immigrant shock is not as punctual as the Mariel Boatlift, studied by Card (1990) and Saiz (2003), but rather occurred in waves with the largest one preceding our observation period. Yet because the

[5] Some hotels also omit the 13th floor considered unlucky in the Western tradition. In Vancouver, many new residential towers also skip the floors numbers that include a four.
[6] Although the Japanese and Korean languages are very different from the Chinese language, they often use Chinese characters to represent some words, including the two numbers. This means that tetraphobia is widespread in East-Asia and many Southeast Asian countries.
[7] The chief economist looked at the asking prices of homes for sale on Trulia.com, from October 2011 to November 2012, excluding foreclosures, to see whether certain numbers showed up in home prices more than others. He also found that in Nevada, 3.8% of listings have "7" as the last non-zero digit, compared with 2.8% outside Nevada.
[8] See Hou and Picot (2004) for details.

effects sought are directly linkable to Chinese culture and predominantly found in Chinese neighborhoods, we can still accurately pinpoint the effects of the Chinese immigration inflows on housing. This is the important advantage of conducting the analysis in a large North American metropolitan area.

We combine a large and detailed real estate data set containing information on all single-family house sales (close to 117,000 transactions) in the Greater Vancouver area over the five-year period from January 2000 to May 2005 with census tract (CT) information from the Canadian Censuses from 1986 to 2001. Our empirical specification begins with a classic hedonic analysis (Rosen, 1974) of the log transaction price where the structural, locational, and neighborhood attributes of a house are thought to affect price. In addition to a host of structural house attributes, we control for detailed location characteristics by including street and CT fixed effects, and we control for seasonal and yearly price effects with month-year fixed effects.

We focus our search for the effects of superstitious beliefs on house address numbers ending with the digits "4" or "8" as beliefs associated with these numbers are thought to be greatest and the last digit of a house number is thought to leave a final impression in the pronunciation of one's address.[9] We perform some limited tests for other digits or combinations of digits in the house number also associated with superstitious beliefs. We employ a difference-in-difference estimation strategy. Once we control for CT fixed effects and the Chinese concentration in the CT, the coefficient of the interaction between the fateful house address numbers and the Chinese concentration in the CT gives us the relative price effect of fateful house numbers in Chinese neighborhoods in comparison to other neighborhoods. We find that, on average, in neighborhoods where the percentage of Chinese residents exceeds the Greater Vancouver average of 18%, houses with address numbers ending in "4" are sold at a 2.2% discount and those ending in "8" are sold with a 2.5% premium in comparison to houses with address numbers ending in any other digits. Interestingly, similar effects of the fateful numbers are also found in repeated sales in non-Chinese neighborhoods, consistent with speculative behavior.

[9] Recently, the city of Richmond Hill, Ont. has agreed to let homeowners with a house currently ending with four apply to add a letter and to make their address end with 4C or 4D. This reflects the fact that ending with a sound like "death" was the main preoccupation. We note that in Chinese, Richmond translates as the "City of Rich Gate" since mond" has the same pronunciation as "gate" in Chinese. Many papers investigating the role of Chinese superstitious beliefs also focus on the last digit effect. For example, Simmons and Schindler (2002) in marketing, and Brown, Chua and Mitchell (2002) in finance focus attention on the last digit of the price.

We argue below that the magnitude of these average effects is consistent with transaction costs limiting arbitrage opportunities. These results add weight to the argument that transaction costs and heterogeneous preferences limit the efficiency of the market for single-family homes (Case and Shiller, 1989; Meese and Wallace, 1994; Rosenthal, 1999.) Case and Shiller (1989) first suggested that arbitrage opportunities in the single-family home market are difficult to exploit due to transactions costs, carrying costs and tax considerations. Rosenthal (1999) on the other hand, concluded that any inefficiency in the housing market must lie in the market for land itself. To the extent that street addresses are a characteristic of the lot rather than of the building, our results are consistent with both views.

We also perform unconditional quantile regressions (Firpo, Fortin, and Lemieux, 2009) and find that the percentage price effects of the lucky numbers are largest at the upper end of the transaction sales distribution, consistent with wealth effects found in other markets. The structure of the paper is as follows. Section II provides the background and rationale for the anticipated effects. Section III introduces the data used. Section IV presents the basic empirical specification and the empirical results. Section IV concludes by interpreting results.

II. Anticipated Effects

There are few markets where the effect of superstitious beliefs can be detected. The small literature on the effects of lucky and unlucky Chinese numbers has been limited to markets where there is a limited supply of such numbers, such as residential markets and the market for special license plates in Hong Kong. We first offer a succinct summary of the empirical and theoretical literature on the price effects of superstitious beliefs. Next we explain why limited relative supply and transaction costs are important for the detection of such effects and offer two distinct predictions with regards to the existence and size of price effects for auspicious and inauspicious Chinese numbers in house addresses.

There are a few studies that present some evidence of Chinese superstitious beliefs on home prices, but they are limited by relatively small sample sizes or by the lack of clear control groups. Bourassa and Peng (1999) consider the effect of unlucky and lucky house numbers on 2,164 house sales in a few neighborhoods of Auckland, New Zealand and find a significant

positive premium for lucky numbers.[10] Chau, Ma and Ho (2001) investigate the effects of lucky floor numbers 8, 18 and 28 on 1,019 apartment sale prices in Hong Kong and find that apartment on lucky floors sell for higher prices during property booms.[11] Liu and Wong (2012) consider the effects of unit numbers ending with a "4" or a "8" on the sale price of new apartments in Singapore. They attempt to distinguish the effect of the investors' "own beliefs" from effects coming from the "beliefs of others", which speculators would take into account. They however failed to find significant price effect differences between investors and speculators. Shum, Sun, and Ye (2012) on the other hand, find evidence that own beliefs are at play. They find that in Chengdu, China, buyers with phone numbers containing more "8s" are also more likely to purchase of apartments on floors ending with an "8". Note that existing studies have only considered markets in Asia and Oceania.

Other papers that investigate the impact of Chinese superstitious beliefs have focused on the willingness to pay (WTP) for special license plates in Hong Kong (e.g. Woo, Horowitz, Luk, and Lai, 2008; Ng, Chonga and Du, 2010). Woo et al (2008) study the impact of lucky numbers on the WTP of consumers at 348 auctions between 1990 and 2005. Because there is a large choice of available digit combinations, the authors are able to study a wide range of three-digit and four-digit combinations, each with a different meaning.[12] They find significantly higher WTP for auspicious license plates numbers that cater to the motorists' superstitions, and they also find that the WTP for these license plates is influenced by economic conditions, which is typical of conspicuous consumption. Ng, Chong and Du (2010) consider the effects of single digits on the WTP for license plates in a larger set of auctions and find that number ''8s" and ''4s" are associated with plates with significantly higher and lower winning bids, respectively. While these results are interesting, the license plate market is a case where the absence of a resale market (for special plates) prevents observations of equilibrium prices, thus the focus on the WTP instead. In the case of license plates, there may also be a WTP for exclusivity as the most prized numbers are likely unique. This exclusivity is similar to that associated with

[10] Bourassa and Peng argue that the Chinese homophonic principles of number interpretation are linked to the practice of *Feng Sui*, a system which is intrinsically linked to the Taoist philosophy and is more substantial than simple superstitions.

[11] Chau et al. (2001) use the transaction records of apartment sales from only one private sector real estate company in Hong Kong's apartment market, which is not necessarily representative of the entire market.

[12] For example, they consider ''228 (double easy prosperity)'', ''338 (double longevity and prosperity)'', ''988 (long-lasting double prosperity)" among many others.

luxurious brand names. In the context of housing, there can be a house number finishing with "88" in each block; exclusivity is more likely associated with certain prestigious streets.

There is relatively little theoretical work in economics that focuses directly on superstitious beliefs, although there is a growing literature in finance that analyses how heterogeneous beliefs among investors generate speculation and trading (Scheinkman and Xiong, 2003). For example, Morris (1996) shows that after an initial public offering, there is room for a speculative premium to emerge before all traders learn about the true distribution of the asset's dividend. In a game-theoretic model with rational learning, Fudenberg and Levine (2006) characterize the conditions under which superstitious beliefs can be expected to persist over time. They argue that these false beliefs are more likely to persist for events off the equilibrium path. In this context, agents are never presented with counterfactual evidence to dispel the superstitious beliefs. In the housing market, fateful outcomes are not easily measured or evaluated, making counterfactuals difficult to construct and leaving room for these beliefs to persist.[13] On the other hand, to the extent that the beliefs are not factual, and because homes represent sizeable assets, there may exist some attractive arbitrage opportunities, so that the belief-based equilibrium could be fragile. We show below that transaction costs limit these arbitrage opportunities, allowing us to observe the price effects associated with the fateful house addresses.

First, for superstitious beliefs to have a quantifiable impact in competitive markets, a sufficient number of buyers need to hold these beliefs. Homebuyers typically choose a neighborhood or set of neighborhoods in which they would like to live, and then search within those neighborhoods for specific houses. In addition, it is well-known that individuals exhibit a preference for living in neighborhoods in which their ethnicity has a notable presence. This is particularly true for immigrants (Bartel, 1989). Notwithstanding arbitrage opportunities, we thus expect to find a premium on houses associated with good luck in neighborhoods where there are more buyers who hold these beliefs than they are such houses available.

We now formulate the relationship between the proportion of superstitious buyers π_S , the proportion of lucky houses π_8, and the market premium δ_8 for a lucky address more precisely. We assume that in the short run there are only two types of buyers in this market: the

[13] Conversely, Brown and Mitchell (2008) who study price clustering on the Shanghai and Shenzhen stock exchanges, find that preferences for prices ending with "8" relative to "4" have declined over time.

superstitious (*S*) and the non-superstitious buyers (*N*). The WTP a premium for a lucky house is greater among superstitious buyers than among non-superstitious buyers, $v_{S8} > v_{N8} = 0$, for whom it is equal to zero. Following a hedonic housing framework, let $\bar{P}_{sct}(H)$ be the average price of a house on street *s* in Census tract *c* at time *t* with a neutral address and housing characteristics H , and let $(1 + \delta_8)\bar{P}_{sct}(H)$ be the price for a house with similar characteristics, but with a lucky address. The δ_8 then represents the percentage premium paid for this property.

Proposition 1: Existence of Price Effects. *i)* The market premium δ_8 will be positive only if $\pi_S > \pi_8$, and *ii)* as long as this inequality is satisfied, increases in the proportion of superstitious buyers π_S will not increase the premium δ_8.

Proof. There are three cases. In the case $\pi_S < \pi_8$, where the proportion of superstitious buyers is below the proportion of lucky houses, there is excess supply of lucky houses and buyers have the bargaining power. As a result, the maximum premium of a lucky house must be the willingness of the non-superstitious buyers to pay a premium for this type of house, and there is no premium for lucky houses, $\delta_8 = v_{N8} = 0$. In the case $\pi_S > \pi_8$, there are more superstitious buyers than the supply of lucky houses. Assuming that all superstitious buyers are willing to pay the same premium v_8 for their preference, the price premium comes from the competition between these buyers: $\delta_8 = v_{S8} > 0$. [14]As long as the fraction of superstitious buyers exceeds the cutoff, further increase in this type of buyer do not increase price premium. In the knife edge case $\pi_S = \pi_8$, the premium $\delta_8 \in (0, v_{S8})$ can take any value in that range. ■

Note that not all ethnic Chinese residents hold superstitious beliefs or cultural preferences for certain addresses. Although, as Tsang (2004) argues, half-believers of superstition may suffer from cognitive dissonance issues and also base their decisions on superstition, even though they know that they should not. Thus in practice, Proposition 1 provides only a lower bound: below a certain proportion of ethnic Chinese residents in a neighborhood, equal to the proportion of lucky houses, we should not expect to see the premium. It sets a necessary but not sufficient condition.

A similar logic applies to the case of unlucky houses; the presence of a discount depends on the mix of buyers. There will be a percentage discount on a house associated with bad luck, say δ_4, in neighborhoods where the proportion of potential buyers who hold these beliefs π_S is greater than the proportion of neutral and lucky houses $(1 - \pi_4)$. With an insufficient number of

[14] If sellers are aware of these preferences, they are more likely to push buyers to engage in price wars/auctions that may push superstitious buyers beyond the limit of their WTP. As shown below, most of our observation period precedes to the period of double digit yearly housing price inflation.

non-superstitious buyers to buy all unlucky houses, $\pi_N = (1 - \pi_S) < \pi_4$, some superstitious buyers will buy the unlucky houses at discount, $\delta_4 = \nu_{S4}$, where ν_{S4} is the percentage discount that makes the superstitious buyers willing to pay for the unlucky property rather than the neutral home. In practice, the proportion of non-superstitious buyers π_N living in a particular neighborhood may be linked to the perceived benefit or cost of living in a Chinese neighborhood. We would observe reduced (or the absence of) discounts on houses associated with bad luck if non-Chinese (non-superstitious) buyers perceive little or no cost to living in Chinese neighborhoods. Determining a precise cut-off for the emergence of superstitious beliefs is thus empirically challenging; our prediction about the stability of the premiums and discounts as the concentration of ethnic Chinese residents increases should be easier to observe.

In the long run and in sufficiently thick markets, the idiosyncratic and revealed preferences of newcomers create some arbitrage opportunities. This raises the basic question: why have arbitrage opportunities not driven the discount/premium to zero? There is ample anecdotal evidence that Chinese cultural preferences have not been ignored by opportunistic real estate agents. In particular, they can act as informed buyers who exploit the existence of both superstitious and non-superstitious buyers.[15] Transaction costs, however, which importantly include the real estate agents' margins of between five and six percent of the transaction price equally split between the agent of the home seller and the agent of the home buyer, limit profitable arbitrage opportunities.[16] Even when real estate agents themselves are involved in the transaction as buyer or seller, they still have to pay the other agent's fee.[17] Consider the case where arbitrage opportunities are exercised within the same day in order to abstract from mortgage bridging costs, which would reduce potential profits and make them depend on the elapsed time between buying and selling. Clearly, intra-day buying and selling represent the ultimate expression of speculative demand for housing and are thus relatively rare. In our sample

[15] Informed buyers (I) in our model are willing to pay more for a lucky property $\nu_{I8} > 0$ than for a neutral property, but because their motive is profit, $\nu_{I8} < \nu_{S8} = \delta_8$. So they will be outbid by superstitious buyers who have a higher WTP because of the fateful glow, unless there are not enough of these buyers in which case the informed buyers may choose to act as intermediaries.

[16] Numerous ads by real estate agents, especially those who cater to a clientele from Mainland China, show that they are fully informed of the superstitious beliefs. Not only do they seek to offer to properties with lucky addresses, but they display asking prices frequently ending with a series of "8".

[17] Some also have to pay a portion to their firms, but some agents are independent. There are also a few discount (1%) real estate agents.

of 22,710 repeated sales, we observe only 128 intra-day transactions, but 20% (4480) of repeated sales occur within 240 days and could be considered speculative.

Proposition 2: Size of Price Effects. Transaction costs, modeled as a linear tax c imposed on the transaction price $\bar{P}_{sct}(H)$, limit the arbitrage opportunities for the fateful addresses in the following way:

i) The maximum premium attainable for addresses ending with the fortuitous number 8 is $\delta_8^* = c/(1-c)$.

ii) The maximum discount for addresses ending with the undesirable number 4 is $\delta_4^* = c$.

Proof. i) An informed house flipper would make a profit buying a house with a street address ending with a number "8" from a non-superstitious seller at $\bar{P}_{sct}(H)$ and selling it at $(1+\delta_8)\overline{P}_{sct}(H)$ to a superstitious buyer, where $\delta_8 > 0$ is the premium for the lucky home. Assuming a linear transaction cost of c, this house flipper will make a profit

$$(1-c)(1+\delta_8)\bar{P}_{sct}(H) - \bar{P}_{sct}(H) \geq 0 \leftrightarrow \delta_8 \geq c/(1-c)$$

Arbitrage opportunities would remain if this was a strict inequality. Consider $\delta_8 = \frac{c}{1-c} + \varepsilon$, with $\varepsilon > 0$. Then a second flipper could buy the house at $(1-c)\left(1+\frac{c}{1-c}+\varepsilon\right)\bar{P}_{sct}(H)$, resell it at the uninformed market price of $\bar{P}_{sct}(H)$, and make a profit of $\varepsilon(1-c)\bar{P}_{sct}(H)$, which may be non-trivial if $\bar{P}_{sct}(H)$ is large. Thus only when $\varepsilon = 0$, and $\delta_8^* = c/(1-c)$ will all potential arbitrage opportunities have been exercised.

ii) Conversely, an informed house flipper could make a profit buying a house with a street address with ending with a number "4" from a superstitious seller at a discounted price $(1-\delta_4)\overline{P}_{sct}(H)$ and selling it at $\overline{P}_{sct}(H)$ to a non-superstitious buyer, where $\delta_4 > 0$ is the discount for the unlucky address. This house flipper would make a profit of $(1-c)\bar{P}_{sct}(H) - (1-\delta_4)\bar{P}_{sct}(H)$ which will be non-negative if $\delta_4 \geq c$. But, as before, if there remains some positive profits, another house flipper could bid it away. As a result, $\delta_4^* = c$ represents the discount after all arbitrage opportunities have been exercised.■

The likelihood of finding such seller/buyer combinations is greater in neighbourhoods that have experienced a recent influx of Chinese immigrants. Because of the manipulation of home addresses, a thinner market for addresses ending with a "4" is likely found in Chinese neighbourhoods where a high proportion of residents have distaste for this home address, and where fewer non-Chinese residents prefer to live. Indeed, there is ample anecdotal evidence that

arbitrage opportunities are being exercised that way. Some homebuyers purchase houses with address numbers ending in "4" and then petition the cities for a change in house number. This reduces the number of inauspicious houses for sale. We do indeed observe that transactions with street addresses ending in "4" represent only 3.9% of sales in CTs with an above average proportion of ethnic Chinese versus 7.4% of sales in other CTs.[18]

In a market where arbitrage opportunities are exercised only by regular homebuyers paying a commission in the 5% to 6% range, we would expect a premium of 5.3% to 6.4% and a discount of 5% to 6%. But, as argued by Levitt and Syverson (2008), real estate agents are more likely to be "rehabbers" than other sellers given that they are more informed than regular homebuyers about client preferences and neighbourhoods dynamics. In this case, because real estate agents incur a transaction cost of only half the total commission (that of the other agent), the premium for house address ending with an "8" would be in the 2.7%- 3.2% range, not accounting for additional fixed closing costs. Conversely, we should see a discount in the 2.5%-3% for houses with street addresses ending with a "4".[19] These correspond to bounds that we would observe when all arbitrage opportunities by rational real estate agents have been exercised.

III. Data

We use high quality housing data compiled by the property assessment firm, Landcor Data Corporation. This firm works closely with the British Columbia Assessment Authority (BCAA), a public corporation responsible for property assessments used to establish property taxes. From the complete universe of transaction records from January 2000 to May 2005, we select sales transactions for single-family dwellings for 13 major cities in the Greater Vancouver area.[20] We omit records from rural areas, estates of more than 10,000 square feet, and other observations with missing values, this brings our sample down to 116,939 observations from a potential of 123,542 observations. Figure 1 displays the average nominal price for the entire

[18] Fearing the disappearance of the number "4", the suburban city of Richmond adopted the following policy in 2008: "Address changes as a result of a personal preference on the part of the property owner are discouraged for any other reason, i.e. superstition and religious beliefs, numerology, etc." (City of Richmond, 2008).

[19] Because of additional closing costs, we expect to find premiums and discounts in this range, but perhaps a little bit smaller in magnitude.

[20] These include Burnaby, Coquitlam, Delta, Langley, Maple Ridge, New Westminster, North Vancouver, Pitt Meadows, Port Coquitlam, Richmond, Surrey, Vancouver, and West Vancouver. Huang (2009) used a subset of these cities.

Greater Vancouver area and for our sample. It shows that by contrast with other North-American metropolitan areas, our data largely precede what some see as a large and continuing bubble in housing prices, which barely burst in the 2008 housing crisis. Year to year variations in the seasonality of prices suggest that month-year fixed effects will best capture the housing price inflation

The housing information includes the street address, the date of the transaction and the transaction price, as well as a host of structural house characteristics: lot size, finished floor area, finished basement area and total basement area, house age, number of bedrooms, full bathrooms, half bathrooms, single-car garages, multiple-car garages and stories, and the presence of a basement suite and a swimming pool.[21] Given that transactions prices are often close to the property assessment, which is based on these characteristics, we view them as quite comprehensive.[22] Nevertheless, we do not have information on major renovations such as new roofs or new kitchens. We argue that the price effect of such renovations are likely smaller than redeveloping the lot which is captured by the age of the house; tearing down houses of less than the maximum allowable floor area and building an entire new structure is common in the Lower Mainland.[23] We then use a procedure based on Gelbach (2012) to evaluate the size of possible omitted variable bias. We do not know the identity or ethnicity of the buyers and sellers or of the real estate agents, nor the details of the transaction (asking price, time of the market, and so on). Thus we cannot directly assess whether the price effects sought would be different depending on the education level, the religious status or income level of the buyer.

We appeal to census data to supplement the ethnicity information at the neighborhood (CT) level. The census asks many questions about immigrant status: country of origin, languages spoken, single and multiple ethnicities, and visible minority status. With the 2001 Census data, we use the Chinese category of the visible minority status question to compute the proportion of

[21] We exclude observations below $100,000 as these are likely to include "other considerations" as part of the transaction. Descriptive statistics on the housing and CT data are available in the online Appendix.
[22] City-by laws in the Lower Mainland cities generally allow a maximum floor area equal to 60% of the lot size. This implies a tight relationship between lot size, floor area, finished basement area and total basement area, and the number of bedrooms and stories. To avoid collinearity problems, we omit the more discrete "number of bedrooms" variable. Our explanatory variables are not thought to be orthogonal to each other, but rather make up an index of house characteristics.
[23] Many houses built in the 1950s and 1960s are 1.5 stories high where the half second story has highly slanted ceilings with reduced useable floor space. These properties are commonly redeveloped. A parody of the dire state of housing in the Lower Mainland is found at: http://www.crackshackormansion.com/.

ethnic Chinese residents in a CT.[24] The census provides information on the average characteristics of the CT based on interviews of one in five residents in the CT.[25] While ethnic Chinese residents made up about 18% of the total population of Greater Vancouver on average in 2001, there are 22 census tracts in Vancouver and its suburb of Richmond where the percentage of ethnic Chinese exceeded 50% of the population. Figure 2 illustrates the percentage of single ethnic Chinese origin by CT in 2001 and shows great diversity across the metropolitan area with concentrations of Chinese residents in the core city as well as in some suburbs. The sales transactions data are merged with Census data for 363 CTs using postal codes.[26]

Figure 3 displays the proportion of house addresses ending with digits 0 to 9, separating CTs with a proportion of ethnic Chinese residents above and below the overall average. The figure focuses on Greater Vancouver, excluding the suburban city of Richmond, (10074 observations) where a disproportionate number of addresses (80%) end in "0" or "1" due to historical lot division and renumbering policies.[27] The numbers are consistent with the Chinese cultural cues. The largest and statistically significant differences in the proportion of home transactions, across more and less Chinese neighborhoods, are found for addresses ending with either "4" (t-stat: 15.8) or "8" (t-stat:−11.9), which are found less and more frequently in more Chinese CTs, respectively.[28] The means of the transaction prices and house characteristics for the unlucky, lucky, and other addresses for CTs with a proportion of ethnic Chinese residents below and above the city's average are reported in Appendix Table A1. Given our large sample sizes, most characteristics are found to be statistically different across the various splits. In particular, houses with addresses ending with a "4" are older, and those ending with an "8" are more recent

[24] This question asks whether the respondent is "Chinese" among other categories of visible minorities. This more precise measure of Chinese ethnicity is not available prior to 1996. When we combine Census data going back to 1986, we use the question about the person's ancestor: "To which ethnic or cultural group(s) did this person's ancestors belong?" In either case, the share Chinese counts only those who reported Chinese as a single ethnic origin. For the years when available, the two measures are highly correlated.

[25] Census tract populations range from 280 to 11,915 residents in our area of interest.

[26] Each street address in the sales transactions data is matched to a postal code, and this postal code is matched to a CT through the postal code conversion files provided by the Canadian Census Analyzer at the University of Toronto.

[27] This usual distribution has arisen from the urbanization of the municipality through the densification of older larger lots. The transformation of 3 digits addresses into 4 digit addresses for many subdivisions was made by adding a "0"(even) or a "1"(odd) to the previous 3-digits address, occasionally intercalating new houses with addresses with other digits.

[28] The fact that transactions of homes with address ending with a "5' are found at a statistically significant higher frequency (t-stat: -6.4) in more Chinese CTs may be due to a greater conversion of addresses ending with "4" in these neighborhoods.

(and have more of the newer features) than those with other addresses.[29] This emphasizes the need to use a hedonic house price model in a difference-in-difference framework.

These differences reflect the fact that superstitious homeowners will likely invest differentially in auspicious and inauspicious addresses: The former are thus more likely to be redeveloped than the latter. Thus the price effects of the fateful numbers could include larger capitalized superstition effects in neighborhoods which have long included a large share of ethnic Chinese residents than in neighborhoods that welcomed Chinese immigrants more recently. We use data on the share of residents of Chinese ancestry from the 1986, 1991, 1996, and 2001 Censuses to identify CTs who crossed in the 18% threshold in the different years and assess the magnitude of the potential capitalization effects. This also reflects some diffusion of Chinese number preferences outside Chinese neighborhoods which we investigate below.

IV. Empirical Analysis

Our more complete empirical specification subsumes the classic hedonic price regression on the logarithm of transaction price of observation *i* on street *s* in CT *c* at time *t*,

$$\ln(P_{isct}) = \beta_0 + \beta_4 L4_{isct} + \beta_8 L8_{isct} + \boldsymbol{H}'_{isct}\boldsymbol{\alpha}_H + \boldsymbol{D}'_t\boldsymbol{\alpha}_t + \boldsymbol{D}'_s\boldsymbol{\alpha}_s + \boldsymbol{D}'_c\boldsymbol{\alpha}_c + \delta_e E_c + \delta_{4e} E_c * L4_{isct} + \delta_{8e} E_c * L8_{isct} + \varepsilon_{isct}, \quad (1)$$

where $L4_{isct}$ and $L8_{isct}$ denote a house address number ending with a four or an eight, respectively, $\boldsymbol{H}'_{isct}$ is a vector of house characteristics, and $\boldsymbol{D}'_t$, $\boldsymbol{D}'_s$ and $\boldsymbol{D}'_c$ are vectors of month-year, street, and CT dummies to control for time and location effects. The *Chineseness* of the census tract is identified with the variable E_c. The parameters β_4 and β_8 thus capture the base effect (in the non-Chinese neighborhoods) on log transaction price of a house street address ending with the fateful numbers, and the parameters δ_4 and δ_8 capture the added effect of the fateful numbers in Chinese neighborhoods. Thus the price of our comparison house is one of a house with a neutral address in a non-Chinese neighborhood, after removing the average street (6100 streets) and time (52 year-month) price effects.

We begin in Table 1 by establishing the distinctiveness of the numbers "4" and "8" by regressing the last digit of the house address on log transaction price, controlling for house characteristics, including 52 month-year dummies, and clustering the standard errors at the CT

[29] Even in our below average CTs, there is a non-negligible Chinese presence up to 18%!

level. Columns (1) and (2), respectively omitting the numbers "4" and "8", show that the effect of the other digits are all statistically different from the omitted category (F-statistic= 9.89), positive in the first case and negative in the second case. We note that none of the other digits have this property.[30] Column (3) shows that without location controls, the negative price effect of a house number ending in four $\hat{\beta}_4$ is about 3.1%, and the positive price effect of a house number ending in eight $\hat{\beta}_8$ is about 3.4% in comparison to house numbers ending in any other digit. The parameter estimates of the other housing characteristics are reported in Appendix Table A2; they show for example that the effect of the lucky and unlucky addresses is comparable in magnitude to the effect of the house possessing a basement suite, an amenity which delivers tangible housing services.[31] In Column (4), we add our extensive set of locational controls, the street and CT fixed effects thought to capture location attributes, such as views or commercial streets, and neighborhoods amenities, such as school quality, proximity to rapid transit, or ethnic mix.[32] In accordance to the "location, location, location" precept of real estate, the introduction of these controls increases the adjusted R^2 from 0.44 to 0.76. Column (4) shows that the effects of fateful numbers are almost entirely absorbed by our location controls. As anticipated, there are some locations where the fateful numbers have an impact and others where they do not.

In Table 2, we unbundle the effects of location controls by singling out the effect of Chinese ethnicity, appealing to various specifications. In our preferred specification in column (1), Chinese ethnicity, $\mathbb{I}[E_c > 0.18]$, is measured using a dummy indicating an above average percentage (greater than 18%) of Chinese residents in the CT in the 2001 Census. The values of $\hat{\delta}_4$ and $\hat{\delta}_8$ indicate a 2.1% discount and a 2.5% premium arising from the fateful numbers in CTs with above average Chinese ethnicity. In Column (2), we exclude within-sample repeated sales and observe an increase in the magnitude of the estimated premium and discount . This is not statistically significant, but suggests that some repeated sales may be used as arbitrage opportunities.[33] In either case, the size of the effects is consistent with the predictions of Proposition 2, which predicts a slightly larger premium associate with the last "8" than the

[30] For each other last digit, the effect of at least one other last digit is not statistically distinguishable. For example, the effects of "0" and "5", "2" and "7" and all of "1", "3", "6" and "9" are not statistically different.
[31] While some basement suites are used as nanny or guest suites, some are actually rented out.
[32] For street fixed effects, we actually use the STATA command "areg" which absorbs the effects of 6,100 streets.
[33] More precisely, column (2) excludes the second, third, and higher transactions on the same property roll-number. When we also exclude the first transaction on these properties, the values of $\hat{\delta}_4$ and $\hat{\delta}_8$ are -0.025 (0.007) and 0.024 (0.006), respectively.

discount associated with the last "4", as well as predicting that the size of the effects should be roughly equal to half of the real estate agents' commissions. Moreover, in both Columns (2) and (3), the effects of the fateful numbers in non-Chinese neighborhoods, $\hat{\beta}_4$ and $\hat{\beta}_8$, go to zero, showing the effects of the fateful numbers originate from CTs with substantial proportions of residents potentially holding Chinese superstitious beliefs.

In Column (4), we present a test of Proposition 1. We display the values of the interaction parameters $\hat{\delta}_4$ and $\hat{\delta}_8$ for several intervals of the proportion of ethnic Chinese residents. The omitted category is the proportion of Chinese below 10% for which, in theory, there should be no price effects. The other intervals correspond roughly to the ones displayed in Figure 1. The point estimates $\hat{\delta}_4$ and $\hat{\delta}_8$ are very close to zero for the interval $[0.10 < E_c \leq 0.18]$, confirming that our choice of control group in columns (1) and (2) is appropriate. As predicted by Proposition 1, as the proportion of ethnic Chinese residents grows in the upper intervals, the point estimates for the discount/premium remain relatively stable between 2% and 3%.

In Table 3, we begin to address the impact of capitalized superstition effects on our estimates. Using data from older censuses, we construct indicator variables for CTs crossing the 18% threshold in 2001, 1996 1991 or 1986. For example, $\mathbb{I}[E_c^{1991} > 0.18]$ will be equal to 1 if a CT had a proportion of residents of Chinese ancestry greater than 18% in the 1991 Census but not in the 1986 Census. In column (1), the estimates of the discount/premium across different vintages of Chinese penetration are found to be in the same 2% and 3% range for most interactions. One exception is for unlucky addresses in neighborhoods that became more Chinese in 1991; there the discount has been driven to zero.[34] Consistent with the idea that repeated sales represent the exercise of arbitrage opportunities, when we remove these sales in column (2), the point estimate returns to the expected range. Another exception is for neighborhoods that were already substantially Chinese in 1986 and where the point estimates indicate that properties with lucky addresses gather a 1% supplemental premium in addition to the original premium. Although this higher premium of 0.038 (0.007) is not statistically different from our preferred estimates of 0.025 (0.005), one could suspect that it might capture additional property investment. We address this concern related to potential omitted variable bias more directly below.

[34] Proposition 2 does not guarantee that arbitrage opportunities will not drive the discount/premium to zero, but simply says they will no longer be profitable.

In columns (3) and (4) of Table 3, we pursue our investigation of the diffusion of Chinese number preferences outside Chinese neighborhoods. We hypothesize that the cultural number preferences initially become well-known outside of the Chinese community among agents involved in speculative house buying and selling. Given a 10 to 15 years median homeowner survival rate (Quigley, 2002; Emrath, 2009), our five-year time horizon is relatively short in terms of housing tenure, thus it is not unreasonable to assume that a sizeable portion of the repeat sales that we observe involve speculative behavior.[35] We capture this potential phenomenon by introducing dummies for repeat sales and interact this with last "4" and last "8" indicators in column (3) of Table 3. The estimates indicate an average potential capital gain of 11% over the period we study, reduced by 3.5% for home addresses ending in "4", but bettered by 2% for home addresses ending in "8". This effect is found across Chinese and non-Chinese neighborhoods, indicating that the Chinese cultural cues are exploited in repeated sales across the Greater Vancouver area. In column (4) of Table 3, we re-introduce the last digit and Chinese ethnicity interactions. The price effects are evident in interactions with repeated sales or with Chinese neighborhoods, but not in both. The triple interaction with repeat sales and Chinese neighborhoods actually undoes one of the double interactions. This is consistent with the exercise of arbitrage opportunities limited by transaction costs. In Table 2, we had found no general prices effects of the superstitious Chinese numbers outside of Chinese neighborhoods, but in Table 3, they re-emerge in repeated sales arguably as a manifestation of speculative behavior. Considering Liu and Wong (2012)'s conjecture about differential price effects arising from own superstitious beliefs and the superstitious beliefs of others, it is interesting that we find similarly-sized effects arising from own beliefs (in Chinese neighborhoods) and from the beliefs of others (in repeated sales outside of Chinese neighborhoods). This is interpreted as support for Proposition 2 in which transaction costs limit effect size.

In Table 4, we perform a variety of tests to determine the potential magnitude of omitted variables bias coming from house characteristics that we do observed. Columns (2) and (3) of Table 4 report estimates from regressing the row-specified house characteristic on the interactions between the fateful last digits and CTs with above average Chinese ethnicity. Each row corresponds to a separate regression of specification (1). They convey the point made earlier

[35] The numbers of homeownership mobility were computed using U.S. data from the Panel Study of Income Dynamics (PSID) in Quigley (2002) and from the American Community Survey (ACS) in Emrath (2009).

that unlucky houses in Chinese neighborhoods are on average older (less likely to have been torn down and rebuilt) than neutral houses in non-Chinese neighborhoods. Conversely, lucky houses are newer and have more of the characteristics such as multiple-car garages and full-bathrooms associated with newer homes. The impact of house characteristics on our estimates of the discount/premium associated with fateful numbers is presented in columns (4) and (5). The first row shows that point estimates $\hat{\delta}_4$ and $\hat{\delta}_8$ from a regression that omits all house characteristics. They are of slightly higher magnitude −0.027 (0.008) and 0.041(0.007) than estimates from our preferred specification, −0.022 (0.005) and 0.025 (0.005), but are not statistically different. Interestingly, the 1% supplemental premium attributed to additional investment in the lucky house (Table 3, column (2)) is similar to the one from column (4). Each subsequent row of Table 4 performs the exercise of removing one house characteristic at a time and reports the estimated coefficients when omitting that variable. As shown by Gelbach (2012), the omitted variable bias can be computed as: $bias_{-x} = \hat{\delta}_{full} - \hat{\delta}_{full-x}$, where *x* is the omitted variable. Not surprisingly removing "finished floor area", the most statistically significant house characteristics with respect to transaction price, leads to the largest omitted variable biases of 0.003 for $\hat{\delta}_4$ and −0.002 for $\hat{\delta}_8$, which are nonetheless very small and not statistically significant. Given that our estimates are very stable across specifications, and to the extent that potential omitted variables biases from unobserved house characteristics are likely in the same range (within standard errors), we conclude that our estimates $\hat{\delta}_4$ and $\hat{\delta}_8$ are robust to superstitious capitalization effects (Altonji et al., 2005).[36]

We conducted additional tests of alternative placement of the fateful digits and found these effects to be dominated by the last digit effects. We report in Table 5 the results of tests for two other salient combinations of digits. The effects of house address numbers ending with the two-digit combination "88", which resembles "double joy" or "happiness", and is sought after by real estate agents who cater to buyers from mainland China, and the two-digit combination "13", thought to be unlucky in the Western tradition. First, the results in columns (1) and (3) of Table 5 (corresponding to Column (5) of Table 1), show that including these additional fateful combinations yield a statistically significant positive effect of 6.1% for the numbers ending in "88", and a negative effect of 2.8% for the numbers ending in "13". Second, these additions do

[36] It is worth noting the differential capitalization based on superstitious beliefs provides additional evidence of real economic activity based on false beliefs.

not change the effects of the last "4" or the last "8" found Column (3) of Table 1 and Column (1) of Table 2, the latter remaining at 2.1-2.2% for the discount and 2.4-2.5% for the premium. Third, we were unable to trace these added effects to the Chinese ethnicity, meaning that the corresponding parameters $\hat{\delta}_{88}$ and $\hat{\delta}_{13}$ were not statistically significant from zero. In the first case, we speculate that for Chinese buyers the desirability of the number "88" may outweigh the desirability of living in a neighborhood with an above average proportion of ethnic Chinese residents. In the second case, the fact that the unluckiness of the numbers ending in "13" did not get any traction in Chinese neighborhoods is consistent with the view that this number is not considered unlucky in the Chinese tradition.

Finally, although we found reliable price effects of the superstitious Chinese numbers, we are unsure about the psychological foundation of the effects. Some buyers of fateful house numbers may believe in the "magic" or fear the "doom" of the numbers. In the license plate market, auspicious and inauspicious outcomes might be measured by the frequency of car crashes.[37] In terms of labor market outcomes, Wong and Yung (2005) have investigated whether individuals born on Dragon years have higher labor market earnings using Hong Kong census data and found inconclusive evidence. In medicine, Phillips *et al.* (2001) found that for Chinese Americans and Japanese Americans, the peak of mortality among chronic cardiac patients occurs on the 4th of the month, a striking pattern not found among White Americans. But one could argue that this pattern is the result of harvesting, rather enhanced mortality. In the housing market, it is not clear that there are such fateful outcomes; fires or burglaries would be not frequent enough to serve as such a measure.

Nevertheless we can provide some limited tests of potential wealth effects by investigating differential effects across the transaction sales distribution. We evaluate the effects of the last "4" and last "8" across the distribution of transaction sales by estimating unconditional quantile regressions (UQR) (Firpo, Fortin, and Lemieux, 2009).[38] The UQR regressions include the same set of covariates as previous regressions, importantly the street and CT fixed effects. In

[37] The China Global Times reported on October 20, 2010, that the Beijing Traffic Management Bureau had stopped issuing license plates that contain the number four. It is not known whether this was the result of simple superstitions or of an impact analysis of the license plate numbers on car accidents, but the later might have been feasible.

[38] With unconditional quantile regressions, we look across the distribution of transaction sales, rather than across the distribution of residuals from the hedonic function of transaction sales, which would correspond to the conditional quantile regression estimates.

Table 6, we report estimates similar to those reported in column1 of Table 2 for the mean, here for the very bottom (5^{th} percentile), the median, and for the top (85^{th} percentile) of the transaction sales distribution. Consider the death-ridden number "4". Moving across columns (2) to (3) on the second row of Table 6, we find an inverted U-shaped effect with a somewhat more negative point estimate at the lower end, although none of the differences in the penalties across the distribution are statistically significant. Is there a more important "fear of doom" effect among buyers of lower priced homes? As indicated above, we do not know the education or income level of the buyers, but if they were correlated with the home price, we could argue that lower educated buyers are more likely superstitious in the "fear" domain (loss aversion) than in the "luck" domain.[39]

Consider now the "wealth"-laden "8". Moving across columns (1) to (3) on the third row of Table 6, we find a U-shaped effect with a point estimate more than twice as large at the top end than at the lower end. Figure 4 further illustrates these effects at each fifth percentile of the transaction sales distribution, contrasting them to the OLS results of Table 2.[40] The UQR estimates of the last "8" in substantially Chinese neighbourhoods are not statistically different from the OLS results in the middle of the distribution (from the 45^{th} to the 75^{th} percentiles) and in the tails of distribution where the confidence bands widen. In the upper tail, we start to find larger effects that are statistically different from the OLS results at the 75^{th} percentile. At the 85^{th} percentile, the point estimate is 0.087 (0.014), more than twice as large as the average premium.[41] We argue that these larger effects at the top of the distribution of transaction prices are consistent with wealth effects or an "ability to pay". We reconcile the larger size of these effects with the predictions of Proposition 2, where arbitrage opportunities are set to drive down the premium for the lucky addresses, by arguing that the thinness of the top tier of the market makes pursuing arbitrage opportunities considerably more risky. Furthermore, the mortgage bridging cost associated with holding higher priced properties (in the CAD$5,000,000 plus range at the 85^{th} percentile) may pose additional cash flow issues for speculators.

[39] We have conducted some tests using the average education level or average income level in the census tract, but the CT average education or income levels turned out to be too remote to give any significant results.
[40] We do not illustrate similar results for last "4" because of limited statistical significance, reported in Table 4. This is due to the reduced number of transaction sales of homes with addresses ending in "4" as shown in Figure 3.
[41] In the extreme upper tail, however the smaller number of observations entails larger standard errors, the difference in no longer statistically different.

IV. Conclusion

This paper deals with the economics of a situation where the agents display some emotional or cognitive weaknesses, thus moves beyond the case of pure economic rationality in a setting where transactions are sizeable. We show that in the presence of non-negligible transaction costs, superstitious beliefs associated with fateful Chinese numbers can sustain statistically and quantitatively significant effects on house prices in a North American residential market with a substantial ethnic Chinese presence. Given a mean nominal house price of about CAD$400,000 over the sample period, we have found that in neighborhoods where the percentage of ethnic Chinese residents exceeds the average of 18%, houses with address numbers ending with the "death"-ridden "4" are sold at a $8,000 discount and those ending with the "wealth"-laden "8" are sold with a $10,000 premium in comparison to houses with address numbers ending in any other digit. Price effects of a similar size are found outside of these Chinese neighborhoods, but only for repeated sales consistent speculative behavior

To what extent could these results be reproduced in other North American housing markets? As noted by Kolko (2012), there are many cities in the U.S. with a sizeable presence of Asian American where "lucky" number effects have been observed in the last digits of the asking prices. Thus, it would not be surprising to find similar discounts and premiums in these locales. Our findings have raised the interest of the popular press in Canada and in the United States, possibly making it more likely that non-superstitious buyers and sellers will act as informed agents in markets with a significant Chinese presence.[42] We have shown that these effects persist long after the arrival of the new immigrants. Whether they will extend to the second generation immigrants or whether the latter will act as speculators remains an open question.

Finally, our results also speak to the impact of immigrants' cultural beliefs on their integration into the host country. Our analysis goes beyond the anecdotal evidence documenting the relatively benign elimination of the number "4" in the elevators of many new residential towers in Vancouver and investigates the price effects of culturally-driven beliefs. A longtime resident of Greater Vancouver living at an address ending in an "8" is likely to be quite welcoming. But, for many living at addresses ending with a "4", it is unwelcome news that because of the recent influx of Chinese immigrants their homes are now likely to be sold for 2%

[42] See among others, The Wall Street Journal (Nov 9, 2012), the Globe and Mail (Nov 26, 2010), and the Vancouver Sun (Nov 25, 2010).

less than homes with neutral addresses. For them, the price of welcoming other cultures and their superstitious beliefs is steep. In several North-American cities, city-councils have in fact enacted by-laws to allow homeowners to change their unlucky home address numbers for a fee. But following the impeding disappearance of addresses ending with “4”, some city-councils have reversed course. The case of superstitious addresses poses some fundamental questions about which social norms should prevail, those based on the irrational beliefs (or cultural sensibilities) of newcomers or those based on the traditional values of the host population.

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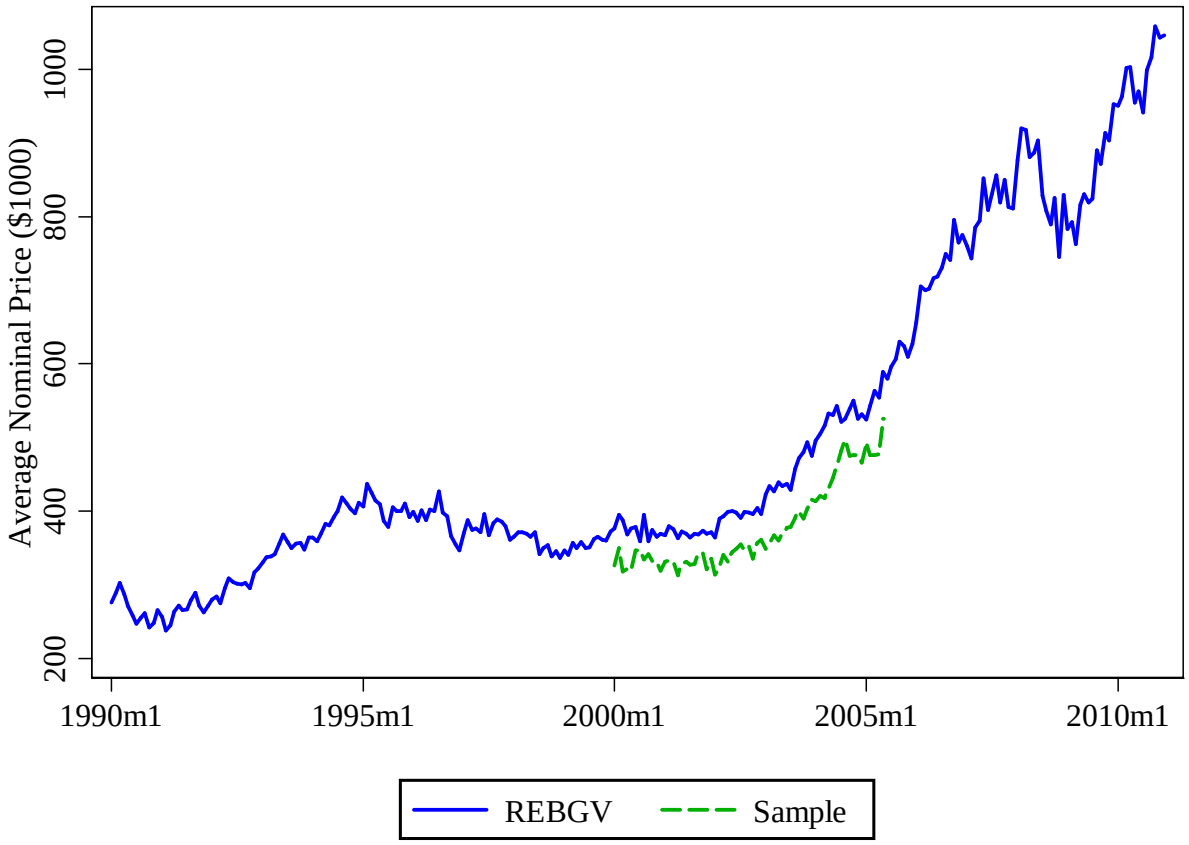
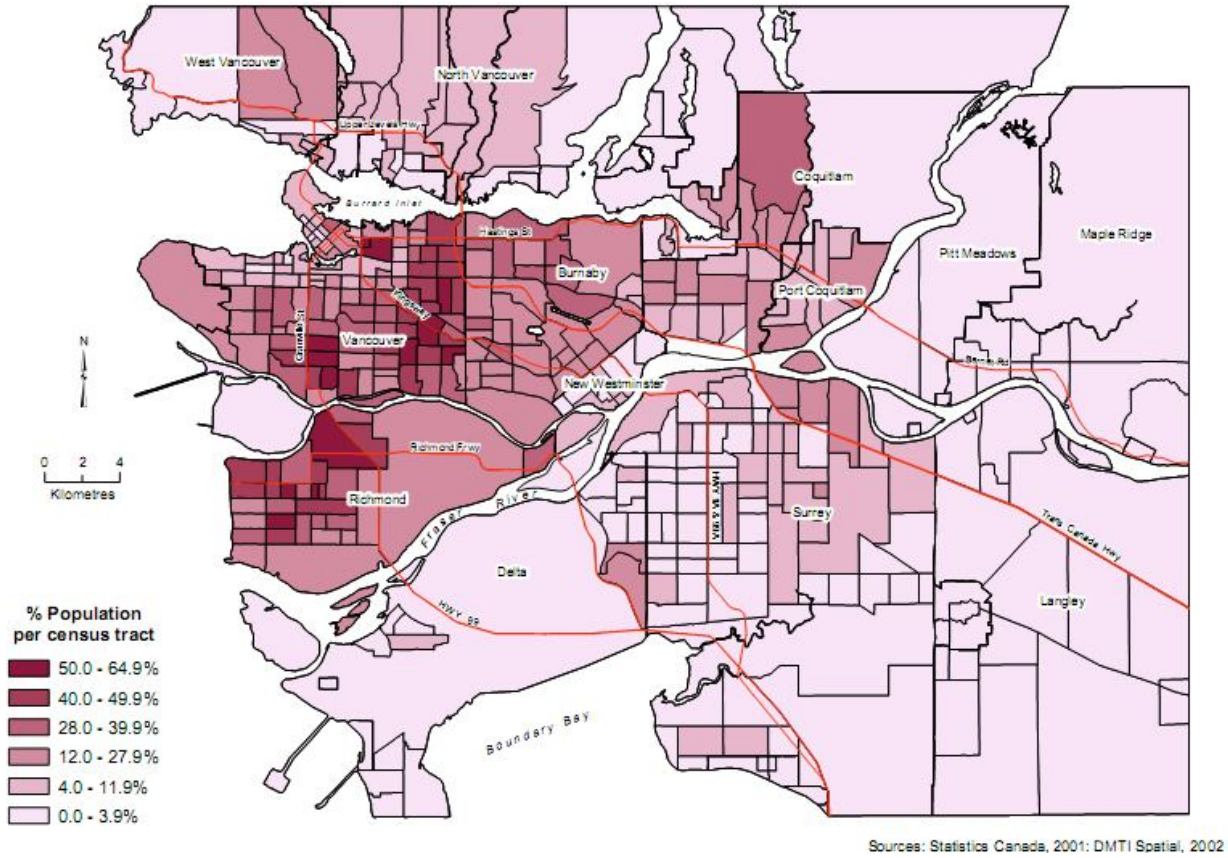
Figure 1 – Average Nominal Price of Detached Homes in the Greater Vancouver Area



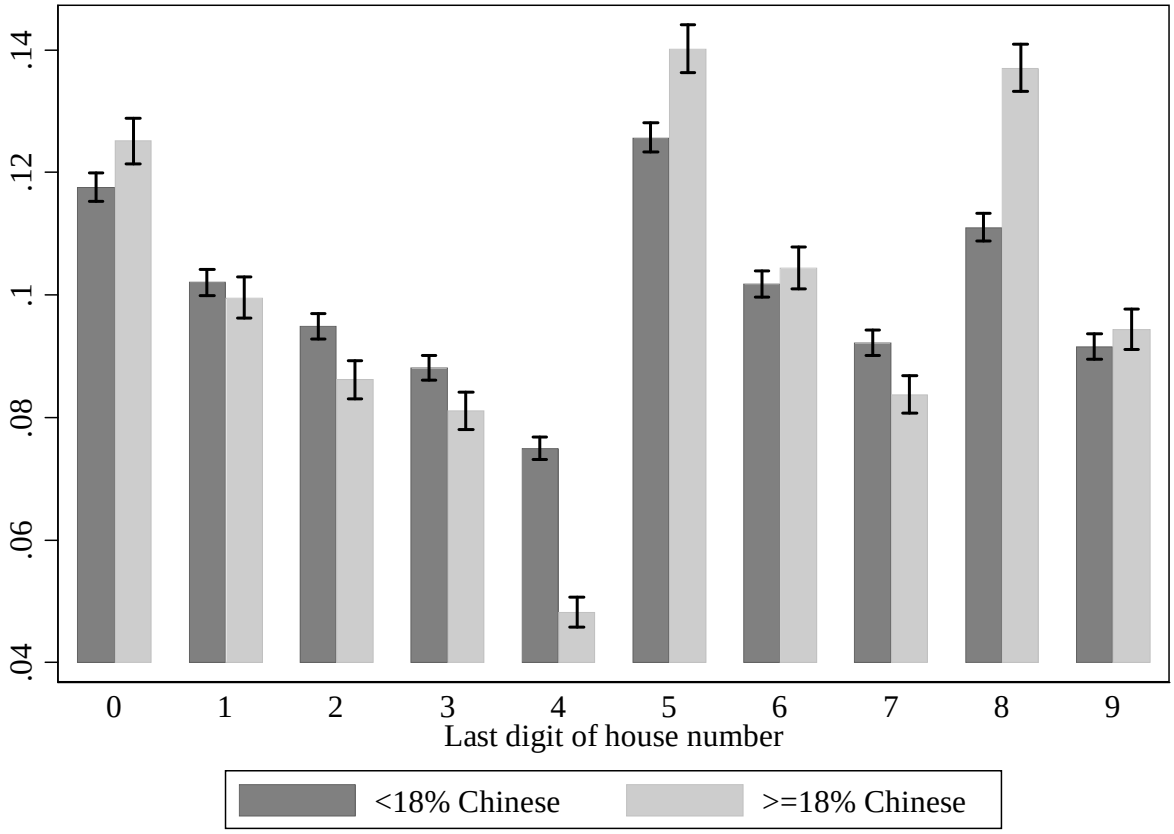
Source: REBGV is the average price data from the Real Estate Board of Greater Vancouver.

Figure 2 – Percentage of Ethnic Chinese (Single Ethnic Origin) by Census Tract (2001)



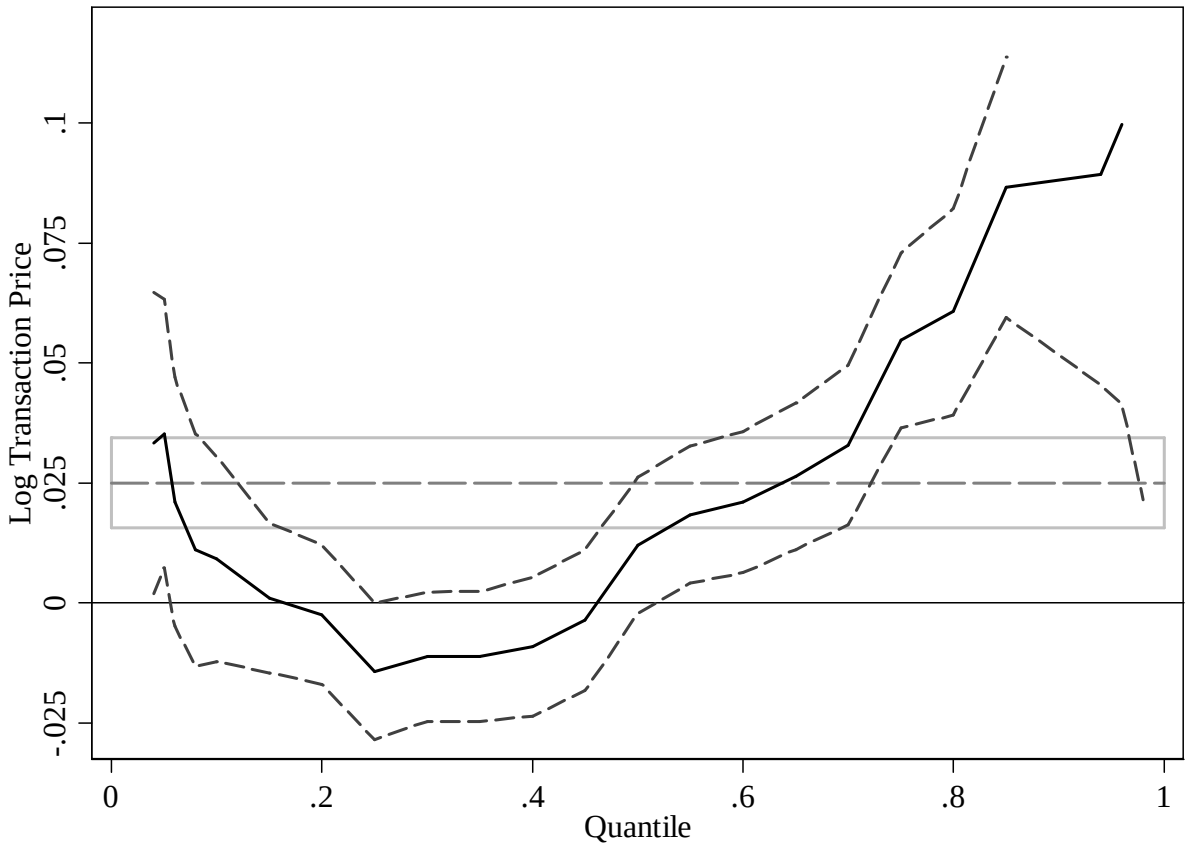
Sources: Statistics Canada, 2001; DMTI Spatial, 2002

Figure 3 – Proportion of House Addresses with Indicated Last Digits
by the Proportion of Ethnic Chinese Residents in the Census Tract



Note: For reasons explained in the text, this figure excludes data from the suburban city of Richmond. The whiskers correspond to the 95% confidence intervals on the proportions.

Figure 4. Unconditional Quantile Partial Effects of Last Digit "8" Interacted with Above Average Chinese Concentration by Percentile of Transaction Sale Price



Note: The solid black line traces the UQR point estimates; the dashed dark lines are its corresponding 95% bootstrapped confidence intervals. The OLS estimates and its 95% confidence intervals are shown in lighter grey solid and dash lines.

Table 1. Estimates of the Last Digit of the House Address Number on Log Transaction Price

	(1)	(2)	(3)	(4)
Last digit = 0	0.045***	–0.020**		
	(0.008)	(0.009)		
Last digit = 1	0.027***	–0.037***		
	(0.009)	(0.009)		
Last digit = 2	0.019***	–0.046***		
	(0.007)	(0.007)		
Last digit = 3	0.026***	–0.038***		
	(0.007)	(0.007)		
Last digit = 4		–0.065***	–0.031***	–0.002
		(0.009)	(0.006)	(0.003)
Last digit = 5	0.043***	–0.022***		
	(0.008)	(0.009)		
Last digit = 6	0.024***	–0.040***		
	(0.007)	(0.007)		
Last digit = 7	0.017***	–0.048***		
	(0.006)	(0.008)		
Last digit = 8	0.065***		0.034***	0.008***
	(0.009)		(0.007)	(0.003)
Last digit = 9	0.030***	–0.035***		
	(0.009)	(0.008)		
Census Tract Dummies	No	No	No	Yes
Street Fixed Effects	No	No	No	Yes
Adj. R-squared	0.444	0.444	0.443	0.756

Note: The dependent variable is the natural logarithm of house transaction price. Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. All regressions include year-month dummies and the following house characteristics: lot size, finished floor area, finished basement area and total basement area (all in 1000 sq ft), house age (10 years), house age squared (100 years) , number of full bathrooms, of half bathrooms, of single car garages, of multi-car garages, of stories, dummies for basement suite and pool. There are 116,939 observations.

Table 2. Estimates of the Interactions of Chinese Ethnicity with a House Address Number Ending with a "4" or a "8" on Log Transaction Price

Explanatory Variables	(1)	(2)	Explanatory Variables	(3)
Sample	Full	No Repeated Sales		Full
Last digit = 4[a]	0.002	0.006	Last digit = 4[a]	0.003
	(0.003)	(0.003)		(0.003)
Last digit = 8[b]	–0.001	–0.002	Last digit = 8[b]	–0.001
	(0.003)	(0.004)		(0.003)
Interactions:			Interactions:	
Last digit = 4 *			Last digit = 4 *	
Chinese >0.18	–0.022***	–0.028***	0.1< Chinese≤0.18	0.001
	(0.006)	(0.006)		(0.008)
			0.18< Chinese≤0.28	–0.018
				(0.011)
			0.28< Chinese ≤0.4	–0.025***
				(0.010)
			Chinese >0.4	–0.025***
				(0.008)
Last digit = 8 *			Last digit = 8 *	
Chinese >0.18	0.025***	0.031***	0.1< Chinese≤0.18	–0.001
	(0.005)	(0.006)		(0.010)
			0.18< Chinese≤0.28	0.017**
				(0.008)
			0.28< Chinese ≤0.4	0.026***
				(0.007)
			Chinese >0.4	0.028***
				(0.008)
Census Tract Dummies	Yes	Yes		Yes
Street Fixed Effects	Yes	Yes		Yes
Adj. R-squared	0.756	0.770		0.757
No. of observations	116,939	94,769		116,939

Note: The dependent variable is the natural logarithm of house transaction price. Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. . The percentage of ethnic Chinese residents ("Chinese") is from the Census 2001. Dummies for being in a CT with the indicated percentage of Chinese residents are included in the regression. All regressions include year-month dummies and the same house characteristics as Table 1. The no repeated sale sample excludes the second and higher transaction on the same property.

[a] There are 7,262 (6,035) sales of houses ending with "4" in the full (non-repeat) sample.

[b] There are 13,093 (10,466) sales of houses ending with "8"in the full (non-repeat) sample.

Table 3. Effects of the Historical Progression of Chineseness and of Speculative Demand on Estimates of a House Address Number Ending with a "4" or a "8" on Log Transaction Price

Explanatory Variables	(1)	(2)	Explanatory Variables	(3)	(4)
Sample	Full	No Repeated Sales	Sample	Full	Full
Last digit = 4	0.002	0.002	Last digit = 4	0.006*	0.012***
	(0.003)	(0.003)		(0.003)	(0.003)
Last digit = 8	–0.002	–0.002	Last digit = 8	0.004	–0.007
	(0.003)	(0.003)		(0.003)	(0.004)
Interactions:			Interactions:		
Last digit = 4 *			Last digit = 4 *		–0.029***
Chinese>0.18	–0.026	–0.026	Chinese >0.18		(0.007)
in 2001[a]	(0.021)	(0.019)	Last digit = 8 *		0.031***
Chinese>0.18	–0.020**	–0.028**	Chinese >0.18		(0.007)
in 1996[a]	(0.010)	(0.012)	Repeat Sale	0.108***	0.115***
Chinese>0.18	–0.005	–0.017		(0.010)	(0.016)
in 1991[a]	(0.014)	(0.013)	Repeat Sale	–0.035***	–0.045***
Chinese>0.18	–0.023***	–0.026***	* Last digit = 4	(0.008)	(0.010)
in 1986	(0.007)	(0.008)	Repeat Sale	0.020***	0.028***
Last digit = 8 *			* Last digit = 8	(0.007)	(0.010)
Chinese>0.18	0.013	0.014	Repeat Sale		–0.044
in 2001[a]	(0.012)	(0.013)	* Chinese >0.18		(0.04)
Chinese>0.18	0.023***	0.029***	Repeat		
in 1996[a]	(0.008)	(0.009)	* Chinese >0.18		0.033*
Chinese>0.18	0.022***	0.035***	* Last digit = 4		(0.019)
in 1991[a]	(0.007)	(0.009)	Repeat		
Chinese>0.18	0.038***	0.043***	* Chinese >0.18		–0.025
in 1986	(0.007)	(0.008)	* Last digit = 8		(0.016)
Census Tract Dummies	Yes	Yes		Yes	Yes
Street Fixed Effects	Yes	Yes		Yes	Yes
Adj. R-squared	0.757	0.771		0.765	0.765
No. of observations	116,939	94,769		116,939	116,939

Note: The dependent variable is the natural logarithm of house transaction price. Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. Dummies for being in a CT with the indicated percentage of Chinese residents are included in the regression. In columns (3)-(4), the percentage of Chinese residents is from the Census 2001. All regressions include year-month dummies and the same house characteristics as Table 1. The no repeated sale sample excludes the second and higher transaction on the same property.

[a] Dummies indicate a CT that crossed the threshold in the indicated census, and that was thus below the threshold in preceding censuses.

Table 4. Estimates of the Interactions of Chinese Ethnicity with a House Address Number Ending with a "4" or a "8" on Indicated Variables

(1)	(2)	(3)	(4)	(5)
Dependent Variable	House Characteristic in column (1)		Log Transaction Price	
Specification	As in Table 2, column (1)		Omitting Variable in column (1)	
	Last digit = 4 * Chinese >0.18	Last digit = 8 * Chinese >0.18	Last digit = 4 * Chinese >0.18	Last digit = 8 * Chinese >0.18
All housing characteristics	—	—	–0.027***	0.041***
			(0.008)	(0.007)
Finished floor area (1000 sq ft)	0.007	0.105***	–0.019***	0.023***
	(0.030)	(0.028)	(0.006)	(0.006)
Lot size (1000 sq ft)	0.001	0.019	–0.022***	0.025***
	(0.012)	(0.012)	(0.006)	(0.005)
Number of full bathrooms	–0.075*	0.188***	–0.023***	0.025***
	(0.040)	(0.041)	(0.006)	(0.005)
Number of half bathrooms	–0.012	0.019	–0.023***	0.025***
	(0.020)	(0.014)	(0.006)	(0.005)
Number of multi car garages	–0.029	0.068***	–0.022***	0.025***
	(0.018)	(0.012)	(0.006)	(0.005)
Number of single car garages	0.0196	–0.043***	–0.022***	0.025***
	(0.0153)	(0.010)	(0.006)	(0.005)
Number of stories	–0.008	0.055***	–0.022***	0.025***
	(0.014)	(0.011)	(0.006)	(0.005)
House age (10 years) and	0.301***	–0.469***	–0.027***	0.027***
House age squared (100 yrs)	(0.094)	(0.079)	(0.006)	(0.005)
Basement suite (dummy)	0.018	–0.010	–0.022***	0.025***
	(0.016)	(0.010)	(0.006)	(0.005)
Basement area (sq ft)	0.027	–0.015	–0.022***	0.024***
	(0.018)	(0.013)	(0.006)	(0.005)
Finished basement area (sq ft)	0.013	0.023*	–0.022***	0.023***
	(0.015)	(0.013)	(0.006)	(0.005)
Swimming pool (dummy)	–0.006	–0.005	–0.023***	0.025***
	(0.004)	(0.004)	(0.006)	(0.005)
Census Tract Dummies	Yes	Yes	Yes	Yes
Street Fixed Effects	Yes	Yes	Yes	Yes

Note: The entries in each row the table come from two different regressions: in columns (2) and (3), specification (1) is estimated on the variables of column (1) and, in columns (3) and (4), it is estimated on log transaction price omitting the variable from column (1). Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. All regressions include year-month dummies.

Table 5. Estimates of Other Digit Combinations in House Address Number on Log Transaction Price

	(1)	(2)	(3)	(4)
Last digit = 4	–0.031***	0.001	–0.031***	0.003
	(0.006)	(0.003)	(0.006)	(0.003)
Last digit = 8	0.027***	–0.002	0.034***	–0.001
	(0.006)	(0.003)	(0.007)	(0.003)
Last two digits=88	0.061***	0.004		
	(0.013)	(0.010)		
Last two digits=13			–0.027	–0.001
			(0.017)	(0.009)
Last digit = 4 *		–0.022***		–0.022***
Chinese >0.18		(0.006)		(0.006)
Last digit = 8 *		0.023***		0.025***
Chinese >0.18		(0.005)		(0.005)
Last two digits=88[a] *		0.011		
Chinese >0.18		(0.015)		
Last two digits=13[b] *				0.025
Chinese >0.18				(0.020)
Census Tract Dummies	No	Yes	No	Yes
Street Fixed Effects	No	Yes	No	Yes
Adj. R-squared	0.444	0.757	0.444	0.757

Note: The dependent variable is the natural logarithm of house transaction price. Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. Dummies for being in a CT with the indicated percentage of Chinese residents are included in the regression. All regressions include year-month dummies and the same house characteristics as Table 1. There are 116,939 observations.

[a] There 1670 sales of houses ending with "88" .

[b] There 658 sales of houses ending with "13".

Table 6. Unconditional Quantiles Regressions of the Effect of a House Address Number Ending with a "4" or a "8" on Log Transaction Price

	(1)	(2)	(3)
Percentile	5	50	85
Last digit = 4	0.027**	–0.002	0.003
	(0.013)	(0.004)	(0.008)
Last digit = 8	–0.018	–0.001	–0.007
	(0.012)	(0.004)	(0.007)
Last digit = 4 *	–0.048***	–0.021*	–0.040**
Chinese >0.18	(0.016)	(0.011)	(0.018)
Last digit = 8 *	0.035**	0.012*	0.087***
Chinese >0.18	(0.013)	(0.007)	(0.014)
Census Tract Dummies	Yes	Yes	Yes
Street Fixed Effects	Yes	Yes	Yes
Adj. R-squared	0.179	0.535	0.503

Note: The dependent variable is the natural logarithm of house transaction price on 116,939 observations. Standard errors computed by block (at the CT level) bootstrap are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10. Dummies for being in a CT with the indicated percentage of Chinese residents are included in the regression. All regressions include year-month dummies and the same house characteristics as Table 1.

Appendix Table A1. Descriptive Statistics

Housing variables	Means	Standard Deviations		Means	Standard Deviations		Means	Standard Deviations
A. CTs with Chinese ≤ 0.18	Last digit =4			Last digit =8			Other last digits	
Transaction price	326,342	189,561	***	345,907	224,337	**	340,893	220,123
Finished floor area (sq ft)	2,137.33	804.49	***	2,459.09	1012.795	***	2,345.28	948.536
Lot size (1000 sq ft)	1,375.96	2,672.39	***	1,111.38	2394.243	***	1,228.55	2556.522
Number of full bathrooms	1.90	0.973	***	2.28	1.141	***	2.12	1.059
Number of half bathrooms	0.60	0.602	***	0.65	0.575	***	0.62	0.588
Number of multi car garages	0.490	0.510	***	0.627	0.499	***	0.573	0.510
Number of single car garages	0.202	0.407	***	0.150	0.364	***	0.165	0.377
Number of stories	1.317	0.454	***	1.491	0.493	***	1.415	0.483
House age (10 years)	27.409	20.068	***	19.891	20.164	***	23.271	20.321
Basement suite (dummy)	0.132	0.339		0.139	0.345		0.134	0.341
Basement area (sq ft)	0.834	0.615	***	0.907	0.652	***	0.877	0.647
Finished basement area (sq ft)	0.518	0.510	***	0.578	0.581	***	0.556	0.559
Swimming pool (dummy)	0.036	0.187		0.033	0.178		0.033	0.180
No. of observations	5715			8505			62693	
B. CTs with Chinese >0.18	Last digit =4			Last digit =8			Other last digits	
Transaction price	383,246	186,781	***	518,022	354,759	***	440,759	271,725
Finished floor area (1000 sq ft)	2,151.74	821.872	***	2,778.94	1,236.262	***	2,517.34	1,122.37
Lot size (1000 sq ft)	16.95	214.634	***	8.25	88.372		7.68	61.366
Number of full bathrooms	1.94	1.001	***	2.73	1.393	***	2.37	1.296
Number of half bathrooms	0.43	0.566	***	0.58	0.614	**	0.55	0.600
Number of multi car garages	0.452	0.513	***	0.697	0.476	***	0.579	0.508
Number of single car garages	0.272	0.452	***	0.159	0.372	***	0.200	0.408
Number of stories	1.292	0.428	***	1.547	0.488	***	1.450	0.484
House age (10 years)	39.382	26.950	***	24.186	25.734	***	29.535	25.229
Basement suite (dummy)	0.341	0.474	***	0.290	0.454	***	0.244	0.429
Basement area (sq ft)	0.947	0.498	***	1.018	0.592	***	0.887	0.612
Finished basement area (sq ft)	0.654	0.459	**	0.767	0.547	***	0.622	0.536
Swimming pool (dummy)	0.019	0.138	***	0.033	0.180		0.033	0.179
No. of observations	1547			4588			33891	

Note: Means of unlucky and lucky addresses are compared to neutral addresses. Asterisks indicate the level of statistical significance of the differences in means: *** p<0.01, ** p<0.05, * p<0.10.

Appendix Table A2. Estimates of Housing Characteristics on Log Transaction Price

Specification	Table 1, Col. (3)	Table 1, Col. (4)	Table 2, Col. (1)
Finished floor area (1000 sq ft)	0.2383***	0.1625***	0.1626***
	(0.0148)	(0.0051)	(0.0051)
Lot size (1000 sq ft)	–0.0266***	–0.0028	–0.0029
	(0.0032)	(0.0043)	(0.0043)
Number of full bathrooms	0.0532***	0.0051*	0.0051*
	(0.0083)	(0.0028)	(0.0028)
Number of half bathrooms	0.0562***	0.0194***	0.0194***
	(0.0076)	(0.0021)	(0.0021)
Number of multi car garages	0.1221***	0.0846***	0.0846***
	(0.0089)	(0.0043)	(0.0043)
Number of single car garages	0.0156**	0.0078***	0.0079***
	(0.0068)	(0.0021)	(0.0025)
Number of stories	0.0323	–0.0162**	–0.0163***
	(0.0206)	(0.0075)	(0.0075)
House age (10 years)	0.1458***	0.0587***	0.0587***
	(0.0104)	(0.0049)	(0.0049)
House age squared (100 years)	–0.0093***	–0.0072***	–0.0072***
	(0.001)	(0.0006)	(0.0006)
Basement suite (dummy)	0.0242	0.0333***	0.0334***
	(0.0162)	(0.0058)	(0.0059)
Basement area (sq ft)	0.0675***	0.0482***	0.0483***
	(0.001)	(0.0045)	(0.0045)
Finished basement area (sq ft)	–0.1979***	–0.1438***	–0.1440***
	(0.0189)	(0.0094)	(0.0093)
Swmming pool (dummy)	0.1407***	0.0779***	0.0779***
	(0.0218)	(0.0068)	(0.0068)
Constant	11.976***	12.488***	12.126***
	(0.0493)	(0.0401)	(0.0536)
Year-Month Dummies	Yes	Yes	Yes
Census Tract Fixed Effects	No	Yes	Yes
Street Fixed Effects	No	Yes	Yes
Observations	116939	116939	116939
Adj. R-squared	0.443	0.757	0.757

Note: The dependent variable is the natural logarithm of house transaction price. Clustered standard errors at the CT level are in parentheses. Asterisks indicate the level of statistical significance: *** p<0.01, ** p<0.05, * p<0.10.Standard errors are in parentheses.