The impact of procyclical margin requirements on financial market liquidity in Hong Kong

Sean Foley, Bernt Arne Ødegaard, Jiri Svec and Angelo Aspris*

February 2022

Abstract

The outbreak of the Covid-19 pandemic caused some of the largest — and fastest — market dislocations in modern history. During the outbreak, global margins rose rapidly across all markets. We look at the case of Hong Kong, which, uniquely among major financial markets, publishes margins for futures contracts on individual stocks. We document the determinants of the required margin level, as well as the factors which lead to the decision to increase or decrease margins. We show that margin levels themselves do not have a significant impact on market liquidity over and above the volatility experienced during March, 2020. Finally, we show that the existence of designated market makers and individual stock futures serve to stabilize trading in the Hong Kong equities market. Amongst its global peers, the Stock Exchange of Hong Kong remained resilient in the face of the dramatic challenges of the Covid-19 pandemic.

*Contact Author - Sean Foley: Macquarie University (sean.foley@mq.edu.au). Ødegaard: University of Stavanger, Svec: University of Sydney, Aspris: University of Sydney. We are grateful for the comments of an anonymous referee. Sean D. V. FOLEY gratefully acknowledges financial support from Hong Kong Institute for Monetary and Financial Research. This paper represents the views of the author(s), which are not necessarily the views of the Hong Kong Monetary Authority, Hong Kong Institute for Monetary and Financial Research, or its Board of Directors or Council of Advisers. The above-mentioned entities except the author(s) take no responsibility for any inaccuracies or omissions contained in the paper.

Introduction

Covid-19 brought some of the swiftest reductions in asset prices seen in modern times. Triggered by the uncertainties of the spread of infection and associated health risks in addition to the economic consequences for countries, companies, and executive teams, price declines of 30-40% were recorded in March 2020, reflecting the significant turmoil in capital markets and investor anxiety. This turbulent period placed a significant strain on exchanges dealing with materially higher order flow and risks of counterparty default, as previously seen during the 2008 Global Financial Crisis (GFC). To mitigate these risks, the margin required by exchanges from market participants increased significantly. These significant and coordinated increases in margin requirements have been shown to have an immediate and negative impact on the provision of liquidity across a wide variety of asset classes, including equity markets (Foley, Kwan, Phillip, and Ødegaard, 2021); corporate bond markets (O'Hara and Zhou, 2020) and government bond markets (Duffie, 2020; Cheng, Wessel, and Younger, 2020)

These empirical studies are supported by theoretical works, particularly that of Brunnermeier and Pedersen (2009) who argue that sharp drops in traders' funding liquidity can generate negative liquidity spirals, particularly when asset prices are falling. Increased margins required by exchanges to alleviate counterparty default risk decreases funding liquidity. Such rising margins can cause reductions in general market liquidity, resulting in pro-cyclical negative liquidity spirals.

Despite the attention that margin requirements have received, few studies have examined the drivers of margin levels (and changes) - particularly in the presence of sharp changes to margins, such as those observed during the Covid-19 pandemic. Our study examines the impact of the Covid-19 outbreak on the liquidity of the Hong-Kong equity markets. This focus is driven by the existence of a wide cross-section of margin levels on individual stock futures (ISFs). In our setting, we observe both scheduled and unscheduled margin changes associated with individual stocks. This cross-sectional heterogeneity allows us to describe the determinants of derivative margin requirements, something that until now has remained guarded by major exchanges. We use this information to present four main findings.

First, we examine the evolution of equity market liquidity in Hong Kong, as well as comparing this to a wide variety of major developed global markets (Australia, Canada, Europe, Scandinavia, UK and the US). Our results show that although all markets suffered falling prices and quoted depth, as well as increases in transactions costs, Hong Kong was the most resilient of all markets assessed. Liquidity and prices fell the least, resulting in a significant saving for traders in Hong Kong markets, and helping to avoid the negative liquidity spiral exhibited in other major markets.

Second, we use the frequent (scheduled and unscheduled) changes in margin requirements induced by the Covid-19 pandemic to analyse the determinants of margin levels and their changes. Our findings suggest that stock-specific factors such as returns, the standard deviation of prices and the range of high-low prices within a day exhibit significant explanatory power in the decision to change margins, as well as the amount by which margins change.

The available quoted depth (which can be enhanced by designated market makers) appears to play a significant role in mitigating the frequency and intensity of margin changes.

Third, we examine the role margins play in explaining the changes in liquidity levels using the exact individual stock future margin required for each individual security. This provides the best available proxy for the margin requirements of stock-level trading in individual securities. We find limited evidence of a direct relationship between margin levels and stock liquidity. This could be due to the muted response in Hong Kong to the Covid pandemic or could indicate that equity market makers are more sensitive to changes in index margins due to their role in hedging the provision of stock liquidity.

Finally, we use a difference-in-differences design exploiting securities both with and without individual stock futures to assess the market quality impacts of the existence of such futures. Our findings suggest that the designated market makers tasked with supplying liquidity in individual stock futures also play a significant role in trading the underlying, reducing equity market transactions costs, particularly during the Covid-19 crisis. However, the importance of margins to these participants is shown to result in reductions in overall depth at points in time when it is most required - during the crisis period.

The fact that the Hong Kong markets did not suffer the same extreme dislocations as its global peers may be attributable to the existence of individual stock futures and their diverse group of market makers. In many cases, there are between 4-8 designated providers of liquidity in these contracts, ensuring that a diverse group of market makers retain sufficient capital to provide uninterrupted liquidity. This suggests that the existence (and potential expansion) of such market making programs can have the capacity to mitigate the liquidity crisis observed during such turbulent market conditions. Further, the existence of individual stock futures (a relatively rare global structure) may facilitate enhancements to equity market quality.

We would encourage Hong Kong to continue to support diversity amongst its market making community, and to ensure that the positive obligations that these market makers are charged with are sufficient to support liquidity even in extremely turbulent conditions. Further, we would encourage regional markets to consider the adoption of similar obligations on designated market makers to act in counter-cyclical ways.

Our paper proceeds as follows: Section 1 reviews the related literature. Section 2 documents the evolution of Covid-19 and its impact on the Hong-Kong equities markets. Section 3 provides institutional details and further information on the margin data on which we rely. Section 4 provides the data and methodology, and Section 5 provides the results. Section 6 provides our conclusions and takeaways for optimal market design.

1 Related Literature

Theoretical models characterise shocks to market liquidity following price declines in a variety of ways. Collateral-based models rely on market makers to absorb these temporary buy-sell imbalances. However, market makers with finite funding levels often obtain financing by posting margins, utilising the underlying securities they hold as collateral. When stock prices fall rapidly, intermediaries find that their funding limits become binding, and are forced to liquidate assets if they are unable to raise more capital. This "liquidity spiral" is famously documented by Brunnermeier and Pedersen (2009), and supported by the work of Weill (2007). Pro-cyclical increases in margins in response to periods of sustained negative volatility limit the ability of participants to provide liquidity, particularly when such constraints become binding - for example when additional sources of regulatory capital are unavailable. Similar models are proposed with funding constrained arbitrageurs who effectively act as liquidity providers (Gromb and Vayanos, 2002) or with short-term traders who are unable to take on inventory due to funding constraints (Morris and Shin, 2004). In a model proposed by Gârleanu and Pedersen (2011), the impact of binding margin requirements becomes "priced," resulting in discounts on high-margin assets.

This pro-cyclicality has been studied extensively in the banking literature in response to the 2008 Global Financial Crisis, both theoretically (Repullo and Suarez, 2013; Hugonnier and Morellec, 2017) and empirically (Behn, Haselmann, and Wachtel, 2016; Berger, Bouwman, Kick, and Schaeck, 2016).

Studies of the margin requirements for equity market makers have been hindered by the lack of available empirical data. In some markets, the link between liquidity provision and binding margin constraints has been explicitly documented. For example, in bond markets, Adrian, Boyarchenko, and Shachar (2017) document larger reductions in liquidity after the GFC in bonds traded by firms with more leverage, indicating the binding nature of their margin requirements. Aramonte and Szerszeń (2020) use a supervisory dataset to examine US corporate bonds and credit default swaps to show that dealer profitability plays a significant role in secondary market liquidity. Daskalaki and Skiadopoulos (2016) examine the commodity futures markets and show that an increase in margins following the Dodd-Frank Act increases transactions costs (such as quoted and effective spreads) and reduces depth. Finally, Dudley and Nimalendran (2011) show that increases in the funding margins for futures markets increase the illiquidity and contagion risk of mutual hedge funds.

Empirical studies of equity trading have *alluded* to the role binding margin constraints play in harming overall market liquidity, but have not been able to directly demonstrate this relation. For example, Hameed, Kang, and Viswanathan (2010) document reductions in liquidity around market declines, particularly at times when the funding markets are tight, which are likely to arise from capital constraints on market makers. Similarly, Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010) show that the inventory levels and trading revenues of NYSE market makers are correlated with their propensity to supply liquidity. In a global study, Karolyi, Lee, and van Dijk (2012) find that commonality in liquidity is greater in countries with higher market volatility, and is also higher at points in time when volatility is greatest, consistent with the impact of binding funding liquidity constraints, particularly amongst a concentrated group of global market makers.

Foley et al. (2021) utilise the margin requirements on equity index futures across a variety of major global markets to show that the rapid and significant increase in margin requirements led to a withdrawal of liquidity by liquidity providers (such as high-frequency traders) particularly when it was most required. Such a withdrawal led to a reduction in depth and increases in transactions costs, as measured by quoted and effective spreads. This empirical evidence provides strong support for the mechanism behind the negative liquidity price spirals observed during 2020.

The importance of margins for the equity markets aligns well with evidence from Duffie (2020), who investigates US Treasury markets and shows that the inventory risk faced by dealers results in bid-ask spreads that increase to over 10 times their (relatively stable) pre-pandemic levels. The larger magnitudes observed in these markets likely reflects the greater leverage (and lower historic volatility) experienced in these settings. Similarly, other recent papers, including Cheng et al. (2020), Fleming and Ruela (2020) and Bent, Duffie, and Zhu (2019), show that increased margin requirements during the Covid-19 pandemic caused significant deterioration in overall measures of market liquidity in Treasury bond markets.

Our paper further complements an emerging literature examining the effects of Covid-19 on equity markets. The onset of the pandemic is arguably an unprecedented shock to the world's economic and financial system (Altig, Baker, Barrero, Bloom, Bunn, Chen, Davis, Leather, Meyer, Mihaylov, Mizen, Parker, Renault, Smietanka, and Thwaites, 2020; Baker, Bloom, Davis, Kost, Sammon, and Viratyosin, 2020). While the majority of the early papers analysing this event aims to understand the asset pricing implications of the pandemic,[1] and changes to investor behaviour[2] we are also starting to see analyses of the *workings* of worlds equity markets during the Covid-19 crisis. For example, Baig, Butt, Haroon, and Rizvi (2020), Cox and Woods (2021) and Brogaard, Ringgenberg, and Roesch (2021) look at the events in the US markets. One of their findings is that the suspension of trading by physical market makers on the trading floor at the NYSE deteriorates overall market quality.

There are also a number of studies looking at the worldwide evolution of liquidity during the onset of the Covid-19 pandemic. Of particular interest for the present analysis is Foley et al. (2021), who show the liquidity evolution over the Covid period for a number of international markets, including Hong Kong, and investigate cross-sectional differences in liquidity in these markets.[3]

Finally, there are a few studies examining in more detail how market participants change their behaviour during the Covid-19 period, such as Ibikunle and Rzayev (2020, 2021), who argue that traders move away from "dark" marketplaces toward the listing exchanges, and Chakrabarty and Pascual (2022), who show that algorithmic traders maintain their liquidity provision during the Covid crisis.

[1]See, for example, Ashraf (2020), Berkman and Malloch (2021), Ellul, Erel, and Rajan (2020), Gormsen and Koijen (2020), Hansen (2020), Pástor and Vorsatz (2020), and Ramelli and Wagner (2020) .

[2]For example, Glossner, Matos, Ramelli, and Wagner (2021) looks at institutional investors, and Ozik, Sadka, and Shen (2021); Chiah and Zhong (2020) investigates the changing behaviour of retail traders.

[3]For some other examples of cross-country investigations see Harjoto, Rossi, Lee, and Sergi (2021) and Zaremba, Aharon, Demir, Kizys, and Zawadka (2021).

2 The Covid-19 Pandemic

The Covid-19 pandemic first emerged in China in December of 2019. From there, it rapidly spread to a number of other counties. While cases increased rapidly in China, they stabilized with strict lockdowns and border closures by March 2020, however by this stage the pandemic had spread to many other countries. Hong Kong, while suffering early exposure to the pandemic, was able to minimise the spread of the pandemic locally, resulting in very few Covid cases when compared to other countries of similar infection time. Covid-19 was eventually declared a global pandemic by the World Health Organization (WHO) on 11 March 2020.

2.1 Stock market evolution

Figure 1: Hang Seng Index (HSI)

The figure plots the evolution of the Hang Seng Index (HSI). The broken vertical line represents March 11, 2020, when the World Health Organization declared the Covid-19 outbreak a pandemic. Data source: Yahoo Finance.

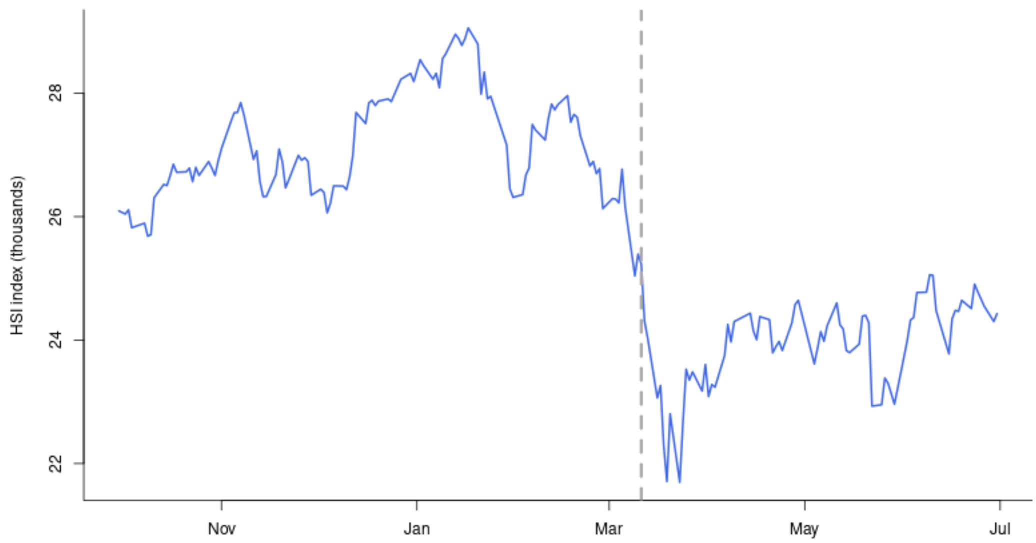
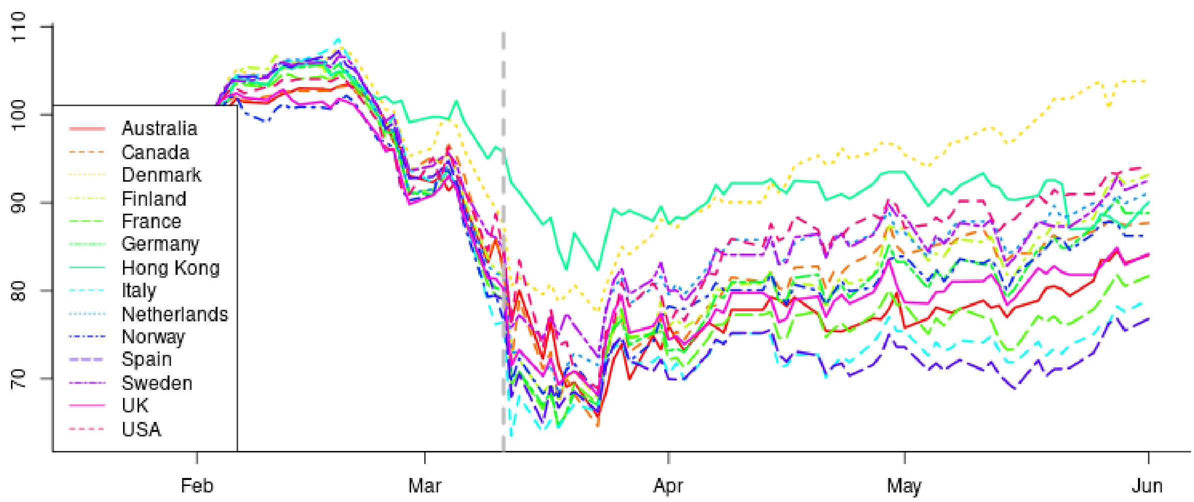


Figure 1 shows the evolution of the Hang Seng Index (HSI) in the period around the initial pandemic announcement. Coming off record highs, the concern around the emerging pandemic drove market instability as early as January 2020. The WHO pandemic declaration caused further selling pressure globally. By mid-March, the Hang Seng had fallen from over 28,000 points to less than 22,000 - a drop of over 21%.

Figure 2 compares the *relative* evolution of stock market indices across a large number of countries, such as Australia, Canada, the US and a number of European countries. We see that among these markets, Hong Kong was the market where the stock market had the *least* fall during the onset of the pandemic (being represented by the light green line in our Figure).

Figure 2: International comparison - Stock index evolution

The figure plots the evolution of a various national stock market indices. For comparison purposes each index is normalised to 100 on February 1, 2020. In addition to Hong Kong, stock market indices for Australia, Canada, Denmark, Finland, France, Italy, Germany, Netherlands, Norway, Spain, Sweden, United Kingdom and USA are displayed. The broken vertical line represents March 11, 2020, when the World Health Organization declared the Covid-19 outbreak a pandemic. Data source: Yahoo Finance.



This is potentially a result of the success of Hong Kong authorities in minimising the spread of the virus locally, limiting the economic damage experienced in other jurisdictions.

2.2 Liquidity Provision and the Covid-19 Pandemic - A Comparative Analysis

A growing body of academic literature has documented the negative impacts of the Covid pandemic on the liquidity of global asset markets. Indeed, Foley et al. (2021) document significant increases in quoted and effective spreads, as well as significant reductions in quoted depth in global equity markets, which they attribute to the rapid increase of margin requirements. To investigate the impact of the Covid-19 pandemic on these elements of liquidity, Figure 3 calculates various daily measures of liquidity for the constituents of the major market index in each country and compares this daily mean to the average level experienced for that market in January, 2020. This allows us to consider the *relative* change in the observed variables, allowing all numbers to be reported as a percent of January 2020 levels.

Panel A presents quoted spreads, which represent the reward required by a market maker for bearing the inventory risk of quoting a two-sided market. As we can see, after the WHO pandemic announcement, all countries experienced significant increases in their quoted spreads. Extreme cases, such as the S&P500 in the US experienced increases in quoted spreads of over 600% on their January 2020 levels. While this is the most extreme response recorded, all countries apart from Hong Kong experienced increases in their quoted spreads of 200-400%. Interestingly, while quoted spreads in Hong Kong were elevated above their January levels, they peaked at approximately 150% of pre-pandemic levels.

Panel B documents the evolution of effective spreads in comparable developed economies. Effective spreads measure the costs of transactions at the time at which they occur and are generally considered to represent the cost of actual liquidity demanded. Unlike quoted spreads, which are time-weighted across the whole day, effective spreads are volume-weighted, with larger transactions garnering larger weights. Effective spreads in Hong Kong remained particularly resilient, with total transactions costs not exceeding more than 150% of their pre-pandemic levels. This compares favourably to the increases of 200-500% observed in countries such as Australia, Canada, Europe, the US and UK

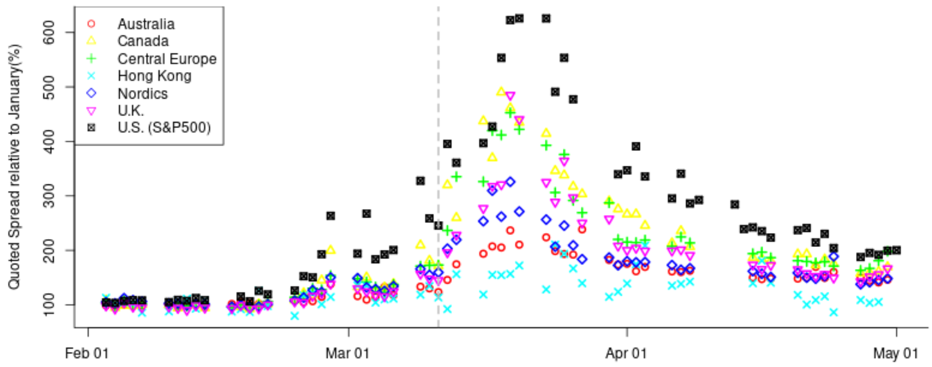
Panel C displays the changes in depth quoted at the best bid and ask. High available depth allows traders to execute large orders without significantly impacting prices. During crises, there is a tendency for high-frequency traders in particular to reduce the size of their quotes in the market in order to reduce the risks of adverse selection - orders to buy in a falling market are much more likely to be executed than orders to sell – and this causes market makers to develop positive inventory in falling markets, resulting in a financial loss. Consistent with expectations, most developed economies experienced significant reductions in their levels of quoted depth, being between 20-60% of the levels observed in January 2020. Liquidity in Hong Kong remained particularly resilient during Covid, dropping to between 60-80% of pre-pandemic levels.

While it is not immediately obvious why the financial dislocation experienced in Hong

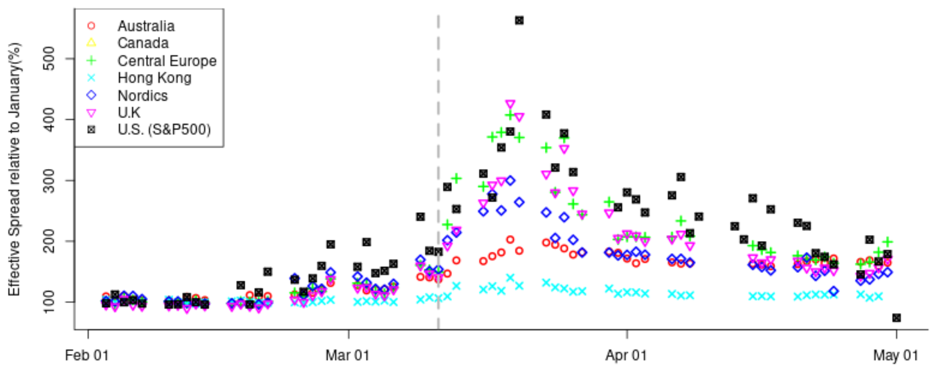
Figure 3: Liquidity Comparison, Hong Kong vs other markets

Liquidity measures relative to January Average. Selected countries Australia, Canada, Hong Kong, United Kingdom, USA and averages of West European and Scandinavian exchanges. For details about the international data see Appendix C. Note that the US data does not include information about depth.

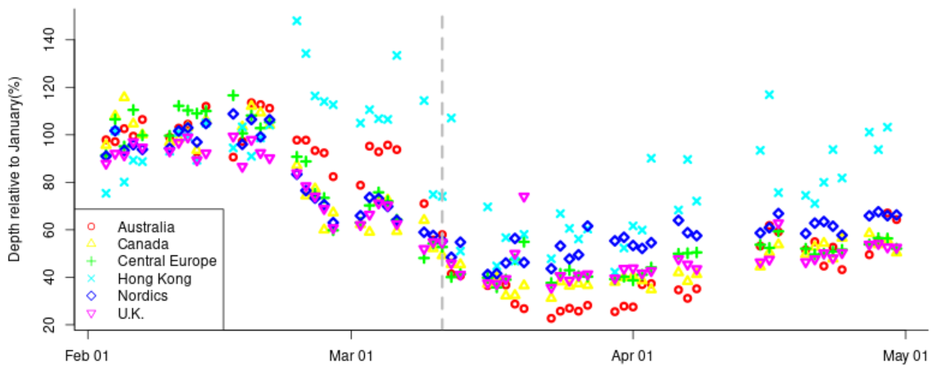
Panel A: Quoted Spread



Panel B: Effective spreads



Panel C: Depth



Kong was not as pronounced as that experienced in other develop markets, there are two potential reasons why this may be the case. The first is the relative speed and success with which the Hong Kong authorities were able to contain the Covid-19 virus. The second potential reason for the muted financial response to Covid-19 in Hong Kong may be the market structure adopted by this exchange – particularly the presence of dealers with positive obligations – a choice which may lead to enhanced liquidity particularly during crisis periods – just when it is required the most. We will examine the latter question further in the remainder of this paper.

3 Institutional Detail

3.1 The Stock Exchange of Hong Kong (HKEX)

HKEX is a securities exchange based in Hong Kong that ranks amongst the largest stock exchanges in the world with over 2,500 listings. HKEX operates two markets on which firms may choose to list their shares: the Main Board (MB) and Growth Enterprise Market (GEM). The two markets operate independently from each other. Each market targets distinct firms and different listing requirements are used. Currently, the HKEX has four trading sessions each day: pre-opening session, morning session, afternoon session, and closing auction session.

3.2 Individual Stock Futures

Individual Stock Futures (ISF) contracts are similar in design to traditional futures contracts. These contracts represent a commitment to buy or sell the financial exposure equivalent of a position in the underlying security at a predetermined price on a specified future date, with settlement occurring in cash using the average of the best bid and ask prices during the final five minutes of the last trading day as the benchmark.[4]

Contract specifications are detailed in Table 1. ISFs are therefore economically equivalent to an outright position in their underlying asset funded entirely with debt and collateralized by a margin. Hong Kong launched ISF trading in 1995 and the market has grown steadily over time reaching approximately 1.1m ISF in 2020. In nine months of trading in 2021, contract value has more than doubled the previous year's volume. ISFs effectively provide investors with the opportunity to create leveraged positions. Importantly, they also provide investors with a simple and cost-effective alternative to short selling securities via the securities lending market. Where short-sale transactions in the traditional lending market represent one-day loans rolled over on a daily basis, so long as the lender is willing and able to continue lending the security, a short futures' position can be maintained over the life of the contract as long as the trader is able to maintain their margin requirements.

[4] All benchmarks are susceptible to manipulation. Specific cases of manipulation have been documented for equities in Hong Kong (Chau, Aspris, Foley, and Malloch (2021)) and between futures and spot-markets (Aspris, Foley, and O'Neill (2020)).

Table 1: SSF Contract Specifications

Item	Contract Terms
Contract Multiplier	One or more Board Lot(s) of the underlying shares
Contracted Value	Contracted price multiplied by Contract Multiplier
Minimum Fluctuation	$0.01
Contract Months	Spot month, the next two calendar months, and the next two calendar quarter months
Trading Hours	09:30am-12:00 noon and 01:00pm–04:00pm
Last Trading Day	The Business Day immediately preceding the last Business Day of the Contract Month
Final Settlement Day	The first Business Day after the Last Trading Day
Final Settlement Price	The Final Settlement Price shall be the average of the midpoints of the best bid and best ask prices for the underlying common share as quoted in the cash market taken at five-minute intervals during the Last Trading Day
Settlement Method	Cash Settled contract of difference
Exchange Fee	$3.50

As of 8 December 2021, there are 92 ISF contracts available for trading on the HKATS.[5] The majority of these ISF contracts have market makers to provide bid and offer quotes for trading, though there are certain exceptions. Where contracts do not have market makers to provide bid and offer quotes, trading is conducted on an order-driven basis. Following a review of the liquidity in the SSF market in 2018, HKEX introduced a new trading fee structure as part of a stock futures market enhancement program which effectively organised securities into one of three tiers, where trading fees per contract were linked to the nominal value of the traded contract. These tier levels are adjusted on an annual basis to adjust for any substantial change in the nominal value of the underlying stock.

3.3 Margins

In this paper we examine margin requirements associated with these ISFs traded in Hong Kong. Initial margin requirements in equity markets determine the maximum loan value of a security. For example, where initial margin requirements are set at a level of 20%, an investor could establish a position in a security by borrowing up to 80% of the security's value. Though margins in derivative markets are functionally similar, a key difference is associated with the role of collateral in these contracts. Margins associated with derivative positions fundamentally serve as a performance bond guarantee and not an economic extension of credit (Kupiec, 1998). However, despite these differences in form and function, the margin requirements on equity derivative contracts can affect the cost of taking positions and implicitly define the maximum amount of return leverage that can be obtained. Where investors face funding constraints, changes in margins across cash and derivatives markets may force investors to close their positions. In the absence of stock margin position data, margin requirements associated with individual stock futures are a suitable proxy to assess the impact of margin credit changes on stock liquidity.

[5] A current list can be found at the following location: https://www.hkex.com.hk/Products/Listed-Derivatives

The heterogeneity associated with the margin requirements on individual securities allows us to better understand the determinants of these margins, and the decision to increase or decrease them, particularly outside of the typical monthly intervals. We examine securities traded in the Hang Seng Index (HSI). At the beginning of 2020 this index contained approximately 50 large, liquid securities chosen from the constituents of two wider indices: the Hang Seng Composite Large Cap and Hang Seng Composite Mid Cap indices.[6]

In the following descriptives we examine stocks in the HSI, and compare them to stocks in the other indices that are *not* constituents of the HSI.

Through the HKATS system, there are listed futures for a variety of individual stocks - both within and outside of the main indices. Each of these is mapped to the underlying equity listing by HKATS. Further, data is provided by HKATS on the margin required for these ISFs, as well as daily updates for any margins which have changed. While there is a rebalance that is held typically once per month, the exchange can (and does) update margins more frequently, particularly during the instability caused by the Covid period.

For each contract, the exchange publishes information on the date on which the margin came into effect, the security name and HKATS code, as well as the initial, maintenance and clearing house margins required. Table 2 provides an example of the margin information provided by HKATS.

Table 2: Example of margin information

Excerpt from margin information at HK exchange, 10 Mar 2020.

Update Date : 20200310
Please be reminded that the minimum margin rates below are for your firm's financially strongest clients. Exchange Participants should set their margin requirements according to each client's individual circumstances.
Stock Futures

Effective Date	Product	HKATS Code		Client Margin Initial (HK$)	Maintenance (HK$)	Clearing House Margin (HK$)
20200302	iShares FTSE A50 China Index ETF	A50	Full Rate /lot	5,213	4,170	3,920
			Spread Rate /spread	1,569	1,255	1,180
20200302	AAC Technologies Holdings Ltd.	AAC	Full Rate /lot	7,354	5,883	5,530
			Spread Rate /spread	2,207	1,765	1,660
...						

In the example, the stock AAC Technologies is trading under the RIC code `2018.HK`. In addition to these dollar margins, the exchange sets a *multiplier* for each contract, the number of stocks underlying each futures contract. An easy way to understand the magnitude of a margin is to calculate it as a percentage of the underlying contract. If we use the example of

[6]The number of stocks in the HSI has since increased towards a target of 70.

the initial client margin, we would calculate it as.

$$\text{Percentage Initial Client Margin} = 100\frac{\text{HKD margin}}{\text{Multiplier} \times \text{Stock Price}}$$

For the AAC example the end of day price on 10 March 2020 was 51.20, and the multiplier is 1,000. Looking at the Full rate, Initial client margin, the *percentage margin* for AAC is thus

$$\text{Percentage (Client) Margin} = 100\frac{5213}{1000 \cdot 51.20} = 10.2\%$$

Panel A in Figure 4 plots the average of this percentage margin across stocks with associated margin. To control for potential cross-sectional differences, Panel B looks at change relative to January: For each stock, we normalise the observations by dividing by the average stock margin in January. We then plot the cross-sectional average. The absolute percentage margin increases from around 6-8% at the start of the year, to over 15% by April. As shown in Panel B, this represents an increase of more than 200% in a period of only a few weeks. In the analysis we use the margin estimates based on the full initial client margin.

3.4 Timing of margin changes

While margins are typically updated at month-end, there can be mid-month changes in response to market turbulence. In Figure 5 we show a time series pattern of update changes, with each bar denoting the number of securities with margin updates. During less volatile months such as January or February, updates to margins are typically made once per month. During March, however, a flurry of unscheduled changes occurs between the typical periodic updates. These unscheduled updates were made in response to the unprecedented volatility and price reductions observed during the Covid-19 pandemic declaration by the WHO.

3.5 The correction of margins

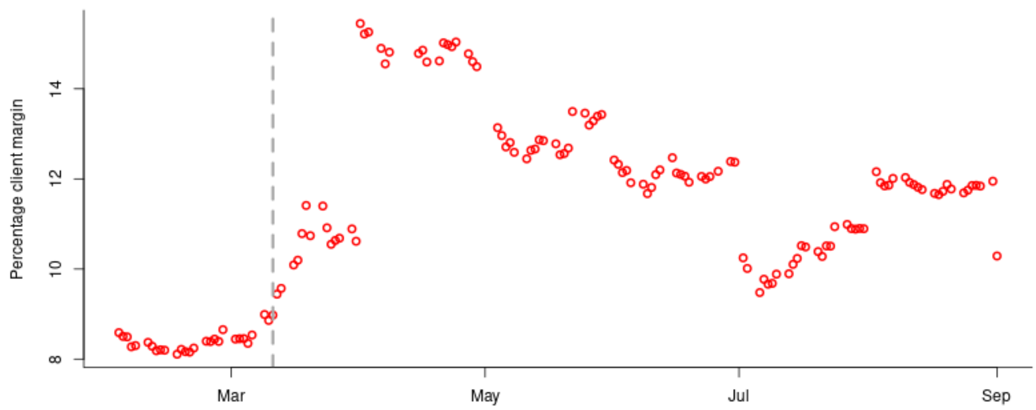
To better understand the level of heterogeneity in the the margin requirements for ISFs in Hong Kong around the breakout of the pandemic, Figure 6 shows margin distribution snapshots at three dates: 6 March (just before the WHO pandemic announcement), 20 March and the 4 April. In each case we plot a histogram of the required (percentage) margin for all stocks with associated ISFs.

On 6 March, almost all required margins were below 10%, with the vast majority sitting at a minimum margin requirement of approximately 6%. By 20 March, two weeks later, the minimum margin level had shifted up to 8%, with numerous securities fitting between 10-20%. By 4 April, approximately three weeks after the official pandemic declaration, a sizeable shift occurred with almost no stocks falling into the below 10% category. Many required over 20% and in one prominent security, a 50% margin was required.

Figure 4: Margin (Initial Client)

For each stock with a corresponding margin, calculate the Percentage margin as HK Dollar margin / (multiplier*stock price). Panel A plots the average of this across HK stocks. Panel B: First, for each stock, calculate the level of the percentage margin relative to the January Average. Then, take the average across stocks of this "relative margin"

Panel A: Percentage Margin



Panel B: Percentage Margin, relative to January Average

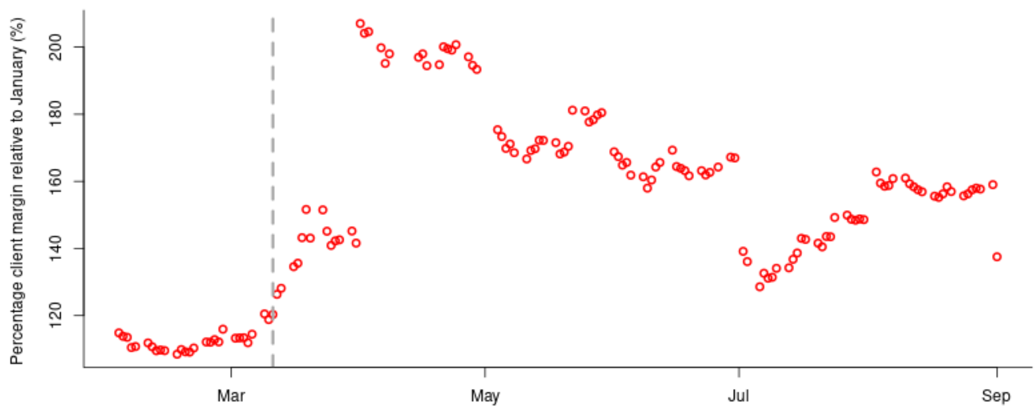


Figure 5: Daily Number of Margin Changes

The figure illustrates the daily number of stocks receiving margin updates (regardless of the direction) during the first half of 2020 (January - July). While once-monthly updates are common, there are more frequent changes to margin levels particularly during the Covid-19 crisis.

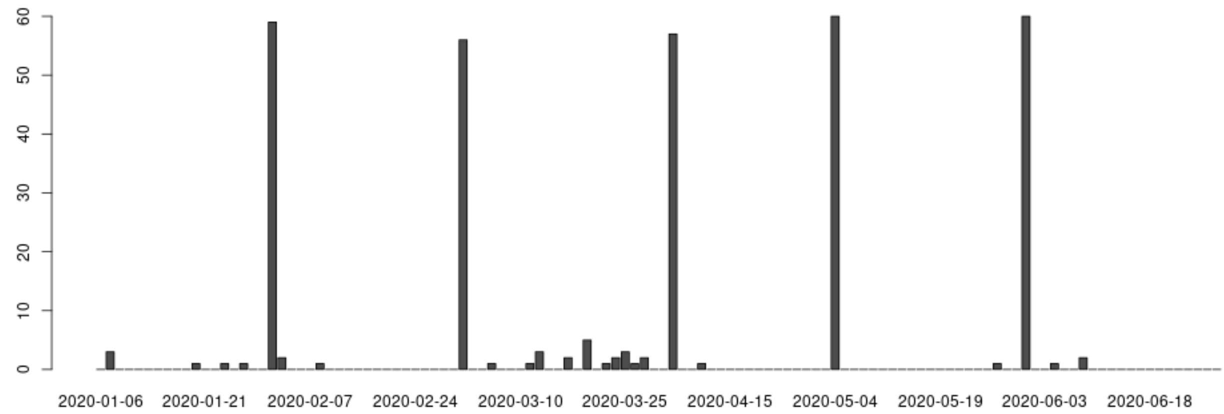
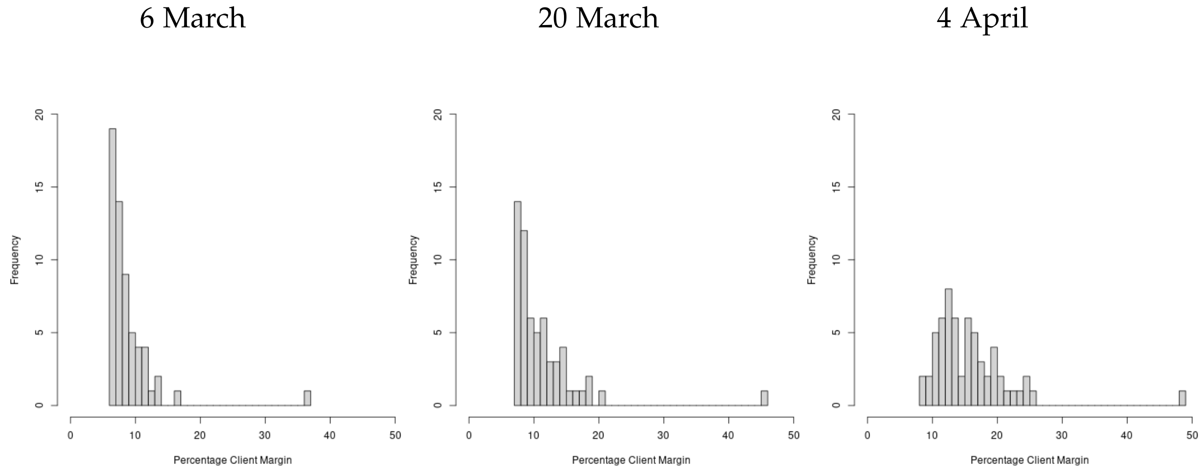


Figure 6: Cross-sectional Distribution of Percentage Client Margin

Histograms illustrating the distribution of Percentage Client (Initial) Margin at three dates: 6 March 2020, 20 March 2020 and 4 April 2020.



4 Data and Methods

We source the data for this study from the Refinitiv database.[7] The data contain millisecond timestamped records of quotes and trades. For each stock, we calculate intraday quoted spread, effective spread, realized spread, and price impact. For the latter two, we use a 10-second delay in the calculations, consistent with the work of Conrad and Wahal (2020). We consider only the trading activity during the continuous trading session at the main (listing) exchange.[8]

Let us start by defining the measures of stock market liquidity. The *Quoted Spread* measures the average reward required by liquidity providers for the marginal unit of posted liquidity. It is measured as the difference between the current best bid and ask in that venue's order book divided by the midpoint, m_{ji}. The quoted spread is recalculated whenever the limit order book is updated. The daily $\text{Quoted Spread}_{it}$ for stock i on day t is the daily time-weighted average.

The *Effective Spread* provides a measure of the cost of executed transactions - or realized liquidity demand. It is defined as:

$$\textit{Effective Spread}_{ji} = \frac{q_{ji}(p_{ji} - m_{ji})}{m_{ji}}, \tag{1}$$

where q_{ji} is an indicator variable that equals $+1$ for buyer-initiated trades and -1 for seller-initiated trades; p_{ji} is the trade price; and m_{ji} is the quote midpoint prevailing at the time of the trade. To determine whether an order is buyer or seller initiated, the transaction price is compared to the previous quote midpoint — if the price is above (below) the midpoint, we classify the order as buyer (seller) initiated. $\text{Effective Spread}_{it}$ is the volume-weighted average of all j trades for stock i on day t. The effective spread can be broken down into two components - the reward for liquidity provision (realized spread) and the permanent price impact of a trade (price impact).

The *Realized Spread* measures the return to liquidity provision, assuming a holding period of 10 seconds, consistent with the empirical findings on liquidity provision of Conrad and Wahal (2020). The Realized spread is defined as:

$$\textit{Realized Spread}_{ji} = \frac{q_{ji}(p_{ji} - m_{i,j+10\text{ sec}})}{m_{ji}}, \tag{2}$$

where $m_{i,j+10\text{sec}}$ is the quote midpoint ten seconds after the jth trade for stock i and q_{ji} has the same definition used for Effective Spread. $\text{Realized Spread}_{it}$ is the volume-weighted average of all j trades for stock i on day t.

The *Price Impact* measures the permanent price impact of a trade, and is often utilized as

[7] Previously called Thomson Reuters Tick History (TRTH).

[8] We remove the first and last fifteen minutes of trading when calculating our liquidity measures to exclude the impact of the opening and closing auctions.

a proxy for the adverse selection imposed on market makers. It is defined as:

$$Price\ Impact_{ji} = \frac{q_{ji}(m_{i,j+10\text{sec}} - m_{i,j})}{m_{ji}}, \tag{3}$$

where $m_{i,j+10\text{sec}}$ is the quote midpoint ten seconds after the jth trade for stock i and q_{ji} has the same definition used for Effective Spread. Price Impact$_{it}$ is the volume-weighted average of all$j$ trades for stock i on day t.

We consider a number of different measures of *depth*. At each point in time, we measure the *depth at the touch* as the sum of trading interest (in HKD) at the best bid and best ask price. The daily depth is the time-weighted average of these depths. We also consider two alternative depth measures. *Depth (2 levels)* sums trading interest at the two best prices at both the bid and ask side, and *Depth (5 levels)* sums trading interest at the five best prices at both the bid and ask side. For most of the analysis we concentrate on the depth at the best prices.[9].

We also collect a number of additional empirical measures relevant for the trading of equities. First, we consider a number of statistics typically used to measure the degree of High Frequency trading in a market. The *Order to Trade* ratio is the number of messages (orders, order updates, etc) in the order book during a day, divided by the number of trades. The *HFTvolume* is the negative of the daily volume (in HKD) divided by the same number of messages as used in the *Order to Trade* calculation.[10] A final measure relevant for the presence of HFT is the *Average time between quote updates*. For this we identify all times with changes to the order book (i.e. prices and/or quantities), and calculate the average duration (in seconds) between each change.

Additionally, we calculate the daily *Volume* as the aggregate HKD traded in a stock during a day. Finally, we calculate a number of measures of the variability of stock prices. The *Realized Volatility* is measured using five-minute intervals during the day. *Idiosyncratic volatility* is calculated as the difference between the daily high and low price observations, divided by the daily average price. We also calculate a longer-period measure, *Monthly Stdev* - The standard deviation of returns over the last 30 days.

All the above measures are calculated using data from the Refinitiv trade-by-trade data. It is calculated for stocks in the HSI, HSCLCap and HSCMidCap indices at the Hong Kong Stock Exchange. For some international comparisons we calculate the same variables for a number of international stock markets. Refinitiv data is used to calculate liquidity measures for Australia, Canada, Denmark, Finland, France, Italy, Germany, Netherlands, Norway, Spain, Sweden, and the United Kingdom.[11]

For liquidity measures for US stocks we rely on summary measures calculated by Sunil

[9] Appendix A provides some arguments for why this measure seems satisfactory for the Hong Kong case.

[10] The usage of these variables follow Malceniece, Malcenieks, and Putniņš (2019), but note that their definition of HFT volume also divides by 100. That is because their volume is measured in 100s of Euros, whereas our volume measures the actual number of HKD.

[11] See Appendix C for some further details about the international data.

Wahal.[12] This data provides daily estimates of quoted, effective and realized spreads, as well as price impact.

For the international data, in addition to the liquidity measures listed above we source stock market prices and returns from Yahoo Finance, and number of shares outstanding from Refinitiv. The number of shares outstanding is used to estimate a firms' *Market Capitalization* as the number of shares outstanding times closing price

Finally, we source data on derivatives traded in Hong Kong, including margins, directly from the Hong Kong exchange website.[13] Here we find data on margins, short sales, and details about market makers.

4.1 Descriptive Statistics

Table 3: Descriptive Statistics

The table provides descriptive statistics for the Hong Kong data for January 2020. The liquidity measures *quoted spread*, *effective spread realized spread* and *price impact* are in basis points. *Depth* (2 / 5 levels) are the aggregate trading interest (in mill HKD) at the best (2 best / 5 best) bid and ask prices. The daily *Realized volatility* is measured using five-minute returns. *Idiosyncratic volatility* is calculated as the difference between the daily high and low price observations, divided by the daily average price. *Market Capitalization* is the last trading price in the day times number of shares outstanding. *Order to Trade* ratio, *HFTvolume* and *Time between quote updates* is related to HFT trading activity. The *percentage client margin* is the initial client margin/(multiplier $\times$ current price).

	HSI	HSCLCap	HSCMidCap
Quoted Spread (bps)	25.34	31.39	42.01
Effective Spread (bps)	6.76	8.79	13.23
Realized Spread (bps)	4.01	2.75	4.57
Price Impact (bps)	4.40	6.10	8.66
Depth (mill HKD)	14.73	5.75	1.36
Agg Depth 2 levels (mill HKD)	32.80	11.99	2.69
Agg Depth 5 levels (mill HKD)	80.07	28.62	7.63
Order to Trade	3.18	2.92	2.65
HFTvolume (thousands)	-47.28	-27.80	-16.25
Time between quote updates	59.05	79.10	130.85
Realized volatility (percent)	7.49	3.62	1.76
Idiosyncratic volatility (percent)	1.05	0.30	0.07
Market Cap (bill HKD)	0.23	0.27	0.28
Number of Trades (thousands)	3.66	3.99	3.87
Trading volume (bill HKD)	0.58	0.13	0.03
Percentage client margin (percent)	7.14	8.38	
N (number of different stocks)	36.00	69.00	163.00
N (stocks with futures)	35.00	23.00	2.00

[12]The data is available at the W. P. Carey Business School at Arizona State University: Center for Investment Engineering. We are grateful to Sunil Wahal for providing this data to the research community.

[13]Found at: https://www.hkex.com.hk/.

Table 3 provides descriptive statistics for the constructed data for Hong Kong.[14] To give a base line of "normal" liquidity levels, we describe the series using data from January 2020, before the onset of the pandemic. We break our sample into their index constituency: Hang Seng Index, Hang Seng Composite Large Cap and Hang Seng Composite Mid Cap.

While quoted spreads are relatively wide in Hong Kong, ranging from 25-42 basis points, trades tend to occur when spreads are narrow, resulting in effective spreads of 6-13 basis points. Of this, market makers earn approximately 3-4 basis points, with the rest representing adverse selection or permanent price impact.

Like transactions costs, liquidity is concentrated in the largest HSI index securities, having depth of $14m HKD at the best quotes, more than doubling to $32m at the second level, and further increasing to $80m at the best 5 levels. Monotonic decreases in depth are observed for the smaller indices, for example at the best levels, the HSI has $14m HKD of depth, while the HSC Large Cap has $5m HKD while the Mid Cap index has an average of only $1m HKD. Similar monotonic declines are observed at the other depth levels. These depth reductions are consistent with the much smaller market capitalizations observed for the securities in the smaller indices.

Across the securities, realized volatility remains relatively stable across the indices, as do the required margins. (Note that there are no ISFs for mid cap securities).

5 Results

In order to more formally explore the determinants of margin requirements, the rationale behind their changes, and the impact of such changes on market quality, we undertake a number of regression analyses with specifications that are designed to address each of these questions in turn.

5.1 The determinants of Client Margins

Margin data at the individual security level have rarely been available to empirical researchers. Table 4 provides empirical evidence of the determinants of client margins. To fully explore this question margin for stock i on day t is measured in two ways: *client margin relative to January* takes the margin observed on any given day as a proportion of the average margin required in the month of January, 2020, while *Client margin percentage* reports the actual margin level observed.

Our regression specification takes the form:

$$\begin{aligned} Margin_{it} &= Price\ Difference_{it} + Realized\ Volatility_{it} + Idiosyncratic\ Volatility_{it} \\ &\quad + Effective\ Spread_{it} + \$Volume_{it} + \#Market\ Makers_{it} + Depth_{it}, \end{aligned}$$

where Margin represents the margin requirements either as an absolute percentage or as

[14] See Appendix C for similar descriptives for the international data.

a proportion of January 2020 levels, *Price difference* is the difference in stock price over the last 7 days, *Realized Volatility$_{it}$* is the standard deviation of daily stock returns calculated over the previous 30 days, *Idiosyncratic Volatility* is the average level of the stocks idiosyncratic volatility calculated over the last 7 days, *Effective Spread* is volume weighted and measured in basis points, *$Volume* is the average daily volume over the previous 30 days in billions of HKD. #*Market Makers*is the number of designated market makers covering the security. *Depth at best*, *Depth Level 2* and *Depth Level 5* is the dollar volume in billions of HKD available at the best bid and offer (and aggregated at levels 1-2 and 1-5, respectively).

Table 4: Determinants of Margin Requirements

The table shows the estimation for linear regression models. The data spans a period from January 1, 2020 to December 31, 2020. The dependent variables are *Client margin relative to January*, which is the ratio of the client margin at day t over the average client margin in January 2020 and *Client Margin Percentage*, which is the required margin expressed as a percentage. *Price difference*is the relative difference in stock price over the last 7 days. ($Price_t/Price_{t-7}$). *Realized Volatility*is the standard deviation of daily stock returns calculated over the previous 30 days. *Idiosyncratic Volatility*is the stock idiosyncratic volatility calculated over the last 7 days. *Effective Spread*are volume weighted and measured in basis points. *$Volume* is the average daily volume over the previous 30 days in billions of HKD. *Depth at best*, *Depth Level 2* and *Depth Level 5*is the dollar volume in billions of HKD available at the best bid and offer (and aggregated at levels 2 and 5, respectively). Estimated with fixed date and stock effects (not reported). Robust standard errors are reported in parentheses and clustered on stock and date. ***, ** and * indicate the statistical significance at the 1%, 5% and 10% level, respectively.

	Client Margin Relative to January			*Client Margin Percentage*		
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	1.536***	0.955***	0.956***	0.241***	0.185***	0.185***
	(0.417)	(0.178)	(0.177)	(0.0370)	(0.0271)	(0.0271)
Price difference (7 day)	−0.579	0.105	0.105	−0.143***	−0.0815***	−0.0815***
	(0.412)	(0.162)	(0.161)	(0.0382)	(0.0211)	(0.0211)
Realized Volatility (30 day)	4.111***	4.705***	4.706***	0.0849	0.0272	0.0273
	(0.682)	(0.261)	(0.261)	(0.0567)	(0.0169)	(0.0169)
Idiosyncratic Volatility (7 day)	0.281	−0.889*	−0.893*	−0.0288	−0.104	−0.104
	(0.921)	(0.486)	(0.482)	(0.0576)	(0.0894)	(0.0889)
Effective Spread	−65.64	−15.07	−17.13	6.162	17.84***	17.69***
	(127.0)	(42.00)	(41.04)	(5.011)	(4.961)	(4.934)
$Volume (30 day)	0.388***	0.198***	0.198***	0.00994***	−0.000206	−0.000216
	(0.0803)	(0.0225)	(0.0226)	(0.00205)	(0.00440)	(0.00440)
Depth at Best	−0.461			−0.00922		
	(0.620)			(0.0285)		
Depth Level 2		−0.0358			−0.00208	
		(0.168)			(0.0210)	
Depth Level 5			0.00542			0.000677
			(0.0841)			(0.0110)
Observations	13,651	7,350	7,350	13,687	7,350	7,350
R-squared	0.646	0.835	0.835	0.712	0.827	0.827

Table 4 shows that movements in prices of the underlying security have weak explanatory power over margins. Short-term price increases are found to result in marginally higher margins, as a percentage of their levels in January. Higher levels of realized 30-day volatility have a significant impact in determining relative margins, with greater realized volatility resulting in higher margins relative to January. Interestingly, when raw margins are examined, realized volatility does not have a significant impact, suggesting that higher standard deviation of returns leads to increased margins *within* a stock, but not *across* stocks. Idiosyncratic volatility, on the other hand, is insignificant in the relative margin regressions, but has a positive and significant relationship with absolute margins, suggesting that larger difference between the daily high and lows experienced by a stock help to explain the variation in margin levels *between* stocks but not *within* stocks.

Effective spread - our proxy for transactions costs, is not found to have a significant relationship with either measure of margins. Higher turnover is found to lead to a significant increase in relative margins, which is likely indicative of a high correlation between selling pressure during Covid leading to significant price reductions within a stock.

Securities with a greater market making presence are characterised by lower overall margins, though this is only weakly significant in one of our specifications. This result provides some support for the stabilising role of market makers with positive obligations can have in a marketplace, potentially mitigating some of the negative effects of a downwards liquidity spiral, as predicted by Brunnermeier (2009).

All measures of depth, whether at the best level, best 2 or 5 levels all have a significant effect on reducing the required margin levels. This is indicative of higher levels of liquidity being able to decelerate rapid price changes, helping to avoid negative liquidity spirals.

Taken together, our results indicate that measures designed to increase market depth can assist in reducing the likelihood of a negative price spiral, including the addition of positive obligations on market makers. Measures which can reduce the variation in prices are also effective at minimising the increases in margins associated with volatile periods.

5.2 Determinants of Margin Changes

In this subsection, we examine the determinants of margin level changes on ISFs. We first examine the decision to increase margins, followed by the choice to decrease margins. In both instances, we undertake a probit model at the stock-day level, using data from January to July 2021. A dummy variable is assigned to a change in the margin level, taking the value of 0 in the case of no change, and a 1 in the case of an increase/decrease (respectively). These are then run in individual probit regressions of the following form:

$$\begin{aligned} \textit{Margin Change}_{it} &= \textit{Price Difference}_{it} + \textit{Realized Volatility}_{it} + \textit{Idiosyncratic Volatility}_{it} \\ &\quad + \textit{Effective Spread}_{it} + \$Volume_{it} + \#\textit{Market Makers}_{it} + \textit{Depth}_{it} \end{aligned}$$

where Margin Change takes a value of 1 in the case of a margin increase(or decrease in our second model) in security i on day t, and 0 otherwise. All other variables are constructed in the same way as for Table 4.

Table 5 shows that neither price movements alone, nor increases in the realized volatility of prices have a significant impact on the likelihood that margins will be increased. However, the 7-day average of idiosyncratic volatility (capturing the difference between daily high and low traded prices) has a significant and positive impact on the probability of a margin increase

Table 5: Determinants of Margin Increases

The table shows the estimation for the likelihood of client margin increases using probit models. The data spans a period from January 1, 2020 to December 31, 2020. In columns 2,4 and 6 the probit coefficients are converted into marginal effects for ease of interpretation. *Price difference*is the relative difference in stock price over the last 7 days. ($Price_t / Price_{t-7}$). *Realized Volatility*is the standard deviation of daily stock returns calculated over the previous 30 days. *Idiosyncratic Volatility*is the stock idiosyncratic volatility calculated over the last 7 days. *Effective Spread*are volume weighted and measured in basis points. *$Volume* is the average daily volume over the previous 30 days in billions of HKD. *#Market Makers*is the number of designated market makers covering the security. *Depth at best*, *Depth Level 2* and *Depth Level 5*is the dollar volume in billions of HKD available at the best bid and offer (and aggregated at levels 2 and 5, respectively). Robust standard errors are reported in parentheses and clustered on stock and date. ***, ** and * indicate the statistical significance at the 1%, 5% and 10% level, respectively.

	Increase	Marginal Effects	Increase	Marginal Eff.	Increase	Marginal Eff.
	(1)	(2)	(3)	(4)	(5)	(6)
Price difference (7 day)	-0.181	-0.00995	-0.513	-0.0303	-0.517	-0.0305
	(0.433)	(0.0238)	(0.383)	(0.0224)	(0.388)	(0.0227)
Realized Vol (30 day)	1.399	0.0771	0.533	0.0315	0.585	0.0345
	(0.921)	(0.0511)	(0.680)	(0.0401)	(0.689)	(0.0407)
Idiosyncratic Vol (7 day)	2.575**	0.142**	3.868***	0.228***	3.677***	0.217***
	(1.262)	(0.0704)	(1.383)	(0.0831)	(1.396)	(0.0841)
Effective Spread	-42.50	-2.341	-93.04	-5.487	-101.3	-5.978
	(33.03)	(1.826)	(60.24)	(3.610)	(63.31)	(3.792)
$Volume (30 day)	0.0625***	0.00344***	0.0937***	0.00553***	0.0940***	0.00555***
	(0.0110)	(0.000616)	(0.0198)	(0.00120)	(0.0200)	(0.00121)
#Market Makers	0.00339	0.000187	-0.0138	-0.000815	-0.0145	-0.000856
	(0.00760)	(0.000419)	(0.0128)	(0.000756)	(0.0129)	(0.000757)
Depth at Best	-1.748**	-0.0963**				
	(0.858)	(0.0471)				
Depth Level 2			-1.516	-0.0894		
			(0.972)	(0.0566)		
Depth Level 5					-0.591	-0.0349
					(0.444)	(0.0260)
Constant	-1.989***		-1.572***		-1.552***	
	(0.443)		(0.399)		(0.405)	
Observations	13,057	13,057	7,022	7,022	7,022	7,022

across all of our specifications.

Similar to our margin level estimations in Table 4, effective spreads do not appear to have a significant impact on the probability of margins being increased.

Recall that our results in Table 4 show that more $Volume is positively associated with higher overall margins. Consistent with this finding, increases in margins are significantly more likely when there is elevated trading activity, as measured using the $Volume over the last 30 stock-days.

We also find that more depth at the best price levels reduces the probability that margins will increase, though depth beyond the best levels (i.e. aggregate depth at Level 2 and 5) do not play a significant role in reducing the likelihood of margin increases.

Table 6: Determinants of Margin Decreases

The table shows the estimation for the client margin decrease likelihood probit models. The data spans a period from January 1, 2020 to December 31, 2020. In columns 2,4 and 6 the probit coefficients are converted into marginal effects for ease of interpretation.*Price difference*is the relative difference in stock price over the last 7 days. ($Price_t/Price_{t-7}$). *Realized Volatility*is the standard deviation of daily stock returns calculated over the previous 30 days. *Idiosyncratic Volatility*is the stock idiosyncratic volatility calculated over the last 7 days. *Effective Spread*are volume weighted and measured in basis points. *$Volume* is the average daily volume over the previous 30 days in billions of HKD. *#Market Makers*is the number of designated market makers covering the security. *Depth at best*, *Depth Level 2* and *Depth Level 5*is the dollar volume in billions of HKD available at the best bid and offer (and aggregated at levels 2 and 5, respectively). Robust standard errors are reported in parentheses and clustered on stock and date. ***, ** and * indicate the statistical significance at the 1%, 5% and 10% level, respectively.

	Decrease (1)	Marginal Effects (2)	Decrease (3)	Marginal Eff. (4)	Decrease (5)	Marginal Eff. (6)
Price difference (7 day)	-0.0432	-0.00296	1.444***	0.0915***	1.459***	0.0925***
	(0.328)	(0.0225)	(0.489)	(0.0298)	(0.490)	(0.0298)
Realized Vol (30 day)	-1.745	-0.120	-35.86***	-2.273***	-36.35***	-2.304***
	(3.560)	(0.244)	(4.086)	(0.249)	(4.129)	(0.253)
Idiosyncratic Vol (7 day)	-2.836*	-0.194*	-1.045	-0.0663	-1.047	-0.0663
	(1.499)	(0.102)	(0.831)	(0.0525)	(0.830)	(0.0523)
Effective Spread	18.99	1.301	74.53**	4.725**	79.53**	5.040**
	(20.81)	(1.423)	(37.42)	(2.308)	(38.39)	(2.366)
$Volume (30 day)	-0.0213	-0.00146	-0.0572	-0.00363*	-0.0550	-0.00348
	(0.0158)	(0.00107)	(0.0348)	(0.00219)	(0.0349)	(0.00219)
#Market Makers	0.0185***	0.00127***	0.0257**	0.00163**	0.0276**	0.00175**
	(0.00660)	(0.000452)	(0.0109)	(0.000687)	(0.0109)	(0.000689)
Depth at Best	1.191	0.0816				
	(0.809)	(0.0559)				
Depth Level 2			-0.499	-0.0316		
			(0.326)	(0.0206)		
Depth Level 5					-0.339**	-0.0215**
					(0.158)	(0.00997)
Constant	-1.761***		-2.611***		-2.621***	
	(0.319)		(0.468)		(0.468)	
Observations	13,146	13,146	7,043	7,043	7,043	7,043

Table 6 provides a similar probit analysis for the observed decreases in margins. Unlike margin increases, there is a positive and significant relationship between price increases and margin decreases. With higher prices, the risk of negative liquidity spirals reduces. This in turn reduces the counterparty default risk, which allows lower margin requirements. While increases in realized volatility were associated with higher probabilities of margin increases, these were not statistically significant. For decreases however, we see that higher realized volatility leads to statistically significant reductions in the probability of observing a margin increase. This is consistent with the price declines observed during our sample increasing price volatility, necessitating increased (or not decreased) margins.

While the number of designated market makers did not have a significant impact on the probability of margin increases, additional market makers result in a significant increase in the probability of margin decreases. This is consistent with their positive obligations to maintain continuous quotations stabilising prices, particularly when they are at their most volatile.

5.3 Impact of Margin Changes on Market Quality

As a first investigation into whether there are cross-sectional differences in liquidity related to margin, we consider the period of the Covid-19 crisis. As shown in the liquidity plots, liquidity, both in terms of spreads and depth, deteriorated around the WTO announcement of a pandemic in early March 2020. We therefore try to predict the relative change in each of our liquidity variables from March 1 to March 20 using Margin related variables, controlling for firm size, HSI membership, stock volatility and trading volume.

$$\begin{aligned} \text{Change in Liquidity}_i &= \alpha + \beta_1 \text{Margin Change}_i + \beta_2 \text{HSI member}_i \\ &\quad + \beta_3 \text{Firm Size}_i + \beta_4 \text{ Stock Volatility}_i \\ &\quad + \beta_5 \text{Trading volume}_i + \varepsilon_i \end{aligned} \tag{4}$$

The Margin change is measured two ways: 1) *Margin relative to January*: Initial Client Margin divided by average of January margins, and 2) *Percentage Margin*: Initial Client Margin divided by (multiplier $\times$ Stock price).

The results of running this regression are shown in Table 7. The coefficient on the margin variables, both the level of the percentage margin, and the margin change since January, are not significant. So while there are cross-sectional differences observed in the margins, we do not find that it directly affects liquidity in the equity market. This indicates that other factors, such as the idiosyncratic volatility of the specific securities have a much larger explanatory power when it comes to equity market liquidity.

To control for the potential for endogeneity, we have adopted an instrumental variable (IV) approach from Daskalaki and Skiadopoulos (2016). These authors examine the impact of margin changes in commodity futures on the underlying spot markets and similarly face the potential that there is a correlation between the liquidity of the underlying asset and the resultant margin change. To address the potential presence of endogeneity, they employ an IV approach which employs a two stage least squares estimator. They use the once-lagged margin change (whenever it occurs) as their instrument. The rationale for such a lagged instrument is that even though the current values of margin changes might be endogenous, it is unlikely that its past value is subject to the same problem. In the first stage, we regress the (potentially endogenous) variable (margin change) on the chosen exogenous instrument (lagged margin change). In the second stage, we regress the dependent variable of interest (market quality variables) on the predicted values from the first stage regressions in place of the potentially endogenous variables. By using the predicted values based only on exogenous variables, we obtain the exogenous part of their variation, removing any potential bias due to endogeneity. The results are reported in panel B in Table 7. Our conclusion (that ISF margins do not play a significant role in market quality) remains robust to this control for potential endogeneity.

The analysis above uses the margin change as a predictive variable. Another way to estimate whether margin changes are linked to liquidity changes is to identify a group of stocks with higher increase in margin, and compare it to a group of stocks with less/no change in margin.

To understand how we construct such a split of the stocks, consider the timing of margin changes. As is shown in Figure 5 in the report, margins are typically changed only at the turn of the month. But there are cases where margins are changed also at other times. This suggest a method of identifying "high margin increases" as those contracts where margins are changed outside of the turn-of-the month – "unexpected margin changes." As Figure 5 shows, there were actually quite a few cases where posted margins are changed during March 2020, unlike the rest of the period.

We ask whether the liquidity of these stocks was different during the post-Covid-declaration in the context of a Diff-in-Diff analysis, with the stocks with unexpected margin changes in March 2020 as the treated sample. Specifically, we estimate the regression

$$\begin{aligned} Liquidity_{it} &= \alpha + \beta_1 Ind(\text{Pandemic})_{it} + \beta_2 Ind(\text{Extra margin change in March})_{it} \\ &\quad + \beta_3 Ind(\text{Extra margin change in March})_{it} \times Ind(\text{Pandemic})_{it} \\ &\quad + \gamma \text{Control variables}_{it} + \varepsilon_{it}, \end{aligned} \tag{5}$$

where $Ind()$ signifies an indicator variable. $Ind(\text{Pandemic})$ is an indicator variable equal to one in the period after the announcement of Covid-19 as a Pandemic (March 11, 2020). $Ind(\text{Extra margin change in March})$ is an indicator variable equal to one if the stocks associated ISF has a margin change during March of 2020. As control variables we consider the daily trading volume, and the stock return.

The results are reported in Table 8. The estimates do not provide strong evidence for a link between unexpected margin changes and stock liquidity. We do find that the coefficients for quoted spread and price impact are significantly different from zero. Note that the liquidity variable used here is the level of liquidity relative to the January average. Hence, for example, the negative coefficient on the interaction term for the quoted spread has the interpretation that the quoted spread is lower for the stocks where margin increased during the month,

Table 7: Do Margin Changes affect Liquidity During the Covid-19 pandemic?

Estimates of running the regression Change in Liquidity$_i$ $= \alpha + \beta_1$Margin Change$_i$ $+ \beta_2$HSI member$_i$ $+ \beta_3$Firm Size$_i$ $+ \beta_4$ Stock Volatility$_i$ $+ \beta_5$Trading volume$_i$ $+ \varepsilon_i$ on stocks with associated futures contracts. Dependent variables: Percentage changes in Quoted spread, Effective spread, Realized spread, Price impact and Depth, between March 1 and March 20. Explanatory variables are observed on March 1, and include: *Margin relative to January*: Initial Client Margin divided by average of January margins. *Percentage Margin*: Initial Client Margin divided by (multiplier $\times$ Stock price). The regression controls for membership in the HSI index, the log of the stocks' *Market Capitalization*, the log of the stocks *Trading Volume* (measured as an average over 7 days), and the stocks *Volatility* (measured as the standard deviation (in percent) of the last 30 days of returns).

Panel A

	Dependent variable:									
	Q.Spread		Eff.Spread		Real.Spread		Pric.Impact		Depth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Margin Relative to January	−4.9		1.2		688.8		86.8		6.7	
	(181.0)		(15.2)		(1,283.6)		(53.0)		(29.7)	
Percentage Margin		67.5		122.0		8,301.1		691.0		−79.0
		(1,433.4)		(118.9)		(10,127.5)		(419.9)		(235.1)
In HSI	3.2	2.3	3.6	3.1	−435.5	−408.9	15.0	20.2	9.3	10.5
	(87.8)	(86.1)	(7.4)	(7.1)	(622.3)	(608.2)	(25.7)	(25.2)	(14.4)	(14.1)
Market Cap	24.7	24.9	−0.1	0.1	−362.9	−365.0	11.0	10.2	−3.2	−3.5
	(39.0)	(38.9)	(3.3)	(3.2)	(276.6)	(274.6)	(11.4)	(11.4)	(6.4)	(6.4)
Volume	−13.2	−13.3	−7.6**	−7.6**	652.5**	657.7**	−26.1**	−25.3**	−10.1	−10.0
	(42.5)	(42.5)	(3.6)	(3.5)	(301.5)	(300.1)	(12.5)	(12.4)	(7.0)	(7.0)
Volatility	−45.1	−49.8	6.9	1.7	−700.9	−865.1	−54.0**	−58.3**	0.3	6.1
	(79.5)	(85.9)	(6.7)	(7.1)	(563.8)	(607.2)	(23.3)	(25.2)	(13.0)	(14.1)
Constant	−162.5	−169.2	169.5**	165.6**	−3,362.1	−3,132.6	301.8	345.0	237.3*	246.0*
	(843.8)	(832.7)	(70.7)	(69.1)	(5,983.4)	(5,883.5)	(247.2)	(243.9)	(138.5)	(136.6)
Observations	59	59	59	59	59	59	59	59	59	59
R^2	0.04	0.04	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1

Panel B: Instrumental Variables estimation

	Quoted Spread		Eff Spread		Real Spread		Price Impact		Depth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	−24.49	−25.40	67.44**	63.47**	−445.0	−33.05	133.8	150.9	77.67	73.84
	(373.4)	(350.1)	(32.59)	(30.26)	(2.756)	(2.581)	(124.7)	(116.7)	(62.32)	(58.28)
Margin Relative to January	−65.63		6.480		528.2		−24.94		−13.25	
	(122.7)		(10.71)		(906.1)		(41.01)		(20.49)	
Percentage Margin		−728.1		105.6		2.506		−421.4		−116.8
		(862.8)		(74.58)		(6.360)		(287.6)		(143.6)
In HSI Index	21.79	15.50	4.030	4.922	−397.4	−373.7	33.83	30.28	12.40	11.38
	(79.27)	(79.53)	(6.918)	(6.875)	(585.2)	(586.2)	(26.49)	(26.51)	(13.23)	(13.24)
Market Cap	17.49	17.29	−4.047	−3.948	−9.818	−15.91	−4.599	−5.012	−8.916*	−8.888*
	(29.86)	(29.78)	(2.606)	(2.574)	(220.4)	(219.5)	(9.975)	(9.926)	(4.984)	(4.957)
Observations	60	60	60	60	60	60	60	60	60	60
R-squared	0.027	0.028	0.049	0.068	0.008	0.012	0.042	0.048	0.044	0.050

which is somewhat counterintuitive. The significance on the coefficient for the interaction term for the quoted spread however disappears when we only consider stocks in the HSI Lcap index.

Table 8: Margin Requirements and Market quality - DiD estimation

This table investigates the changes to liquidity measures around the Covid-19 pandemic for stocks with and without "unexpected" margin changes during the month of March. (Which is 10 stocks) The estimated regression is $Liquidity_{it} = \alpha + \beta_1 Ind(\text{Pandemic})_{it} + \beta_2 Ind(\text{Extra margin change in March})_{it} + \beta_3 Ind(\text{Extra margin change in March})_{it} \times Ind(\text{Pandemic})_{it} + \gamma \text{Control variables}_{it} + \varepsilon_{it}$ The dependent variables are Quoted Spread, Effective Spread, Realized Spread, Price impact and Depth. For each stock, we normalise the liquidity measure based on the daily average of the liquidity measure over January. $Ind(\text{Pandemic})$ is an indicator variable equal to one in the period after the WHO announcement of Covid-19 as a Pandemic (March 11, 2020). $Ind(\text{Extra margin change in March})$ is an indicator variable equal to one if the stocks associated ISF has a margin change during March of 2020, *log(Volume)* is the natural logarithm of the daily number of shares traded in the stock. *Market return* is the percentage return for the HSI. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels.

Panel A: All stocks in the HSI, HSCLCap and HSCMidCap

	Dependent variable:					
	Q.Spread	Eff.Spread	Real.Spread	Pric.Impact	Depth	Dpth.5.Levels
	(1)	(2)	(3)	(4)	(5)	(6)
Interaction Pandemic/Margin Change March	-15.6^{**}	-6.2	21.7	-20.3^{**}	-6.0	-15.4
	(6.3)	(7.2)	(34.7)	(8.6)	(11.9)	(11.2)
Pandemic	43.6^{***}	19.9^{***}	-10.0	50.8^{***}	-40.5^{***}	-37.2^{***}
	(7.9)	(3.2)	(11.9)	(6.2)	(4.8)	(3.8)
Margin Change March	-10.6	-2.2	-41.6	0.7	8.1	19.4
	(13.9)	(3.3)	(33.0)	(5.2)	(12.2)	(12.7)
Volume	5.3	-1.0	1.4	-1.8	3.3	0.3
	(3.4)	(1.7)	(6.7)	(2.3)	(3.1)	(2.9)
Market return	4.3^{**}	-0.5	-2.8^{**}	-0.7	-1.3	-0.7
	(1.9)	(0.5)	(1.4)	(1.1)	(0.9)	(0.8)
Constant	2.8	122.1^{***}	79.9	138.7^{***}	36.2	93.9
	(65.1)	(34.3)	(129.1)	(45.2)	(61.8)	(58.6)
Observations	2,516	2,516	2,516	2,516	2,516	2,516
Adjusted R^2	0.05	0.2	0.004	0.3	0.1	0.2

Panel B: Only stocks in HSCLCap

	Dependent variable:					
	Q.Spread	Eff.Spread	Real.Spread	Pric.Impact	Depth	Depth.5.Levels
	(1)	(2)	(3)	(4)	(5)	(6)
Interaction Pandemic/Margin Change March	-15.0	-15.1	133.4	-50.8^{***}	5.0	-17.0^{*}
	(10.8)	(10.9)	(130.1)	(6.7)	(6.4)	(10.3)
Pandemic	40.8^{***}	14.6^{***}	-41.8^{***}	52.8^{***}	-39.1^{***}	-36.1^{***}
	(11.2)	(3.4)	(12.2)	(8.4)	(7.1)	(4.6)
Margin Change March	-7.5	-5.5	-144.7^{*}	-14.2	9.2	10.4
	(28.2)	(8.6)	(86.4)	(16.9)	(12.0)	(9.6)
Volume	12.6	1.3	26.3^{**}	3.1	4.1	2.0
	(9.2)	(3.9)	(12.6)	(6.3)	(6.6)	(6.3)
Market return	1.8	-0.6	1.9	-1.0	-1.2	-0.5
	(3.1)	(0.5)	(1.8)	(1.2)	(1.0)	(0.8)
Constant	-147.2	75.0	-423.4^{*}	46.3	8.9	51.7
	(178.0)	(77.8)	(247.9)	(120.7)	(131.6)	(128.8)
Observations	626	626	626	626	626	626
Adjusted R^2	0.05	0.1	0.04	0.3	0.2	0.2

5.4 Does the Existence of ISFs Improve Market Quality?

Across the three indices on the Hong Kong market, ISFs exist only for a subset of these securities. This raises a natural question: Does the existence of ISFs improve market quality, particularly during the pandemic? To answer this question, we undertake a Difference-in-Difference estimate - comparing stocks with and without ISFs before and after the pandemic. More formally, our regression specification takes the following form:

$$\begin{aligned} \text{Market Quality}_{it} \quad = \quad & \alpha + \beta_1 Ind(\text{ Pandemic})_{it} + \beta_2 Ind(\text{Has Future})_{it} \\ & + \beta_3 Ind(\text{Pandemic})_{it} \times Ind(\text{Has Future})_{it} \\ & + \beta_4 \$Volume_{it} + \beta_5 Market\ Return_{it} + \varepsilon_{it}, \end{aligned} \tag{6}$$

where $Ind()$ signifies an indicator variable. $Ind(\text{Pandemic})$ is an indicator variable equal to one in the period after the announcement of Covid-19 as a Pandemic (March 11, 2020). $Ind(\text{Has Future})$ is an indicator variable equal to one if the stocks' associated ISF has a margin change during March of 2020. As control variables we consider the daily trading volume, and the stock return. The dependent variable, Market Quality, is one of our measures of liquidity; Quoted Spread, Effective Spread, Realized Spread, Price Impact, and Depth at the best quotes, as well as at the top 5 levels.

The validity of our difference-in-differences estimates in Table 9 does not require that treated and control sample stocks are similar in their levels of liquidity, only that they follow similar trends. Appendix D shows that although stocks with and without ISFs differ in their levels of liquidity, their trends in liquidity are graphically indistinguishable in the pre-Covid period (January - November, 2019) across all dependent variables, supporting the common trends assumption.

Panel A of Table 9 presents the summary of our findings for the impact of ISFs on all stocks listed across the three indices of interest, while Panel B examines only the HSC Large Cap index, for which we observe the greatest variation in ISF inclusion (All stocks in the HSI have ISFs).

Panel A shows that the existence of ISFs causes a significant reduction in effective spreads - the cost of liquidity demand - as well as price impact (the adverse selection component of the spread). This is likely driven by the existence of designated market makers in the ISFs who also need to trade in the underlying securities. The significant reduction observed in depth is also likely driven by these market makers, who will experience significant increases in the cost of providing liquidity across both stocks and ISFs as margins increase, leading them to withdraw some of the quoted depth from the market in the underlying securities. Panel B reports qualitatively similar results when the results are re-run only for those securities which are constituents of the HSC Large Cap fund.

Table 10 seeks to provide further evidence on why we may observe the differences between stocks with ISFs and those without. Foley et al. (2021) show that the increased margin require-

Table 9: Do ISFs Improve Market Quality?

This table reports the changes to liquidity measures around the Covid-19 pandemic for stocks with and without associated futures contracts. Our sample period covers February 11, 2020 to April 11, 2020. The dependent variables are Quoted Spread, Effective Spread, Realized Spread, Price impact and Depth. For each stock, we normalise the liquidity measure based on the daily average of the liquidity measure over January. *Pandemic* is an indicator variable equal to 1 for the period after the World Health Organization declares the Covid-19 outbreak a pandemic, and 0 otherwise. *Has Future* is an indicator variable equal to 1 if the stock belongs in the main market index for the stock's listing market as outlined in Table C.1. *log(Volume)* is the natural logarithm of the daily number of shares traded in the stock. *Market return* is the percentage return for the HSI. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels.

Panel A: All stocks in the HSI, HSCLCap and HSCMidCap

	Dependent variable:					
	Q.Spread	Eff.Spread	Real.Spread	Pric.Impact	Depth	Dpth.5.Levels
	(1)	(2)	(3)	(4)	(5)	(6)
Interaction Pandemic/Has Future	−0.3	−4.8***	63.6	−4.9*	−17.7***	−16.5***
	(3.9)	(1.3)	(52.9)	(2.7)	(2.7)	(2.2)
Pandemic	42.7***	23.7***	−69.0***	52.3***	−23.6***	−23.5***
	(1.4)	(0.5)	(19.5)	(1.0)	(1.0)	(0.8)
Has Future	4.7	2.4**	−11.7	2.6	−0.2	−1.1
	(3.0)	(1.0)	(41.1)	(2.1)	(2.1)	(1.7)
Volume	−0.7	−1.1***	−4.5	−1.8***	1.8***	1.3***
	(0.5)	(0.2)	(6.5)	(0.3)	(0.3)	(0.3)
Market return	0.4	−0.8***	−1.6	−0.8***	−1.0***	−0.1
	(0.3)	(0.1)	(4.1)	(0.2)	(0.2)	(0.2)
Constant	114.8***	121.9***	204.2*	136.2***	68.1***	79.2***
	(8.3)	(2.9)	(113.9)	(5.7)	(5.9)	(4.7)
Observations	18,507	18,507	18,507	18,507	18,507	18,507
Adjusted R^2	0.1	0.1	0.000	0.1	0.04	0.1

Panel B: Only stocks in HSCLCap

	Dependent variable:					
	Q.Spread	Eff.Spread	Real.Spread	Pric.Impact	Depth	Depth.5.Levels
	(1)	(2)	(3)	(4)	(5)	(6)
Interaction Pandemic/Has Future	−7.0	−10.9***	82.8***	−5.4	−19.1***	−15.3***
	(12.0)	(2.3)	(31.6)	(4.0)	(5.0)	(4.0)
Pandemic	46.9***	24.0***	−101.3***	52.3***	−19.8***	−23.4***
	(5.6)	(1.1)	(14.8)	(1.9)	(2.3)	(1.9)
Has Future	−9.3	1.7	−20.4	9.8***	−15.2***	−14.3***
	(8.8)	(1.7)	(23.3)	(2.9)	(3.7)	(3.0)
Volume	3.9*	−3.0***	−19.8***	−3.8***	7.4***	4.2***
	(2.4)	(0.5)	(6.2)	(0.8)	(1.0)	(0.8)
Market return	0.5	−0.9***	4.4	−1.0***	−1.0**	−0.2
	(1.1)	(0.2)	(2.9)	(0.4)	(0.5)	(0.4)
Constant	32.5	157.3***	495.4***	172.5***	−40.8**	24.4
	(44.5)	(8.7)	(117.7)	(14.8)	(18.5)	(15.0)
Observations	2,891	2,891	2,891	2,891	2,891	2,891
Adjusted R^2	0.03	0.2	0.02	0.2	0.1	0.1

ments as a result of the Covid-19 pandemic led to the withdrawal of liquidity providers. To analyze the potential impact of ISFs on HFT activity, we examine the Order to Trade ratio, the HFT Volume metric as well as the time between quotes.[15]

Panel A of Table 10 shows that both the pandemic and the existence of ISFs has a significant impact on the activity of high frequency traders across all index securities. The pandemic induced more frequent quoting behaviour, with significant increases observed in the order to trade ratio leading to a significant reduction in the time between quote updates. However, this activity was driven by significant increases in the amount of trade activity, leading to reductions in the HFT Volume metric. The existence of ISFs had a mixed impact on HFT activity, with significant increases in the order to trade ratio indicating heightened activity, while the significant reduction in HFT Volume and increase in time between quote updates are indicative of the existence of ISFs being associated with HFT withdrawal. The primary variable of interest - the interaction between the existence of ISFs in the post-pandemic period indicate that there was significant reduction in HFT activity, with reductions in the order to trade ratio and HFT Volume. While the time between updates also declined, this could be driven by increased overall trading activity.

Panel B of Table 10, which considers only those stocks which are part of the HSC Large Cap index shows relatively similar results to Panel A - the post pandemic period for stocks with ISFs resulted in reductions in HFT Volume, despite small increases in the order to trade ratio.

Overall, the results of our Difference-in-difference methodology confirm the importance of ISFs (and their market makers) in both retaining resilient liquidity in the underlying securities, leading to reduced transactions costs, but at the same time the increase in margins led to a withdrawal of depth at the best by these market makers, with generally lower measures of HFT activity combined with significant reductions in depth for those securities with ISFs.

[15]Specific details on the construction of these variables is provided in Section 4.

Table 10: Do ISFs Impact HFT Activity?

This table reports the changes to HFT measures around the Covid-19 pandemic for stocks with and without associated futures contracts. Our sample period covers February 11, 2020 to April 11, 2020. The dependent variables are Order to Trade, HFT Volume and Time between Quote Updates. For each stock, we normalise the liquidity measure based on the daily average of the liquidity measure over January. *Pandemic* is an indicator variable equal to 1 for the period after the World Health Organization declares the Covid-19 outbreak a pandemic, and 0 otherwise. *Has Future* is an indicator variable equal to 1 if the stock belongs in the main market index for the stock's listing market as outlined in Table C.1. *log(Volume)* is the natural logarithm of the daily number of shares traded in the stock. *Market return* is the percentage return for the HSI. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels.

Panel A: All stocks in the HSI, HSCLCap and HSCMidCap

	Dependent variable:		
	Order to Trade	HFTvolume	Time Betw Quote Updates
	(1)	(2)	(3)
Interaction Pandemic/Has Future	-2.6^{***}	-5.1^{*}	-9.3^{***}
	(1.0)	(2.7)	(2.4)
Pandemic	0.9^{**}	-12.6^{***}	-38.5^{***}
	(0.4)	(1.0)	(0.9)
Has Future	6.5^{***}	-22.9^{***}	23.8^{***}
	(0.8)	(2.1)	(1.9)
Volume	-2.8^{***}	9.4^{***}	-9.5^{***}
	(0.1)	(0.3)	(0.3)
Market return	0.3^{***}	-0.04	0.4^{**}
	(0.1)	(0.2)	(0.2)
Constant	148.5^{***}	-66.1^{***}	259.5^{***}
	(2.1)	(5.9)	(5.2)
Observations	18,507	18,507	18,507
Adjusted R^2	0.03	0.05	0.2

Panel B: Only stocks in HSCLCap

	Dependent variable:		
	Order to Trade	HFTvolume	Time Between Quote Updates
	(1)	(2)	(3)
Interaction Pandemic/Has Future	2.6	-8.1^{***}	-4.6
	(1.7)	(2.9)	(3.6)
Pandemic	-1.3^{*}	-9.5^{***}	-40.5^{***}
	(0.8)	(1.4)	(1.7)
Has Future	3.0^{**}	-6.3^{***}	2.6
	(1.3)	(2.1)	(2.7)
Volume	-5.2^{***}	11.6^{***}	-8.6^{***}
	(0.3)	(0.6)	(0.7)
Market return	0.02	0.5^{*}	0.9^{***}
	(0.2)	(0.3)	(0.3)
Constant	198.0^{***}	-124.2^{***}	252.3^{***}
	(6.5)	(10.8)	(13.5)
Observations	2,891	2,891	2,891
Adjusted R^2	0.1	0.1	0.3

6 Conclusion

We examine an unprecedented period of instability in global equity markets due to the Covid-19 pandemic. The March 11 pandemic declaration by the WHO sent global margins in all security markets soaring, leading to the steepest hike in margins observed since the GFC in 2008. Such increases in margin have been shown to have severe impacts on global liquidity in these markets (see Foley et al. (2021), O'Hara and Zhou (2020), Duffie (2020), and Cheng et al. (2020)), generally leading to significant illiquidity - increased transactions costs and reduced depth. Such environments of constrained market liquidity at the same time as fire-sales of assets (such as occurred during the Covid-19 pandemic) can lead to negative liquidity spirals. Brunnermeier and Pedersen (2009) pioneered the theoretical work in this area, showing that increased trading margins required by exchanges to minimise counterparty default risk between participants increases funding liquidity costs. This increase in the cost of funding liquidity cause reductions in market liquidity, resulting in pro-cyclical negative liquidity spirals. Our paper presents four main findings.

First, we examine the evolution of both index levels and equity market liquidity in Hong Kong, as well as a number of other major developed global markets (including Australia, Canada, Europe, Scandinavia, UK and the US.). our results show that although all markets suffered falls in index levels and market depth, as well as increases in transactions costs, amongst the markets analyzed Hong Kong experienced the least dislocation in its market. Prices fell the least, and liquidity remained the most resilient.

Second, we use the extensive and frequent changes to margin levels precipitated by the Covid-19 pandemic to analyze the determinants of margin levels and their changes. Our findings suggest that the major drivers of required margin levels include returns, the standard deviation of prices as well as the high-low range experienced by securities. Interestingly, quoted depth at 1, 2 and 5 levels also plays a significant role in mitigating increases in margin requirements. When analysing margin increases and decreases, we find that elevated volumes associated with fire-sale market behaviour has a significant impact on the likelihood of margin increases, but not decreases. Elevated price volatility is associated with an increased probability of margin increases and a reduced probability of margin decreases. Finally, we find that increases in the number of designated market makers significantly increases the probability of margin reductions, consistent with their role in stabilising both prices and liquidity.

Third, we examine the role that margins play in explaining the observed changes in liquidity levels. Unlike existing studies (such as Foley et al. (2021)) which use market-wide index margins, we are able to identify the exact margin levels associated with each stock. Utilising this heterogeneity during the period of significant volatility in required margins allows us to provide causal evidence on the impact of stock-level margins. Our results show that heterogeneity in individual margins do not play a significant role in explaining market liquidity variables such as quoted and effective spreads, price impact or quoted depth. This could be due to the muted response in Hong Kong to the Covid pandemic or could indicate that equity market makers are more sensitive to changes in index margins due to their role in hedging the provision of stock liquidity.

Finally, we use a difference-in-differences design to examine the impact of having individual stock futures on the underlying market quality of the securities in which they are denominated. Our findings suggest that the designated market makers which exist in the individual stock futures also need to trade in the underlying asset, reducing equity market transactions costs. However, the relevance of margin requirements for these market makers also results in a withdrawal of quoting activity, resulting in reductions in overall market depth at a time when it is most required.

Our findings have several important policy implications. First and foremost, our research indicates that design choices around market structure can play an important role in mitigating pro-cyclical negative liquidity spirals during periods of extreme market volatility, as documented by Brunnermeier and Pedersen (2009). The systemic risk inherent in such liquidity spirals present increasing concerns for global regulators, particularly as global liquidity provision becomes concentrated in "capital efficient" high-frequency market makers such as Virtu and Citadel. The correlated nature of the global increase in margins and immediate reduction in global liquidity belies the potential issue of concentrating the function of liquidity provision across a small handful of participants.

The fact that the Hong Kong markets did not suffer as extreme dislocations as their global peers may in many cases be attributable to the existence of individual stock futures and their diverse group of market makers. In many cases, there are between 4-8 designated provides of liquidity in these contracts, ensuring that a diverse group of market makers retain sufficient capital to provide uninterrupted liquidity. This suggests that the existence (and potential expansion) of such market making programs can have the capacity to mitigate the liquidity crisis observed during such turbulent market conditions. Further, the existence of individual stock futures (a relatively rare global structure) may further facilitate enhancements to equity market quality.

We would encourage Hong Kong to continue to support diversity amongst its market making community, and to ensure that the positive obligations that these market makers are charged with are sufficient to support liquidity even in extremely turbulent conditions. Further, we would encourage regional markets to consider the adoption of similar obligations on designated market makers to act in counter-cyclical ways.

Despite the success of these market makers in limiting the impact of the Covid-19 pandemic in Hong Kong, we have provided evidence of significant HFT withdrawal from the market due to the pandemic, likely induced by the increases in margins. The regulator may want to consider establishing regulatory capital reserves which can act as a "countercyclical buffer" in times of stress, providing such capital to market makers to enhance their ability to absorb increased margins. Such regulatory capital reserves have been deployed in other settings (such as banking) for this exact reason. These buffers could be funded through modest taxes on trades, or even orders, with minimal impact on the overall marketplace.

References

Tobias Adrian, Nina Boyarchenko, and Or Shachar. Dealer balance sheets and bond liquidity provision. *Journal of Monetary Economics*, 89:92–109, August 2017. doi: 10.1016/j.jmoneco.2017.03.011.

Dave Altig, Scott Baker, Jose Maria Barrero, Nicholas Bloom, Philip Bunn, Scarlet Chen, Steven J. Davis, Julia Leather, Brent Meyer, Emil Mihaylov, Paul Mizen, Nicholas Parker, Thomas Renault, Pawel Smietanka, and Gregory Thwaites. Economic uncertainty before and during the covid-19 pandemic. *Journal of Public Economics*, 191:104274, 2020. doi: 10.1016/j.jpubeco.2020.104274.

Sirio Aramonte and Paweł J Szerszeń. Cross-market liquidity and dealer profitability: Evidence from the bond and CDS markets. *Journal of Financial Markets*, 51:100559, November 2020. doi: 10.1016/j.finmar.2020.100559.

Badar Nadeem Ashraf. Stock markets' reaction to COVID-19: Cases or fatalities? *Research in International Business and Finance*, 54, 2020. doi: 10.1016/j.ribaf.2020.101249.

Angelo Aspris, Sean Foley, and Peter O'Neill. Benchmarks in the spotlight: The impact on exchange traded markets. *Journal of Futures Markets*, 40:1691–1710, 2020. doi: 10.1002/fut.22120.

Ahmed S Baig, Hassan A Butt, Omair Haroon, and Syed Aun R Rizvi. Deaths, panic, lockdowns and us equity markets: The case of COVID-19 pandemic. *Finance Research Letters*, 30:101701, 2020.

Scott R Baker, Nicholas Bloom, Steven J Davis, Kyle Kost, Marco Sammon, and Tasaneeya Viratyosin. The Unprecedented Stock Market Reaction to COVID-19. *The Review of Asset Pricing Studies*, 10(4):742–758, 07 2020. doi: 10.1093/rapstu/raaa008.

Markus Behn, Rainer Haselmann, and Paul Wachtel. Procyclical Capital Regulation and Lending. *Journal of Finance*, 71(2):919–956, 2016. doi: 10.1111/jofi.12368.

Antje Bent, Darrell Duffie, and Yichao Zhu. The decline of too big to fail. Working Paper, Australia National University, December 2019.

Allen N. Berger, Christa H. S. Bouwman, Thomas Kick, and Klaus Schaeck. Bank liquidity creation following regulatory interventions and capital support. *Journal of Financial Intermediation*, 26:115–141, April 2016. doi: 10.1016/j.jfi.2016.01.001.

H Berkman and H Malloch. Stock valuation during the Covid-19 pandemic: An explanation using option-based discount rates. *Journal of Banking and Finance*, 2021. doi: 10.1016/j.jbankfin.2021.106386.

Jonathan Brogaard, Matthew C Ringgenberg, and Dominik Roesch. Does floor trading matter? 2021.

Markus K Brunnermeier. Deciphering the liquidity and credit crunch 2007–2008. *Journal of Economic Perspectives*, 23(1):77–100, Winter 2009.

Markus K Brunnermeier and Lasse Heje Pedersen. Market liquidity and funding liquidity. *The Review of Financial Studies*, 22(6):2201–2238, 2009.

Bidisha Chakrabarty and Roberto Pascual. Stock liquidity and algorithmic market making during the Covid-19 crisis. *Journal of Banking and Finance*, page 106415, 2022. doi: 10.1016/j.jbankfin.2022.106415.

C Chau, A Aspris, S Foley, and H Malloch. Quote-based manipulation of illiquid securities. *Finance Research Letters*, 39, 2021. doi: 10.1016/j.frl.2020.101556.

Jeffrey Cheng, David Wessel, and Joshua Younger. How did COVID-19 discrupt the market for U.S. treasury debt? Working paper, Hutchins Center, Brookings Institution, 2020.

Mardy Chiah and Angel Zhong. Trading from home: The impact of COVID-19 on trading volume around the world. *Finance Research Letters*, 37, 2020. doi: 10.1016/j.frl.2020.101784.

Carole Comerton-Forde, Terrence Hendershott, Charles M. Jones, Pamela C Moulton, and Mark S Seasholes. Time Variation in Liquidity: The Role of Market-Maker Inventories and Revenues. *The Journal of Finance*, 65(1):295–331, 2010. doi: 10.1111/j.1540-6261.2009.01530.x.

Jennifer Conrad and Sunil Wahal. The term structure of liquidity provision. *Journal of Financial Economics*, 136(1):239 – 259, 2020. doi: 10.1016/j.jfineco.2019.09.008.

T Copeland and D Galai. Information effects and the bid–ask spread. *Journal of Finance*, 1983: 1457–1469, 1983.

Justin Cox and Donovan Woods. Covid-19 and market structure dynamics. *Journal of Banking and Finance*, page 106362, 2021. ISSN 0378-4266. doi: 10.1016/j.jbankfin.2021.106362.

Charoula Daskalaki and George Skiadopoulos. The effects of margin changes on commodity futures markets. *Journal of Financial Stability*, 22: 129–152, February 2016. doi: 10.1016/j.jfs.2016.01.002.

Evan Dudley and Mahendrarajah Nimalendran. Margins and Hedge Fund Contagion. *The Journal of Financial and Quantitative Analysis*, 46(5): 1227–1257, 2011.

Darrel Duffie. Still the world's safe haven? Redesigning the U.S. Treasury market after the COVID-19 crisis. Working paper, Stanford University, May 2020.

Andrew Ellul, Isil Erel, and Uday Rajan. The COVID-19 pandemic crisis and corporate finance. *The Review of Corporate Finance Studies*, 9 (3):421–429, 10 2020. doi: 10.1093/rcfs/cfaa016.

Michael Fleming and Francisco Ruela. Treasury market liquidity during the COVID-19 crisis. Liberty Street Economics, Federal Reserve Bank of New York, April 2020.

Sean Foley, Amy Kwan, Richard Phillip, and Bernt Arne Ødegaard. Contagious margin calls: How Covid-19 threatened global stock market liquidity. *Journal of Financial Markets*, 2021. doi: 10.1016/j.finmar.2021.100689.

Simon Glossner, Pedro Matos, Stefano Ramelli, and Alexander F Wagner. Do institutional investors stabilize equity markets in crisis periods? evidence from covid-19. Swiss Finance Institute Research Paper No. 20, 2021.

Niels Joachim Gormsen and Ralph S J Koijen. Coronavirus: Impact on Stock Prices and Growth Expectations. *The Review of Asset Pricing Studies*, 10(4):574–597, 09 2020. doi: 10.1093/rapstu/raaa013.

Denis Gromb and Dimitri Vayanos. Equilibrium and welfare in markets with financially constrained arbitrageurs. *Journal of Financial Economics*, 66(2):361–407, November 2002. doi: 10.1016/S0304-405X(02)00228-3.

Nicolae Gârleanu and Lasse Heje Pedersen. Margin-based Asset Pricing and Deviations from the Law of One Price. *The Review of Financial Studies*, 24(6):1980–2022, June 2011. doi: 10.1093/rfs/hhr027.

Allaudeen Hameed, Wenjin Kang, and S Viswanathan. Stock Market Declines and Liquidity. *The Journal of Finance*, 65(1):257–293, 2010. doi: 10.1111/j.1540-6261.2009.01529.x.

Lars Peter Hansen. Repercussions of Pandemics on Markets and Policy. *The Review of Asset Pricing Studies*, 10(4):569–573, 10 2020. doi: 10.1093/rapstu/raaa020.

Maretno Agus Harjoto, Fabrizio Rossi, Robert Lee, and Bruno S. Sergi. How do equity markets react to Covid-19? Evidence from emerging and developed countries. *Journal of Economics and Business*, 115:105966, 2021. doi: 10.1016/j.jeconbus.2020.105966.

Julien Hugonnier and Erwan Morellec. Bank capital, liquid reserves, and insolvency risk. *Journal of Financial Economics*, 125(2):266–285, August 2017. doi: 10.1016/j.jfineco.2017.05.006.

Gbenga Ibikunle and Khaladdin Rzayev. Grey rhinos in financial markets and venue selection: The case of Covid-19. *Covid Economics*, page 88, 2020.

Gbenga Ibikunle and Khaladdin Rzayev. Covid-19: Venue selection effects and implications for market quality. Working Paper, SSRN, October 2021.

G Andrew Karolyi, Kuan-Hui Lee, and Mathijs A van Dijk. Understanding commonality in liquidity around the world. *Journal of Financial Economics*, 105(1):82–112, July 2012. doi: 10.1016/j.jfineco.2011.12.008.

Paul H Kupiec. Margin requirements, volatility, and market integrity: What have we learned since the crash? *Journal of Financial Services Research*, 13(3):231–255, 1998.

Laura Malceniece, Kārlis Malcenieks, and Tālis J. Putniņš. High frequency trading and comovement in financial markets. *Journal of Financial Economics*, 134:381–399, 2019. doi: 10.1016/j.jfineco.2018.02.015.

Stephen Morris and Hyun Song Shin. Liquidity Black Holes. *Review of Finance*, 8(1):1–18, January 2004. doi: 10.1023/B:EUFI.0000022155.98681.25.

Maureen O'Hara and Xing (Alex) Zhou. Anatomy of a Liquidity Crisis: Corporate Bonds in the COVID-19 Crisis. *Journal of Financial Economics*, May 2020. doi: 10.2139/ssrn.3615155. forthcoming.

Gideon Ozik, Ronnie Sadka, and Siyi Shen. Flattening the illiquidity curve: Retail trading during the covid-19 lockdown. *Journal of Financial and Quantitative Analysis*, 56(7):2356–2388, 2021.

Ľuboš Pástor and M Blair Vorsatz. Mutual Fund Performance and Flows during the COVID-19 Crisis. *The Review of Asset Pricing Studies*, 10(4): 791–833, 09 2020. doi: 10.1093/rapstu/raaa015.

Stefano Ramelli and Alexander F Wagner. Feverish stock price reactions to Covid-19. *The Review of Corporate Finance Studies*, 9(3):622–655, 07 2020. doi: 10.1093/rcfs/cfaa012.

Rafael Repullo and Javier Suarez. The Procyclical Effects of Bank Capital Regulation. *The Review of Financial Studies*, 26(2):452–490, February 2013. doi: 10.1093/rfs/hhs118.

Pierre-Olivier Weill. Leaning Against the Wind. *The Review of Economic Studies*, 74(4):1329–1354, October 2007. doi: 10.1111/j.1467-937X.2007.00451.x.

Adam Zaremba, David Y. Aharon, Ender Demir, Renatas Kizys, and Dariusz Zawadka. Covid-19, government policy responses, and stock market liquidity around the world: A note. *Research in International Business and Finance*, 56, 2021. doi: 10.1016/j.ribaf.2020.101359.

Appendix

A Is depth at the top of the book representative?

In a limit order market, the *depth* is the total trading interest at the best bid and ask quotes. Larger depth indicates more trading interest, and is empirically used as a measure of market quality. In many of the world's financial markets the advent of high-frequency traders has led to a decline in the trading interest at the top of the book. This is because these traders use their speed advantage to get to the front of the queue of traders wanting to update their bids. HFT traders thus do not have to show their whole trading interest by actually posting quantity at the best. Such a strategy avoids giving away the "option value" of an actual order in the limit order book.[16] Instead, HFT traders may rather post quantity at prices slightly away from the current best quantity and be the first to update these prices.

To investigate whether this is an issue in Hong Kong we also calculate the depth at the best two and five prices. In cases where the top of the book is less informative, depth at two and five levels will be better reflections of the total trading interest.

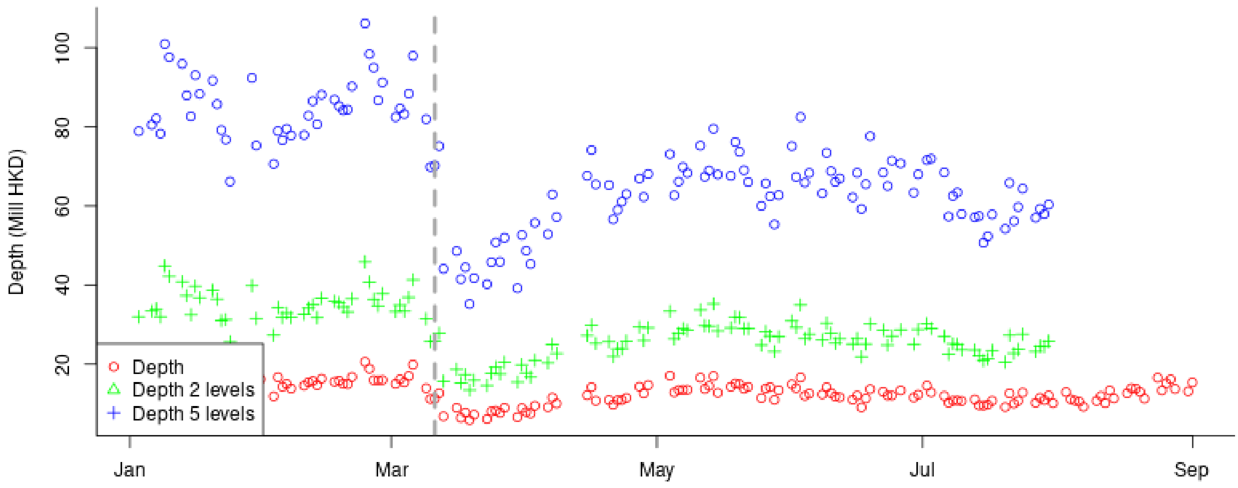
Figure A.1 shows that in the Hong Kong market, the depth at the top of the book does not seem to have much of such issues. In the figure, panel A shows the averages of depth across stocks with associated futures contracts. While the depth at five levels in absolute magnitude is clearly larger, and falls substantially more, during the Covid crisis, in relative terms, depth at one, two and five levels seem to drop by similar magnitudes. In the analysis we therefore rely mainly on depth at the best bid and ask prices.

[16] This adverse selection cost of posting limit orders was first shown in Copeland and Galai (1983).

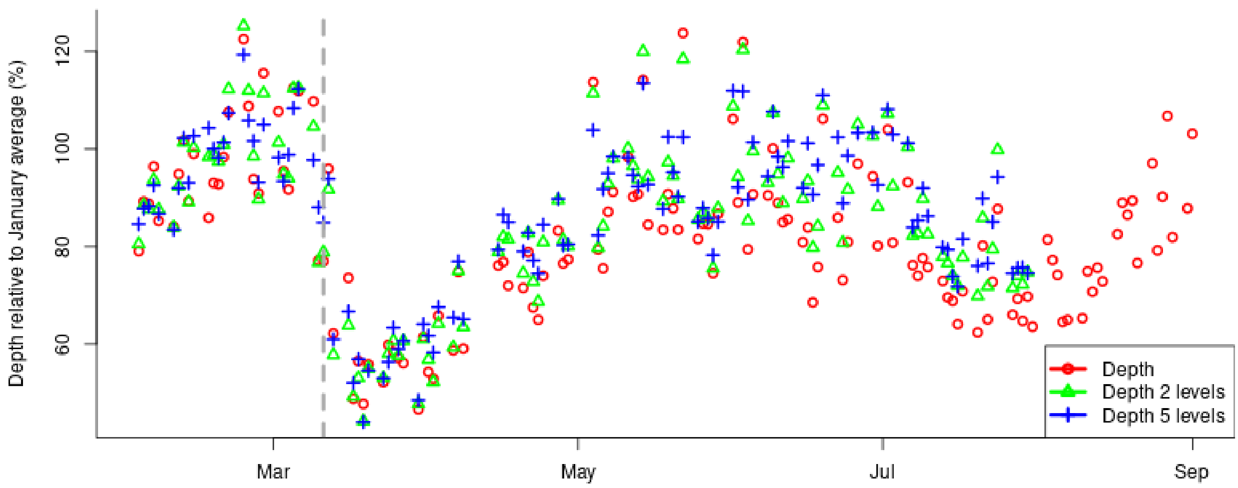
Figure A.1: Depth

Depth for the stocks with futures margin. Panel A: Depth (in mill HKD). Three versions of depth: Depth at the touch, aggregate depth at 2 and 5 levels. Panel B: Depth relative to january average. For each stock calculate average depth in January, and then look at depths relative to this average.

Panel A: Depth



Panel B: Relative Depth



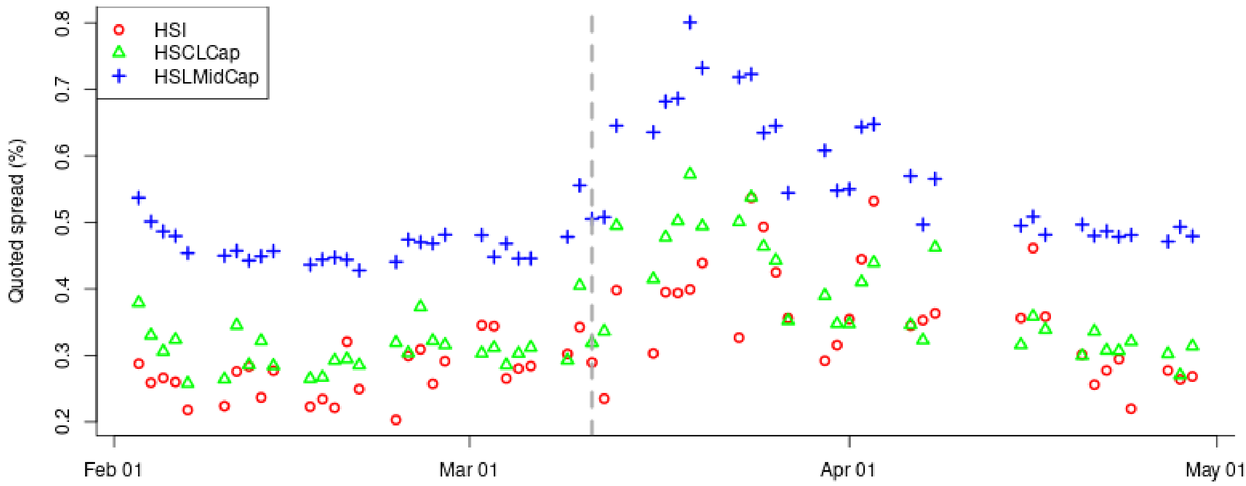
B The evolution of liquidity in the Hong Kong market

In this appendix we provide some additional plots describing the evolution of the various liquidity measures for the Hong Kong market during the Covid crisis.

Figure B.1: Quoted Spread - Constituents of HSI, HSCLargeCap and HSCMidCap

Quoted spreads early 2020. Panel A: Averages of quoted spreads. Panel B: Quoted spreads relative to January average

Panel A: Quoted Spreads



Panel B: Quoted Spreads relative to January average.

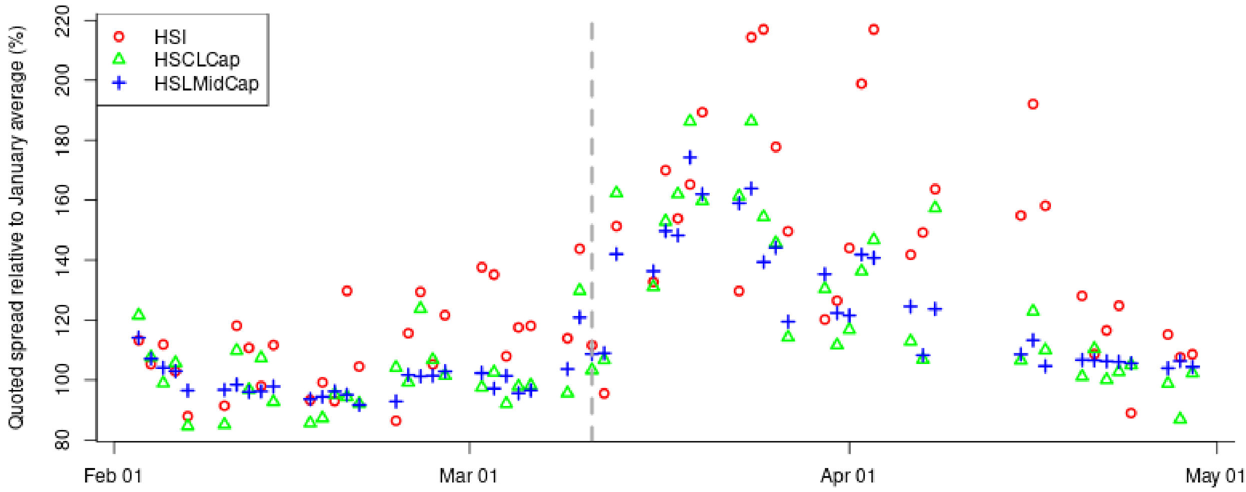
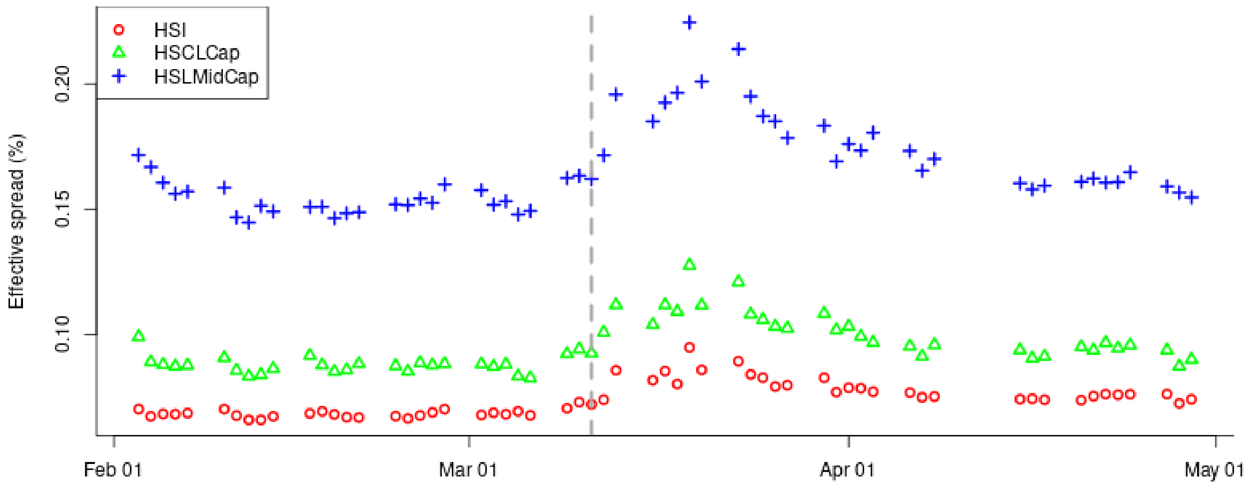


Figure B.2: Effective Spread - Constituents of HSI, HSCLargeCap and HSCMidCap

Effective spreads early 2020. Panel A: Averages of effective spreads. Panel B:Effective spreads relative to January average

Panel A: Effective Spreads



Panel B: Effective Spreads relative to January average. (%)

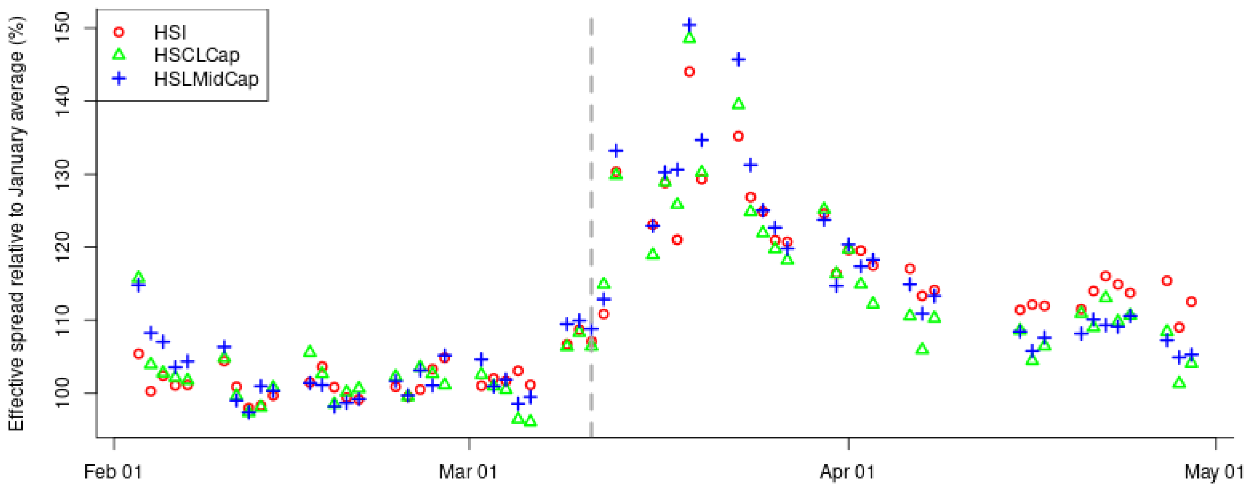
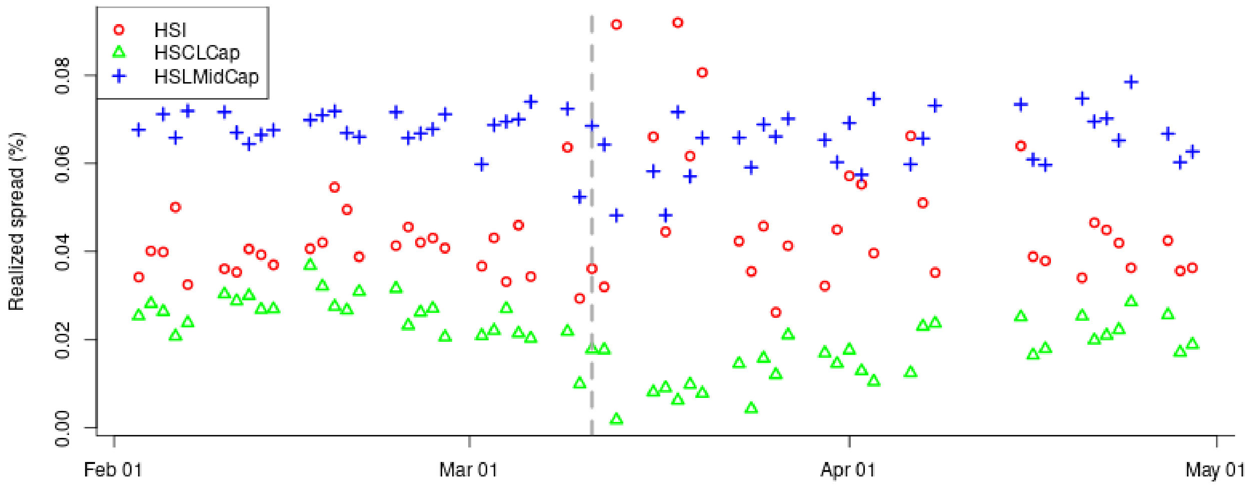


Figure B.3: Realized Spread - Constituents of HSI, HSCLargeCap and HSCMidCap

Realized spreads early 2020. Panel A: Averages of realized spreads. Panel B: Realized spreads relative to January average

Panel A: Realized Spreads



Panel B: Realized Spreads relative to January average. (%)

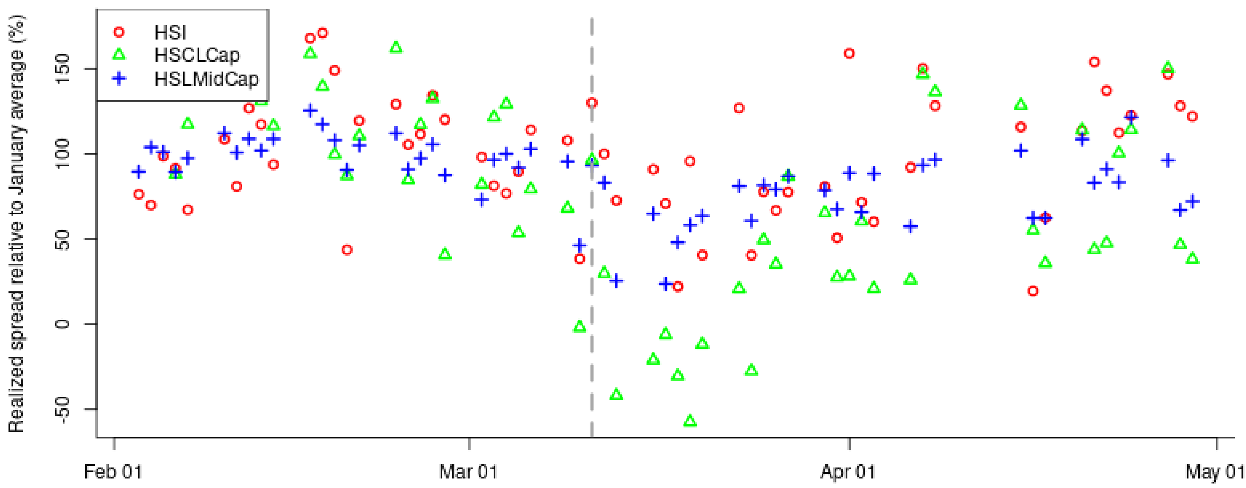
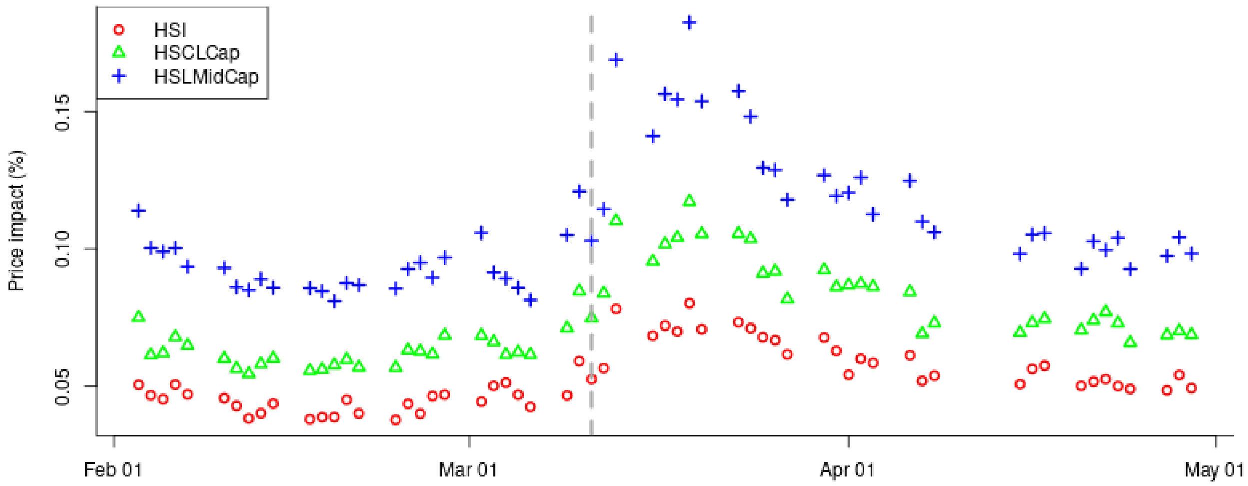


Figure B.4: Price impact - Constituents of HSI, HSCLargeCap and HSCMidCap

Price impacts early 2020. Panel A: Averages of price impacts. Panel B: Price impacts relative to January average.

Panel A: Price Impact



Panel B: Price impact relative to January average. (%)

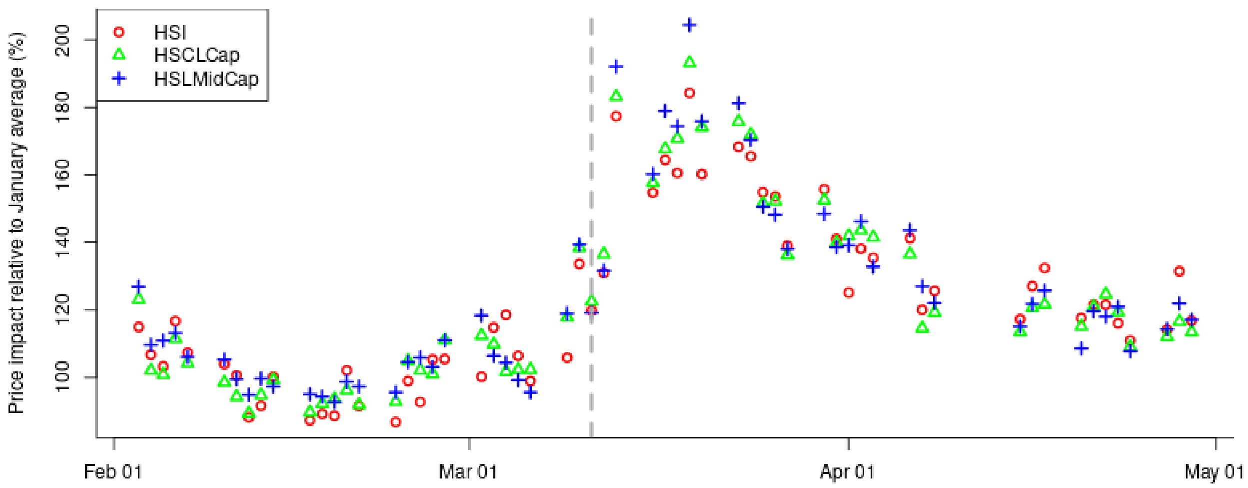
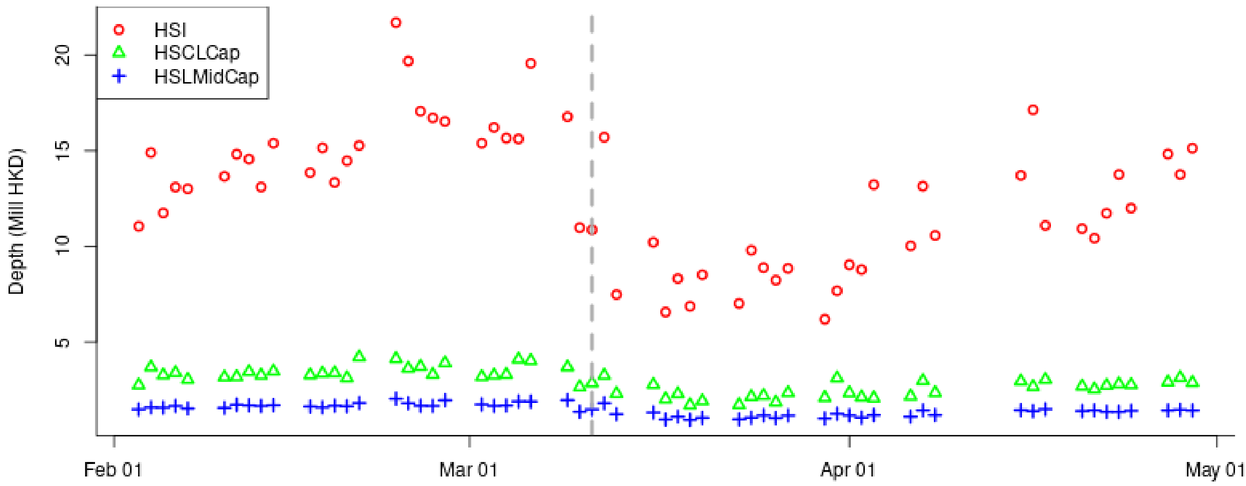


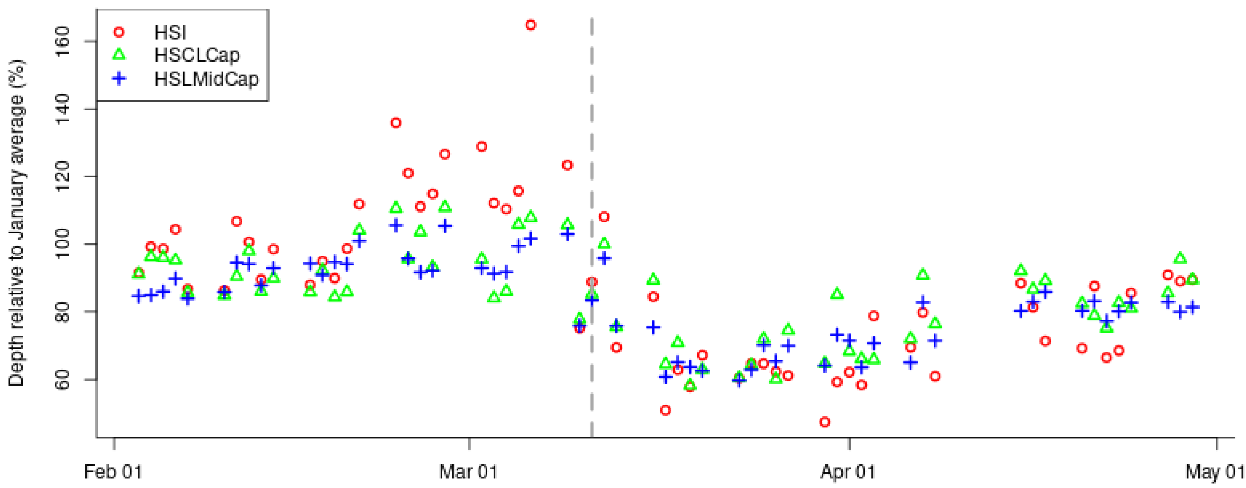
Figure B.5: Depth - Constituents of HSI, HSC Large Cap and HSC Mid Cap

Depth early 2020. Panel A: Averages of depth. Panel B: Depth relative to January Average.

Panel A: Depth



Panel B: Depth relative to January average. (%)



C International data

This appendix provides some information about the sample of international stocks used to make comparisons with Hong Kong.

Table C.1: International Stock Markets used for comparisons with Hong Kong

Overview of the non-Hong Kong markets considered in the study. For these markets we calculate liquidity measures for constituents of the major index in each market, as indicated by the column "Index"

Country	Index	No Stocks in index
Australia	ASX	50
Canada	TSX	60
Denmark	Copenhagen	25
Finland	Helsinki	25
France	CAC	40
Italy	MIB	40
Germany	DAX	30
Netherlands	AMX	25
Norway	OBX	25
Spain	IBEX	35
Sweden	OMX	30
United Kingdom	FTSE	100
USA	S&P	500

Table C.2 provides some descriptive statistics for this international sample of stocks. These tables are averages over the period January 1 to February 15. and show the stocks which are constituents of the primary domestic index, as listed in Table C.1.

Table C.2: Descriptive Statistics

This table provides descriptive statistics for our liquidity variables for January 1 to February 15, 2020. The quoted spread is the difference between the best bid and ask, divided by the current midpoint. The effective spread is the difference between the traded price and the current midpoint, relative to the current midpoint. Realized spreads and Price impacts are calculated using a 10-second delay. Depth is the sum of trading interest at the best bid and ask quotes, translated into US dollars. The realized volatility is calculated from five-second returns. Note: The US data is calculated by Sunil Wahal in a similar manner to what is done for the other markets, except for the Realized Spread and Price Impact. For the US measures these are calculated against a 5 second delay, not 10 seconds. The US data do not include depth and realized volatility. The statistics in panel A are for stocks in the main indices, as listed in Table C.1. In panel B we describe the stocks we use outside of the main indices. For the UK, we use the constituents of the FTSE 250 as the sample. For the other four markets (Australia, Canada, Norway and Sweden), we only include stocks with market capitalisation higher than the median company outside of the main index, and with more than 100 daily trades.

	Quoted Spread (bp)	Effective Spread (bp)	Realized Spread (bp)	Price Impact (bp)	Depth (thous USD)	Realized Volatility (%)
Panel A: Index stocks						
Australia	10.5	3.6	2.6	1.0	267	0.20
Canada	5.2	2.3	-0.2	2.5	1	0.12
Denmark	6.9	3.4	-0.5	3.9	48	0.13
Finland	8.2	3.8	-0.3	4.1	42	0.14
France	3.9	1.4	0.6	0.8	114	0.10
Germany	3.4	1.4	-0.1	1.5	135	0.10
Italy	6.2	2.1	0.8	1.3	84	0.12
Netherlands	4.1	1.4	0.6	0.8	98	0.10
Norway	9.9	4.4	7.0	0.7	35	0.16
Spain	7.5	3.4	-0.1	3.5	63	0.13
Sweden	6.7	3.3	0.4	3.2	46	0.15
UK	6.2	2.5	-0.3	2.8	44	0.11
USA	5.4	4.7	1.8	2.8		
Panel B: Non-index stocks						
Australia	40.7	15.7	10.9	4.8	125	0.29
Canada	31.0	14.4	2.1	12.3	0	0.50
Norway	37.4	14.2	11.2	3.5	23	0.32
Sweden	18.5	8.9	2.4	6.7	34	0.20
UK	19.0	7.1	0.4	6.8	28	0.16

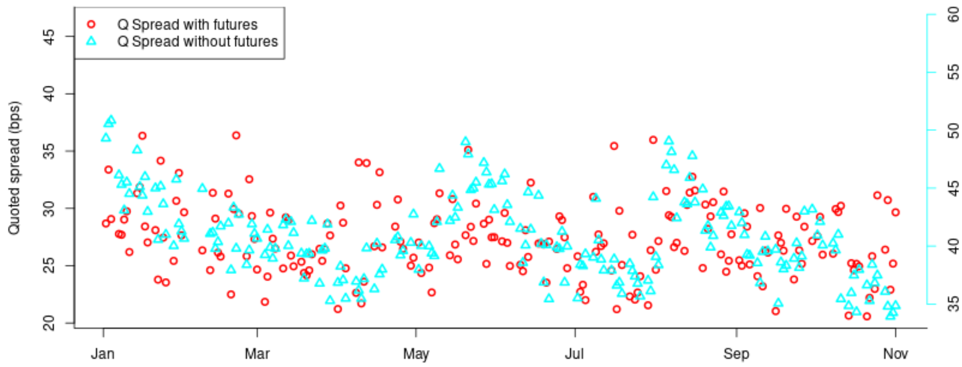
D Investigating the parallel trends assumption

In the report we use data for the early part of 2020 in a Difference-in-Difference (DiD) estimation. A necessary condition for such a DiD estimation is the "parallel trends assumption" that, without the intervention, the two groups in the DiD will have parallel evolutions. A common way to investigate the reasonableness of this assumption is to plot the time series of the two groups in a period *before* the analysis. We therefore gathered data for the dependent variables in the DiD for the period 2019:01–2019:11 (Before any Covid-related news), and look at the trends of two groups of stocks, those with an associated future (ISF) and those without. Visual inspection shows that the parallel trend assumption seems to hold for the vast majority of our dependent variables of interest.

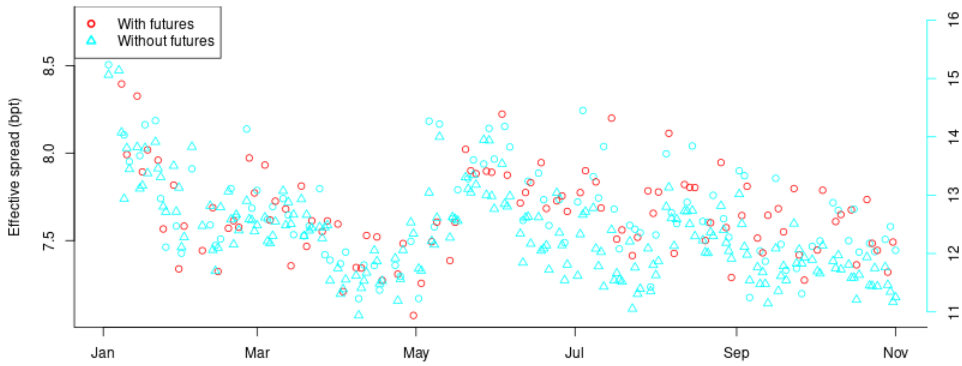
Figure D.1: Time series plots, liquidity measures 2019

The figures plots the time series behaviour of liquidity measures for stocks in the HSI, HKCLCap and HKMidCap indices, grouped by whether they have an associated future. For stocks with or without associated futures, we plot the time series behaviour 2019:01–2019:11 for Quoted Spread, Effective Spread, Realized Spread, Price Impact and Depth. Series are plotted against two axes. The axis on the left: Stocks with associated future. The axis on the right: Stocks without associated futures.

Panel A: Quoted Spread



Panel B: Effective Spread



Panel C: Realized Spread

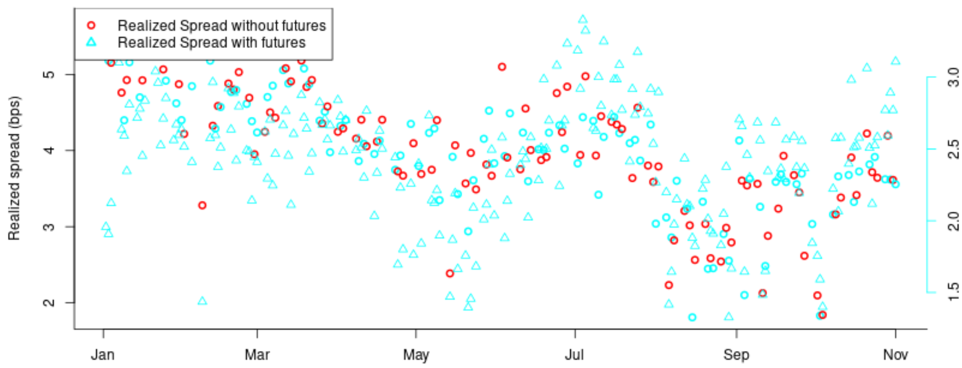
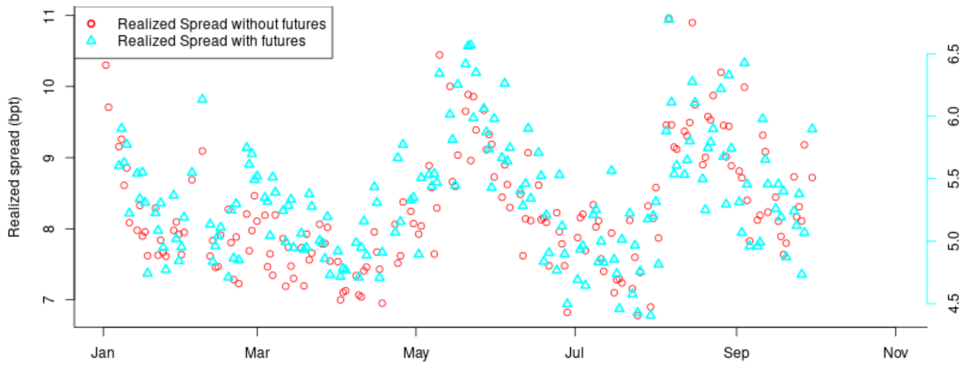


Figure D.1: (continued)

Panel D: Price Impact



Panel E: Depth

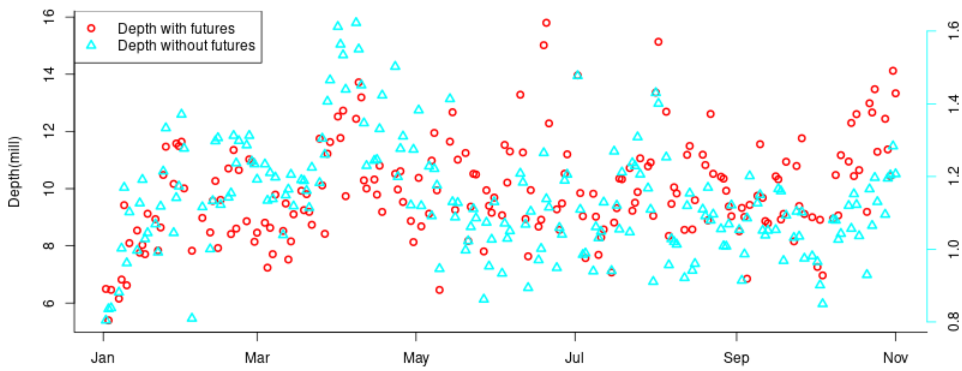
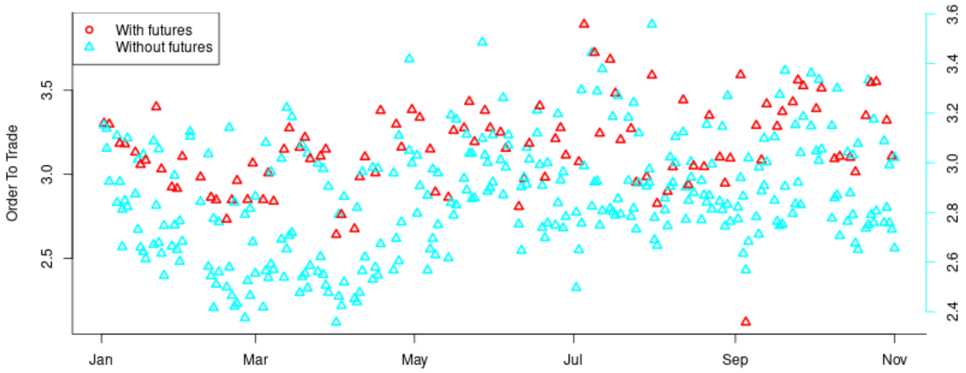


Figure D.2: Time series plots, HFT measures 2019

The figures plots the time series behaviour of measures of HFT for stocks in the HSI, HKCLCap and HKMidCap indices, grouped by whether they have an associated future. For stocks with or without associated futures, we plot the time series behaviour 2018:01–2018:11 for the Order to Trade ratio and HFT volume. Series are plotted against two axes. The axis on the left: Stocks with associated future. The axis on the right: Stocks without associated futures.

Panel A: Order to Trade ratio



Panel B: HFT volume