Detecting the "Hidden Bomb":

Building an Integrated Surveillance Framework for Highly Leveraged NBFIs

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The paper proposes an integrated surveillance framework to monitor highly leveraged non-bank financial institutions (NBFIs) such as hedge funds and family offices in a timely manner, in order to detect "hidden bombs" like Long-Term Capital Management (LTCM) or Archegos, which may impose systematic risks to financial markets.

Specifically, our framework produces a watchlist to identify any build-up of systemic vulnerabilities arising from highly leveraged NBFIs. To do so, we draw from multiple data sources, collecting granular transaction-based data, trade repository data, textual big data and macroeconomic data on top of traditional regulatory banking data. The aim of the framework is to transform scattered data from diverse sources into systematic and insightful information that helps policymakers to conduct macroprudential surveillance and take pre-emptive measures to address risks arising from the interconnectedness of various sectors. We implement the framework in the context of Hong Kong and arrive at some initial findings, then offer suggestions for future study and development.

One of the lessons learned from the analysis, as well as from the experience of implementing it in Hong Kong, is that granular data can be extremely useful, able to be integrated in innovative ways for NBFI monitoring. As more supervisory authorities around the world embrace supervisory technology (suptech) and pursue granular data collection, we hope this paper will shed light on a new approach to NBFI risk monitoring.

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1. Introduction

Purpose of the study

Since the Global Financial Crisis, non-bank financial institutions (NBFIs) have considerably expanded their footprint in the global financial system. While NBFIs provide diversification benefits to the financial system, they have also become a major source of financial instability and have attracted increasing policy attention (Carstens, 2021; Aramonte, Schrimpf and Shin, 2022). Of particular concern to policymakers are "highly leveraged NBFIs" which, through excessive leveraging and interconnectedness, can magnify shocks to financial stability, as seen during the collapse of Archegos, a family office, in 2021.

This paper focuses on highly leveraged NBFIs such as hedge funds and family offices (Box 1). Generally, there is consensus that enhanced and systematic market surveillance by regulatory authorities is much needed to identify rising risks and vulnerabilities posed by highly leveraged NBFIs. Such a task is often impeded by the practical question of how it can be done, especially since the sector tends to be opaque and is evolving rapidly[1]. To address this shortcoming, we are taking an initial step by proposing an integrated surveillance framework for the timely monitoring of highly leveraged NBFIs. The framework combines and transforms scattered data from diverse sources into systematic and insightful information, with the aim of detecting "hidden bombs" that could have systemic consequences. We hope to maximise the signal-to-noise ratio of our information base, which would in turn help policymakers conduct macroprudential surveillance and take pre-emptive measures to address risks arising from the interconnectedness of various sectors.

[1] A key theme emerging from work carried out by the Financial Stability Board (FSB) is the existence of important data gaps in authorities' NBFI risk monitoring.

Box 1. Highly leveraged NBFIs

Non-bank financial institutions that use significant leverage to maximise returns include, but are not limited to, hedge funds and family offices. They often exhibit vulnerabilities stemming from hidden leverage, concentration of exposures, liquidity mismatch and interconnectedness. The paper excludes NBFIs that are under prudential regulation, such as broker-dealers and insurance companies, from the scope of analysis. Money market funds, index funds and large asset managers are also excluded. Although some of these entities may also use leverage via derivatives, securities lending and other means, their purpose is to hedge risks or reduce costs rather than to maximise returns.

We characterize such highly leveraged NBFIs as "hidden bombs". They are hidden in the sense that they are small in size and diverse in nature; they engage in complex or opaque derivatives transactions, and their trading strategies can change rapidly to explore market opportunities. Because of such business nature, they are usually under-the-radar, unregulated and difficult to subject to prudential regulation or an entity-level disclosure regime. On the other hand, the potential risk presented by such entities can be like a bomb as they have direct and indirect market linkages, so their high leverage amplifies liquidity stress. The resulting crisis is usually in a form of event risk that may lead to systemic consequences. The sector has been growing fast and their increasingly active role in markets amplifies their importance from a financial stability perspective.

The framework

The key features of the integrated surveillance framework are as follows:

First, the framework draws on a variety of data sources and information, combining these diverse data sets creatively and effectively. The data consists of traditional template-based regulatory banking data, trade repository (TR) data, granular transaction-based banking data, textual big data and macro-financial market data.

Second, the output from this study is a watchlist of top NBFIs that warrant further close monitoring. The watchlist is produced by aggregating and standardising a number of risk indicators to arrive at an overall risk score on impact and vulnerability for each NBFI, and then ranking the NBFIs according to their overall risk scores.

The NBFI framework was adopted by the Hong Kong Monetary Authority (HKMA) in Q3 2021 as part of its regular financial stability surveillance toolkit. At the time of writing, the framework had served over time to flag a number of hedge funds and family offices which were later reported in negative news or became involved in legal proceedings, suggesting the framework could unmask certain hidden vulnerabilities and risks before they manifested themselves. In the case of Archegos, we back-tested the model with the firm's over-the-counter (OTC) derivative positions just before its collapse in March 2021 and found that it would have ranked as number one on the NBFI watchlist, with elevated scores both on impact and vulnerability scores, if its trading activities had taken place in Hong Kong. These two findings substantiate the usefulness of the framework in identifying hidden risks and providing early warnings against an opaque market segment, provided comprehensive data is available.

Having said the above, the framework has its limitations, which are discussed in section 4.5.

Going forward

One of the most important lessons learned from our model and data analysis, as well as from the experience of implementing it in Hong Kong, is that granular data can be extremely useful in monitoring NBFI risks as it is able to be integrated and reconstructed in innovative ways to unveil NBFIs' positions. As more supervisory authorities around the world embrace suptech and pursue data collection efforts, we hope the current paper would shed light on a new approach to NBFI risk monitoring. Central banks and other supervisory authorities around the world should continue to promote the collection of high-quality granular data and the

peer sharing of relevant intelligence and analysis, to safeguard global financial stability from risks in the NBFI sector.

Organisation of the paper

The rest of the paper is structured as follows: Section 2 describes the literature on highly leveraged NBFIs and potential policy options. Section 3 proposes a general integrated monitoring framework, including the methodology and underlying data sources, while Section 4 applies the general framework to Hong Kong as a specific case study with back-testing exercises. Finally, Section 5 summarises the key findings and concludes by raising policy implications.

2. Current landscape: what is missing?

2.1 Revival of policy discussions on NBFIs

During recent decades, each episode of volatility in financial markets has intensified policymakers' discussions on the systemic implications of financial institutions outside the existing regulatory perimeter, in particular the risks posed by highly leveraged NBFIs.

Regulators first became attentive to highly leveraged NBFIs in the wake of the 1997 Asian financial crisis and during global market turbulence that accompanied the collapse of the hedge fund Long-Term Capital Management (LTCM) in September 1998 (Box 2). The failure of LTCM precipitated investigations into highly leveraged institutions (HLIs) by major central banks and regulatory bodies, including the President's Working Group on Financial Markets (1999) [2], the International Organization of Securities Commissions (IOSCO) (1999) [3], the Basel Committee on Banking Supervision (1999)[4] and the Financial Stability Forum (2000)[5].

Literature shows that the policy debates have often been very polarised, with stakeholders either arguing in favour of imposing stricter micro and macroprudential requirements on hedge funds for reasons of financial stability and consumer protection, or making a case for the unsuitability and impracticality of applying uniform regulatory standards to hedge funds in the same manner as to other financial institutions (Danielsson, Taylor and Zigrand, 2005). In fact, discussions on regulating HLIs such as hedge funds did not recommend direct regulation of leverage, but instead usually

[2] President's Working Group on Financial Markets (1999), "Hedge funds, leverage, and the lessons of Long-Term Capital Management".
[3] Report of the Technical Committee of the International Organization of Securities Commissions (1999), "Hedge Funds and Other Highly Leverage Institutions".
[4] Basel Committee on Banking Supervision (1999), "Technical Report: Banks Interactions with Highly Leveraged Institutions".
[5] Financial Stability Forum (2000), "Report of the Working Group on Highly Leveraged Institutions (HLIs)".

called for improved HLI disclosures, a strengthening of risk management practices by HLIs and counterparties, as well as activity restrictions, according to the literature reviewed.

Box 2. Long-Term Capital Management

- LTCM was a highly leveraged hedge fund, and its meltdown in 1998 has become a classic case study of a crisis event in financial markets.

- The hedge fund was primarily engaged in "relative value trades". More specifically, it bought high-yielding, less liquid bonds, such as Danish mortgage-backed securities, bonds issued by emerging markets and junk corporate bonds, and sold low-yielding, more liquid bonds such as United States government bonds, in a bet that the yield spread between high and low-risk bonds would narrow. In pursuing its strategy and seeking high rates of return, LTCM amassed substantial leverage, through an extensive use of interest rate swaps to replicate the trades, that its leverage ratio was reportedly more than 20 times in early 1998. In so doing, LTCM built up very large positions, some of which were in relatively small and illiquid markets.

- As the Asian financial crisis continued to fester and Russia defaulted on its local sovereign debt in 1998, the yield spread sharply widened, which was the opposite of LTCM's expected outcome. When its investments turned sour, LTCM had difficulties in paying creditors and derivatives counterparties. The threat was that if its numerous counterparties all exited from their positions at the same time, widespread fire sales would be created on top of the already turbulent market, which might trigger severe liquidity shortages and sharp falls in asset prices.

- To avoid such adverse market consequences and preserve financial market stability, the US Federal Reserve eventually intervened by facilitating a bail out by LTCM's major creditors.

Sources: News reports, 1999, "A review of financial market events in autumn 1998", Committee on the Global Financial System, BIS, Oct; Edwards, F.R., 1999, "Hedge funds and the collapse of Long-Term Capital Management", Journal of Economic Perspectives, Vol.13, No.2, Pages 189-210.

LTCM's case was not unique, nor it was the last one, as demonstrated by the Archegos debacle in 2021 and its ripple effect across markets (Box 3). To some extent, the collapse of Archegos was linked to both its own fraudulent behaviours and the failure of many investment banks to manage risk. Nevertheless, the fundamental problems were not much different from the collapse of LTCM and have the potential to recur elsewhere. Specifically, both LTCM and Archegos were NBFIs that had built up

excessive leverage, enabled by a failure of market discipline while their counterparties failed to appreciate the magnitude of the risks, until the wake-up call became too huge to ignore. In the case of LTCM, the Fed foresaw the potential for market contagion and intervened before the crisis worsened, whereas the Archegos incident developed into margin calls and fire sales that set off a chain of distress in financial market. However, the banking sector was in general more resilient compared to two decades ago, which helped to contain the potentially material impact on the financial system.

Repeated occurrences of such cases have exemplified continued structural vulnerabilities in the NBFI sector, with some NBFIs exposed to acute financial stress, which may amplify or transmit stress in the financial system. Market stakeholders have called for more concerted efforts to address NBFI regulation and monitoring from a system-wide perspective (Carstens, 2021)[6].

While views might differ as to how and how much to regulate highly leveraged NBFIs, the general consensus is that enhanced market surveillance in a systematic way is a much-needed crucial endeavour for regulatory authorities to identify rising risks and vulnerabilities relating to market dynamics. Traditionally, surveillance methods have included periodic surveys, regular contact with market participants, review of risk management practices and enhanced public dialogue (2007)[7], which are insufficient for dynamic risk monitoring of the fast-evolving NBFI sector.

[6] See also "Enhancing the Resilience of Non-Bank Financial Intermediation", progress report by FSB, Nov 2022, and "Newsletter on Bank Exposure to Non-bank Financial Intermediaries", Basel Committee on Banking Supervision (BCBS), Nov 2022.
[7] Financial Stability Forum (2007), "Update of the FSF Report on Highly Leveraged Institutions", May.

Box 3. Archegos Capital Management

- Archegos was a highly leveraged family office, and its collapse in 2021 was reported in the news as a "Lehman moment".

- Archegos held large positions concentrated in a number of US stocks such as Viacom and Discovery and a few Chinese stocks like Baidu and Tencent. Some of the positions were held via total return swaps, a type of derivative that allowed it to take big, leveraged stakes without disclosing these positions in public. Archegos' leverage ratio was reportedly over five times, and in some trades, as high as 20 times as of early 2021.

- Its bets started to incur losses after Viacom's stock offering fell apart. Archegos failed to pay additional margins to its derivatives counterparties, prompting a massive fire sale of stocks as some of its counterparties rushed to exit from the fund's positions. Since Archegos' market footprint was substantial in those stocks, the simultaneous exits led to sharp falls in asset prices in those market segments.

- The failure of Archegos resulted in more than USD10 billion in losses across several large banks, including Credit Suisse and Nomura, which were affected the most.

Sources: News reports, "Leverage and derivatives - the case of Archegos", European Securities and Markets Authority, May 2022.

2.2 Progress on supervisory data

In the past decade, policymakers have made considerable progress on improving the quality and granularity of supervisory data to facilitate more detailed and timely assessments of financial stability risks. The work has been partly facilitated by technological innovation in financial supervision (suptech)[8] and driven by the G20 Data Gaps Initiative[9].

An important regulatory development is that central banks and security regulators have been increasingly using TR data to assess risks in certain market segments. TR data are trade-level data on OTC derivatives, which

[8] FSB (2020), "The Use of Supervisory and Regulatory Technology by Authorities and Regulated Institutions: Market Developments and Financial Stability Implications".
[9] FSB, IMF (2022), "The Financial Crisis and Information Gaps; G20 Data Gaps Initiative: Progress Achieved, Lessons Learned and the Way Forward".

G20 jurisdictions started to collect using trade repositories after the GFC. For example, in chronological order:

- The Federal Reserve Board used TR data on credit default swaps to monitor the market and identify developments that might constitute sources of systemic risk (Heitfield, 2014).
- The HKMA (2015) started developing a new framework for TR data analysis to assess the financial stability of the market and potential risks.
- The Bank of England used TR data on OTC derivatives to understand the market dynamics during the Swiss franc's unpegging from the Euro in 2015 (Cielinska et al, 2017).
- The Japanese Financial Services Agency analysed transaction networks based on TR data to understand market features of OTC derivatives (Kawai and Yagi, 2021).
- The European Systemic Risk Board (ESRB), using an entity-level data set of European Union banks' exposures to shadow banking entities, tried to identify potential feedback and contagion channels arising from the connections between banks and shadow banking entities (Abad et al, 2022).

Despite the significant progress made, a key theme emerging from the work carried out so far by the FSB is the existence of important data gaps in authorities' NBFI risk monitoring[10]. Our framework is an effort to use the available data sources more creatively and effectively to identify NBFI risks and take pre-emptive action to address risks arising from linkages among financial sectors.

2.3 New approach to NBFI surveillance

The integrated surveillance framework proposed in the current paper seeks to bring about timely monitoring of highly leveraged NBFIs in the context of their positions in the financial market. A main feature and value added of this new approach is the attempt to integrate a host of diverse data sets – not just traditional regulatory banking data but also TR data, granular transaction-based banking data, macroeconomic data and textual big data – into a structured framework. The data collection and analysis are enabled by recent data collection efforts and the advancement of suptech, so that risk exposures to, and risk characteristics of, a big number of NBFIs can

[10] FSB (2021), Global Monitoring Report on Non-Bank Financial Intermediation, Dec.

be identified. The framework is implemented in the context of the Hong Kong market, with the aim to inspire further policy discussions in the area.

Regulators in other regions have also been making an effort recently in a similar direction. For example:

- The Hedge Fund Working Group (HFWG) under the US Financial Stability Oversight Council has made progress in developing its risk monitor, which draws on qualitative and quantitative information about hedge fund activities in financial markets[11].
- The European Securities and Markets Authority (Bouveret and Haferkorn, 2022) and the ESRB used supervisory data from the European Market Infrastructure Regulation (EMIR) to show how EMIR data could monitor risk by tracking Archegos positions with EU counterparties. The monitoring showed that high leverage and high concentration risks were already visible in early 2021, a few weeks before the collapse of the firm in March that year[12].
- At the international level, the IOSCO is also doing more work to ensure data from trade repositories can be used to detect risk build-up ex ante[13].

3. Proposed General Framework

3.1 Overview

This section introduces the proposed integrated surveillance framework that aims to assess potential systemic risks arising from highly leveraged NBFIs. The first part presents a general framework that can be adopted by regulatory authorities, assuming that all relevant data is available. The second part details a specific application of the framework to Hong Kong.

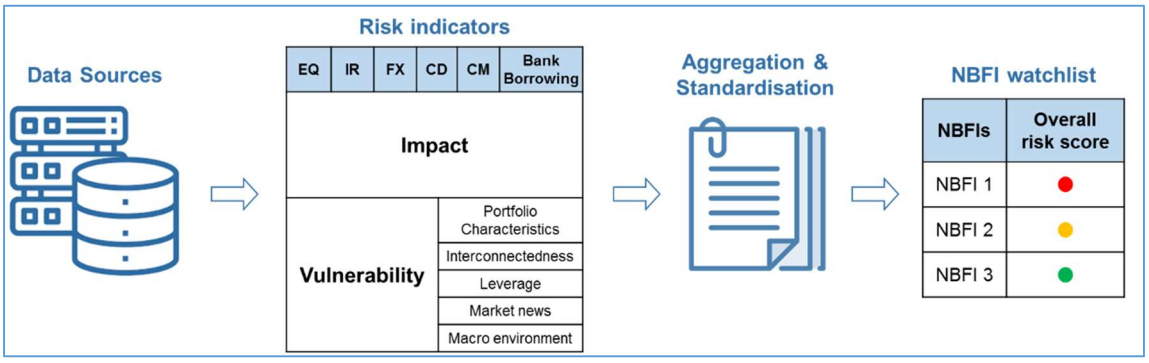
The key features of this framework are as follows:

[11] Readout: Financial Stability Oversight Council Meeting on July 28, 2022, U.S. Department of the Treasury
[12] EU Non-bank Financial Intermediation Risk Monitor July 2022 (europa.eu)
[13] A global perspective on derivatives regulation, keynote address at ISDA Annual General Meeting 2021 by Ashley Alder

- First, the framework draws on a variety of data sources and information, combining these scattered, diverse data sets into an integrated framework. The data sets range from traditional regulatory banking data to TR data, granular transaction-based banking data, textual big data and financial market data.
- Second, the output of the data collection and integration will be a watchlist that ranks the riskiest NBFIs based on their impacts and vulnerabilities, as calculated in the model and discussed in section 3.2.

Diagram 1 illustrates an example of the output and key steps in the process. Various data sets are used to produce a list of risk indicators under two categories, Impact and Vulnerability (see section 3.2 for detailed definitions), across five derivative asset classes and bank borrowing. The risk indicators are then aggregated and standardised to arrive at an overall risk score for each NBFI in a way that reflects the underlying risk of different asset classes. Finally, a watchlist is produced by ranking the NBFIs according to their overall risk scores. Three colours, red (high risk), amber (medium risk) and green (low risk), illustrate the riskiness of the NBFIs based on thresholds defined in the current paper. Section 3.2 and the Appendix have more details.

Diagram 1: Key steps in producing NBFI watchlist



The caveat is that, while the framework includes all major derivative asset classes – such as equities, credit (CD), commodities (CMs), interest rates (IRs) and FX – it leans towards equities, which tend to have better data availability and also more coverage by the literature. In addition, the

framework does not consider the potential correlation among different derivative asset classes, given the practical difficulties involved.

Section 3.2 illustrates the model, while section 3.3 discusses the data requirements.

3.2 The model

In developing the surveillance model, a number of risk indicators are developed to assess the potential systemic risk posed by individual NBFIs and to calculate the overall risk score of each NBFI, against which they are ranked to produce a watchlist of the 10 riskiest NBFIs. As argued in Drehmann and Tarashev (2011), an indicator-based approach to assessing systemic importance may be more suitable and practical for policymakers than model-based approaches that could be more rigorous but also more complex. The Basel Committee's assessment methodology for Global Systemically Important Banks (G-SIBs) adopts a similar approach.

Risk indicators in the framework are defined along two dimensions: Impact and Vulnerability. It can be conceptualized that a highly leveraged NBFI's failure could have a systemic impact via two channels: its failure could generate losses for counterparties, and the fire sales of its positions may affect asset prices and market volatility (King and Maier, 2009). The potential direct losses for counterparties are measured by the Impact dimension. On the other hand, the Vulnerability dimension measures potential market stress arising from an NBFI's portfolio composition as well as potential risk amplifiers, such as leverage, interconnectedness[14] , and market volatility. (see Table 1)

[14] While some argue that interconnectedness is also a measure of the NBFI's impact, we think of it as an amplifier and we classify it as such.

Table 1: List of risk indicators and coverage

Dimensions/Categories		Risk Indicators	
Impact		1	*Size*
Vulnerability	**Portfolio characteristics**	2	*Volatility*
		3	*Stock concentration*
		4	*Sector concentration*
		5	*Small-cap stocks*
		6	*Substantial interest stocks*
		7	*Illiquid stocks*
	Interconnectedness	8	*Number of counterparties*
		9	*Prime broker concentration*
		10	*Crowded trade*
	Leverage	11	*Leverage*
		12	*Fast-growing position*
	Market news	13	*Market news*
	Macro-environment	14	*Macro-environment*

Impact indicator

When measuring the potential direct losses that can arise by the default of an NBFI, the total leveraged position of an NBFI is more relevant than its net asset value or Assets Under Management (AUM) in obtaining a full picture of its systemic impact. Specifically, the NBFIs' positions are calculated using two channels of leverage: derivatives and bank borrowing.

$$(1)\ Size = Gross\ derivative\ positions + borrowing\ positions.$$

For derivatives, size is measured using gross notional positions in Over-the-Counter (OTC) and Exchange-Traded (ETD) derivatives. Alternative measures of the size of derivative positions include mark-to-market values and net notional positions (netting long and short positions in the same underlying instrument). Mark-to-market values are based on current market prices and therefore may not reflect the potential risk in NBFIs' positions. While net notional positions may be a more accurate reflection

of risk in some cases, we consider it more prudent to use gross notional positions, given that market risk may not be fully eliminated after netting, such as due to differences in the maturity or type of derivative transactions.

In order to gain a more comprehensive picture of NBFIs' systemic impact, their outstanding derivative positions across all asset classes are considered. Different derivative asset classes tend to have different underlying risks. For example, equity derivatives are typically considered to be riskier than interest rate derivatives over a long-time horizon. Therefore, for gross derivative positions in the size indicator, the risk-weighted sum of gross positions from all asset classes is calculated based on risk weights derived from the BCBS-IOSCO standardized approach for initial margin.[15] As the initial margin reflects the size of the potential loss on the positions at the start of the contract, it can serve as a proxy of the underlying riskiness of the derivative positions (see the Appendix for details).

In addition, compared with equity derivatives, it may be common in other derivative asset classes to have large offsetting gross positions which result in net positions in the same underlying instrument in various sizes. To monitor the magnitude and direction of net positions, we also develop supplementary risk indicators for FX, IR, CD and CM derivatives based on net positions, to ensure NBFIs that are building up risky positions in these asset classes can be detected.

Vulnerability indicators

In the vulnerability dimension, we capture five categories: portfolio characteristics, interconnectedness, leverage, market news and macro-environment. We develop 13 risk indicators which are summarised in Table 1 and described below. More details on the calculation of these risk indicators can be found in the Appendix.

[15] BCBS and IOSCO (2013), Margin requirements for non-centrally cleared derivatives, Appendix A.

Portfolio characteristics: We construct a number of position-based indicators using transaction-level data to assess the vulnerability of an NBFI arising from its portfolio composition, notably the potential concentration, liquidity risk and market risk in the NBFI's portfolio.

The availability of granular data enable us to take this alternative approach from the traditional ways of evaluating the risk-taking or potential failure of individual hedge funds, for example, by measuring hedge funds' volatility and returns (Agarwal et al, 2017), or by assessing fund-level variables such as fund performance, size, age and leverage (Liang and Park, 2010).

For equities, the indicators used are st*ock volatility, stock concentration, sector concentration, share of small-cap stocks, share of substantial interest stocks* and *share of less liquid stocks*. The literature has established that portfolio risk is positively correlated with stock volatility, stock concentration and the share of small-cap stocks (Zaimovic et al, 2021), all of which are included in the framework.

In addition, ample research evidence shows that the unwinding of sizeable positions can generate large potential losses (King and Maier, 2009), which we capture in the framework using the indicator on substantial interest stocks, in which the NBFI holds a large derivative position in a stock relative to its market cap, and using the indicator on the share of less liquid stocks.

Ideally, one would also look at indicators of NBFIs' funding liquidity risk, such as their liquidity reserves and redemption frequencies, to assess their overall vulnerability. We do not include these in the framework due to practical difficulties. Data on NBFIs' liquidity profiles is generally not available, making it difficult to evaluate the adequacy of liquidity reserves relative to the funding risks of NBFIs.

For asset classes other than equities, the *Volatility* indicator is calculated to assess the riskiness of the portfolio. For example, for FX derivatives, the share of positions in volatile currency pairs is used to calculate the

Volatility indicator. Other indicators of portfolio characteristics are not extended to non-equity asset classes. The average *Volatility* indicator is then calculated across all asset classes, weighted by the size of the NBFI's risk-weighted positions in each asset class.

Interconnectedness: In this group, three risk indicators serve to assess potential contagion risks posed by NBFIs: number of counterparties, prime broker concentration and crowded trade. When an NBFI with more counterparties fails, it may or may not have a greater contagion impact, depending on the size of the shock and the loss-absorbing capacity of its counterparties. However, as revealed in the Archegos incident in 2021, the family office was able to build very large positions partly because it had many counterparties, each of which was unaware of Archegos' total positions and unable to manage risks effectively (Bouveret and Haferkorn, 2022). The number of counterparties is a simple indicator that can capture such potential risk.

As shown in literature on the network analysis of systemic risk (Acemoglu et al, 2015), the potential contagion risk from a network node depends on not only the number of counterparties, but also the size of exposures the node has relative to other linked nodes. Therefore, the indicator on prime broker concentration is introduced to reflect the risk that an NBFI may have a large concentrated position with an individual prime broker, such that its failure could greatly affect the prime broker.

Many studies have highlighted the potential for hedge funds to engage in crowded trades (in which several entities build similar positions on the same stock) and herd behaviour, which could have a destabilising effect on markets (Kyle and Xiong, 2001; King and Maier, 2009). We use the crowded trade indicator to capture the risk of indirect contagion from similar positions held by NBFIs. Specifically, we identify a number of stocks in which many NBFIs have significant positions and calculate the share of NBFIs' portfolios in such crowded trades.

Leverage: Leverage is often considered as an important indicator of hedge fund risk. A sequence of negative events leading to market stress can start

with losses on leveraged positions (Liang and Park, 2010). Hedge funds can leverage up in a number of ways, and they usually prefer derivatives and other arrangements in which positions are established by posting margins rather than direct borrowing in the form of loans. As information on NBFIs' leverage is usually unavailable on a comprehensive and accurate basis, we introduce a proxy indicator on fast-growing positions in addition to the standard leverage indicator. The intuition is that fast growth in an NBFI's positions is likely to reflect a build-up of leverage[16].

Market news: Apart from the quantitative indicators described above, a market news or sentiment score indicator is included to take into account negative news about specific NBFIs as reported in the financial press. This indicator is based on textual analysis using public databases, such as the Global Database of Events, Language, and Tone.

Macro-environment: The macro-environment indicator measures the degree of overall financial market uncertainty or stress based on stock market volatility indices. Hedge fund returns are negatively correlated with market volatility, and with the VIX index in particular (Dash and Moran, 2005). This implies that NBFIs' positions tend to be more vulnerable to shocks when markets are volatile. The indicator is market-wide and not specific to individual NBFIs, therefore it comes in the form of a multiplier meant to magnify the vulnerabilities during times of market stress.

Overall risk scores

After the risk indicators are calculated, the indicators are combined to produce overall risk scores for NBFIs following the steps below.

- First, the risk indicators are converted into standardized scores ranging between 1 and 3 according to predefined thresholds. No fixed approach is specified in setting the thresholds because this

[16] We are mindful of the limitations here. For example, the growth in positions may reflect fund inflows or intra-group transfers. A fast build-up of leverage could also be followed by a reduction, although more frequent monitoring could help.

would depend on the availability and distribution of data in each jurisdiction. For example, if enough historical data on NBFIs' positions is available and the distribution of data is close to normal distribution, the thresholds can be set based on sample standard deviations; otherwise, a more ad hoc approach may be needed. Section 4 details the approach taken when applying the framework to Hong Kong.

- Second, overall scores for impact and vulnerability are calculated for each NBFI. The impact score is simply the standardized score for the size indicator. The vulnerability score is calculated as the simple average of the risk scores in the four risk categories of portfolio characteristics, interconnectedness, leverage and market news. The risk indicators are assumed to have equal weight, because variable weights would be difficult to estimate accurately and could change over time. This approach is consistent with similar studies in the literature, such as Dattels et al (2010) and Aikman et al (2018). The vulnerability score is then multiplied by the macro-environment indicator, reflecting the fact that market volatility could amplify an NBFI's vulnerabilities in all dimensions. Specifically,

$$VulnerabilitySc \quad = \frac{\sum_{i=1}^{N} k_i}{N} \cdot M$$

where N denotes the total number of risk indicators, k_i denotes the standardized score of risk indicator i (including the average $Volatility$ indicator as calculated previously), and M is the macro-environment indicator. The overall impact score and vulnerability score are categorized as "High", "Medium" or "Low" based on certain thresholds, such as a linear distribution of 1 to 3.

To reach an overall risk assessment of each NBFI, an overall risk score is calculated according to the color matrix shown in Table 2, which assigns the overall risk score based on the combination of the impact and vulnerability scores being in the High, Medium or Low bracket. For

example, an NBFI's overall risk score is red if both its impact and vulnerability scores are in the High bracket.

Table 2: Impact – Vulnerability matrix

		Impact		
		High	Medium	Low
Vulnerability	High			
	Medium			
	Low			

The watchlist

Finally, the NBFI watchlist is produced by ranking the NBFIs according to their overall risk score being red, amber or green. When NBFIs have the same overall risk score, the ranking in the watchlist gives precedence to NBFIs with the highest impact score. Generally speaking, NBFIs with amber overall risk scores would require close monitoring and NBFIs with red overall risk scores would be considered for possible follow up action.

3.3 Data requirements

The general framework described in sub-section 3.2 is based on the assumption that all relevant data is available on a regular basis. The data should include granular information on each NBFI's derivative and borrowing positions, such as position size, long/short direction, underlying stock name and counterparty name (ideally using standardized identifiers to facilitate aggregation), and leverage.

In most jurisdictions, though, highly leveraged NBFIs are subject to voluntary or very limited disclosure requirements, and therefore data on their portfolios will have to be sourced and reconstructed through, for example, the reporting by regulated financial intermediaries as their counterparties.

However, traditional template-based regulatory data are typically not granular enough to assess risks in the portfolios of individual NBFIs, and are reported with time lags and at different frequencies, hindering timely analysis.

The availability of data on NBFIs should improve in the coming years as authorities around the world embark on new initiatives to collect granular data on financial transactions. For example, trade reporting requirements have been introduced at the global level for OTC derivatives as part of post-crisis reforms, and a number of regulatory authorities have started the collection of granular transaction-level data on banks' loans in recent years. While most major jurisdictions have introduced trade reporting requirements, individual jurisdictions may not have access to the global positions of NBFIs that have footprints in multiple markets. This presents a remaining challenge for the global data efforts.

For OTC derivatives, data analytical capabilities in identifying, rescaling, aggregating and validating the data is also essential. In particular, when analysing data from OTC derivative trade repositories, the potentially large data volume and complexities involved (van Lelyveld, 2017) may call for significant statistical resources to ensure that the risk indicators can be updated accurately on a timely basis. Authorities may adjust the framework as appropriate when applying it in their jurisdictions, and should be aware of the potential limitations.

Box 4 provides a summary of data sources that can be used in the NBFI surveillance framework and their availability to regulatory authorities around the world.

Box 4: Data sources for NBFI surveillance framework

Template-based regulatory data: Most jurisdictions collect data from banks regarding their top counterparties, including NBFIs, for example as part of the regulatory regime on large exposures[17]. However, these regulatory returns typically capture only NBFI exposures above a certain threshold and do not have granular information about NBFI portfolios.

Trade repository data on OTC derivatives: The G20 Leaders initiated a fundamental overhaul of OTC derivatives markets at the Pittsburgh Summit in 2009, including a commitment to report OTC derivatives to TRs. According to the Financial Stability Board (FSB), most major jurisdictions have implemented trade reporting requirements for OTC derivatives.[18] Some jurisdictions, such as the European Union, also collect data on Exchange-Traded derivatives.

Trade repository data on securities financing transactions: The FSB recommended in 2015 that authorities should collect trade-level data for repo markets, and should consider doing the same for securities lending markets[19]. Some jurisdictions have implemented or started to implement the recommendation, such as the European Union[20], the United States[21] and Japan[22].

Transaction-level data on bank loans: In recent years, many central banks and regulatory authorities have started to collect granular transaction-level data on bank loans. Examples include the European Central Bank's AnaCredit project[23], China Banking and Insurance Regulatory Commission's On-site Examination and Analysis System Technology (EAST) system, Hong Kong Monetary Authority's Granular Data Reporting (GDR) initiative[24], and Bank of Thailand's Regulatory Data Transformation (RDT) project[25].

Commercial databases: Financial market-related information, such as stock market capitalisation and volatility, can be obtained from data providers such as Bloomberg and Capital IQ. There are also commercial databases on hedge fund size and performance, such as Preqin and EurekaHedge.

[17] BCBS (2014), Supervisory framework for measuring and controlling large exposures.
[18] FSB (2021), OTC Derivatives Market Reforms: Implementation progress in 2021.
[19] FSB (2015), Regulatory framework for haircuts on non-centrally cleared securities financing transactions.
[20] ESMA (2022), Q&A on SFTR data reporting.
[21] SEC (2021), SEC Proposes Rule to Provide Transparency in the Securities Lending Market.
[22] Bank of Japan (2020), New Initiatives to Improve the Transparency of Securities Financing Markets in Japan: Publication of Statistics on Securities Financing Transactions in Japan.
[23] European Central Bank website.
[24] Wu and Liu (2020).
[25] Bank of Thailand Annual Report 2020.

4. Applying the framework to Hong Kong

The previous section presents a general framework that regulatory authorities can adopt, assuming all relevant data are available on a regular basis. In this section, the framework is applied to Hong Kong with some adjustments, given the specific data constraints.

4.1 Background on Hong Kong's leveraged NBFI sector

In Hong Kong, banks remain the largest sector of the financial system, accounting for over 60% of total domestic financial assets. Nevertheless, the size of the NBFI sector (defined as OFIs[26]) reached almost 10% of total domestic financial assets, and had been growing at 9.3% in terms of compound annual growth rate over 2016-2020, warranting closer monitoring.

In particular, highly leveraged NBFIs such as hedge funds experienced notable growth in Hong Kong, according to the Securities & Futures Commission (SFC)'s latest Asset and Wealth Management Activities Survey[27]. In Hong Kong, hedge funds accounted for around 6% of the asset management and fund advisory business in 2021, while total hedge fund AUM expanded to US$197 billion in 2021 from US$132 billion in 2017, an increase of nearly 50%.

[26] FSB (2021, 2022) Global Monitoring Report on Non-Bank Financial Intermediation.
Reported OFIs (other financial intermediaries) form the largest component of the NBFI sector, which is composed of all financial institutions that are not central banks, banks, public financial institutions, insurance corporations, pension funds or financial auxiliaries. OFIs include investment funds, captive financial institutions and money lenders (CFIMLs), central counterparties (CCPs), broker-dealers, finance companies, trust companies and structured finance vehicles.
[27] SFC (2022), Periodic reports and surveys.

4.2 Applying proposed surveillance framework to Hong Kong

The NBFI surveillance framework is applied to Hong Kong by assessing the risk of highly leveraged NBFIs with a Hong Kong nexus via two dimensions: impact and vulnerability. The risk indicators within each dimension are calculated and combined to arrive at an overall risk score, according to which NBFIs are ranked to produce a top 10 watchlist.

Some specifications are made to the framework based on Hong Kong-specific circumstances, as explained below.

- First, while the generic framework focuses on NBFIs' positions in both OTC and exchange-traded derivatives plus bank borrowings, data limitations restrict the current study to only NBFIs' OTC derivative positions and borrowings from Hong Kong banks.
- Second, some elements in the generic framework are adapted to the local context. For example, given that most equity derivatives in Hong Kong are referenced to stocks listed in Hong Kong, Mainland China, the US and Japan, the macro-environment indicator is calculated using the average of the volatility indices in the four relevant stock markets (HSI Volatility Index, CBOE China ETF Volatility Index, CBOE VIX and Nikkei Stock Average Volatility Index).
- Third, some parameters in the generic framework, including the thresholds used to standardize the risk indicators, are calibrated using the following reference points:
    - Publicly available information. For example, the 5% threshold for the share of substantial interest stocks indicator is based on the approach of the Securities and Futures Ordinance (SFO) Part XV – Disclosure of Interests[28], and the classification of small-cap stocks in Hong Kong is based on the Hang Seng Composite SmallCap Index.

[28] It states that substantial shareholders - individuals and corporations who are interested in 5% or more of any class of voting shares in a listed corporation, must disclose to both the HKEx and the listed corporation their interests, and short positions, in voting shares of the listed corporation.

- Distribution of actual data. Where objective quantifications are not available of what constitutes high or low level of risk, thresholds for risk indicators are calibrated using expert judgement based on the distribution of the data[29], such as setting the top 25 percentile as the high-risk threshold.

The primary data source used in the Hong Kong application of the framework is the Hong Kong Trade Repository (HKTR), which was created from post-crisis reform to improve transparency in OTC derivative markets globally. The HKTR data covers all OTC derivative transactions in five asset classes – equity (EQ), interest rate (IR), foreign exchange (FX), credit (CD) and commodity (CM) – that are either booked or conducted in Hong Kong[30]. For each transaction, a comprehensive set of data fields is reported by regulated financial institutions, namely, authorized institutions (AIs) and approved money brokers (AMBs) licensed and regulated by the HKMA under the Banking Ordinance; and licensed corporations (LCs), recognised clearing houses (RCHs) and automated trading services-central counterparties (ATS-CCPs) licensed and regulated by the SFC under the SFO. The data fields, which include counterparty, notional value and the underlying assets from which the derivative derives its value, allow us to gauge the size and riskiness of NBFIs' positions through data re-aggregation. The data is updated on a daily basis.

As an additional data source, bank lending to NBFIs is also taken into consideration when applying the framework to Hong Kong. For this purpose, two additional regulatory data sets are incorporated, namely supervisory data on non-bank large exposures and data from the HKMA Granular Data Reporting (GDR) initiative. The GDR initiative was launched in 2019 to collect structured data at transaction level on banks' lending activities, covering a wide range of information including loan amount, tenor, pricing, counterparty and collateral. These data sets can be used to quantify Hong Kong banks' loans to NBFIs, thereby providing a

[29] Distribution of NBFIs based on HKTR data for individual risk indicators is not shown here due to confidentiality of HKTR data.
[30] A transaction is regarded as "conducted in Hong Kong" if it was carried out by a trader in Hong Kong on behalf of the overseas entities of its employer.

more complete picture of the systemic impact of NBFIs[31] on financial system stability. The GDR data is updated on a monthly basis.

It is worth mentioning that, despite our best efforts, our data still does not cover all aspects of NBFIs' positions in Hong Kong. For example, NBFIs' positions in stocks using cash markets and exchange-traded derivatives, and their activities outside Hong Kong, are not captured. Moreover, there is a lack of precise information on the leverage of NBFIs and the collateral posted by them. Efforts are being made by authorities around the world to explore new ways to close the data gaps.

4.3 Results

This section provides an overview of the results based on Hong Kong data, including a summary of NBFIs' positions and risk indicators[32], as well as high-level findings from the NBFI watchlist.

Summary of NBFIs' positions and impact indicator

The size of each NBFI's OTC derivative position gives a measure of its impact on the financial system. Our findings show that NBFIs have the largest gross positions in FX derivatives, at around HK$3.3 trillion (US$419 billion), followed by HK$2.7 trillion (US$342 billion) in equity derivatives, HK$1.4 trillion (US$175 billion) in interest rate derivatives, HK$117 billion (US$15 billion) in credit derivatives and HK$26 billion (US$3 billion) in commodity derivatives.

Summary of NBFIs' vulnerability indicators

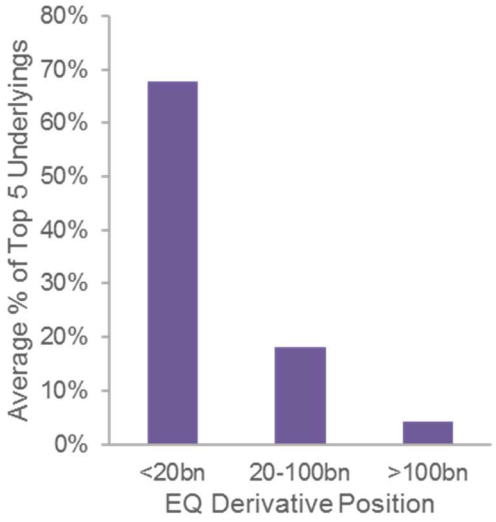
The analysis of NBFIs' vulnerability covers their portfolio concentration, portfolio volatility and interconnectedness.

On portfolio concentration, the results suggest that the smaller NBFIs are the ones that tend to take more concentrated positions, with higher volatility and resulting in a substantial interest in the underlying stock. NBFIs with large positions tend to be more diversified and are less concentrated in their equity derivative portfolio. Chart 1 plots the average

[31] Given that neither the supervisory large exposures nor the GDR data has complete coverage, the two data sets complement each other.
[32] Unless otherwise stated, data presented in this section refers to NBFI positions in December 2022.

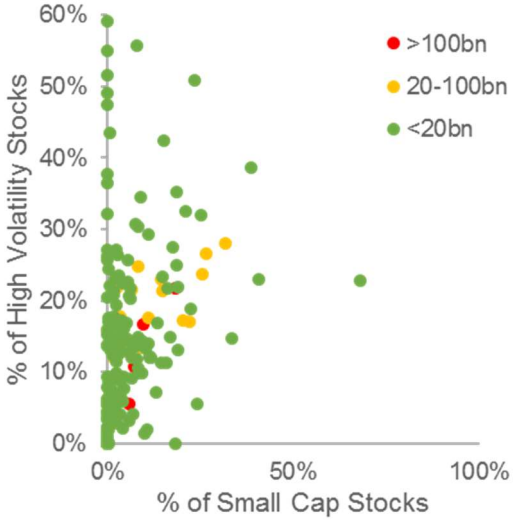
share of top five underlyings in an individual NBFI's portfolio based on the size of its equity derivative position. NBFIs with more concentrated portfolios have smaller positions. The results for substantial interest stocks are largely similar.

Chart 1: % of top 5 underlyings by NBFI EQ derivative position size



Note: Top 5 underlyings exclude equity indices.

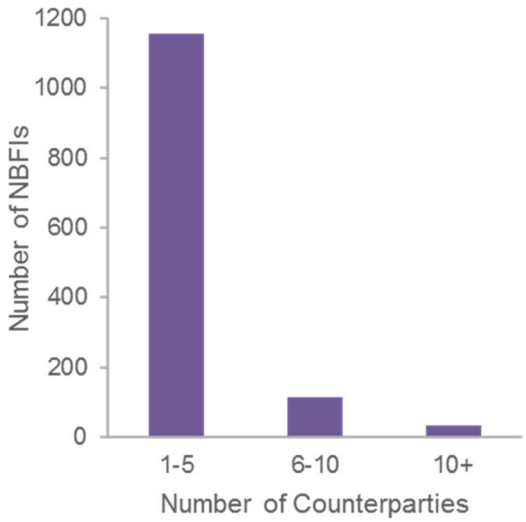
Chart 2: % of high-volatility stocks vs. % of small-cap stocks



Note: Top 5 underlyings exclude equity indices.

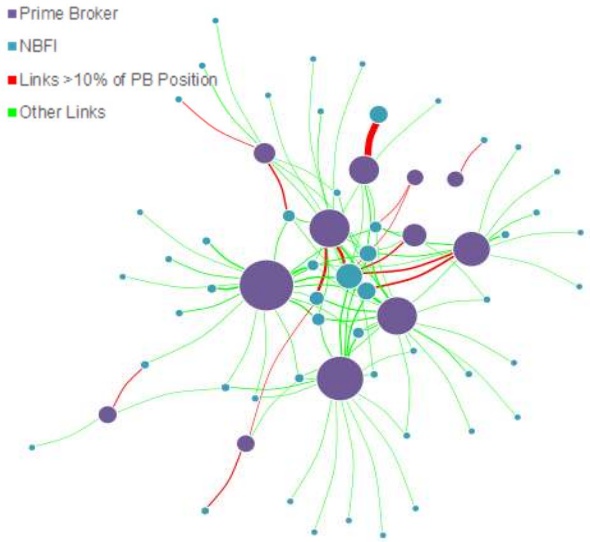
On portfolio volatility, the results generally show that NBFIs with large positions tend to have lower portfolio volatility. Chart 2 gives a scatter plot between two indicators on equity derivatives – the share of high-volatility stocks and the share of small-cap stocks. NBFIs with larger equity derivative positions are coloured in red or amber. The chart shows that NBFIs which have relatively high portfolio volatility indicators generally have less than HK$20 billion in assets. The results for other OTC derivative asset classes are largely similar. For example, NBFIs with large FX derivative positions tend to have a lower percentage of their portfolio in volatile currency pairs, while those with large credit derivative positions tend to have a lower percentage of their portfolio in reference entities rated BB or below.

Chart 3: Number of NBFIs by number of counterparties



Note: All positions include HKTR derivatives (equity and other asset classes) and bank loans.

Chart 4: Network diagram of NBFIs' positions with top 12 prime brokers



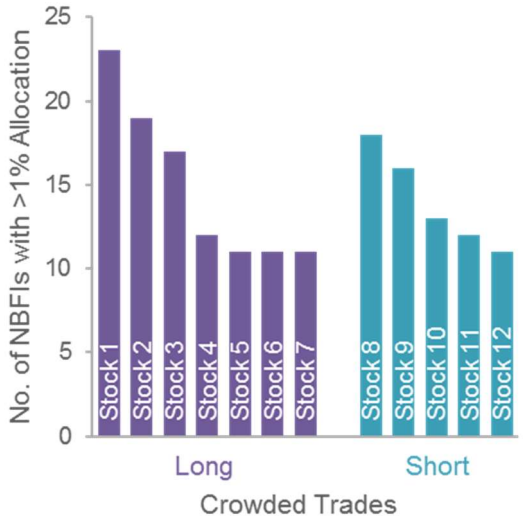
Note: Only equity derivative positions are included. The size of nodes is proportional to the total position of the NBFI or prime broker, and the width of links is proportional to the size of positions between NBFIs and prime brokers. Links with less than HK$5bn (US$600mn) in size are excluded.

On interconnectedness, Chart 3 shows that most NBFIs have no more than five counterparties. However, as mentioned earlier, the number of counterparties alone does not take into account the size of the NBFIs' positions relative to their prime brokers' portfolios. Chart 4 is a network diagram showing the interconnectedness between NBFIs (coloured in blue) and the largest 12 prime brokers (coloured in purple) in equity derivatives. Some NBFIs have positions that account for more than 10% of their prime brokers' total position with all NBFIs (coloured in red). This means that if these NBFIs default, their counterparties may suffer large losses.

Another indicator in the interconnectedness category is the crowded trade indicator, which captures the indirect interconnectedness among NBFIs via common market risk exposures. Chart 5 shows crowded trades that were earlier identified based on the number of NBFIs with at least 1% of their portfolio allocated to the same stock. Chart 6 shows the average percentage of NBFIs' positions allocated to crowded trades based on the size of their equity derivative position. The results show that NBFIs,

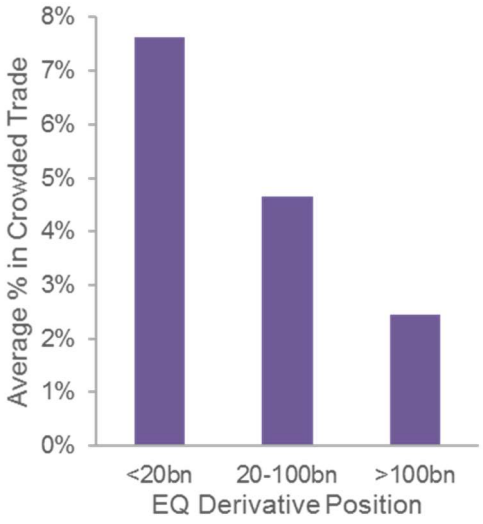
especially those with large positions, generally have a relatively low share of their portfolio in crowded trades.

Chart 5: Number of NBFIs that allocate over 1% of portfolio to stocks



Note: Stock indices are excluded from crowded trades. NBFIs with a total equity derivative position of less than HK$1bn (US$130mn) are excluded.

Chart 6: Percentage of portfolio in crowded trades by NBFI EQ derivative position size



Note: Crowded trades are defined as long or short positions in stocks where more than 5% of NBFIs allocate at least 1% of their portfolio to the trade.

NBFI watchlist results

Based on the information collected, NBFIs with large derivative positions face relatively limited risks in their portfolio. No Archegos-like entities are identified.

Table 4 is an anonymized version of the NBFI watchlist based on data as of December 2022. The results show that none of the NBFIs at the top of the watchlist have a red vulnerability score, which is consistent with the finding that NBFIs with large positions have relatively limited risks at the time of writing. Nevertheless, some medium-sized NBFIs are found to score relatively high on certain risk indicators. For example, some NBFIs on the watchlist put a significant share of their equity derivative portfolio in the top five underlying stocks, and some others have equity derivative positions that appear large relative to the market capitalization of the underlying stocks.

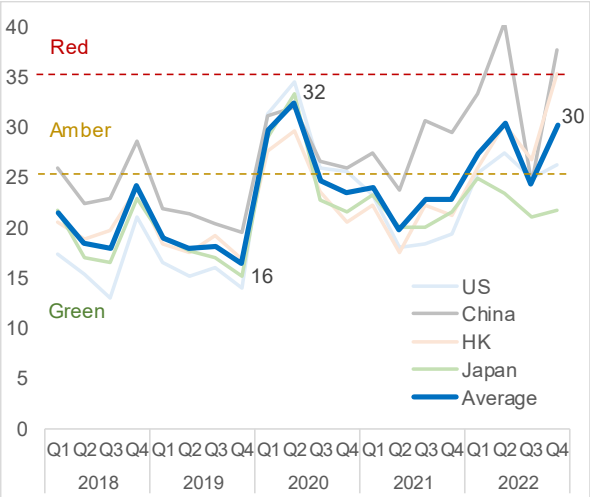
Table 4: NBFI watchlist

Top 10 NBFIs	Impact score	Vulnerability score						Overall assess-ment
		Average	Portfolio Characteristics	Interconnectedness	Leverage	Market News	Macro environment	
Entity 1								
Entity 2								
Entity 3								
Entity 4								
Entity 5								
Entity 6								
Entity 7								
Entity 8								
Entity 9								
Entity 10								

Note: Data as of 16 December 2022.

The framework also considers the impact of market events, such as general stock market shocks, using the macro-environment risk indicator. If volatility increases sharply in markets key to HKTR exposures, it will push up NBFIs' vulnerability scores to reflect the fact that NBFIs' portfolios tend to become more illiquid and potentially more vulnerable to further shocks. Chart 7 shows the trend of macro volatility in recent years. In Q1 2022, market shocks such as the Russian-Ukrainian conflict introduced uncertainty into the market and increased volatility. The more volatile macro-environment drove up the vulnerability scores of some of the NBFIs to either amber or red.

Chart 7: Macro volatility in four markets key to HKTR OTC derivative exposures



Note: US volatility is measured by the CBOE VIX, China volatility by the CBOE China ETF VIX and S&P China 500 1-Month Realised Volatility Index (from Q1 2022), HK volatility by the HSI VIX, and Japan volatility by the Nikkei VIX.

4.4 Back testing the framework

To check the robustness of the framework, it is back tested in two ways.

The first way to back test the model is to assess whether the framework can unmask hidden risks ex ante before they manifest themselves. This is carried out by checking if the top 10 NBFIs on the watchlist are revealed afterwards as being more vulnerable or risky. If so, it suggests that the framework is able to sound an early warning by flagging vulnerable NBFIs for closer monitoring.

The HKMA adopted the proposed framework in Q3 2021 as part of its financial stability surveillance toolkit. The resultant watchlists have, over time, been able to identify several NBFIs which were later reported in negative news, such as being involved in legal proceedings.

Table 5 presents the results of back testing the NBFI watchlists produced by the HKMA between Q3 2021 and Q3 2022. One of the NBFIs, represented by the blue shadow, has been followed over time. It first appeared on the NBFI watchlist in Q3 and Q4 2021, and was later reported in the news in Q2 2022 for its involvement in regulators' legal proceedings.[33] Another NBFI, shadowed in green in Table 5, was initially flagged on the Q1 2022 watchlist. Later it was reported in the news during Q2 2022 that some prime brokers were taking pre-emptive risk management action against the NBFI due to concerns about its trading behaviour. This exercise shows that the framework can provide early warning signals to facilitate timely surveillance on NBFIs.

[33] The specific NBFI dropped in ranking after the initial alert due to a reduction of its exposures, which lowered its impact score.

Table 5: Back-testing NBFI watchlist using negative news

Top 10 NBFIs	2021		2022		
Ranking	Q3	Q4	Q1	Q2	Q3
1					
2					
3					
4					
5					
6					
7				AMC	
8					
9					
10				LE	

Note: The dots indicate the overall assessment score of the top 10 NBFIs on each quarterly watchlist. Negative news: legal event (LE); actions by market counterparties (AMC).

A second way to back test the model and check the validity of the NBFI framework is by feeding through the framework the OTC derivative positions of Archegos just before its collapse in March 2021. Archegos had a negligible Hong Kong nexus, such that the HKTR has limited data on the size of Archegos' positions, hence FSB data was used to assess the global derivative positions of Archegos[34]. The back-testing exercise shows that Archegos would have ranked as number one on the Hong Kong NBFI watchlist with both a red impact score and a red vulnerability score if its trading activities had taken place in Hong Kong (Table 6). This result suggests that the framework can identify risks and give an early warning in an opaque market segment if comprehensive data is available.

[34] The data is not disclosed in the paper due to confidentiality reasons.

Table 6: Back-testing the NBFI watchlist using Archegos' global positions

Top 10 NBFIs	Impact score	Vulnerability score						Overall assess-ment
		Average	Portfolio Characteristics	Interconnectedness	Leverage	Market News	Macro environment	
Archegos	🔴	🔴	🔴	🔴	🔴	🟢	🟢	🔴
Entity 1	🔴	🟡	🟡	🟡	🟢	🟢	🟢	🟡
Entity 2	🔴	🟡	🟢	🟡	🟢	🟡	🟢	🟡
Entity 3	🟡	🟡	🟡	🟡	🟢	🔴	🟢	🟡
Entity 4	🟡	🟡	🟡	🟡	🟢	🔴	🟢	🟡
Entity 5	🟡	🟡	🟡	🟡	🟢	🔴	🟢	🟡
Entity 6	🟡	🟡	🟡	🟡	🟢	🟡	🟢	🟡
Entity 7	🟡	🟡	🟡	🟡	🟡	🟡	🟢	🟡
Entity 8	🟡	🟡	🟡	🟡	🟢	🔴	🟢	🟡
Entity 9	🟡	🟡	🟡	🟡	🟢	🔴	🟢	🟡

Note: Archegos' scores are based on confidential FSB data about its global derivative positions.

4.5 Limitations of the framework

Limitations in the proposed surveillance framework for highly leveraged NBFIs lie primarily in three areas.

1. The measurement of impact and vulnerability indicators is indicative due to a lack of perfect information. We do not have access to all the information about the NBFIs, such as their entire positions globally or leverage levels. To overcome this shortcoming, proxy measures are built to indicate the size of their positions and the relative levels of leverage for risk assessment.

2. The consolidation of information may be imperfect. The consolidation of multiple indicators is kept simple to ensure users can understand the framework easily and be able to identify what drives a change in the impact and vulnerability scores. In addition, the framework focuses on the first-order effects and does not include second-order market effects such as the correlation of exposures within or among different asset classes.

3. The global aggregation of information across multiple jurisdictions is difficult, given legal and regulatory restrictions regarding data sharing. One possible solution is to share red flags based on the analyses of individual jurisdictions as an interim arrangement while the sharing of cross-boundary data remains to be resolved.

Despite these limitations, the framework can serve its purpose to process large amounts of information from various sources and to provide useful indications of vulnerable NBFIs for closer monitoring and potential action.

5. Conclusion

This paper proposes and examines the use of an integrated framework to monitor potential systemic risks posed by NBFIs with large leveraged positions, like Archegos. The framework is built on a wide range of risk indicators, which are assessed at the level of multiple asset classes and instruments. Large amounts of scattered data from diverse sources can be integrated and transformed into an insightful and structured set of information that becomes instrumental in surveillance and the formulation of pre-emptive measures.

Overall, for the HKMA, the holistic integration of various types of data – both traditional macro/aggregated data and granular data – has proven to enhance the efficacy of monitoring financial stability risks by enabling regulators to see NBFI risks in ways that were not possible before. Using this framework, the risks of the largest NBFIs in Hong Kong are found to be relatively low as of December 2022, and no Archegos-like entities are identified. At the same time, a number of NBFIs are identified for further close monitoring. The back-testing exercise shows the framework has served to detect and flag risky NBFIs.

As a practical tool, the aim of the framework is to organise a large body of information in a manageable way and to obtain early warning indicators for closer monitoring and potential action. We recognise its limitations; nonetheless it is worthwhile to have the NBFI monitoring framework in place to make use of all the available information and flag any NBFIs with large risky positions. The framework and the underlying thought process are not static, and can be improved via an iterative process or tailored to meet specific supervisory needs.

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Appendix: Calculation of the risk indicators

Impact indicator

$Gross\ derivative\ positions = \sum_s w_s P_s$, where s denotes the asset class (equity, FX, IR, CD or CM), P_s is the size of the NBFI's position in asset class s, and w_s is the weight used for asset class s, with $w_{equity} = 1$, $w_{FX} = 0.4$, $w_{IR} = 0.27$, $w_{CD} = 0.67$, and $w_{CM} = 1$.

Vulnerability indicators

Portfolio characteristics:

(2) $Volatility(EQ) = \frac{Positions\ in\ high-volatilit\ \ stocks}{Total\ positions}$, where high-volatility stocks are defined as stocks with 60-day volatility in the top quartile of the whole sample across all leveraged NBFIs.

$Volatility(FX) = \frac{FX\ positions\ in\ volatile\ currency\ pairs}{Total\ FX\ positions}$, where volatile currency pairs are defined as currency pairs with option-implied volatility in the top quartile of the whole sample across all leveraged NBFIs.

$Volatility(IR) = \frac{IR\ positions\ with\ duration>5Y}{Total\ IR\ positions}$. The share of positions with a duration of longer than five years is used to capture the duration risk in the NBFI's interest rate portfolio.

$Volatility(CD) = \frac{CD\ positions\ rated\ BB\ or\ below}{Total\ CD\ positions}$. The share of positions that have reference entities rated BB or below is used to measure the riskiness of the NBFI's credit portfolio.

$Volatility(CM) = \frac{Positions\ in\ volatile\ commodities}{Total\ CM\ positions}$, where volatile commodities are defined as commodities that have realised volatility above a certain threshold.

$$AverageVolatility = \sum_{s=1}^{5} k_s \cdot \frac{w_s P_s}{\sum_{s=1}^{5} w_s P_s}$$

where k_s denotes the $Volatility$ risk indicator for asset class s.

(3) $StockConcentration = \frac{Positions\ in\ top\ 5\ stocks}{Total\ positions}$, where the stocks under analysis are limited to individual equities and stock indices are not included in the top five stocks.

(4) $SectorConcentration = \frac{Positions\ in\ largest\ individual\ sector}{Total\ positions}$, where sectors can be defined based on the industrial sector of the underlying stocks, such as technology.

(5) $SmallCapStocks = \frac{Positions\ in\ small-cap\ stocks}{Total\ positions}$, where small-cap stocks are either based on industry classifications or defined as the lower quartile of the one-year average market capitalisation of all stocks in the sample.

(6) $SubstantialInterestStocks = \frac{Positions\ in\ substantial\ interest\ stocks}{Total\ positions}$, where a stock is a substantial interest stock for an NBFI if the NBFI's position in that stock is 5% or more of the stock's one-year average market capitalisation.

(7) $IlliquidStocks = \frac{Positions\ in\ illiquid\ stocks}{Total\ positions}$, where illiquid stocks can be defined as stocks with average daily trading volume (normalised by the market cap) below a certain threshold.

Interconnectedness:

(8) $NumberOfCpty =$ Number of counterparties of the NBFI in OTC derivatives (including all asset classes) and bank borrowing.

(9) $PBConcentration = \frac{\sum_{j=1}^{N} \frac{P_{ij}}{P_j}}{N}$, where P_{ij} is the gross position of lending or OTC derivatives between NBFI i and prime broker j, P_j is the total gross position of prime broker j with all NBFIs, and N is the number of prime brokers in the sample. This indicator measures the risk that several prime brokers have concentrated exposures to a particular NBFI.

(10) $CrowdedTrade = \frac{Positions\ in\ crowded\ trade\ stocks}{Total\ positions}$. This indicator aims to capture the risk that NBFIs with positions in the same stock (crowded trade) may be vulnerable to a common shock. A stock is defined as a crowded trade stock if the stock is held by at least 5% of NBFIs in the sample, and if each NBFI invests at least 1% of its portfolio in that stock. For simplicity, the crowded trade indicator is not extended to other asset classes.

Leverage:

Derivatives do not have a standard definition of leverage. Thus, an approach outlined in the International Monetary Fund (2018) is adopted to compute a fund's leverage from derivatives as the ratio of gross derivative positions divided by the fund's net asset value (NAV). The proxy indicator on fast-growing positions is defined as the three-month growth rate in the NBFI's outstanding derivative positions (including all asset classes) and bank borrowings. Specifically:

(11) $Leverage = \frac{Gross\ derivative\ positions + Borrowing}{NAV}$.

(12) $FastGrowingPosition = \frac{Total\ positions\ thre\ \ months\ ago}{Current\ total\ positions} - 1$, where total positions include gross derivative positions and borrowings.

Market news:

We source the tone (usually ranging from -10 to +10, with 0 indicating neutral) and volume of articles related to each NBFI to calculate a daily volume-weighted tone. As a measure of the sentiment score on the NBFI, the daily positive and negative results over the previous year are ranked, and the score with the most negative sentiment for the NBFI is selected after excluding possible outliers.

(13) $MarketNews = Sentiment\ score\ from\ textual\ analysis$

Macro-environment:

(14) $MacroEnvironment = Stock\ market\ volatility\ index$. If the NBFIs are active in more than one market, the average of volatility indices across all markets is used.