HONG KONG MONETARY AUTHORITY

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THE IMPACT OF CLIMATE CHANGE ON HONG KONG HOUSING PRICES: AN INITIAL ANALYSIS

Key points

- *Climate change is not a remote issue for mankind, and the resultant extreme weather conditions can affect a broad range of economic activities including property trading and housing prices, which can in turn impact banking and financial stability via changes in the collateral value of mortgages. Against this backdrop, this study provides an initial analysis on the impact of climate change on Hong Kong housing prices, focusing on physical risks such as temperature and typhoons. As such, our research echoes the international call for integrating climate-related risks into financial stability monitoring.*

- *Using a big data of residential property transactions and other climate change indicators, we have conducted a macro analysis on the impact of relevant climate variables on the average housing prices in the 18 districts of Hong Kong during 2000-2021. Our empirical strategy puts emphasis on identifying pertinent exposure, in addition to the source of climate-related risks.*

- *Our empirical results suggest that (i) global warming can meaningfully lower housing prices in the long run alongside ageing properties; (ii) increased frequency of severe typhoons may dampen housing price through related coastal hazards; and (iii) there was very small historical impact from higher rainfall and the associated flooding, partly reflecting Government's preventive measures (for example, better drainage system) that reduced climate risk exposure.*

- *On policy implications, our study can facilitate the assessment on banking sector risk, for instance, by designing stress test scenario assumptions on housing prices. Future research may also dig deeper using big data and data science*

analytics to incorporate climate-related risks into banks' property valuation models or appraisal methods. It should be noted that our research results are better treated as an initial analysis, as some climate projections provided by the Hong Kong Observatory will be revised over time, and more climate variables or exposure data may become available in the future.

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I. INTRODUCTION

1. "The era of global warming has ended; the era of global boiling has arrived," said the United Nations Secretary-General António Guterres in July 2023 as that month becomes the hottest month ever recorded in human history. **Undoubtedly, climate change is not a remote issue for mankind, and the resultant extreme weather conditions may affect a broad range of economic activities including property trading and housing prices, which can in turn impact banking or financial stability**. International organisations and academia have often found different negative impacts of climate change (for instance, hurricanes, inundation risk) on real estate valuation[2], and this could affect banking stability through changes in the value of properties used as collaterals in lending. The pilot climate risk stress test (CRST) launched by the Hong Kong Monetary Authority (HKMA) in 2021 also suggested that, under extreme scenarios, climate risks could potentially cause significant adverse impacts on Hong Kong's banking sector, although the overall assessment stressed that the banking sector remained resilient to climate-related shocks given the strong capital buffers built up by the banks over the years.[3]

2. **Against this backdrop, this paper provides an initial analysis on the impact of climate change on Hong Kong housing prices, leveraging on available climate change indicators and a big dataset of residential property transactions**. Specifically, we have conducted a macro analysis on the impact of different climate variables on the average housing prices in the 18 districts of Hong Kong during 2000-2021. To preview our research results, we find that global warming and the potentially higher frequency of severe typhoons could lower Hong Kong housing prices. Yet, the adverse impact can be mitigated by measures that reduce exposure or vulnerability. One policy implication is that our empirical results may help assess banking sector risk, for instance, via the design of CRST scenarios. **From a broader perspective, our research echoes the international call for integrating**

[2] For example, Ortega and Taspinar (2018) found that the relative prices of properties in flood zones in New York City fell and stayed low following the Hurricane Sandy in 2012. Bernstein et al. (2019) also found that among houses with similar observable characteristics, those exposed to sea level rise and hence inundation risks sold at a discount.

[3] For more details, see the report "Pilot Banking Sector Climate Risk Stress Test" published by the HKMA in December 2021, the associated press release and Yue (2021). More recently, drawing on the experience gained from the pilot CRST in 2021 and the banks' feedback, the HKMA has enhanced the CRST framework and started the second round of the CRST spanning from June 2023 to June 2024.

climate-related risks into financial stability monitoring.[4]

3. The rest of the paper is organised as follows. Section II first reviews the relationship between climate change and housing prices as well as their major transmission channels, and then on that basis generically discusses our empirical strategies. Section III presents the estimation results. In particular, we utilise the long-term climate projections by the Hong Kong Observatory (HKO) to put our model estimates into perspective. Section IV looks into the related policy implications and provides some concluding remarks.

II. HOW CLIMATE CHANGE IMPACTS HOUSING PRICES: MAJOR TRANSMISSION CHANNELS AND OUR EMPIRICAL STRATEGY

Major transmission channels

4. **Conceptually, climate change can affect housing prices through direct and indirect channels** as shown in Chart 1. Very often, **climate-related risks are broadly classified into two types: physical and transition risks**. Physical risks may arise from more frequent and intense extreme climate events, such as floods, storms, typhoons[5] and extreme temperatures ("current climate"), and also from progressive changes in climate patterns, such as rising sea level or temperature due to elevated greenhouse gases (GHG) in the atmosphere ("future climate"). On the other hand, transition risks emerge from the process of adjustment towards a low-carbon economy brought by policies, regulations or technology advancements. As a widely-cited example, fossil fuel assets can become stranded (i.e. subject to devaluations) because new regulations by the government limit the use of fossil fuels.[6]

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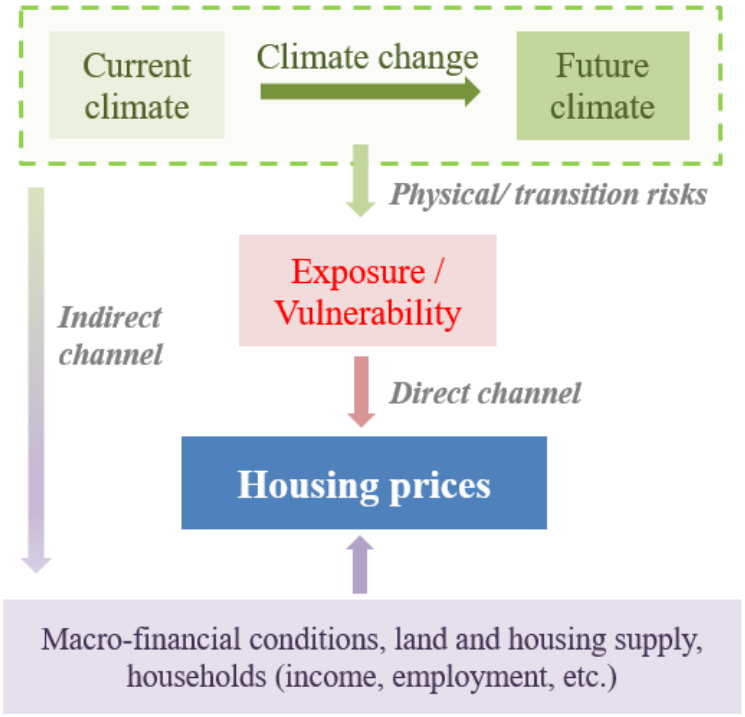
[4] For example, see the Network for Greening the Financial System (NGFS) (2019). "A call for action. Climate change as a source of financial risk", Paris, April 2019.

[5] Based on HKO's information, "cyclones" that form over the ocean in the tropical regions are generically called "tropical cyclones", although they are also known by different names in different ocean basins, such as "typhoon" in the western North Pacific, "hurricane" in the North Atlantic and "cyclonic storm" in the North Indian Ocean. In Hong Kong, the expression "typhoon" is commonly used.

[6] In Hong Kong, the Government has set out the target to cease new registration of fuel-propelled private cars (including hybrids) in 2035 or earlier, acting in tandem with the global trend to phase out fuel-propelled vehicles progressively. In the UK, transition risk arose from the implementation of minimum energy efficiency standard for buildings, and Ferentinos et al. (2021) found that prices of carbon-intensive properties affected by this policy decreased relative to unaffected ones.

Chart 1: How climate change impacts housing prices: major transmission channels



Note: Simplified and for illustration only.
Sources: IMF (2020) and HKMA staff illustration.

5. **In the face of changing climate, some residential properties are more exposed or vulnerable**[7] **to specific types of climate-related risks**. For example, housing prices in coastal areas may have larger risk exposure and higher vulnerability to typhoons compared to inland areas. Similarly, houses in low-lying areas may be more likely to fall victim to heavy rainstorms and flooding. These examples illustrate the direct channels and highlight the importance of taking into account exposures and vulnerability when assessing the impact of climate-related risks. It should be noted that, like climate risks, exposure and vulnerability are dynamic and can evolve over time.[8]

[7] In this study, we use the same terminology as in IPCC (2012). Exposure is defined as "the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in place that could be adversely affected." Vulnerability is defined as "the propensity or predisposition to be adversely affected". Resilience is the opposite of vulnerability.

[8] In addition, "exposure" and "vulnerability" can have a psychological dimension as people may form beliefs or perception about climate change risks that can trigger adjustments in property values. Indeed, Baldauf et al. (2020) and Giglio et al. (2021) found that attention paid to climate risks and beliefs in climate change affected the pricing of physical risks in housing markets.

6. **Apart from the direct channels mentioned above, climate change could also affect housing prices by altering macro-financial conditions, such as land and housing supply, employment and household incomes, as well as productivity (i.e. the indirect channels)**. Nevertheless, it is important to notice that these indirect effects can be highly uncertain, with potentially diverse forces pulling in different directions. As an illustration, some studies see climate-related risks or the transition to a low-carbon economy as negative for productivity growth and economic output[9]; by contrast, advocates of green development have long argued that the investment in clean energy technology and renewables can boost long-run potential growth. These offsetting forces of economic growth can in turn perturb the path of housing prices over the long run. Partly for this reason, our empirical study will focus on the direct channels, and hopefully set the scene for future research that will deal with the indirect channels more systematically.

Empirical strategies

7. In order to capture the major direct impact of climate change on housing prices, **our empirical strategy is to regress housing prices on a set of relevant climate variables and simultaneously take into account appropriate exposure and vulnerability**. In practice, we multiply a climate variable by exposure or vulnerability measurements to generate an interaction term and plug it into the empirical model. Since exposure or vulnerability variables are operationally similar from an empirical standpoint, from now on we shall use "exposure" and "vulnerability" interchangeably for simplicity. Schematically, we model housing prices as follows.

$$Housing\ \ prices = (\beta\ \times \boldsymbol{climate\ \ variables} \times \boldsymbol{exposures}) + other\ \ variables$$

where β is a set of parameters of interest that measures the impact of a specific climate change risk on housing prices under different levels of risk exposure. In gist, the impact of climate risks on housing prices will also depend on exposure, rather than the climate variable per se.

[9] At the sectoral level, this is especially true for some oil and gas companies as well as enterprises linked to the fossil fuel.

8. As for the selection of variables, it is obvious that not all climate hazards are relevant for a particular economy (for example, some inland economies may not have a typhoon season at all). Based on expert judgement, data availability[10] and the scope of our research[11], **we have identified three sets of climate and exposure variables that appear to be most relevant for Hong Kong, namely temperature, severe typhoons, rainfall and their related hazards and exposure**. Our macro study will cover all three sets of variables. Some explanation is in order.

- ***Temperature*** × ***ageing of property***. Hotter climate may lead to higher demand for utilities and maintenance costs (especially for older buildings or houses), thereby raising the carrying costs of owning a house or the investment cost of buy-to-let properties. In particular, the older the property, the larger the expected adverse impact, other things being equal.

- ***Super typhoon*** × ***high risk coastal areas***. Severe typhoons[12] can create heavy rainfall, strong winds, storm surges, overtopping waves, sea water inundation, flooding, etc., and housing prices in some high-risk coastal areas may be adversely affected. In a coastal city like Hong Kong, some seaside buildings are particularly vulnerable.

- ***Rainfall*** × ***inland flooding risk***. Higher rainfall could cause heavy flooding and other damages to a property, and lower the amenity value. Some low-lying, inland areas, especially those with poor drainage systems or insufficient drainage capacity, would be more exposed to this risk.

9. **It should also be noted that these different climate and**

[10] Data availability is definitely a constraint on climate risk analysis. For example, a rise in sea level may matter for Hong Kong, and in rare extreme events, some coastal areas may not be habitable anymore. In the case of Hong Kong, however, it is unclear how to measure relevant exposure, and more importantly there is probably a lack of precedents for us to estimate the impact of rising sea level.

[11] The scope of study is also a factor to consider. For example, while landslides can affect the prices of houses or mansions at hilly or cliff-side locations, many large housing estates that exert the most influence on overall housing prices in Hong Kong does not seem to be materially affected by such risk. This, coupled with the Government's strenuous efforts to tackle landslide problems and regulate geotechnical works, made us believe that landslide risk may not be a significant housing price driver at a macro level and is therefore excluded in our macro study.

[12] We emphasise severe typhoons here because the impact of milder typhoons on housing prices appears to have been insignificant (see more discussion in the subsequent section).

exposure variables are likely interrelated so that care should be taken when interpreting the impact of a specific climate variable. For instance, higher temperature may also come with more severe typhoons[13] in the long run. As such, temperature would also have "pass-on" effect through its impact on the occurrence of severe typhoons. Having said that, in our macro empirical exercise, we can add the impact of temperature and severe typhoons together to come up with the "total" impact (see also Section III) such that our estimates did not omit these "pass-on" channels. It is just that our model is silent on how rises in temperature would exactly increase the number of severe typhoons in Hong Kong.[14] In the next section, we turn to our empirical results.

III. A MACRO (DISTRICT-LEVEL) STUDY

10. **In our empirical study, we adopt a macro approach and estimate how Hong Kong-specific climate variables and the associated risk exposure would affect the average housing prices in the 18 districts of Hong Kong**[15]. First, we use our big data of residential property transactions to calculate the average transacted prices[16] at the district level, which become the dependent variable in our empirical equation. Second, regarding the explanatory variables, we collect the climate variables and the exposure measurements as discussed in Section II. To be more specific, three sets of variables are assembled: (i) the average temperature of a district, and the average age of transacted residential properties in a district; (ii) the number of severe typhoons in a particular year, and the number of coastal risk spots in a district; (iii) the rainfall, the scale of flooding and the number of flooding

[13] As a result of global warming, a warming ocean will provide more energy to fuel the storms in the future. The number of intense tropical cyclones and the associated precipitation rate will increase. Sea level rise caused by global warming will also raise the frequency and threat of severe storm surge.

[14] To the best of our knowledge, the HKO does not have such projections.

[15] There are 18 officially defined districts in Hong Kong: (1) Central and Western, (2) Eastern, (3) Southern, (4) Wan Chai, (5) Kowloon City, (6) Kwun Tong, (7) Sham Shui Po, (8) Wong Tai Sin, (9) Yau Tsim Mong, (10) Islands, (11) Kwai Tsing, (12) North, (13) Sai Kung, (14) Sha Tin, (15) Tai Po, (16) Tsuen Wan, (17) Tuen Mun, and (18) Yuen Long. Districts (1)-(4) are collectively known as the Hong Kong Island, districts (5)-(9) as Kowloon, and districts (10)-(18) as the New Territories.

[16] In terms of the Hong Kong dollar per saleable area, which is a very common measure of flat prices in Hong Kong. According to the Rating and Valuation Department of the Hong Kong Government, "saleable area" is defined as the floor area exclusively allocated to a residential unit including balconies, verandahs, utility platforms and other similar features but excluding common areas such as stairs, lift shafts, pipe ducts, lobbies and communal toilets. It is measured to the exterior face of the external walls and walls onto common parts or the centre of party walls. Bay windows, flat roofs, top roofs, stairhoods, cocklofts, gardens, terraces, yards, air-conditioning plant rooms, air-conditioning platforms, planters or flowers boxes and car parking spaces are excluded.

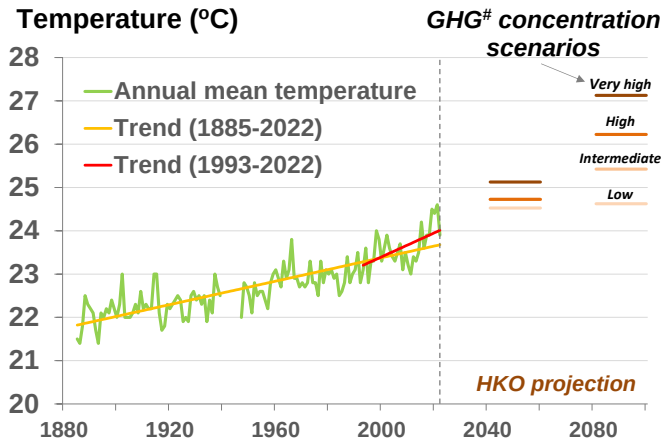
blackspots in a district[17]. Finally, we come up with a balanced panel dataset of 18 districts spanning between 2000 and 2021 (at an annual frequency)[18]. In the estimation process, we also control for district fixed effects (i.e. time-invariant, unobservable district differences) and year fixed effects (i.e. year-specific unobservable factors affecting all districts). In what follows, we go through the estimation results of the three sets of variables one by one (more technical details can be found in Annex A).

(i) $\textit{Temperature} \times \textit{ageing of property}$

11. **To give some background, Hong Kong's weather is getting hotter and its residential properties are ageing on average**. Information collected by the HKO shows that the average temperature in Hong Kong is rising over the years (Chart 2, yellow line), and the rising trend appears to have accelerated in recent decades (Chart 2, red line). Under the different GHG concentration scenarios ("Low", "Intermediate", "High", "Very high") hypothesised by the HKO, the average temperature is likely to rise further beyond 2022, for instance, to over 24 degree Celsius by 2041-2060[19] (say around 2050).[20] On the other hand, our big data of housing transactions suggest that the transacted properties in Hong Kong are ageing on average, from about 14 years in early 2000s to about 26 years in 2021 (Table 1).

[17] For this set of variables, we also compile and use a text-based climate news index to capture the awareness of climate risk based on related article counts of a Hong Kong-based, English-language newspaper "The South China Morning Post".
[18] Data up to 2021 after taking into account the data availability of different covariates.
[19] Instead of a more exact time frame, the HKO just gave an interval spanning two decades.
[20] It should be noted that these projections are subject to changes by the HKO over time and what we have used here is a snapshot taken in late 2023.

Chart 2: Annual mean temperature for Hong Kong and its projection



Note: # GHG stands for Greenhouse Gas.

Sources: HKO and HKMA staff estimates.

Table 1: Average age of transacted residential properties in Hong Kong

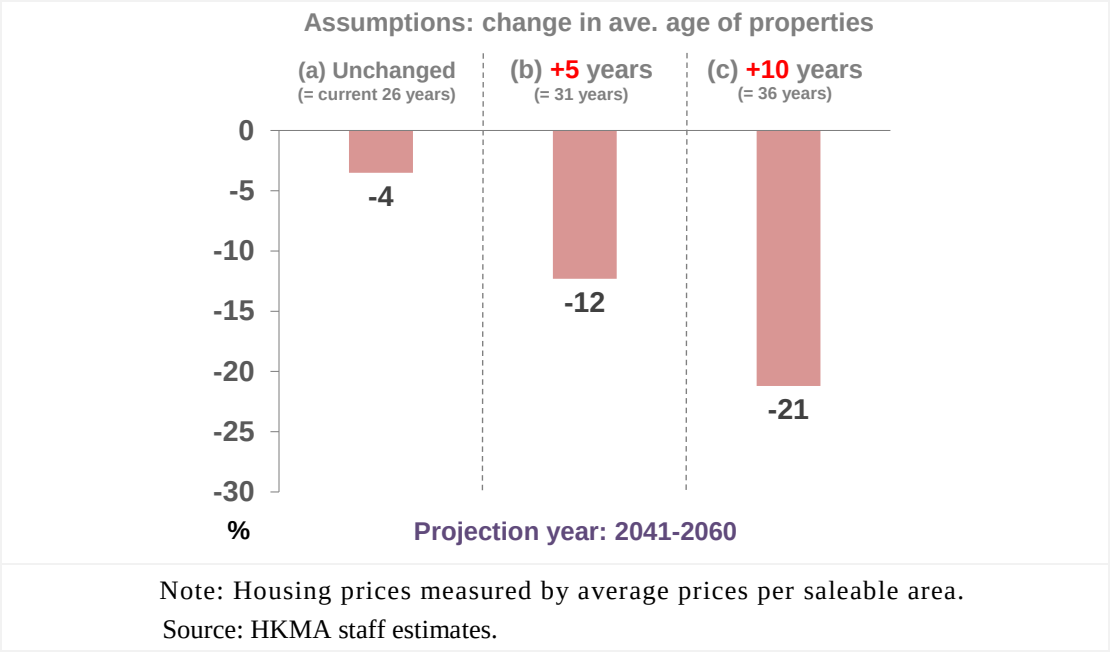
Year	Average age (unit: number of years)
2001-2005	14.1
2006-2010	18.4
2011-2015	22.1
2016-2020	25.2
2021	26.1

Sources: Land Registry, EPRC and HKMA staff estimates.

12. **Our estimation results suggest that global warming can meaningfully lower Hong Kong housing prices in the long run**. To put our estimate of β (see Section II) into perspective, we adopt the scenario of "High" GHG concentration by the HKO so that average temperature is projected to rise to over 24 degrees Celsius by around 2050, and assess the long term impact of rising temperature on housing prices. By further making some assumptions on the average age of residential properties going forward[21], we estimate that average housing prices could be 4% to 21% lower by around 2050 under the "High" GHG concentration scenario (Chart 3).

[21] Our assumptions on the average age of property tend to be conservative, and we believe, for good reasons. (i) From Table 1, one can see that the average age of transacted properties increased by about 10 years during 2001-2020 (i.e. from 14.1 years to 25.2 years). As such, we include +10 years as one of our assumptions. (ii) Using our transactional big data, we find that the rise in the average age of transacted properties seemed to be fattening in the past decade (not shown here). (iii) The Northern Metropolis Development and the Kau Yi Chau Artificial Islands are going to increase land and housing supply in Hong Kong in the years to come. As greater new flat supply is available, the average age of property may increase at a slower pace (or even decline) in the longer run. In view of (ii) and (iii), we therefore assumed some more conservative numbers (i.e. +0 and +5 years). Of course, these are assumptions only and we can always change the numbers if other observations or reasons prompt us to use other more appropriate figures.

Chart 3: Impact of long run temperature rises on housing prices (now to projection year) under "High" GHG concentration



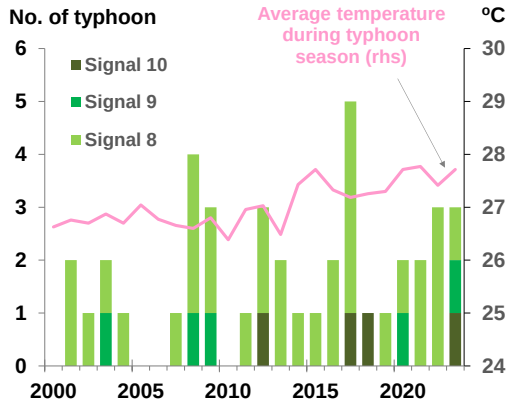
Note: Housing prices measured by average prices per saleable area.
Source: HKMA staff estimates.

13. There are a few points to note here. First, when we talk about the impact of temperature, which is a slow-moving variable, it appears to be appropriate to adopt a longer time frame (in this case, now to around 2050). Second, the relatively higher 21% estimate roughly translates into less than 1% impact per year, which appears to be plausible and not something far off the mark. Third, our results do not mean that we will be actually seeing the housing prices in Hong Kong to decline by that much by around 2050. This is partly because there are other demand and supply forces at work in the housing market, and future intervention measures (for example, Hong Kong's Climate Action Plan 2050) can mitigate the potential adverse outcomes. Fourth, some people may find the impact of temperature on housing prices a little far-fetched at first. However, most people would agree that the ageing of the properties could dampen property prices, and from another angle our result suggests that it is not only an extra year older of the unit that matters but also a higher temperature. Fifth, it is obvious that the size of the impact given above depends on the climate projection scenarios provided by the HKO, which are themselves subject to revision over time.

(ii) ***Super typhoon* × *high risk coastal areas***

14. **Second, we discover that increased frequency of severe typhoons – a type of acute climate hazard – may dampen housing prices too**. In recent years, along with rising temperature, Hong Kong has seen more severe typhoons[22] that could have a devastating impact on high-risk coastal areas (Chart 4). Indeed, the Government has identified 26 coastal low-lying or windy residential areas with higher risks of coastal hazards: for example, Heng Fa Chuen, Tseung Kwan O South, and Yuen Long North West (for details, see Annex B). To estimate the impact of the occurrence of severe typhoons on housing prices, we measure the relevant exposure as the number of Government-defined risk spots in each district – the more the risk spots, the higher the risk exposure. Estimation results indicate that severe typhoons (Signal No. 8 or higher) (but not lower ones[23]) may hurt housing prices. If the number of severe typhoons per year doubles from the average of 2 over the past two decades to 4, housing prices would be reduced by 1.4% by around 2050 (Chart 5). Theoretically, this impact can be added to those of temperature discussed in the previous subsection if the two events occur together (that is, rising temperature and more frequent severe typhoons).

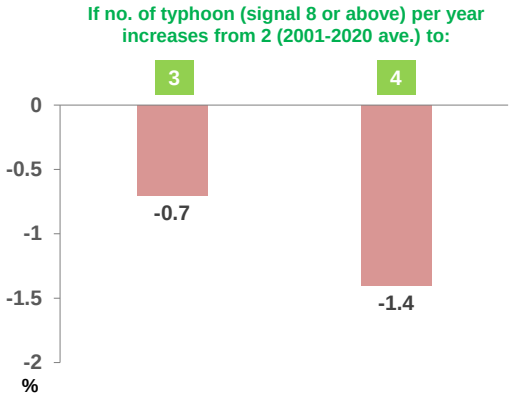
Chart 4: Temperature and the number of severe typhoons



Note: Typhoon season refers to May-November.

Sources: HKO and HKMA staff calculations.

Chart 5: The impact of severe typhoons on housing prices



Note: Housing prices measured by average prices per saleable area.

Source: HKMA staff estimates.

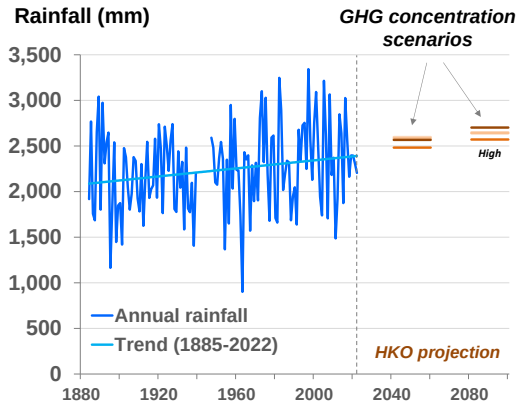
[22] Defined as those belong to Signal No. 8 or higher. Tropical cyclone warning signals are to warn the public of the threat of winds associated with a tropical cyclone. In Hong Kong, there are a number of signals: Standby Signal No. 1; Strong Wind Signal No. 3; No. 8 (Southeast, Southwest, Northeast, Northwest) Gale or Storm Signal; Increasing Gale or Storm Signal No. 9, and Hurricane Signal No. 10.

[23] We have also tried the occurrence of all typhoons (Signal No. 1 to 10) or only the milder ones (Signal No. 3 or lower), but their estimates are not statistically significant.

(iii) ***Rainfall* × *inland flooding risk***

15. **Finally, our macro study finds very small historical impact of higher rainfall and the associated flooding on average housing prices, partly reflecting reduced exposure over time (for example, better drainage system)**. Besides temperature, annual rainfall in Hong Kong is also creeping up over the years (Chart 6, blue line), and the HKO has projected higher rainfall under global warming, which in turn could cause inland flooding. We use the flooding blackspots identified by the Drainage Services Department (DSD) of the Government to measure exposure. It should be noted that these blackspots exclude locations susceptible to flooding problems dominated by tidal influence and are therefore different from the coastal risk areas mentioned earlier. In fact, both the number of flooding blackspots (Chart 7, purple line and area) and their flooding scale (Chart 7, red line) diminished in our sample period as assessed by the DSD (see also discussion below). Estimation results further reveal that the impact of higher rainfall (through inland flooding) on housing prices is smaller than 1% by around 2050 even under "Very high" GHG concentration scenario. This may in part due to the Government's prevention strategy and improvement measures (for example, improved drainage system) over the years. **The upshot of this finding is that the adverse impact of climate-related risk can be mitigated by reducing exposure**.

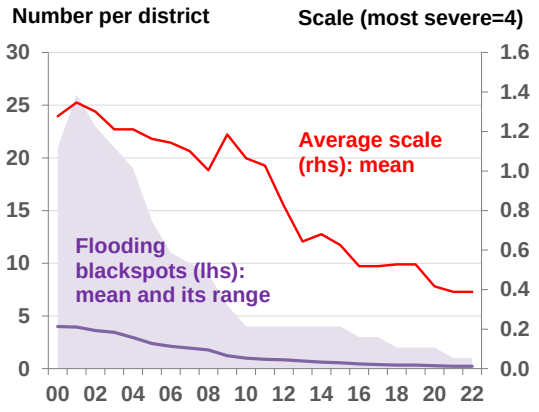
Chart 6: Annual rainfall for Hong Kong and its projection



Note: The brownish lines on the right refer to Greenhouse Gas concentration scenarios, from "Low" to "Very high" as labeled in Chart 2.

Source: HKO.

Chart 7: Flooding situations in Hong Kong



Sources: Drainage Services Department (DSD) and HKMA staff calculations.

16. More recently, Hong Kong saw a reportedly "once-in-500-years" rainstorm in September 2023, recording more than 600 millimeter of rainfall within a short period which amounted to a quarter of the city's total annual level.[24] The extreme weather event triggered the longest-ever black rainstorm warning, turned some streets into rivers, left cars submerged in water, stranded drivers and passengers in vehicles, flooded railway stations and shopping malls in some low-lying areas, and caused landslides in some hilly areas. In addition, the local drainage system – designed to cope with the "once-in-200-years" rainstorms – was under pressure as over 60 flooding reports were recorded. Whether the current climate projections and the exposure assumptions should be amended may require more scientific evidence, but the projected impact of rainfall on housing prices can be larger if (i) the future annual rainfall is even higher than currently assumed due to more frequent extreme rainstorms and (ii) the relevant exposure is assessed to be larger because of the existing design of the drainage system. It would be useful to conduct some studies in the future to analyse the impact of this rainstorm on housing prices when more data are available.

IV. POLICY IMPLICATIONS AND CONCLUDING REMARKS

17. **To conclude, global warming (or boiling) and other climate changes can have adverse impact on Hong Kong housing prices**, in part through higher temperature and ageing properties, as well as more frequent occurrence of severe typhoons and related coastal hazards. Nevertheless, these climate change impacts are not time-invariant; they depend on risk exposure such as the coverage of vulnerable residential areas over time. **More importantly, measures can be implemented to reduce the risk exposure and mitigate the climate change impact on housing prices**, as shown by our finding on the very small historical impact of rainfall on housing prices following the Government's flood prevention measures. Looking forward, faster urban renewal to replace older houses and green and energy-efficient building may help reduce the hotter climate risk, while large-scale coastal protection measures and wave wall upgrading as suggested by the Government may provide some relief to the typhoon-related hazards.

[24] According to the South China Morning Post.

From a broader perspective, commitment to carbon neutrality[25] and the use of green and sustainable finance[26] to incentivise are important.

18. **Methodologically, our empirical results highlight the importance of identifying exposure, in addition to the source of climate-related risks**. **In this regard, adequate, reliable and more detailed data that can facilitate assessment of exposure to climate risks under different scenarios and time horizons will be immensely helpful going forward**. Our investigation would not be possible without the big data on residential property transaction[27] and the study of high-risk coastal areas commissioned by the Government. In view of the importance of data, international organisations, governments and central banks have pushed forward various climate or green-related data initiatives to improve data availability and quality. For example, HKMA's Green and Sustainable Finance (GSF) Data Portal contains a set of available data sources for assisting climate risk management and other green and sustainable finance related analysis and research.

19. **Our study can also facilitate the assessment on banking sector risk**, for example, by designing stress test scenario assumptions on housing prices. The devaluation of housing assets may pose a threat to the collateral value of banks' mortgage loan assets, and therefore merits close monitoring from the perspective of banking and financial stability. **Building on our initial analysis, future research may also dig deeper using big data and data science analytics to incorporate climate-related risks into banks' property valuation models or appraisal methods**. In this regard, the HKMA has engaged an external consultant to develop a cloud-based platform for banks to assess the impact of physical hazards on real estate in Hong Kong under different scenarios by simply inputting the address of a property in Hong Kong – one of the first banking supervisors in the world to provide this kind of utilities for the banking industry.[28]

20. Finally, some caveats are in order. **Our results are better treated as an initial analysis, as some climate projections by the HKO will**

[25] For more information, see "Carbon Neutrality and Sustainable Development Website" by the Government.
[26] For more information, see the Centre for Green and Sustainable Finance on HKMA's website. The Centre is a cross-sector platform which coordinates the efforts of financial regulators, Government agencies, industry stakeholders and the academia in capacity building and policy development.
[27] For example, the calculation of district-level housing prices in the macro analysis.
[28] See the welcome remarks at the Centre for Asian Philanthropy and Society Conference "Building Back Greener: Addressing Climate Change in Asia" on 5 December 2023 by Eddie Yue, and the opening remarks at the "Green and Sustainable Banking Conference" on 11 December 2023 by Arthur Yuen, both available on HKMA's website.

be revised over time, and more climate variables or exposure data may become available in the future. For example, housing prices may also be subject to transition risk, and the impact can be particularly conspicuous under a disorderly transition scenario. More research into this area can be done when more data are available in the future.

Annex A

Details on the estimation model and results: macro study

The empirical models

A panel data model with fixed effects is used. Different specifications have been tried and following a general-to-specific method, the estimated model for the purpose of projection is shown below.

$$
\begin{aligned}
&\ln(housing\ \ price)_{i,t} \\
&= \ \beta_1 ln(temperature)_{i.t} \\
&+ \ \beta_2 ln(temperature)_{i.t} \times ln(ave.age\ \ of\ \ property)_{i,t} \\
&+ \ \beta_3 (no.\ \ of\ \ severe\ \ typhoons)_t \times (no.of\ \ coastal\ \ risk\ \ spots)_i \\
&+ \ \beta_4 ln(rainfall)_t \times (no.of\ \ flooding\ \ blackspots)_{i,t} \\
&\qquad \times (scale\ \ of\ \ flooding)_{i,t} \times (climate\ \ news\ \ index)_t \\
&+\delta(other\ \ control\ \ variables)_{i,t} \\
&+year\ \ effect + district\ \ fixed\ \ effect + \epsilon_{i.t}
\end{aligned}
$$

where $\ln(housing\ \ price)_{i,t}$ is the logarithm of average housing price per net floor area (i.e. saleable area) in district *i* in year *t*. $(climate\ \ news\ \ index)_t$ captures the awareness of climate risk based on related article counts of the South China Morning Post.[29] Other terms in the equation are self-explanatory. The control variables include some demand and supply side factors such as district-level population density, income and property completion. All estimated coefficients are statistically significant at the 10% level.

Whether different typhoon damage drivers were studied when analysing the effect of severe typhoons on housing prices?

While not directly relating to housing prices, we have come across a study by Sajjad and Chan (2020) which found that rainfall had the most significant effect on typhoon-related economic damage in Hong Kong, followed by wind. Storm surge was also studied but was found to be an insignificant factor. It should be noted that their analysis differs from our macro study in that they

[29] We have also tried interacting this variable with others, but they did not yield statistically significant results.

focused on economic damage (including the number of vessels damaged or sunk, the number of people dead or went missing, as well as total economic losses), instead of housing prices. As such, their results are not strictly comparable to ours. For our macro study, we have also tried to study different typhoon damage drivers (e.g. rainfall × typhoon, wind speed × typhoon, etc.) but they are statistically insignificant (even having wrong signs at times). Having said that, our variable "no. of severe typhoon × no. of coastal risk spots" should measure the total impact of rainfall, wind speed, storm surge and all other relevant weather conditions. It is just that we cannot differentiate the importance of different typhoon damage drivers.

Whether the drop in housing prices after a severe typhoon is temporary or long term as there are quite a few studies from other countries showing that post-hazard impacts are temporary and vanish after some period of time?

While it is worth looking into the issue, it is likely that the persistence of impact can change over time. For example, researchers also find that heterogeneity in beliefs about long-run climate change risks matters. As more people believe in the importance of climate risk, post-hazard impacts may become more persistent. On the other hand, in the face of climate risks, if people pro-actively reduce their exposure, post-hazard impacts may become less persistent over time (the importance of exposure is also a message we try to highlight in our study). The bottom line is that despite the temporary impact as revealed in some studies, many researchers would also agree that an increased frequency of severe climate hazards due to climate change would be capable of longer term impact.

Annex B

26 coastal low-lying or windy residential areas with higher risks under extreme weather and climate change

A study by the Civil Engineering and Development Department (CEDD) in 2022 has identified 26 coastal low-lying and windy residential areas more vulnerable to higher potential risks during extreme weather with climate change projection up to 2050 (see Chart B below).

Chart B: Identified areas vulnerable to coastal risks in Hong Kong

Source: CEDD (2022, p. 22).

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