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## Recommended Citation

Wong, G. (2008). Has SARS Infected the Property Market? Evidence From Hong Kong. *Journal of Urban Economics*, 63 (1), 74-95.  
<http://dx.doi.org/10.1016/j.jue.2006.12.007>

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# Has SARS Infected the Property Market? Evidence From Hong Kong

## **Abstract**

This paper uses the 2003 Hong Kong Severe Acute Respiratory Syndrome (SARS) epidemic as a natural experiment to investigate how housing markets react to extreme events. A panel data set of large-scale housing complexes (estates) is used to exploit the cross-sectional variation in the spread of SARS to estimate the effect of the disease on real estate prices and sales. SARS risk is measured by: (1) the estate-level SARS infection rate, (2) news reports, and (3) government announcements of infections. The average price declines by 1–3 percent if an estate is directly affected by SARS, and by 1.6 percent for all estates as a result of the outbreak of the disease. A back-of-the-envelope calculation of the expected price fall under the rational asset-pricing model implies that the economic value of life consistent with the SARS-related price movement was less than \$1 million. This low figure contrasts with the predictions of overreaction from psychological and behavioral economics theories. An analysis of transaction volume suggests that the absence of price overreaction is likely to be related to housing market characteristics, including transaction costs, credit constraints and loss aversion.

## **Keywords**

SARS, housing prices, overreaction, shocks, epidemics

## **Disciplines**

Marketing | Real Estate

# Has SARS Infected the Property Market?

Evidence from Hong Kong<sup>†</sup>

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<sup>†</sup> This is an update of the first chapter of my PhD thesis at Princeton University. I am indebted to my advisors Alan Krueger and Cecilia Rouse for continuous support. I thank Joe Gyourko and Peter Linneman for helpful suggestions. I have benefited from detailed discussions with Orley Ashenfelter, Robin Burgess, Janet Currie, Richard Green, Harrison Hong, Rohini Pande, Jesse Rothstein, Jose Scheinkman and Nancy Wallace, and with seminar participants at Princeton University, the London School of Economics, the Wharton School, Georgetown University, the Haas School of Business and the Sauder Business School. Eugene Brusilovskiy, Anna Huang, Elaine Huang and Alexandra Infeld provided excellent research assistance. Financial support from the Industrial Relations Section, Mellon Foundation/Princeton University Research Program in Development Studies, and MacArthur Foundation/Princeton University Centre of International Studies is gratefully acknowledged. All errors remain mine.

**Abstract:** This paper uses the 2003 Hong Kong Severe Acute Respiratory Syndrome (SARS) epidemic as a natural experiment to investigate how housing markets react to extreme events. A panel data set of large-scale housing complexes (estates) is used to exploit the cross-sectional variation in the spread of SARS, comparing the impacts on prices and sales of (1) the estimated estate-level infection rate, (2) news reports, and (3) government announcements of infections. The average price decline is 1-3 percent for the average SARS-affected estate, and 1.6 percent for all estates. A back-of-envelope calculation of the implied economic value of life, at less than \$1 million, helps put the price decline in perspective. This contrasts with the predictions of psychological and behavioral economics theories. An analysis of transaction volume suggests that the absence of price overreaction is likely to be related to housing market characteristics, including transaction costs, credit constraints and loss aversion.

**Key Words:** SARS, housing prices, overreaction, shocks, epidemics

## 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 SARS deaths worldwide. The risk of contracting SARS in Hong Kong during the epidemic (0.026 percent) exceeded the yearly risk of contracting AIDS in high-income countries (0.008 percent in 2002). This apparent vulnerability raises the possibility that Hong Kong has since been perceived as a less desirable place in which to work and live.<sup>1</sup> Coincident with the unanticipated epidemic, housing prices in Hong Kong fell by 8 percent. Is this dramatic price decline – representing a total value of \$28 billion, equal to about \$16 million per SARS case – a continuation of the pre-SARS downward trend, or a response to the epidemic?<sup>2,3</sup>

This paper attempts to answer this question. Firstly, the extent to which the drop in housing prices can be attributed to the SARS epidemic is estimated. Using a unique panel data set of weekly transaction prices of 44 housing complexes (estates), the cross-sectional variation in the timing and spread of SARS within Hong Kong is exploited. The perceived location-specific risk is measured by analyzing all major sources of public information related to the 44 estates. A best estimate of the estate-level SARS infection rates is also created.<sup>4</sup> Next, we investigate whether the drop in prices can be characterized as overreaction, as compared to the predictions of the standard asset pricing model [25]. To better understand the price movements, a similar analysis is performed for turnover rates in the housing market.

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 declines. Cross-sectional differences in price changes come from variations in the spread of SARS.

Because of its exogeneity and extreme consequences, the SARS epidemic provides a unique setting to measure market reactions to extreme events. Unlike other exogenous extreme events that have previously been studied (e.g., flooding), the 2003 epidemic involves a clear change in 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 reaching 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 [33, 34]. This tendency to overreact to new risk may be offset in this case, however, because there is reason to believe that cognitive errors in judgment are less likely when the costs to the decision maker are high [9]. Housing sale 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 evaluate the significance of 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 [27].<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. Consequently in focus is the "medium-run" impact of the various indicators over a period of 38 weeks, 13 during the epidemic and 25 after, which is relevant to most households given the long holding period of housing units.<sup>7</sup> 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 on 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, a range of estimates of the marginal willingness-to-pay to avoid the risk of the epidemic is presented.

Several noteworthy results emerge from this analysis. A price decrease of 1.6 percent is identified after the start of the epidemic for all housing estates, as well as an additional decrease of 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 \$121,000 to just over \$1 million, falls towards the lower end of the range based on studies of non-extreme risks. Although the nature of the SARS risk limits the extent to which this value of life estimate can be generalized, it helps put the SARS-related price decline in perspective. I conclude there is no evidence for price overreaction.

These results also provide insight concerning the dissemination of public health information during the SARS epidemic. Despite the absence of any publicly available measure of estate-level SARS risk, we can identify a significant negative price reaction in response to the estimated infection rate. Independently, the per capita number of SARS-related mentions of specific estates in the English-language (but not Chinese-language) newspapers was associated with significant price decreases. However, public exposure through the government SARS-list did not have similar effects.<sup>8</sup> Price reactions towards all SARS indicators are small, providing little evidence for a magnification of noises in public information [21].

Several explanations for the lack of observed price overreactions are examined through a similar analysis of transaction volumes. Measurement errors in the SARS risk indicators attenuate coefficient estimates in the price regressions, but significant decreases in turnover rates identified suggest that this does not drive the price results.<sup>9</sup> A “wait-and-see” attitude, driven by either liquidity constraints [32] or loss aversion [8], implies a decline in volume and an attenuation of negative price reactions. Evidence for this phenomenon is found in the significant turnover rate declines associated with the SARS-list and the Chinese news indicators, to which there is a lack of related price responses.<sup>10</sup>

The following section provides a chronology of the 2003 epidemic. Section 3 then discusses the related literature, Section 4 describes the data, Section 5 reports the empirical findings, and Section 6 offers conclusions.

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

Figure 1 shows a timeline of the 2003 epidemic. 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>11</sup> March 26, 2003 is adopted as the start date, as this marks the point at which Hong Kong’s residents were left with no doubt that SARS was to affect the general population, not merely the small circle of close medical and family contacts of existing SARS cases.<sup>12</sup> Using alternative dates adjusts estimates slightly upwards.

As residents became 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.

More than two weeks after the start of the epidemic, the Hong Kong Department of Health began publishing a daily "List of Buildings of Confirmed SARS Cases" (SARS-list) on April 12, making it available to the general public, to the 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 coarse 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. Suspected SARS cases mentioned in the newspapers might or might not appear on the government SARS list, and there was often information on specific cases in other dimensions, such as demographics. A detailed study is conducted on newspaper reports that related specific housing estates to the epidemic.

The first official scientific SARS analysis was published on April 17, 2003, in a Hong Kong Department of Health report on the Amoy Gardens outbreak. It ruled out the theory that SARS was airborne, but concluded that sewage flaws, sharing of communal facilities, environmental contamination, and pests played parts in spreading the virus. An independent WHO investigation (May 16) resulted in similar findings. A predicted SARS risk measure is generated based on these findings.

After a large-scale shutdown of normal activities, including a suspension of all school classes for more than three 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, but many medical experts believe that SARS will return.

Amoy Gardens deserves extra attention, since it was the site of the first and most severe cluster of SARS in Hong Kong, with a total of 329 cases. In addition, a large number of these cases occurred before precautionary measures had been taken. The number of news reports on Amoy Gardens with a direct relation



to the epidemic is 10 times that of the average estate appearing on the government list (Table 1). Section 5 describes estimation results both with and without Amoy Gardens in the sample.

### 3. Theoretical Background

#### A. Rationality and Forward-Looking Behavior

Under the standard asset-pricing model [25], any expected change in the net present value of future housing services, either due to health risk or to 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>13</sup> The housing services are discounted by the effective real interest rate  $r$ :

$$(2) \quad r = (1-\theta)(L*i_b) + (1-L)i_l - \pi$$

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  $\pi$  the inflation rate. (It should be noted that mortgage interest payments are deductible from salary (personal income) taxes in Hong Kong.)

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

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

To consider an extreme but transitory shock, suppose that six months of housing services are destroyed completely 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 and 2.58 percent, which implies a decline of 1.21-1.29 percent.<sup>14</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 decrease in prices.

Besides decreasing the general quality of life in Hong Kong, thus creating a territory-wide impact, SARS also created a new health risk specific to each building. To consider the implications, higher-quality

housing units can be conceived 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. Denoting 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. Thus, it is unambiguous that prices of housing structures with higher SARS risks would decrease after the epidemic, relative to those of housing structures with lower or no SARS risk, other things being constant. The estate-specific SARS indicators offered here attempt to capture this price decrease.

### **B. Overreaction**

Although appealing, the assumption of rationality upon which the asset-pricing model is based is probably not appropriate, since strong emotions and uncertainty associated with the SARS epidemic might cause decisions to deviate from rationality.<sup>15</sup> The SARS risk was likely 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 [29]. Prospect theory [13] 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 [2, 28, 14, 29].

There is a vast economic literature documenting risk perception biases, where rare risks tend to be overestimated. [34] provides a survey and illustrates that 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 tends to be the most significant when a risk is discovered, and the probability jumps from zero to positive.

### **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 invest substantial resources in the search process [16].

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., [37], 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. [32] 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 either postpone sale, or to set a higher asking price and wait to "fish" for a higher-than-average price offer. This implies an attenuated price decline 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 behavior.

Alternatively, [8] turns 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 purchase price, or the highest price their homes have ever attained [13, 14]. 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**

The current panel data set represents 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 (or about half of the total population). Twenty of the 44 estates were listed on the Department of Health SARS-list at some point during the epidemic.<sup>16</sup>

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>17</sup> The data span 64 weeks, including 25 before the start of the epidemic and 25 after its end.

The structure of the data offers an analytical advantage. 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 three transactions in an estate per week. The panel structure of the data allows the circumvention of two problems often encountered in housing studies. Heterogeneity in housing units in cross-sectional samples gives rise to comparability problems, since structural and locational characteristics are often difficult to measure. In repeat sales samples, the sample of units that are sold multiple times may not be representative.<sup>18</sup> The substantial similarity of units within each housing estate makes this sample an attractive alternative.

To investigate the potential bias of the CCL, based on contracts handled by Centaline only, compare it with the Centa-City Index (CCI).<sup>19</sup> While both indices are derived from hedonic-adjusted price data for the same 44 constituent estates, the CCI is computed using prices from all transactions registered with the Land Registry. In addition, 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 nine 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**

The Memorial Day Book of the Hong Kong Land Registry, from January 2001 to June 2003,<sup>20</sup> contains the date of registration, address of the property, consideration (price) and date of execution for 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, data are assembled 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, the last two weeks of observations in June 2003 are removed from the sample, so that the first 24 weeks of 2003 are in focus.<sup>21</sup>

## **C. Housing Estates Characteristics**

Hand-collected data considers characteristics of the 44 housing estates that might be related to the spread of SARS, including: age, number of floors, number of flats per floor, and number of blocks.<sup>22</sup> To generate an estimate of each estate's population, the total number of flats (blocks times floors times flats per floor) is multiplied 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>23</sup> (Table 1)

The travel time to city center from an estate is measured by the amount of time spent on the most prevalent form of public transport to the closer of the two main commercial/financial centers in Hong Kong, Tsim Sha Tsui and Central. Information on travel time to city center was collected from the transportation companies and real estate agents.<sup>24</sup>

## **D. SARS Indicators**

### (i) Territory-Wide Onset of SARS Epidemic Indicator

The onset of the SARS epidemic indicator is defined as March 26, 2003, when the Chief Executive of Hong Kong declared that the outbreak had reached epidemic levels. Experimenting with alternative definitions does not materially change the results.

(ii) SARS Infection Rate

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

An estimate of the estate-level SARS infection rate is calculated as follows. For Amoy Gardens, the largest cluster of cases, the SARS infection rate is calculated by dividing the number of cases by estate population. For twenty-four other estates with no listing, the infection rate is assumed to be 0. For the 19 remaining estates, the number of cases is estimated by multiplying the number of times each appeared on the SARS-list by the average number of cases per listing outside the four largest clusters.<sup>25</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 used in estimating the SARS infection rate became available only after the epidemic had ended. Therefore, SARS risk variable is defined as 0 before the end of the epidemic, and as equal to the estate-specific infection rate afterwards.

(iii) SARS-List Indicators

Because the SARS infection rate is not directly or accurately observed, it will be interesting to contrast its price impact with that of SARS-related public information. The primary official source of information on SARS during the epidemic was the Hong Kong Department of Health List of Buildings with Confirmed SARS Cases, published daily. SARS-related public exposure of each estate is measured by the cumulative number of days an estate appeared on the SARS-list. This captures how frequently government announcements related each estate to the epidemic, experimenting with both the raw count and the per capita measure.

(iv) SARS-Related News Count

The media was an alternative source of information about SARS during the epidemic. To create a news count, newspaper articles mentioning each of the 44 estates in connection to SARS are tabulated from

four prominent newspapers, two in English and two in Chinese (the two official languages in Hong Kong), with a total daily circulation of approximately 320,000 copies.<sup>26</sup> The news count is then created by dividing the number of articles by estate population. The information content of the news articles does not perfectly correspond to that of the SARS-list statistics.<sup>27</sup> The period in focus spans March 26-June 24, 2003, outside of which individual housing estates were rarely mentioned in connection with SARS.

(v) Predicted SARS Infection Risk

Based on links drawn between living conditions and the spread of SARS in the scientific reports, a predicted SARS risk measure is created using a Tobit regression:

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

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. The explanatory variable  $X_i$  includes the baseline price level in 2002, travel time to the center of the city, and building attributes, including the availability of communal facilities and a population quadratic. Thus, this analysis makes use of information not readily available to the public.

Table 2 contains the regression results. [38] offers a more detailed discussion of how the spread of SARS relates to living conditions and socioeconomic status.<sup>28</sup> The predicted SARS risk is generated 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

Focusing on the 64-week period beginning 25 weeks before the epidemic and extending to 25 weeks after its end, and using weekly prices of 44 housing estates, Feasible General Least Squares (FGLS) are estimated as regressions of the form:

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

$P_{it}$  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, the regression is weighed by the total number of flats in each estate to adjust for heteroskedasticity.<sup>29</sup>

“SARS” refers to one of the SARS indicators outlined in Section 4.  $\Psi(t)$  is a time control depending on SARS: weekly fixed effects are controlled for 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.

Panel A of Table 3 shows the primary results. Column 1 demonstrates 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, such as when the WHO defined SARS as a new disease on March 15, 2003. Column 1 was repeated using data from 12 months before the epidemic, resulting in no similar decline in prices. This suggests that the frequently cited 8 percent drop 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.

Estate-specific SARS indicators measure the price movements directly attributable to the epidemic. Firstly, the impact of the best estimate of the estate-specific SARS infection rate (per 1,000) is investigated. 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 decline of 2.78 percent.<sup>30, 31</sup> A significant price decrease of smaller magnitude is identified when Amoy is included.

Interestingly, there is no significant price decline for public exposure as measured by the number of days an estate remained on the SARS-list, both adjusted and unadjusted for estate population (columns 3 & 4). The housing market seems to have correctly taken into account the fact that a longer stay on the list meant less than a higher number of separate listings, which is proportional to the infection rate estimate.

To put this estimate in context, the implied economic value of life is calculated and compared with findings in the literature on non-extreme events.<sup>32</sup> Without knowledge of how much of the price decrease is attributable to the non-fatal SARS risk, a range for the implied value of life is calculated in Table 4. It can be derived by dividing the mean price decline by the unconditional mortality risk (SARS infection rate times



case mortality risk). Assuming that the price decline 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 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 \$121,000 to just over \$1 million. Compared with labor market study estimates of economic value of life from \$600,000 to over \$10 million (see [36], Table 2 for a summary of the literature), our estimate suggests that the housing prices did not overreact to the SARS risk. While this is a rough calculation based on an average concept, it provides useful insights into the question of overreaction.<sup>33</sup>

These estimates are also much smaller than what [19] finds in two surveys conducted during the epidemic in Taiwan (\$3 million-\$12 million) via contingent valuation methods. The authors note that the time of data collection might have led to large estimates. Our results suggest that the analytical approach might also play a role, because similar evidence in the Hong Kong housing market is not found around the same period.

Besides the government SARS list, the mass media was another important information source during the epidemic. 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 mentioned.<sup>34</sup> Further separating the news mentions by the language of the papers, we 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, in terms of source, content and timing. The infection rate could only be known after the end of the epidemic, while estates ceased to be mentioned in direct relation to SARS in the newspapers slightly before that time. Newspaper reports making references to specific estates often referred to unofficial sources, such as neighborhood 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 a significant price impact. This measure serves as an index of observable housing characteristics that are empirically correlated to the SARS infection rate. This is a surprising result, since the scientific reports linking living conditions and 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 decline (lasting for 25-75 days) of 1.6 percent. This is sensitive to the rebound cut-off point, and should be taken as suggestive only, as other SARS indicators do not show similar rebound patterns.

At the bottom of Panel A are 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 the mean suffer roughly half the price decline of those at the 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 the 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 expensive estates more significantly. Given that the standard deviation of housing prices in Hong Kong is more than seven times the standard deviation in the current sample, caution should be exercised in extrapolating these results to draw conclusions about the territory as a whole.

#### **B. Why Was There No Price Overreaction? – Impact of SARS on Turnover**

Under the same framework as above, we can 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 conceived as the probability of any unit in estate  $i$  being sold in week  $t$ . The three control groups included as before – the estate-fixed effects, district-specific linear time trends and time effect – are significant at the 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>35</sup> Column 1 shows a significant territory-wide drop in turnover rate of 0.05 percentage points. Compared to the average pre-SARS turnover rate of 0.068 percent, this is a 72 percent decrease. The per capita SARS-list indicator has a significant impact on turnover, contrary to what is found in prices (column 2). The average impact on the typical SARS-affected estate is 0.02 percentage points. The magnitude of the turnover responses to the SARS indicators alleviates concerns about significant attenuation bias in the price impacts due to measurement errors.

To explore whether this is mainly due to an increase in search costs, the On-list indicator is defined as the number of days on which 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 are most important. Column 3 shows the contrary, lending support 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 reduce the turnover rate by 0.01 percentage points on average (column 4), which is mainly driven by the Chinese-language newspapers (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, the results point to a “wait-and-see” attitude, which led to decreased turnover frequency and an attenuated price response. This is consistent with the down payment and loss aversion models.

There is only very weak evidence for any differential in turnover rate reactions according to pre-SARS prices (Table 5, Panel B). My estimates of the primary 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 the 10 percent level only. Because of the lack of volume data after the end of the epidemic, the impact of the SARS infection rate on turnover rates is not examined.

## **6. Conclusions**

SARS first struck human populations in 2003, infecting 8,422 people worldwide and killing 916. The 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 fewer cases of SARS, and it was unclear whether the 8 percent housing price decline was a market reaction to expectations of a significant decrease in demand. Exogenous and unanticipated, the 2003 SARS epidemic provides a unique setting to study whether emotions associated with extreme events have strong market implications as predicted by psychological and behavioral economics theories, or 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 decline of 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 declines directly attributable to public information related to the SARS epidemic. This specification points to an average price decline of 2.61 percent.

The best estimate of the SARS infection rate at the estate level compensates for the lack of public record. The price changes correlated with the estimated infection rate suggest that the marginal buyer in the housing market was aware of the SARS infection risk at the estate level, without given any direct information on the magnitude of the risk. Price responses are also associated with per capita measures of newspaper mentions. No reaction is identified towards the more visible but cruder measures, such as the number of days listed on the government list or of news mentions. This paints a different picture than some models of financial markets under which agents with private information overweigh noises in public information (e.g., [21]). To put the SARS-related price decline in perspective, the implied economic value of life ranges from

\$110,000 to approximately \$1 million. This estimate is toward the bottom end of the range in the existing literature, consistent with my conclusion that the housing market did not overreact to the epidemic.

The magnitude of the price responses is unlikely to be caused by measurement errors, because substantial turnover declines are identified using the same indicators. Further findings indicate a turnover dry up that is more persistent than the increase in search costs brought about by the epidemic. Moreover, marked decreases in turnover are found in response to SARS indicators that do not have significant price impacts. This pattern points to a mechanism where expected downward pressure on prices leads to non-participation of sellers in the market and therefore a muted price response [32, 8]. [9] argues that under situations when the costs of errors to the decision makers are high, mistaken beliefs such as overweighing of short-term well-being and overreaction should be less common. 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 response to the SARS epidemic, without showing significant signs of overreaction.

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**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.; \$)	370.08 (176.81)	281.78 (93.42)	391.84 (185.57)
Sales price in 2002 (per sq. ft.; \$)	417.17 (195.41)	329.47 (96.93)	490.26 (226.64)
Weekly turnover rate in Jan-June 2003 (%)	0.07 (0.08)	0.06 (0.05)	0.07 (0.10)
Weekly 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	1.36	3.61	--
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 \$/ 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].

<sup>2</sup> Using Log housing prices as the housing value indicator produces very similar results.

Source: Wong (2004).

**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)

SARS Indicator	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Start-of-epidemic dummy	SARS infection rate	Per capita, cumulative no. of days listed*	Cumulative no. of days listed	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
<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 in 2002 (‘000 \$)	Median housing value in 2002 (‘000 \$)	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 decline 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 decline as a non-fatal SARS case.

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

**Table 5: Volume Impact of Various SARS Information Channels**

Dependent Variable: Weekly turnover rate (%)  
Tobit regressions

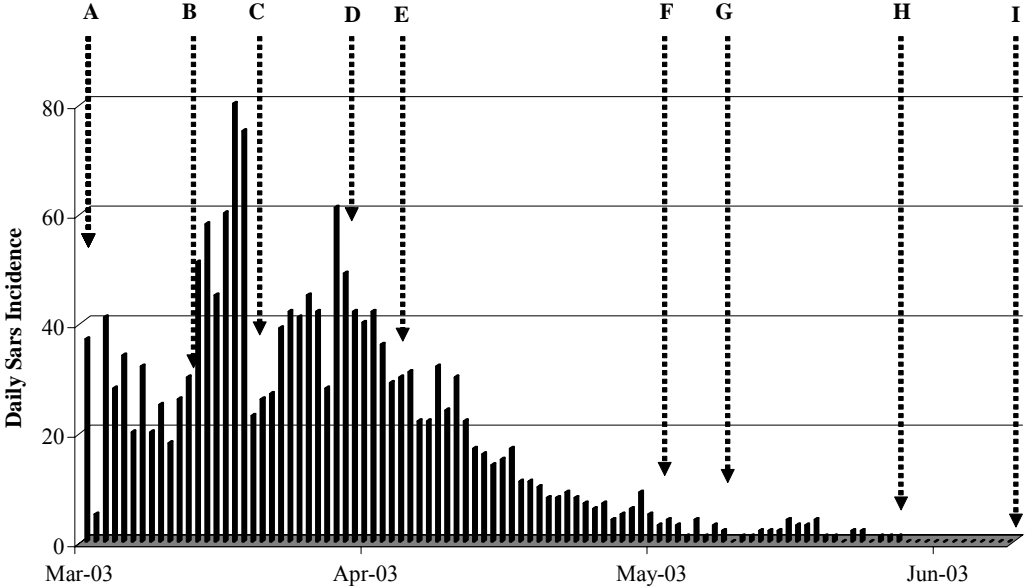
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Start-of-epidemic dummy	Per capita, cumulative no. of weeks listed	Proportion of current week on list	Per capita, cumulative no. of all news articles	Per capita, cumulative no. of English news articles	Per capita, cumulative no. of Chinese news articles	Predicted SARS risk
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

<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

<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.

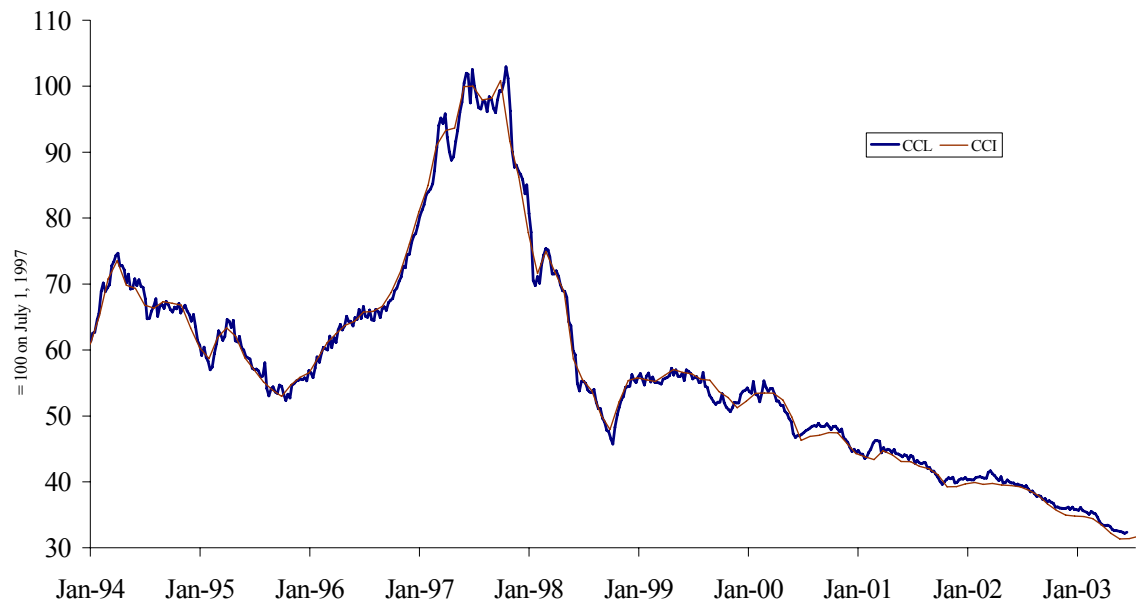
**Figure 1: Daily Incidence and Main Events in the 2003 SARS Epidemic in Hong Kong**



**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**



## 8. Footnotes

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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.

<sup>2</sup> The value of private housing stock is evaluated using year-end 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 decline 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 percent) to the acceleration of the housing price decline 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.

<sup>4</sup> The main information sources include the daily Department of Health SARS-building list (the only form of government announcement related 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.)

<sup>5</sup> For example, see [29, 2].

<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 asset prices react to the difference between the prior expectation and the realization of announcements, and we have no information for the former. 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 unfavorable announcements seem tame. This paper abstracts from short-run price movements.

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

<sup>9</sup> The average decline in turnover rate is between one to five basis points. The pre-SARS average turnover rate is 6.8 basis points.

<sup>10</sup> A search model predicts a dry up in transaction volume when search costs are high. While this might be part of the story, persistent drops in turnover rates imply this is not a complete explanation.

<sup>11</sup> Adding to the complication, there was high-profile denial by the government about community spread of SARS on March 17, 2003.

<sup>12</sup> As it turned out, less than a quarter of all SARS cases in Hong Kong affected 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.

<sup>13</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.



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<sup>14</sup> The average 1-month HIBOR (Hong Kong Interbank Offered Rate) during the first quarter of 2003 was 1.38 percent. The deflation rate was approximately 1.20 percent. The present calculations are based on a mortgage ratio ranging from 0 to 80 percent.

<sup>15</sup> For example, 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 fears by sending SMS messages to 6 million mobile phones. The modern psychology literature illustrates the importance of affective reactions in decision-making, especially under uncertainty. [12], for example, argue that affective reactions are crucial even in more “objective” contexts such as financial investment decisions.

<sup>16</sup> The Appendix Section, available on my website <http://earl.wharton.upenn.edu/~wongg/>, shows more details.

<sup>17</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>18</sup> For example, [3] show that repeat sales data give rise to spurious serial correlation. For a survey of empirical issues in house price estimations, see [5].

<sup>19</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.

<sup>20</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>21</sup> The mean lag between execution dates and registration dates is 20 days.

<sup>22</sup> These data were compiled by internet research, telephone communications with real estate agents and property developers, and visits to some estates. Age, the number of floors, and flats per floor are averages across the housing estate; number of blocks is often counted from site plans of the estates.

<sup>23</sup> There is little 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>24</sup> Twenty-two of the 44 housing estates are situated near an MTR (underground) station, and seven 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.

<sup>25</sup> The average number of cases per listing outside the four largest clusters = (total number of cases in Hong Kong – total number of cases in the four largest clusters) / (total number of listed addresses – total number of times the four largest clusters were listed).

<sup>26</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.

<sup>27</sup> Rumours or unconfirmed suspicion of SARS cases in specific estates were often reported in the papers. Some of them proved to be false, others to be local knowledge slightly ahead of the Health Department.

<sup>28</sup> Amoy Gardens is excluded. Similar conclusions were drawn from analogous regressions on the total number of days each housing estate appeared on the SARS-list. The age of building, proximity to healthcare facilities, formation of a residents’ association, style of

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building management, and whether the housing estate is public or private do not have a significant correlation with the spread of SARS.

<sup>29</sup> In all regressions presented in this section, omitting the district-specific linear time trends produces 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 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 [38].

<sup>30</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 rescaled version of the start of epidemic indicator. In results not shown, this alternative indicator is not statistically significant.

<sup>31</sup> Conditional on having at least one case, the infection rate in the 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.

<sup>32</sup> Please note that the value of life calculation is more for comparison purposes than for understanding how much markets value human lives.

<sup>33</sup> Calculation is based on 2002 housing prices. Using 1997-1998 prices inflates estimates by 100 percent, but they are still low compared to estimates in the literature. Thanks to Joe Gyourko for pointing this out.

<sup>34</sup> Using the number of news articles unadjusted for population yields a negative but insignificant point estimate.

<sup>35</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.