

# Has Sars Infected the Property Market?

Evidence from Hong Kong<sup>†</sup>

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**Abstract:** This paper uses the Hong Kong Severe Acute Respiratory Syndrome (Sars) epidemic in 2003 as a natural experiment to investigate how housing markets react to extreme events. I use a panel data set of large-scale housing complexes (called estates) and exploit the cross-sectional variation in the spread of Sars to measure the housing price movements associated with the epidemic. I contrast the impact on prices and sales of government announcements of SARS infections, news reports and the estimated estate-level infection rate. The average impact is 1-3 percent drop in price for the average Sars-affected housing complex, and an overall price fall of 1.6 percent for all estates. The implied economic value of life is between USD 121,000 and 1 million, which falls towards the lower end of estimates from non-extreme events. No evidence of overreaction in prices is found. An analysis on changes in transaction volume suggests that the absence of overreaction in housing prices is probably a result of high transaction costs and loss aversion.

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## 1. Introduction

Severe Acute Respiratory Syndrome (Sars) is the first new, serious and contagious illness of the 21<sup>st</sup> century. Three hundred Hong Kong residents died during the 2003 Sars epidemic (March – June), accounting for a third of all Sars deaths in the world. Hong Kong's apparent vulnerability raises the possibility that Hong Kong has since been perceived as a less desirable place to work and live in.<sup>1</sup> Coinciding with the unanticipated epidemic, housing prices in Hong Kong fell by 8 percent. Though tantalizing and widely cited, this dramatic price fall – representing a total value of USD 28 billion, equal to about \$16 million per Sars case – could have been a continuation of the strong pre-Sars downward trend instead of a response to the epidemic itself.<sup>2, 3</sup>

This paper examines the impact of the Sars epidemic on the Hong Kong housing market. First I estimate the extent to which the observed fall in housing prices can be attributed to the SARS epidemic. Using a unique panel data set of weekly transaction prices of 44 housing complexes (estates), I exploit the cross-sectional variation in the timing and spread of Sars within Hong Kong. I measure the perceived location-specific risk by analysing all major sources of public information related to the 44 estates. I create

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<sup>1</sup> Hong Kong was the most severely hit city in the world in the 2003 Sars epidemic, accounting for 21 percent of all Sars cases and 33 percent of Sars deaths. In just three months, the risk of contracting Sars in Hong Kong (0.026%) exceeded the yearly risk of contracting AIDS in high-income countries (0.008%).

<sup>2</sup> The value of private housing stock is evaluated using end of 2002 prices. Source: Hong Kong Housing Authority <http://www.housingauthority.gov.hk/hdw/ihc/pdf/bhfs.pdf>.

<sup>3</sup> Many related the housing price fall in the second quarter of 2003 to the Sars epidemic. David Carse, the Deputy Chief Executive of the Hong Kong Monetary Authority, attributed the sharp increase in negative equity loans (by HKD 30 billion, or 22%) to the acceleration of housing price fall due to Sars (<http://www.info.gov.hk/hkma/eng/press/2003/20030814e4.htm>). DTZ Debenham Tie Leung, a prominent property consultancy, claimed that Sars had a “devastating impact” on the Hong Kong housing market shortly after the outbreak started.

my best estimate of the estate-level Sars infection rates.<sup>4</sup> The Sars epidemic appears to have resulted in a 1-3 percent fall in housing prices. Next I ask whether this drop in prices can be characterized as “overreaction”. To further understand the price movements, I perform a similar analysis on transaction volume.

While the epidemic is unlikely to have any significant impact on the supply of the housing stock, it is likely to reduce demand for housing in Hong Kong. If only a small part of the population believes that Hong Kong is more susceptible to another outbreak and subsequently moves away, it can translate to lower agglomeration benefits for all residents, translating to territory-wide price falls. Cross-sectional differences in price changes come from variations in the spread of Sars.

Sars provides a unique setting to measure market reactions to extreme events because it was unanticipated and exogenous. Unlike other exogenous extreme events that have been previously studied (such as flooding), the 2003 epidemic involves a clear change in the risk level. A growing body of research points to social amplification of risks when they involve unknown and dreaded events beyond the control of the individual, causing rippling effects much greater than the direct impacts and far beyond the direct victims.<sup>5</sup> Economists have also long observed that societal responses to health risks tend to be extreme and inconsistent, suggesting an overestimation of the frequency of rare risks (Viscusi 1989, 1990). This tendency to overreact to new risk may be offset in this case, however, because there is reason to believe that cognitive errors in

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<sup>4</sup> The main information sources include the daily Department of Health Sars-building list (which is the only form of government announcements that relates to Sars cases in specific buildings) and local newspaper reports. There is no record of the Sars infection rate in different parts of Hong Kong below the district level. Hong Kong consists of 18 districts. See Section 4 for details.

judgement are less likely when the costs to the individual are high (Glaeser 2003). Housing prices are likely to have a significant impact on household wealth positions, especially for leveraged households. Thus, the Sars epidemic provides an interesting example to probe the importance of overreaction to information in markets.

This paper provides an indirect measurement of the marginal households' evaluation of the Sars risk by estimating the compensating differential in the housing market (Roback 1982).<sup>6</sup> Given the low turnover rate in housing markets as compared to other asset markets, measurement errors make it difficult to test precisely when new information has an impact on the housing market.<sup>7</sup> Consequently, I focus on the "medium-run" impact of the various indicators over a period of 38 weeks, which is relevant to most households given the long holding period of housing units. It is worth pointing out that the measured compensating differentials reflect not only on the economic value of life and the Sars risk, but also the perceived permanence of the risk and the disutility related to non-fatal Sars cases. Because we have no direct measurement of the perceived persistence of the epidemic or the disutility of nonfatal incidents of the disease, instead of a point estimate I present a range of estimates of the marginal willingness-to-pay to avoid the risk of the epidemic.

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<sup>5</sup> For example, see Slovic (1987) and Burns et al. (1990).

<sup>6</sup> Because the Sars epidemic was unexpected, pre-sorting of households into different housing locations according to their valuation of the risk is less likely.

<sup>7</sup> Another difficulty arises because assets prices react to the difference between the prior expectation and the realization of announcements, the former of which we have no information on. The "news" component in an announcement can be denoted as  $n=(V-E)/\sigma$ , where V stands for the realized value of an economic variable, E a surveyed expectation prior to the announcement, and  $\sigma$  the sample standard deviation of (V-E). An overly pessimistic view of the future on a previous day will make today's market response to unfavourable announcements seem tame. This paper abstracts from short-run price movements.

Several noteworthy results emerge from my analysis. I identify a price decrease of 1.6 percent after the start of the epidemic for all housing estates, and an additional decrease less than 3 percent for the average Sars-affected estate, i.e., those that were publicly known to have had Sars cases or were mentioned in the newspapers in relation to Sars. The implied economic value of life, from USD 121,000 to just over 1 million, falls towards the lower end of the range based on studies on non-extreme risks. I do not find evidence for overreaction in terms of prices.

My results also provide an understanding of the dissemination of public health information during the Sars epidemic. Despite the absence of any publicly available measure of estate-level Sars risk, I identify a significant negative price reaction in response to the estimated infection rate. Sars-related mentions of specific estates in the English-language (but not Chinese-language) newspapers also were associated with significant price falls, independent of the Sars infection rate. However, public exposure through the government Sars-list did not have similar effects.<sup>8</sup>

I also identify significant decreases in turnover rates, both across the territory and in Sars-affected estates. Interestingly, the Sars-list stay and the Chinese news indicators turn out to have significant impacts on transaction volume, given the lack of related price responses. This points to a “wait-and-see” attitude predicted by the down-payment model (Stein 1995) or loss aversion model (Genesove and Mayer 2001), both of which predict a decline in volume and an attenuation of negative price reactions.

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<sup>8</sup> I also calculated a predicted Sars risk indicator related to the living conditions, based on scientific links cited in government and WHO reports. It does not have a significant impact.

The remainder of this paper is organized as follows: the next section provides a chronology of the 2003 epidemic; Section 3 discusses the related literature; Section 4 describes the data; Section 5 reports the empirical findings; and Section 6 concludes.

## **2. The 2003 Sars Epidemic in Hong Kong**

Figure 1 shows a timeline of the 2003 epidemic against the number of Sars cases. Several events are particularly relevant for this study. The time lag between the occurrence of the first case in February and the government confirmation of the community spread of Sars on March 26 highlights the difficulty in pinning down the start date of the epidemic.<sup>9</sup> Throughout this paper, I adopted March 26, 2003 as the start date because this was when the Hong Kong people were left with no doubts that Sars was to affect the general population outside the small circle of close medical and family contacts of existing Sars cases.<sup>10</sup> Using alternative dates adjusts my estimates slightly upwards.

Since then, residents began to be infected across the board, including the educated, the young and the previously healthy. Unanswered questions about diagnosis, treatment and transmission mechanism added to feelings of uncertainty and trepidation. There was anecdotal evidence for people taking refuge in friends' or relatives' homes in areas with fewer known Sars cases. The World Health Organization (WHO) issued a travel advisory to suspend all but essential travels to Hong Kong on April 2.

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<sup>9</sup> Adding to the complication, there was a high-profile denial by the government about community spread of Sars on March 17, 2003.

<sup>10</sup> As it turned out, less than a quarter of all Sars cases in Hong Kong were health care workers and most of the 329 infected residents in Amoy Gardens were strangers to each other. Source: *The Standard*; *Oriental Daily*; WHO website.

More than 2 weeks after the start of the epidemic, the Hong Kong Department of Health started to publish a daily “List of Buildings of Confirmed Sars Cases” (Sars-list) on April 12, making it available to the general public, media and on the internet. It was relied upon as the main source of statistics. A building appeared on the list only within 10 days (the incubation period) of the onset date of any known Sars case. If the case was diagnosed after 10 days of the onset date, the building would not be listed. No information on the Sars case demographics, number of cases related to each listing or connection among the cases was made available. As such, the Sars-list contained only crude information about the relative severity of the outbreak by location.

The mass media filled part of the information gap. After March 26, Sars-related reports dominated newspaper headlines. Suspect Sars cases mentioned in the newspapers might or might not appear in the government Sars list, and there was often information on specific cases in other dimensions such as demographics. I focus on newspaper reports that related specific housing estates to the epidemic.

The first official scientific analysis on Sars was published in the form of a report on the Amoy Gardens outbreak by the Hong Kong Department of Health on April 17. It ruled out the theory that Sars was air-borne, but concluded that sewage flaws, sharing of communal facilities, environmental contamination and pests played a part in spreading the virus. An independent WHO investigation (May 16) had similar findings. Based on these findings, I generated a predicted Sars risk measure.

After a large-scale shutdown of normal activities, including a suspension of all school classes for more than 3 weeks, the last Sars case was isolated on June 2. Hong

Kong was removed from the WHO List of Areas Affected by Sars on June 23, 2003.

Many medical experts believe that Sars would return.

Amoy Gardens is worth extra attention in my analysis. Not only it was the first and most severe cluster in Hong Kong, with a total of 329 cases, a large part of the cases also occurred before precautionary measures were taken in the society. The number of news reports on Amoy with a direct relation to the epidemic is 10 times the number on the average estate ever listed on the government list. (Table 1) In Section 5, I describe estimation results both with and without Amoy Gardens in the sample.

### **3. Theoretical Background**

#### **A. Rationality and Forward-Looking Behaviour**

In this section I consider the predictions of the standard asset-pricing model (Poterba 1984). Under this model, any expected change in the net present value of future housing services, either due to the health risk or reduction in agglomeration benefits, causes an immediate change in prices:

$$(1) \quad Q(t) = \int_t^{\infty} S(z) e^{-r(z-t)} dz$$

where  $Q(t)$  is the real value of a housing unit at time  $t$ , and  $S(z)$  denotes the real value of housing services provided in period  $z$  minus depreciation, taxes, and maintenance costs.<sup>11</sup>

The housing services are discounted by the effective real interest rate  $r$ :

$$(2) \quad r = (1-\theta)(Lib) + (1-L)il - \pi$$

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<sup>11</sup> Two property taxes in Hong Kong – the Government Rent and Rates – are charged annually at 3 percent and 5 percent respectively on most housing units in Hong Kong.

where  $\theta$  is the salary tax rate,  $L$  the mortgage-to-value ratio,  $i_b$  the nominal borrowing rate,  $i_l$  the nominal lending rate, and  $\pi$  denotes the inflation rate. Mortgage interest payments are deductible from salary (personal income) taxes in Hong Kong.

For a back-of-the-envelope calculation, assume the service value of the housing unit, tax rate, interest rate and inflation rate are all time-invariant, equation (1) reduces to:

$$(3) \quad Q(t) = S/r.$$

To consider an extreme but transitory shock, suppose six months of housing services are totally destroyed by the epidemic. The percentage decrease in  $Q$  will be:

$$(4) \quad \Delta Q/Q = 0.5S / (S/r) = 0.5r.$$

During the fiscal year 2003-04, the after-tax real interest rate in Hong Kong is between 2.41-2.58 percent, which implies a drop of 1.21-1.29 percent.<sup>12</sup> Any permanent decrease in annual housing service flows  $S$ , by contrast, causes a decrease one-for-one in  $Q$ . Clearly the permanence of the Sars threat leads to a much larger drop in prices.

Besides decreasing the general quality of life in Hong Kong, thus creating a territory-wide impact, Sars also creates a new health risk specific to each building. To consider the implications, higher-quality housing units can be thought of as units that produce a larger quantity of homogeneous housing services during any given time period. That is, health risk is substitutable for other building characteristics such as number of rooms. Denote the housing services provided by housing structure at time  $t$  by  $H_t$ , a positive Sars risk reduces  $H$  to  $H_t < H_{t-1}$ . The newly recognized health risk decreases the total expected units of housing services available in the market, reducing the supply of

housing services and leading to a higher unit price for housing services. An unambiguous prediction is that prices of housing structures with higher Sars risks decrease after the epidemic relative to those of housing structures with lower or no Sars risk, other things being constant. My estate-specific Sars indicators attempt to capture this price decrease.

## **B. Overreaction**

Although appealing, the assumption of rationality that the asset-pricing model is based on might not be appropriate because strong emotions and uncertainty associated with the Sars epidemic might cause decisions to deviate from rationality.<sup>13</sup> The Sars risk might be perceived at a higher level than the actual infection and fatality risks.

Research in psychology highlights three factors that increase the level of perceived risk: how dreaded, uncontrollable and fatal the risk is; how unobservable, unfamiliar and unknown it is; and the level of personal and social exposure to the risk (Slovic 1987). Prospect theory (Kahneman & Tversky 1979) predicts that rare events tend to be overweighed, in the absence of the risk-learning process through repeated experience. “High-signal” events – relatively small incidents in poorly understood systems – are also likely to cause a social amplification of risks (Burns et al., 1990; Slovic 1987; Kasperson et al., 1988; Slovic and Weber 2002).

There is a large economic literature that documents risk perception biases, where rare risks tend to be overestimated. Viscusi (1990) provides a survey and illustrates that

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<sup>12</sup> The average 1-month HIBOR (Hong Kong Interbank Offered Rate) during the first quarter of 2003 is 1.38 percent. Deflation rate is around 1.20 percent. I based my calculation on a mortgage ratio ranging from 0 to 80 percent.

<sup>13</sup> One example is when a hoax message posted by a 14-year-old on the internet resulted in a wave of panic-buying of food stock. The government quieted the fears by sending SMS messages to 6 million mobile phones. The modern psychology literature illustrates the importance of affective reactions in decision-

upwards-biased risk perception causes a steeper increase in compensation, as long as the marginal utility of income in the healthy state is at least as high as that in the unhealthy state. Moreover, this difference in market responses tend to be the most significant when a risk is discovered, and the probability jumps from zero to a positive amount.

### **C. Related Theories on Transaction Volume**

The standard asset-pricing model has no clear implication for the effect of an exogenous shock on trading volume. The market-clearing condition abstracts from the existence of frictions, a likely phenomenon in real estate markets where both buyers and sellers are observed to invest substantial resources in the search process (Krainer 1999).

During the epidemic, search costs were likely to have increased significantly due to the risk of contracting Sars. Because this risk was expected to decrease after the epidemic ended, it would be rational to delay house searching activities. A standard search model, e.g., Wheaton (1990), predicts that transaction volume decreases with an increase in search costs, and returns to normal when search costs do so.

Two alternative theories predict more persistent movements in transaction volume. Stein (1995) shows that the down payment requirement leads to a dependence of housing demand on buyers' liquidity. In imperfect capital markets, homeowners who would have been able to trade down are constrained to stay when prices fall, if repayment of the mortgage prevents them from making a down payment for a new home. They might either decide not to put the flat up for sale, or set a higher asking price and wait for a longer time to "fish" for a higher-than-average price offer. This implies an attenuated

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making, especially under uncertainty. Holtgrave and Weber (1993), for example, argue that affective reactions are crucial even in more "objective" contexts such as financial investment decisions.

price fall in the event of an adverse shock, and a decrease in turnover rate, because “fishing” does not always pay off. The more severe the shock is, and the higher the share of liquidity-constrained homeowners, the more significant the impact on volume will be. This theory explains decreases in volume in the presence of an exogenous negative shock to housing prices under the assumption of rational behaviour.

Alternatively, Genesove and Mayer (2001) turn to prospect theory for an explanation. Loss aversion implies that reactions to current housing prices might differ depending on the level of prospective losses, i.e., the difference between the current price and the reference price, such as the initial price they paid for their homes or the highest price their homes have ever attained (Kahneman and Tversky 1979; Tversky and Kahneman 1992). A loss-averse seller will try to attenuate the prospective loss by setting a higher asking price, thus taking a longer time to sell. Therefore, like the liquidity constraint explanation, loss aversion will lead to an attenuated price reaction to an adverse shock, compared with the prediction of the standard asset-pricing model, and a decrease in observed trading volume.

#### **4. Data**

##### **A. Measuring Housing Prices in Hong Kong**

I use a panel data set of hedonic-adjusted prices on 44 housing estates that form a widely-used residential housing market index, the Centa-City Leading Index (CCL). The 44 estates are located in 14 of Hong Kong’s 18 districts. With an average population of 13,000, each estate forms a mini-city by itself, with variability in age, layout and other

characteristics across the estates, and little variability within estates. Collectively, these estates house 18 percent of the Hong Kong private-housing population (which is about half of the total population). Twenty of the 44 estates were listed on the Department of Health Sars-list at some point. The Appendix shows more details on the estates.

The prices are weekly averages after hedonic adjustments of quality variations across housing units within each estate, such as floor level and view. They are based on preliminary contract prices of secondary residential property transactions handled by a leading estate agent with a 20 percent market share (Centaline Property Agency Ltd.).<sup>14</sup> The data span 64 weeks, 25 before the start of the epidemic and 25 after the end.

An analytical advantage comes from the structure of my data. The size of the estates and the similarity of housing units within an estate allow reasonably accurate measurements of estate-level weekly price movements, with an average of 3 transactions in an estate per week. The panel structure of the data allows me to circumvent two problems often encountered in housing studies. Heterogeneity in housing units in cross-sectional samples gives rise to comparability problems because structural and location characteristics are often difficult to measure. In repeat sales samples, the sample of units that are sold multiple times may not be representative.<sup>15</sup> The substantial similarity of units within each housing estate makes my sample an attractive alternative.

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<sup>14</sup> The hedonic-adjusted price data series has a high correlation (0.96) with the unadjusted data. I repeat all estimations with the unadjusted transaction price data, obtaining qualitatively identical results. Provisional agreements include the payment of an initial deposit, forfeitable in case of default (3-5 percent of the price).

<sup>15</sup> For example, Case and Shiller (1989) show that repeat sales data give rise to spurious serial correlation. For a survey of empirical issues in house price estimations, see Cho (1996).

To investigate the potential bias of the CCL from being based on contracts handled by Centaline only, I compare it with the Centa-City Index (CCI).<sup>16</sup> While both indices are based on hedonic-adjusted price data of the same 44 constituent estates, the CCI is computed using prices from all transactions registered with the Land Registry. Also, the CCI is based on final transaction prices, instead of preliminary contract prices. However, the estate-level prices which form the CCI are not available. Figure 2 shows the movements of the two indices over the past 9 years. Obviously, there has been a close correspondence between the two. The correlation coefficient between the monthly average of the weekly CCL and the monthly CCI is 0.998, using data from 1994 to the first quarter of 2004.

#### **B. Transaction Volume Data**

I obtained access to the Memorial Day Book of the Hong Kong Land Registry from January 2001 to June 2003.<sup>17</sup> This source contains the date of registration, address of the property, consideration (price) and date of execution of all property transactions. A total of 245,240 sales and purchase instruments were registered over this period.

The weekly transaction volume of a housing estate is defined as the number of sales and purchase contracts executed during each particular week. To eliminate contracts involving non-residential properties, I have assembled these data on a weekly basis for the 44 estates covered by the Centa-City price series. To avoid a potential downward bias of volume caused by the time lag between execution and registration of a contract, I

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<sup>16</sup> CCI is another widely-used residential housing market index. Both indices are part of a joint project between Centaline and the City University of Hong Kong (the Centa-City team) to monitor the Hong Kong secondary residential housing market.

removed the last 2 weeks of observations in June 2003 from my sample, and focused on the first 24 weeks of 2003.<sup>18</sup>

### **C. Housing Estates Characteristics**

I hand-collected data on characteristics of the 44 housing estates that might be related to the spread of including: age, number of floors, number of flats per floor, and number of blocks.<sup>19</sup> To generate an estimate of each estate's population, I multiplied the total number of flats (blocks X floors X flats per floor) by the number of households in each housing unit, and the number of persons in each household. The last two measures are district-level averages from the Hong Kong Census 2000.<sup>20</sup> (Table 1)

I measure the travel time to city centre from an estate by the amount of time spent on the most prevalent form of public transport to the closer of the two main commercial/financial centres in Hong Kong, Tsim Sha Tsui and Central. Information on travel time to city centre was collected from the transportation companies and real estate agents.<sup>21</sup>

### **D. Sars Indicators**

#### **(i) Territory-Wide Start of Sars Epidemic Indicator**

I have defined the start of the Sars epidemic indicator to be equal to 1 after March 26, 2003, when the Chief Executive of Hong Kong declared that the outbreak reached

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<sup>17</sup> This data purchase was generously supported by a grant from the Andrew M. Mellon Foundation through the Research Program in Development Studies, Princeton University.

<sup>18</sup> The mean lag between execution dates and the registration dates is 20 days.

<sup>19</sup> These data were compiled by research on the internet, phone calls to real estate agents and property developers, and visits to some of the estates. Age and the number of floors and flats per floor are averages across the housing estate; number of blocks are often counted from site plans of the estates.

<sup>20</sup> There is not a lot of variation across districts. Mean [s.d.] of household per quarter = 1.02 [0.03]; Mean [s.d.] of persons per household = 3.16 [0.19].

<sup>21</sup> Twenty-two of the 44 housing estates are situated near a MTR (underground) station, and 7 others are close to a KCR (train) station. The rest of the estates are served by bus, minibus, or ferry and for those in the Mid-levels, by taxi.

epidemic levels. I also experimented with alternative definitions, which did not materially change the results.

(ii) Sars Infection Rate

If there were a perfect measure of the perceived health risk, any other measures of Sars should have no additional impact on prices. In reality, perceived risks are unobserved. There is no publicly known, scientific estimate of estate-specific health risk from Sars either. In fact, the number of cases in each building or estate was not recorded by the Department of Health, outside of the 4 sites with the largest clustering of cases.

I generate my best estimate of the estate-level Sars infection rate as follows. For Amoy Gardens, which was the largest cluster of cases, I calculated the Sars infection rate by dividing the number of cases by estate population. Twenty-four other estates were not listed at all and I assumed the infection rate to be 0. As for the 19 other estates, I estimated the number of cases by multiplying the number of times each of them was on the Sars-list by the average number of cases per listing outside the 4 largest clusters.<sup>22</sup> The ratio of the estimated number of cases to the estate population gives the Sars infection rate in these 19 estates. Analogous estimation at the district-level creates Sars infection rate estimates highly correlated ( $\rho=0.96$ ) with the actual district-level rates provided by the Department of Health. The information I made use of in estimating the Sars infection rate is only available after the epidemic ended. Therefore I defined the Sars risk variable as 0 before the end of the epidemic and equal to the estate-specific infection rate afterwards.

(iii) Sars-List Indicators

The main official source of information about Sars is the Hong Kong Department of Health List of Buildings with Confirmed Sars Cases, which was published daily. I measure Sars-related public exposure of each estate with the cumulative number of days an estate had been on the Sars-list. This captures how frequently the government announcements related each estate to the epidemic. I experimented with both the raw count and the per capita measure.

(iv) Sars-Related News Count

An alternative source of information about Sars was the media. I counted the number of newspaper articles mentioning each of the 44 estates in connection to Sars from 4 prominent newspapers, two in English and two in Chinese (the two official languages in Hong Kong), with a total daily circulation around 320,000 copies.<sup>23</sup> I then create the news count by dividing the number of articles by estate population. Information content of news articles does not perfectly correspond to that of the Sars-list statistics.<sup>24</sup> I focussed on the period March 26 – June 24, 2003, outside of which individual housing estates were rarely mentioned in connection to Sars.

(v) Predicted Sars Infection Risk

Based on links drawn between living conditions and the spread of Sars in the scientific reports, I create a predicted Sars risk measure using a Tobit regression:

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<sup>22</sup> The average number of cases per listing outside the 4 largest clusters = (total number of cases in Hong Kong – total number of cases of the 4 largest clusters) / (total number of listed addresses – total number of times the 4 largest clusters were listed).

<sup>23</sup> According to the United Nations, the per capita circulation of daily newspapers in Hong Kong in 1996 was 786 per thousand people, compared to 324 in Singapore, 329 in the United Kingdom and 212 in the United States.

$$(5) \quad \text{Sarsp}_i = \alpha + X_i \beta + \gamma_d + \varepsilon_i$$

where  $\text{Sarsp}_i$  refers to the Sars infection rate of housing estate  $i$ ,  $\alpha$  is a constant term,  $X_i$  a vector of time-invariant pre-Sars housing estate characteristics,  $\gamma_d$  a district fixed effect, and  $\varepsilon_i$  is a normally distributed error term. As explanatory variables  $X_i$ , I have included the baseline price level in 2002, travel time to the centre of the city, and building attributes including the availability of communal facilities and a population quadratic. This analysis makes use of information that might not be readily available to the public.

Table 2 contains the regression results. Wong (2004) offers a more detailed discussion of how the spread of Sars relates to living conditions and socioeconomic status.<sup>25</sup> I generate the predicted Sars risk from column (5) as an index of empirically important observables in determining the spread of Sars. The predicted Sars risk indicator is defined as zero before the publication of the Amoy report (April 17, 2003).

## 5. Estimation Results

### A. Impact of Sars Epidemic on Housing Prices

I focus on the 64-week period starting from 25 weeks before the epidemic to 25 weeks after its end. Using weekly prices of 44 housing estates, I estimate Feasible General Least Squares (FGLS) regressions of the form:

$$(6) \quad \ln(\text{Pit}) = \alpha + \beta \text{SARS} + \theta_i + \Psi(t) + \gamma_d t + \varepsilon_{it}.$$

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<sup>24</sup> Often rumours or unconfirmed suspicion of Sars cases in specific estates were reported in the papers. Some of them proved to be false, others to be local knowledge slightly ahead of the Health Department.

<sup>25</sup> Amoy Gardens is excluded. Similar conclusions were drawn from analogous regressions on the total number of days each housing estate was on the Sars-list. The age of building, proximity to healthcare facilities, formation of residents' association, the style of building management and whether the housing estate is public or private do not have a significant correlation with the spread of Sars.

$P_{it}$  is the weekly average of transaction prices in estate  $i$  (after within-estate quality adjustment) during week  $t$ ,  $\alpha$  is a constant term,  $\theta_i$  is an estate fixed effect,  $\gamma_d t$  is a set of district-specific linear time trends, and  $\varepsilon_{it}$  is an error term assumed to follow an estate-specific AR(1) process to allow for serial correlation in the price series. Because price observations are weekly averages for estates that vary in size and transaction frequency, I weigh the regression by the total number of flats in each estate to adjust for heteroskedasticity.<sup>26</sup>

SARS refers to one of the Sars indicators as outlined in Section 4.  $\Psi(t)$  is a time control depending on SARS: weekly fixed effects are controlled for in regressions with an estate-specific Sars indicator, while a cubic time effect is used in the case of the territory-wide Sars indicator.  $\beta$  is informative of whether and how, controlling for time trends and estate fixed effects, housing prices responded to Sars-related information.

Table 3 Panel A shows the main results. Column (1) shows that on average, housing prices fell by 1.6 percent after the community spread of Sars was known, after controlling for estate fixed effects and a cubic time trend. This estimate is insensitive to alternative definitions of the start of the epidemic as when the WHO defined Sars as a new disease on March 15, 2003. I repeated column (1) using data 12 months before the epidemic, finding no similar price drop. This suggests the frequently-cited 8 percent fall in the housing price index from March to June 2003 was largely due to historical trends. Adding Amoy to the sample produces almost identical estimates.

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<sup>26</sup> In all regressions presented in this section, omitting the district-specific linear time trends gives qualitatively and quantitatively similar results. The three groups of control variables – estate fixed effects, the time effect (weekly or polynomial) and the district-specific linear time trends – are all significant at the

Estate-specific Sars indicators measure the price movements directly attributable to the epidemic. First I investigate the impact of my best estimate of the estate-specific Sars infection rate (per 1,000). Column (2) reports a significant and negative impact of every Sars case per 1,000 people at 7 percent, implying that conditional on a non-zero infection rate, an average estate suffers a price fall of 2.78 percent.<sup>27, 28</sup> A significant price decrease of smaller magnitude is identified when Amoy is included.

Interestingly, I do not find any significant price fall for public exposure as measured by the number of days an estate stayed on the Sars-list, both adjusted and unadjusted for estate population (Columns 3 & 4). The housing market seemed to have correctly taken into account of the fact that a longer stay on the list meant less than a higher number of separate listings, which is proportional to my infection rate estimate.

To put my estimate in context, I calculate the implied economic value of life and compare it with findings in the literature on non-extreme events. Without knowledge of how much of the price decrease is attributable to the non-fatal Sars risk, I calculate a range for the implied value of life in Table 4. It can be derived by dividing the mean price fall by the unconditional mortality risk (Sars infection rate X case mortality risk). Assuming that the price fall is solely due to the fatal risks involved with Sars, at the WHO world-average of 15 percent, an upper bound of the value of life is obtained. The lower bound is derived under the assumption that Sars deaths led to as much price

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1 percent level in all specifications presented in this paper. For more details on the econometric specifications, please refer to the earlier version of this paper (Wong 2004).

<sup>27</sup> I have also experimented with a Sars risk indicator that is zero before the *start* of the epidemic and constant thereafter, which can be viewed as a re-scaled version of the start of epidemic indicator. In results not shown, this alternative indicator is not statistically significant.

<sup>28</sup> Conditional on having at least one case, the infection rate in my sample is 39.67 per 100,000. The territory-wide infection rate in the 2003 Sars epidemic is  $1,755 / 6.8\text{million} = 25.81$  per 100,000.

decrease as a non-fatal Sars case. Using average housing prices for three different samples, the implied economic value of life falls within the range of USD 121,000 to just over 1 million. Compared with labour market study estimates of economic value of life from USD 600,000 to over 10 million (see Viscusi 1993, Table 2 for a summary of the literature), my estimate suggests that the housing prices did not overreact to the Sars risk. While it is a rough calculation based on an average concept, it provides useful insights into the question of overreaction.

My estimates are also much smaller than what Liu et al. (2003) find from two surveys during the epidemic in Taiwan (USD 3 to 12 million) via contingent valuation methods. The authors note that the time of data collection might have led to large estimates. My results suggest that the analytical approach might also play a role, because I did not find similar evidence in the Hong Kong housing market around the same period.

Besides the government Sars list, the mass media is another important information source. Returning to Table 3, column (4) shows a 5 percent decrease per news mention per 1,000 estate population, implying an average impact of 1.25 percent for estates ever mentioned.<sup>29</sup> I further separate the news mentions by the language of the papers, and find that the news mention impact in Column 5 is mainly driven by the English-language newspaper reports (Columns 6 & 7).

It is worth pointing out that the Sars infection rate indicator in column (2) and the English news mention indicator in column (7) represent very different information, both in terms of source, content and timing. The infection rate could only be known after the

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<sup>29</sup> Using the number of news articles unadjusted for population yields a negative but insignificant point estimate.

end of the epidemic, while estates ceased to be mentioned in direct relation to Sars in the newspapers slightly before then. Newspaper reports making references to specific estates often referred to unofficial source, such as neighbourhood interviews or volunteered information from local residents. The correlation of these two indicators for the 43 estates (excluding Amoy) is -0.01. Interestingly, the Chinese news mentions indicator, which does not have a significant impact, shares a much higher correlation with the infection rate indicator (0.63). A regression with both the Sars infection rate indicator and the English news mention indicator provides individually significant estimates almost identical to those reported in columns (2) and (6). This implies that the two indicators are essentially orthogonal to each other. The combined average impact, conditional on being non-zero, is 2.61 percent.

Column (8) shows that the predicted Sars risk does not have any significant price impact. This measure serves as an index of observable housing characteristics that are correlated to the Sars infection rate empirically. This result is surprising because the scientific reports linking living conditions and the Sars risk were highly publicized and widely cited. The predicted Sars risk for Amoy Gardens is within two standard deviations from the mean; the estimates with Amoy Gardens included are qualitatively and quantitatively almost identical to those presented. In results not shown, allowing for a rebound in prices points to a temporary price fall of 1.6 percent that lasted for 25 to 75 days. This is sensitive to the rebound cut-off point and should be taken as suggestive only. Other Sars indicators do not show similar rebound patterns.

At the bottom of Panel A I have included the conditional average impact and the unconditional impacts at the 25<sup>th</sup> and 75<sup>th</sup> percentiles of each significant indicator.

Panel B of Table 3 presents results allowing for baseline price interaction terms with the Sars indicators. Demeaned average prices in 2001 are used. The Sars infection rate indicator shows a significant differential impact by pre-Sars average sales price. Housing estates with baseline average prices one standard deviation (0.43) below mean suffer roughly half the price fall than those at mean. This is consistent with the view that households with a higher level of income or wealth have higher values of life. However, given that baseline price might either be directly related to the spread of Sars in each estate or correlated with other factors affecting it (Table 2), this differential might be due to non-linearities. There is some evidence that a long stay on the Sars-list affected the expensive estates more significantly. Given the standard deviation of housing prices in Hong Kong is more than 7 times the standard deviation in my sample, caution should be exercised in extrapolating these results to draw conclusion about the territory as a whole.

### **B. Impact of Sars on Turnover**

Under the same framework as above, I estimate Tobit regressions of the form:

$$(7) \quad T_{it} = \alpha + \beta \text{SARS} + \theta_i + \Psi(t) + \gamma_d t + \varepsilon_{it}$$

where  $T_{it}$  is the turnover rate in housing estate  $i$  during week  $t$  (i.e., 100 times the number of units sold divided by the total number of flats) and the other variables are as before.  $T_{it}$  can be thought of as the probability of any unit in estate  $i$  being sold in week  $t$ . Three control groups included as before, the estate fixed effects, district-specific linear time

trends and time effect, are significant at 1 percent level in all regressions presented.  $\beta$  represents the average change (in percentage points) in turnover rates due to Sars.

Table 5 Panel A presents the results.<sup>30</sup> Column (1) shows a significant territory-wide fall in turnover rate of 0.05 percentage points. Compared to the average pre-Sars turnover rate at 0.068 percent, this is a 72 percent decrease. The per capita Sars-list indicator has a significant impact on turnover, contrary to what I found with prices (Column 2). The average impact on the typical Sars-affected estate is 0.02 percentage points. To explore whether this is mainly due to increase in search costs, I define the On-list indicator to be the number of days the estate was listed during that week. Although spillovers of search cost increases are expected, the On-list indicator should pick up most of the volume dry up if search costs were the most important. Column (3) shows the contrary. This points to the more complex stories on transaction volume, which relates credit constraints and loss aversion in a down market to the observed price and volume changes. Sars-related news mentions reduces the turnover rate by 0.01 percentage points on average (Column 4), which is mainly driven by the Chinese-language papers (Columns 5 & 6).

Compared with the predicted Sars risk measure which has no price or volume effect (Column 7), the per capita Sars-list and the Chinese news indicators reduce turnover volume while having no significant impact on prices. Instead of suggesting that the Sars-list or Chinese-language newspapers were ineffective in disseminating information, my results point to a “wait-and-see” attitude, which led to decreased

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<sup>30</sup> In all regressions presented in Table 5, Amoy Gardens was excluded. Results including it are available on request, showing similar results with smaller point estimates.

turnover frequency and an attenuated price response. This is consistent with the downpayment and the loss aversion models.

I find very weak evidence for any differential in turnover rate reactions according to pre-Sars prices (Table 5 Panel B). My estimates of the main effects remain stable in magnitude but are measured with less precision. The territory-wide impact seems to have a greater impact on the more expensive estates, but the interaction term is significant at 10 percent level only. Because of the lack of volume data after the end of the epidemic, I have not examined the impact of the Sars infection rate on turnover rates.

## **6. Conclusions**

Sars first struck human populations in 2003, infecting 8,422 people worldwide and killing 916 of them. This virus bears a particular relevance to the housing market because it is believed that building characteristics and environmental conditions made some housing estates more susceptible to the spread of the disease than others. During the epidemic, many Hong Kong residents took refuge in relatives' and friends' homes located in areas with less Sars cases, and it was unclear whether the 8 percent housing price fall was the market reaction to expectations of significant decreases in demand. As an extreme event that elicited strong emotions in the society, the 2003 Sars epidemic provides a unique setting to study whether emotions associated with extreme events have strong market implications as predicted by modern psychology theories, and whether standard economic models built upon the assumption of rationality serve as reasonable benchmarks in predicting housing market reactions to extreme events.

Despite the widely-held belief that Sars devastated the already-frail Hong Kong housing market, this study finds little evidence of overreaction. The territory-wide indicator points to an average price fall less than 2 percent after the start of the outbreak, controlling for estate fixed effects and a historical time trend. Using weekly fixed effects to absorb any territory-wide Sars impact or trend shifts, the various estate-specific Sars indicators capture price falls directly attributable to public information related to the Sars epidemic. Together, they point to an average price fall of 2.61 percent.

My best estimate of the Sars infection rate at the estate level compensates for the lack of public record. The price changes correlated with my infection rate measure suggests that the marginal buyer in the housing market was aware of the Sars infection risk at the estate-level, without being informed of the magnitude of the risk directly. The implied economic value of life ranges from USD 110,000 to around 1 million. A comparison with the existing literature confirms the lack of overreaction.

Further findings strongly indicate a fall in turnover in response to the Sars epidemic, which seems to be more persistent than the increase in search costs brought about by the epidemic. Moreover, I find marked decreases in turnover related to Sars indicators that do not have significant price impact. This points to a mechanism where expected downward pressure on prices leads to non-participation in the market and therefore a muted price response. Given the importance of housing in the average Hong Kong household wealth portfolio, it is perhaps not surprising that the market adopted a cautious, wait-and-see attitude in reaction to the Sars epidemic, without showing significant signs of overreaction.

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## **8. Appendix: Background**

### **A. Epidemiology**

The agent of the severe acute respiratory syndrome (Sars) is a newly identified strain of corona-virus. The first known Sars case is believed to have occurred in the Guangdong Province of China in November 2002, though the exact origin of the virus is unknown.<sup>31</sup> So far there is no definitive diagnosis or any proven treatment method. The case-fatality ratio is estimated to be 15 percent, with the median age at 40. At least initially, the outbreak of Sars was particularly alarming because it proved fatal in healthy, young adults, and appeared to spread relatively easily from person to person. The disease had infected 8,422 people and had caused 916 deaths worldwide as of August 7, 2003. (WHO website) The virus is believed to be moderately transmissible under normal circumstances, with an average of 3 secondary infections per case in a population which has not yet instituted control measures, but it is unclear why some virus-carriers demonstrated higher-than-normal infectivity in “super-spreading” events.<sup>32</sup> Transmission mechanism of the virus has so far been identified as via respiratory exudates, fecal-oral contacts, contaminated surfaces. There is also evidence of higher risk of transmission within confined spaces, such as elevators and airplanes. Rodents and cockroaches have been found to be mechanical vectors of transmission. Samples from the corridor and elevator areas near Room 911 in the Metropole Hotel, where the first (or “index”) patient spent a single night, tested positive for the virus RNA 3 months after his stay, raising

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<sup>31</sup> *Nature* 423, 905 – 906, June 26, 2003; Riley et al., 2003; WHO website. The corona-virus has been found in civet cats, a popular exotic cuisine in Southern China, but the virus is suspected to have originated from another, more exotic species.

questions about the persistence of the virus in the environment. (Lipstitch et al., 2003; Riley et al., 2003; WHO website)

Residential density – which affects the level of person-to-person contact and sharing of communal facilities such as elevators, functioning of the sewage system and general sanitary conditions – therefore plays a role in determining the extent of Sars transmission within a building. The age of the building and the initial price level of the flats are also likely to correlate with these transmission factors, through their connection with residents’ living habits and frequency of maintenance and cleaning of the building.

Although vigorous control and precautionary measures have proven to be effective in containing the spread of Sars, scientists and health authorities believe that Sars remains a threat (WHO website; *Science*; Hong Kong Department of Health). The lack of a definitive diagnosis test and the similarity of Sars symptoms to those of other respiratory diseases make early isolation of patients difficult, and infectivity remains high within the first 10-14 days after onset of symptoms. Sars cases can also be without clinical symptoms yet infectious – the failure to isolate a sub-clinical case led to the second outbreak in Toronto, Canada in late-May 2003. The diagnosis of a Sars case in Singapore in early September 2003 has heightened fears about a Sars comeback.

## **B. The Hong Kong Housing Market**

The property market in Hong Kong is of much interest in its own right. Hong Kong has among the highest property values in the world, and the market is widely believed to have experienced a bubble in the 1990s. Hong Kong real estate prices have

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<sup>32</sup> In one super-spreading event, at least 16 guests and visitors contracted Sars from the “index patient” in Metropole Hotel during his stay of one night, before spreading the disease worldwide through air travel.

experienced a sharp decline since mid-1997 (see Figure A1).<sup>33</sup> By the end of 2002, Hong Kong residential housing prices had declined by more than 65 percent from their peak level in 1997. Since 1999, however, housing prices in Hong Kong have followed a relatively steady, gradual downward trend.

The Hong Kong government owns all the land in the territory, and controls the land supply. All instruments which affect real and immovable property, including sales and purchases of flats, are usually registered with the Land Registry subject to the provisions of the Land Registration Ordinance, which prevent a loss of priority to any subsequent registered transactions. Most owners sell their properties through estate agencies, according to the Hong Kong Estate Agents Authority.

Since 1998 the Hong Kong government has devised various interim policy schemes to stabilize housing prices, but to little effect.<sup>34</sup> Regulations on the completion period of construction projects and on the pre-sale period on uncompleted flats (which restricts sales activities to start no more than 20 months before completion), limit the scope to which developers have to schedule completion and launching of new units. It is unlikely that supply management would have caused a discrete jump in prices during the period under study.

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<sup>33</sup> *Business Week*, May 19, 2003. The reasons for this crash are complicated, and possibly include the land and public housing supply policies of the government before and after the handover, the Asian financial crisis, and speculative behaviour by investors.

<sup>34</sup> JP Morgan, July 3, 2003, *The Standard*. In November 2002, the government suspended the sales of land and of all subsidized flats under the Home Ownership Scheme, limiting long-term supply of housing units to support the housing prices. However, the main property developers have a holding of farmland available for conversion equivalent to four years' supply. Many blame the excess supply of residential flats in Hong Kong for the continuous fall in prices.

**Table 1: Summary Statistics**

	Mean (s.d.)		
	All 44 Estates	20 Listed Estates	24 Unlisted Estates
Sales price in Jan-July 2003 (per sq. ft.; USD)	370.08 (176.81)	281.78 (93.42)	391.84 (185.57)
Sales price in 2002 (per sq. ft.; USD)	417.17 (195.41)	329.47 (96.93)	490.26 (226.64)
Turnover rate in Jan-June 2003	0.07 (0.08)	0.06 (0.05)	0.07 (0.10)
Turnover rate in 2001-2002	0.09 (0.09)	0.09 (0.06)	0.09 (0.11)
Number of blocks	23.07 (21.84)	30.60 (23.07)	16.8 (19.01)
Number of floors per block	31.66 (10.20)	29.10 (5.99)	33.79 (12.43)
Number of flats per floor	6.67 (5.52)	7.02 (1.71)	6.38 (3.05)
Estate resident population ('000)	13.74 (12.97)	19.53 (14.09)	8.92 (9.86)
Building age	14.27 (5.37)	16.13 (5.52)	12.72 (4.82)
Number of times listed	1.24 (2.17)	2.70 (2.58)	0.00 (0.00)
Number of times listed excluding Amoy Gardens	1.03 (1.72)	2.32 (1.97)	--
Number of days listed	5.12 (7.66)	11.20 (7.97)	0.00 (0.00)
Number of days listed excluding Amoy Gardens	4.91 (7.63)	11.05 (8.16)	--
Number of Sars cases	10.37 (49.46)	22.35 (72.35)	0.00 (0.00)
Number of Sars cases excluding Amoy Gardens	2.76 (4.52)	6.21 (5.09)	--
Sars infection rate (%)	0.07 (0.31)	0.15 (0.46)	0.00 (0.00)
Sars infection rate (%) excluding Amoy Gardens	0.02 (0.03)	0.04 (0.04)	--
Total number of news mentions in connection to Sars up to 24 June	5.84 (46.46)	27.67 (101.38)	0.46 (4.55)
Total number of news mentions excluding Amoy Gardens	1.36 (2.96)	3.61 (4.68)	--
Predicted Sars risk (%)	0.02 (0.03)	0.05 (0.03)	0.01 (0.01)

<sup>1</sup> Listed refers to housing estates that were ever listed on the Department of Health "List of Buildings with Confirmed Cases". Amoy Gardens was the first and most serious cluster site.

**Table 2: Pre-Sars Estate Characteristics and Sars Infection Rate**

Dependent Variable: No. of Cases/ 100,000 Estate Residents  
Tobit Regressions [weighted by no. of flats in each housing estate]

	(1)	(2)	(3)	(4)	(5)
Pre-SARS median sales price 2002 in USD / 10,000	-1.36*** (0.49)	-1.17** (0.51)	-1.54*** (0.54)	-1.72*** (0.61)	-1.20** (0.61)
Travel time to city center (hours)	--	26.18 (27.67)	--	--	67.59** (30.74)
Availability of estate facilities (1 = Yes)	--	--	89.99*** (18.24)	--	43.91** (19.00)
Estate population ('000)	--	--	--	10.30*** (2.18)	8.91*** (2.26)
Estate population squared	--	--	--	-0.15*** (0.04)	-0.13*** (0.04)
<i>P-value of F-tests</i>					
Population quadratic	--	--	--	0.00	0.00
Model log likelihood	-481.3	-480.9	-463.2	-454.2	-448.29
No. of observations	280	280	280	280	280

<sup>1</sup> All regressions include a constant term. Standard errors reported in parentheses. \*\*\* denotes statistical significance at 1%, \*\* at 5% and \* at 10%. Weighted mean [standard deviation] of the dependent variable is 17.20 [31.46].

**Table 3: Price Impact of Various Sars Information Channels**

Dependent Variable: Ln(Hedonic-adjusted Weekly Prices per sq. ft.)  
GLS regressions with Estate-specific AR(1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Sars Indicator</b>	<b>Start-of-epidemic dummy</b>	<b>Sars infection rate</b>	<b>Per capita, cumulative no. of days listed*</b>	<b>Cumulative no. of days listed</b>	<b>Per capita, cumulative no. of all news articles</b>	<b>Per capita, cumulative no. of English news articles</b>	<b>Per capita, cumulative no. of Chinese news articles</b>	<b>Predicted Sars risk</b>
<b>A. Main effect</b>	-0.016*** (0.004)	-0.071*** (0.014)	-0.039 (0.070)	0.006 (0.004)	-0.052*** (0.020)	-0.054** (0.024)	-0.061 (0.041)	-0.016 (0.026)
Conditional avg impact on affected estates (%)	1.60	2.78	--	--	1.30	1.11	--	--
Impact on 25th percentile (%)	1.60	0.00	--	--	0.00	0.00	--	--
Impact on 75th percentile (%)	1.60	1.78	--	--	1.15	0.63	--	--
<b>B. Main effect</b>	-0.014*** (0.004)	-0.080*** (0.014)	-0.135* (0.078)	0.004 (0.004)	-0.050** (0.020)	-0.053** (0.024)	-0.070* (0.041)	-0.022 (0.027)
<b>Ln 2001 price interaction term</b>	0.007 (0.005)	-0.088*** (0.021)	-1.066*** (0.316)	0.001 (0.003)	0.013 (0.061)	0.010 (0.077)	0.109 (0.113)	-0.010 (0.008)
No. of estates	43	43	43	43	43	43	43	43
No. of observations	2,752	2,752	2,752	2,752	2,752	2,752	2,752	2,752

<sup>1</sup> Standard errors reported in parentheses. All regressions include a constant term, estate fixed effects and district-specific linear time trends. They also include weekly fixed effects, except for Column 1 where I control for a cubic time effect. All controls are significant at 1%. \*\*\* denotes statistical significance at 1%, \*\* at 5% and \* at 10%.

<sup>2</sup> Mean [standard deviation] of the dependent variable is 5.80 [0.43].

<sup>3</sup> Mean [standard deviation] of the log pre-Sars baseline price is 0.00 [0.43] for the 43 estates included in Column 2.

\* An estate was listed on any given day if it appeared on the Department of Health "List of Buildings with Confirmed Cases".

Table 4: Risk Valuation and the Implied Economic Values of Life

Sample	Sars risk (per 100,000)	Mean housing value (‘000 USD)	Median housing value (‘000 USD)	Implied Economic Value of Life			
				<i>[Mean housing value]</i>		<i>[Median housing value]</i>	
				Lower Bound	Upper Bound	Lower Bound	Upper Bound
44 CCI constituent estates, excl Amoy Gardens	17.55	273.07	212.83	110.27	735.14	85.94	572.95
Territory-wide	25.80	448.93	207.74	123.32	822.11	57.06	380.43
Territory-wide, excl Amoy Gardens	21.02	450.04	208.65	151.74	1011.59	70.35	468.99

<sup>1</sup> All calculations make use of my estimate of a 7.08 percent housing price fall for each Sars case in 1,000 people. The upper bound is derived under the assumption that the Sars-related price fall is solely due to the fatality risk of 15%, but not the morbidity risk. The lower bound is derived assuming that a Sars death caused as large a price fall as a non-fatal Sars case.

<sup>2</sup> Median value of owner-occupied housing units in the US in year 2000 is USD 119,600. The 1999 median household income in the US is USD 42,000, compared to around USD 30,000 in Hong Kong in 2001.

**TABLE 5: Volume impact of various Sars information channels**

Dependent Variable: Weekly transaction turnover rate  
Tobit regressions

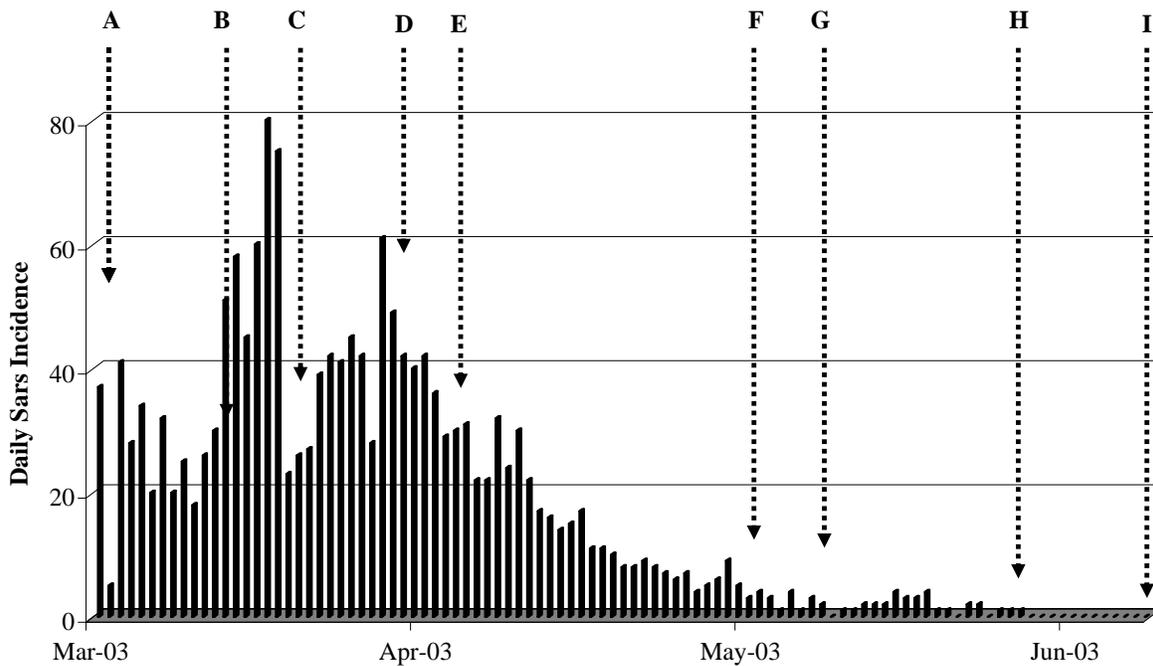
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Start-of-epidemic dummy	Per capita, cumulative no. of weeks listed	Proportion of current week on list	Per capita, cumulative no. of all news articles	Per capita, cumulative no. of English news articles	Per capita, cumulative no. of Chinese news articles	Predicted Sars risk
A. Main effect	-0.050*** (0.018)	-1.723* (1.032)	-2.411 (3.060)	-0.535* (0.292)	-0.237 (0.367)	-1.285** (0.541)	0.042 (0.044)
Conditional avg impact on affected estates	-0.05	-0.02	--	-0.01	--	-0.01	--
Impact on 25th percentile	-0.05	-0.004	--	0.00	--	0.00	--
Impact on 75th percentile	-0.05	-0.02	--	-0.003	--	0.00	--
B. Main effect	-0.051*** (0.018)	-1.535 (1.089)	-2.533 (3.293)	-0.491 (0.313)	-0.262 (0.388)	-1.146 (0.827)	-0.020 (0.058)
Ln 2001 price interaction term	-0.048* (0.026)	2.695 (5.036)	-1.516 (15.141)	-0.247 (0.639)	0.145 (0.720)	-0.398 (1.793)	-0.107* (0.064)
No. of estates	43	43	43	43	43	43	43
No. of observations	1,118	1,118	1,118	1,118	1,118	1,118	1,118

<sup>1</sup> Standard errors reported in parentheses. All regressions include a constant term, estate fixed effects and district-specific linear time trends. They also include weekly fixed effects, except for Column 1 where I control for a cubic time effect. All controls are significant at 1%. \*\*\* denotes statistical significance at 1%, \*\* at 5% and \* at 10%.

<sup>2</sup> Mean [standard deviation] of the dependent variable is 0.060 [0.080]. Mean [standard deviation] of the dependent variable for the pre-Sars period is 0.068 [0.078].

<sup>3</sup> Mean [standard deviation] of the log pre-Sars baseline price is 0.00 [0.43] for the 43 estates included in Column 2.

**Figure 1: Daily Incidence and Main Events in the 2003 Sars Epidemic in Hong Kong**



**Main Events:**

- A: WHO defined Sars as a new disease. (Mar 15, 2003)
- B: Community spread of Sars confirmed by Hong Kong Government. (Mar 26, 2003)
- C: WHO travel advisory against all non-essential travels to Hong Kong. (Apr 2, 2003)
- D: Start of the daily Government List of Buildings with Confirmed Sars Cases. (Apr 12, 2003)
- E: Publication of the Amoy report, identifying links between living conditions and the spread of Sars. (Apr 17, 2003)
- F: WHO report on Amoy published. (May 16, 2003)
- G: WHO travel advisory lifted. (May 23, 2003)
- H: Last Sars patient diagnosed. (Jun 12, 2003)
- I: Hong Kong removed from the WHO list of Sars-affected areas. (Jun 23, 2003)

**Figure 2: The Centa-City Leading Index vs. The Centa-City Index**



**Appendix: Characteristics of Housing Estates**

Estate	No. of times Listed	No. of days on list	No. of blocks	No. of floors	No. of flats per block	Age	Travel time to city center	Flat size	Per Sq. Ft. Price, 1997 (USD)	Per Sq. Ft. Price, 2002 (USD)	Total Value, 2002 (USD mil)	Price Change, 1997-2002
1	1	4	61	30	208	21	12	911	1,007	432	4,999	-57%
2	2	12	48	19	136	15	19	894	983	397	2,318	-60%
3	0	0	17	30	242	11	21	791	942	362	1,177	-62%
4	3	23	20	40	288	15	27	600	680	265	917	-61%
5	0	0	88	16	120	15	20	775	981	374	3,062	-62%
6	2	13	19	33	318	13	33	770	672	281	1,305	-58%
7	1	2	15	30	240	12	70	740	461	194	516	-58%
8	1	8	23	33	240	17	38	440	599	274	666	-54%
9	5	19	52	27	216	19	26	707	708	305	2,423	-57%
10	10	14	19	33	264	19	23	490	692	293	719	-58%
11	0	0	32	30	208	16	12	909	996	396	2,394	-60%
12	0	0	33	27	47	26	23	1,500	851	399	919	-53%
13	0	0	2	47	651	8	10	1,243	1,757	744	1,204	-58%
14	2	10	58	35	274	8	70	1,162	537	209	3,850	-61%
15	0	0	10	38	250	7	28	1,329	1,198	473	1,571	-61%
16	0	0	13	33	178	9	28	706	807	263	430	-67%
17	0	0	18	20	60	13	57	2,266	1,911	791	1,936	-59%
18	2	7	38	27	212	11	21	790	888	330	2,106	-63%
19	0	0	5	40	79	11	10	2,100	2,408	1,019	845	-58%
20	1	1	11	35	69	14	3	1,700	1,231	633	817	-49%
21	0	0	14	28	171	18	10	1,044	985	438	1,094	-56%
22	0	0	34	42	332	10	35	1,000	1,000	387	4,373	-61%
23	8	29	99	20	153	30	12	850	602	236	3,038	-61%
24	0	0	33	7	48	8	10	1,000	1,338	538	853	-60%
25	1	1	41	26	122	22	21	570	778	308	878	-60%
26	0	0	33	28	147	12	60	750	777	242	879	-69%
27	0	0	5	29	208	9	35	630	649	285	187	-56%
28	3	21	11	38	296	13	20	580	735	316	596	-57%
29	6	22	20	32	240	9	70	800	791	344	1,321	-57%
30	0	0	12	27	200	12	46	600	564	238	343	-58%
31	1	6	6	24	192	9	48	550	689	312	198	-55%
32	0	0	1	46	595	13	3	976	2,102	709	411	-66%
33	2	12	17	25	100	20	10	1,200	908	417	850	-54%
34	0	0	3	47	261	6	10	808	1,242	497	315	-60%
35	1	8	17	19	135	15	12	728	954	422	706	-56%
36	0	0	20	27	212	23	18	600	781	340	866	-56%
37	1	6	20	26	154	22	39	570	664	307	539	-54%
38	1	6	17	30	235	20	23	570	742	315	718	-58%
40	0	0	7	22	44	16	5	1,900	1,608	754	441	-53%
41	0	0	2	40	120	9	10	2,250	1,988	778	420	-61%
42	0	0	2	45	352	10	5	800	1,272	564	317	-56%
43	0	0	3	66	187	18	10	2,800	1,877	764	1,201	-59%
44	0	0	6	32	240	15	60	710	554	212	217	-62%
45	0	0	10	44	350	13	60	650	485	199	453	-59%
<b>Sum</b>	54	224									55,387	
<b>Mean</b>	1.23	5.09	23.07	31.66	213.50	14.27	26.89	994	1,009	417	1,259	-59%
<b>s.d.</b>	2.19	7.74	21.84	10.20	121.95	5.37	19.69	538	474	195	1,135	4%