THE IMPACT OF THE NSFR ON THE PRECIOUS METALS MARKET

London Bullion Market Association (LBMA) and the World Gold Council (WGC) welcome the opportunity to respond to the Prudential Regulation Authority's (PRA) Consultation Paper 5/21 on the Implementation of Basel Standards. LBMA and the WGC intend to focus their response on the application of the Net Stable Funding Ratio (NSFR), as provided under chapter 12 of the consultation paper, and in particular the unintended consequences that the NSFR would have on the precious metals market.

The paper is structured as follows:

EXECUTIVE SUMMARY

Current legislation prescribes a punitive liquidity treatment for gold and other precious metals. This is reflected in provisions setting out the application of the Liquidity Coverage Ratio (LCR) and the application of the Net Stable Funding Ratio (NSFR).

We are supportive of the NSFR's objective to oblige banks to finance long-term assets with long-term money and thus avoid the liquidity constraints and failures witnessed during the 2007-2008 global financial crisis.

However, we consider that current proposals under the NSFR fail to take into account the damaging effect that the rules will have on the precious metals clearing and settlement system, potentially undermining the system completely, and on the increased costs of financing of precious metals production. In addition, the proposal fails to take account of the quantitative evidence, which suggests that in a liquidity crisis, gold acts as an extremely liquid asset.

It is therefore important for the precious metals markets that the Prudential Regulation Authority (PRA) can resolve the unintended consequences stemming from the application of the NSFR.

It is proposed by LBMA that:

1. **Clearing and Settlement:** The PRA should assess whether it would be justified to exempt precious metals held by members of London Precious Metals Clearing Limited (LPMCL) in the provision of clearing services from being subjected to NSFR. LPMCL provides the clearing and settlement services of precious metals such as gold, silver, platinum and palladium (see Section 1 for further details). In the event that such an exemption

cannot be granted, LBMA would like to discuss with the PRA the potential to recognise LPMCL as a Co-operative Network and what that would involve.

2. **Gold as a Currency:** The PRA should note that when gold is deposited and lent, it is treated as the currency by market participants (see section 5). When functioning as the currency, gold has no cash funding requirement when used as the underlying asset in financing transactions. Appropriate regulatory treatment would mean that gold loans backed by equivalent deposits from central banks and financial institutions would not be negatively impacted by the NSFR.

3. **HQLA:** The PRA should also review gold's position as a High Quality Liquid Asset (HQLA). LBMA, the WGC and the members of the market they each represent believe that gold should be reclassified as an extremely HQLA. This position is justified by the trade data that members have been reporting to LBMA since 2018. This quantitative data confirms that gold retains the consistent liquidity characteristics of an extremely HQLA and proven to be highly resilient to global liquidity shocks, such as that in early 2020 (see Annex 2 for further details).

1. About LBMA and LPMCL

LBMA is the Independent Authority for Precious Metals, representing the global OTC market. Its mission is to ensure the highest levels of leadership, integrity and transparency for the global precious metals industry by setting standards and developing market services. Participants in these markets include central banks, mining companies, precious metals producers, bullion banks, refiners and fabricators.

London Precious Metals Clearing Limited (LPMCL) was created by LBMA members in 2001 for the specific purpose of developing and administering a system for the clearing and settlement of gold and silver transactions. It is a not-for-profit company owned and operated by four LBMA member banks: HSBC, ICBC Standard Bank, JP Morgan and UBS. The default settlement location for most global OTC spot gold and silver transactions is Loco London[1] using an LPMCL account. This type of account is referred to as an 'unallocated account'. The LPMCL members' balance sheet treatment for unallocated accounts means that the metal amount in ounces is treated as an asset and the client credit is treated as the corresponding liability.

2. About the WGC

Based in the UK, with operations in India, China, Singapore and the US, the World Gold Council (WGC) is an association whose members comprise the world's leading gold-mining companies.

The WGC is the market development organisation for the gold industry. Its purpose is to stimulate and sustain demand for gold, provide industry leadership and be a global authority on the gold market. It develops gold-backed solutions, services and products, based on authoritative market insight, and works with a range of partners to put its ideas into action. Additionally, it provides insights into the international gold markets, helping people to understand the wealth preservation qualities of gold and its role in meeting the social and environmental needs of society.

3. About the Precious Metals Markets

Precious metals markets are used daily by a wide range of market participants, from central banks to jewellers, to mining companies to manufacturers. Gold is the largest and most important precious metals market. Gold is used in a wide range of consumer goods and industrial processes. It is also commonly used as a safe alternative to foreign exchange currencies and is the ultimate safe harbour asset (offering zero credit risk and high liquidity characteristics) for professional and retail investors in times of uncertainty, as was evidenced during the early Covid period of April/May 2020. The data available from this period supports gold's characteristic as an extremely High Quality Liquid Asset (HQLA).

1. Refers to precious metals that are physically held in London and comply with LBMA or LPPM Good Delivery standards.

3.1 Clearing and Settlement

LPMCL operates the clearing and settlement system for precious metals transactions. LPMCL serves clients including central banks, central counterparties (CCPs), other commercial banks, financial institutions and many varied non-bank market participants. CCPs rely on the LPMCL system to manage precious metals collateral and the physical delivery of precious metals derivative contracts. Commercial banks rely on the LPMCL system for safe clearing and settlement of precious metals transactions. Non-

bank market participants rely on the LPMCL system for short-term liquidity. With daily average cleared gold transactions alone of over US$30 billion, the LPMCL system is unique and indispensable.

In summary, LPMCL works as an administrator and ensures that counterparties can access the bullion market, particularly for those who do not have the ability to store physical gold. Such counterparties will have an allocated and/or an unallocated account with one of the LPMCL members.

Allocated Metal: A proportion of the precious metals held by the four LPMCL clearing banks is assigned to specific owners ('allocated metal') - in other words, each owner has title to specific bars. The LPMCL clearing banks act as custodians for the allocated metal, which is available to the owner at any time. The clearing bank cannot sell or transfer this metal to a third party, other than under instruction from its owner. The allocated metal is neither an asset nor a liability for the clearing bank. The allocated metal is held 'off-balance sheet' and is excluded from the proposed required stable funding (RSF) calculation.

Unallocated Metal: The majority of precious metals held by LPMCL clearing banks for clearing and settlement purposes is 'unallocated metal'. This is metal deposited with clearing banks by market participants. It is an account where specific bars are not set aside and the customer has a general entitlement to the metal. This is the most convenient, cheapest and most commonly used method of holding metal. The holder is an unsecured creditor. The metal can therefore be used by the clearing banks to clear and settle physical metal transactions between market participants. This unallocated metal is fungible and, as such, provides the liquidity of the clearing and settlement system. It allows the clearing banks to debit or credit market participants' accounts with metal immediately, before the seller's metal is delivered to the buyer (which usually occurs within two working days of the day of the transaction or 'T+2'). Unallocated metal deposited with the clearing bank is recorded as an asset and is held 'on-balance sheet'. It is subject to the proposed RSF calculation.

Precious metals are recorded on the balance sheet of LPMCL members and are accounted for as assets subject to a proposed 85% RSF factor. These assets have to be matched by liabilities for which the CRR II proposal ascribes a 0% available stable funding (ASF) factor. Therefore, there is no offsetting effect. As a consequence, credit institutions would be obliged to hold stable funding at a value of 85% of precious metals assets to reach the NSFR of 100%. In such circumstances, clearing and settlement would become a significantly more expensive business for LPMCL members, and we expect that one or more members would exit the market and cease clearing and settling transactions Loco London. Currently there are only four members, and it would be extremely difficult to attract new participants given the impact of the NSFR.

3.2 Precious Metals Transactions

LBMA member banks provide various financial services to precious metals market participants. Most common amongst these services are short-term precious metals loans. Such loans are available to a variety of non-bank market participants. These loans facilitate precious metals refining, fabrication and manufacturing of consumer goods and jewellery. The loans are usually made and repaid in metal over terms of less than 180 days and constitute short-term assets on bank balance sheets. When a bank enters into a gold financing transaction, it will take an active business decision to do so, proceeded by standard counterparty checks. Importantly, loans are offered on an uncommitted basis and, as such, there is no automatic extension or 'rollover' of loans based on pre-agreed conditions.

Other typical financing transactions include process financing arrangements – uncommitted facilities under which a bank may loan metal to a market participant to finance or facilitate an industrial or manufacturing process such as refining precious metals. Transactions under such facilities are for terms of less than 180 days. Banks will also finance precious metals refining by purchasing metal ore from mining companies and merchandisers, and loaning this ore to refiners for processing. Bank and

non-bank market participants alike prefer such financing transactions to more complex, costly and risky derivative or repurchase transactions.

4 The Impact of the NSFR on the Precious Metals Markets

The Basel Committee on Banking Supervision (BCBS) NSFR standard is designed to oblige banks to finance long-term assets with long-term money and thus avoid the liquidity constraints and failures witnessed during the 2007-2008 global financial crisis. However, the BCBS standard does not expressly exclude from bank NSFR calculations the unallocated balances of precious metals held on balance sheet by the LPMCL clearing banks as a result of clearing and settlement activities nor recognise that gold does behave as a currency when providing a gold loan or borrowing against gold.

Indeed, had the BCBS considered the treatment of unallocated balances in the clearing and settlement system, or had information to understand how gold is treated in a financing transaction, we believe that these unallocated balances would have been expressly excluded from the NSFR calculations, and gold would have been treated in the same way as currency, in the appropriate transactional context.

An 85% RSF charge would:

- **Undermine clearing and settlement** – The required stable funding for short-term assets would significantly increase costs for LPMCL clearing banks to the point that some would be forced to exit the clearing and settlement system, which may even be at risk of collapsing completely.
- **Drain liquidity** – The required stable funding would dramatically increase costs for remaining LPMCL members taking gold on deposit to be held as unallocated metal relative to the cost of providing custody of allocated metal. This would prevent LPMCL clearing banks from holding unallocated metal and drain essential liquidity from the clearing and settlement system. These unallocated balances are the only material source of liquidity in the clearing and transaction financing systems. Without this liquidity, there would be a material deleterious effect on the global precious metals market.
- **Dramatically increase financing costs** – The required stable funding would penalise LBMA members who hold unallocated balances of precious metals. This would increase the cost of short-term precious metals financing transactions as stable funding costs are passed through to non-bank market participants. Such cost increases would impact miners, restrict refining and raise the costs of an inelastic key input to industrial and consumer goods. This includes some essential medical equipment and technologies required to reduce pollutants (such as catalytic converters).
- **Curtail central bank operations** – Fewer LPMCL clearing banks may curtail central bank deposit, lending and swaps in precious metals. These operations are essential to offset the costs of storing gold reserves and generating income. In addition, this provides important liquidity to the market.

The effects of an 85% RSF charge would not just be limited to the London OTC market, but would be felt globally across the entire gold value chain. While London acts as the default settlement location for most global OTC spot transactions, the precious metals market is international. An undermining of the clearing and settlement system, reduced market liquidity, significantly increased financing costs and curtailed central bank activity would fundamentally alter the structure and attractiveness of this market.

5. Proposals

5.1 Clearing and Settlement

There are no viable alternatives to the clearing and settlement system operated by the LPMCL clearing banks or the financing transactions described above. All market participants including banks, trading venues and CCPs rely on the clearing and settlement system for physical and paper transactions. OTC derivative substitutes to precious metals loans and similar transactions are significantly more expensive due to foreign exchange risk and margin requirements, and are, in any case, subject to Capital Requirements Regulation (CRR) requirements in respect of the liquidity coverage ratio, the leverage ratio and the NSFR.

Interdependent assets and liabilities: We note that Switzerland proposes to treat precious metals assets held by banks resulting from precious metals loans as interdependent assets and liabilities (therefore relying on an equivalent of Article 428f(2) CRR II). This would exclude the majority of precious metals assets held by Swiss banks from the NSFR calculation.

We believe that 428f CRR II may offer a viable means to at least safeguard clearing and settlement for precious metals transactions. We believe that the system should be considered a market utility without which precious metals transactions would take many days to settle, resulting in increased settlement risk for all market participants. Within the four clearing bank members of LPMCL that provide this service, there will always be a corresponding asset and liability for every transaction that is placed through them for clearing purposes. Note that this is not a novation agreement whereby a central counterpart takes on all credit risk but is simply the mechanism where a client instructs the clearing bank to make or take delivery of gold and the clearing member bank therefore checks that the other counterparty can indeed make or take delivery.

It is therefore proposed that the PRA exclude the clearing and settlement of precious metals transactions, from the NSFR. Alternatively, we would welcome a discussion on whether it is possible for LPMCL to rely on the exemption provided to a Co-operative Network (CRR Annex III point 10).

5.2 Precious Metals Lending and Borrowing

Gold is a unique asset class, which can behave like a commodity but also as a currency. In all lending/borrowing scenarios, gold is always treated as the currency. A common misconception about gold is that it has no interest rate. Conversely, market participants mitigate the funding requirements, stemming from price and time risk management, by using a loan denominated in gold. It is common practice within the precious metals market to lend and borrow precious metals.

The following financing examples illustrate that cash is not required to fund precious metals transactions as the metal is the currency:

Example 1: Central Bank Gold Loans

A central bank may deposit physical gold with a commercial bank. In such cases, the central bank receives the interest payment accumulated on the deposit in ounces of metal.

The commercial bank that has received the gold deposit from a central bank uses the metal for several different reasons. For example, it will provide gold loans to:

- Corporates such as jewellers and other precious metals fabricators
- Gold refineries to finance transformation of unrefined gold to refined gold
- Interbank lending to support the liquidity of the market.

Example 2: Commercial Bank Gold Lending

Another example is a gold loan from a commercial bank to a gold refiner. Gold refiners convert unrefined material to refined material, including investment grade bullion. The initial unrefined material is delivered from a mining company to a refiner. For payment, the miner requires payment upon delivery in refined gold ounces. The refiner fulfils the commitment by borrowing the refined gold ounces from a commercial bank, which will cover the time taken to refine the miner's unrefined gold. The refiner can then sell the refined gold and repay the loan to the commercial bank.

In these examples, no other currency is used besides gold. The interest generated is also denominated in gold. This amount can be converted to allow for settlement in another currency. This is done by selling the gold interest amount in the desired currency.

Therefore, the PRA is asked to provide a view on whether gold should be treated as a currency for lending/borrowing transactions with symmetric ASF/RSF for maturities of less than one year.

Applying the NSFR to Gold Loans

Market participants must consider three factors to apply the NSFR:

1. Type of lender/depositor
2. Type of borrower
3. Duration of loan.

Example 3: Credit Intermediation of a Central Bank Gold Deposit and a Corporate Jewellery Loan

4. Type of lender/depositor: Central bank
5. Type of borrower: Corporate
6. Duration of loan: Six months

Based on these factors and the BCBS guidance, the transaction would acquire 50% Available Stable Funding (ASF) and require 50% RSF as it is from a central bank and has a maturity of six months. The balanced ASF and RSF mean that the stable funding for this transaction would be neutralised with no additional funding required.

Typically, these transactions between central banks and corporates have a maturity of three months. This transaction would acquire 0% ASF[2] and require 50% RSF[3]. This funding risk requirement cannot be mitigated by gold as an asset as it is not recognised as an HQLA. However, in practice, gold would be used for funding requirements. Should there be a liquidity crisis, the asset used for funding requirements will always be gold, rather than another currency or asset class.

Example 4: Clearing Account Provided by Clearing Bank in order to Settle Trades Denominated in Ounces of Metal

A client can trade within the Loco London markets through a bilateral agreement with a member of LPMCL. The LPMCL member provides the client with an unallocated account, allowing it to enter into precious metals trades with any other entity operating an account with LPMCL. This means the trades can all physically settle within the same clearing system.

Here, the LPMCL member provides the same unallocated account facility as it might for a coin or note deposit in the client's current account. In addition, there is no other currency besides gold used in these transactions.

These examples demonstrate that cash is not required to fund all precious metals transactions. Instead, the metal is used as a currency. Metal used in these examples should therefore be considered a currency for stable funding purposes, as separate funding using an HQLA is not required.

6 Revisiting HQLA

Whilst the CP5/21 does not highlight any questions on HQLA, we would like to take the opportunity to provide our position and follow this up with a further discussion. Please also see the detailed analysis provided in the Annexure below.

The lack of relevant data in 2013 led the European Banking Authority (EBA) to classify gold as a non-liquid asset in its report on appropriate uniform definitions of extremely high-quality liquid assets (extremely HQLA) and high-quality liquid assets (HQLA). Consequently, gold is currently not classified as an extremely HQLA or HQLA in the Commission Delegated Regulation (EU) 2015/61 on liquidity coverage requirement for credit institutions (CDR 2015/61).

Stemming from classification of gold as a non-liquid asset is the application of the 85% required stable funding (RSF) factor to holdings of unallocated physical commodities, including gold, as set out in

[2] Ibid, paragraph 36(c)
[3] Ibid, paragraph 40

Regulation (EU) 575/2013 on prudential requirements for credit institutions and investment firms, which introduce the NSFR into European law.

The data within Annex 2 includes a recent study of liquidity during the Covid period of early 2020 and longer-term data studies are also included for 2007-2019 that cover multiple different liquidity events. In both data samples, we believe that gold meets all of the required characteristics used by both the BCBS and EBA to be considered an HQLA. Furthermore, based on trade data that became available from November 2018, LBMA has identified compelling evidence of high levels of liquidity in the gold market, as well as significant shortcomings in the data used and conclusions drawn in the EBA's 2013 Report.

We would like therefore to encourage the PRA to support a collaborative and transparent process for the reclassification of gold. We intend to also present this data to the EBA as well as the BCBS and to ask them to revisit the classification of gold.

7 Conclusion

We would like to thank the PRA for publishing its recent Consultation Paper, CP5/21 and to summarise our position by responding directly to two relevant questions outlined in the paper:

Question 4: To what extent do you consider that the proposed approach to RSF and ASF factors adequately reflects the underlying risks of, or has any material unintended consequences for, particular business lines

As provided in Section 3 of this paper, the negative impact of the NSFR on:

- the clearing and settlement system (LPMCL); and
- gold loan and borrowing

was an unintended consequence.

Had the BCBS considered the treatment of unallocated balances in the clearing and settlement system, or had information to understand how gold is treated in a financing transaction, LBMA believes that these unallocated balances would have been expressly excluded from NSFR calculations, and gold would have been treated in the same way as currency.

Question 5: To what extent do you consider that the proposed NSFR would enhance the proportionality of liquidity requirements?

LBMA and the WGC do not consider that the proposed rules on NSFR, as they apply to gold, are prudent or proportionate. The proposal fails to take account of the evidence, which suggests that in a liquidity crisis, gold acts as an extremely liquid asset.

It is unfortunate that appropriate data was not available in 2013 to help the EBA to prepare its report. However, given that LBMA has been gathering data since 2018, we believe this merits a revisit of gold's classification as a non-HQLA (Commission Delegated Regulation (EU) 2015/51). This then resulted in an 85% RSF for gold, along with unallocated physical commodities.

LBMA, its members and the WGC remain at your disposal to discuss any of the elements of this paper and to provide additional information or clarifications if and as required.

Yours Sincerely

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ANNEX 1

Supporting evidence of gold as a high-quality liquid asset
April 2021

Gold has important characteristics that make it stand out as a valuable asset in financial markets. As a real asset, it bears no credit risk, it is widely accepted as collateral, and provides ample liquidity to those who hold it.[4] Collectively, gold volumes reach daily average above US$150 billion per day,[5] with an estimated US$60 billion traded daily through the LBMA members in Loco London and Loco Zurich.[6]

Two studies conducted by the Rozetta Institute,[7] provide solid evidence that gold's performance and behaviour – not only during normal times, but in periods of crisis – aligns with that of assets considered to be high-quality liquid assets.

The first study, *Market Quality: Gold*, explores the performance of gold over four recent market stress periods spanning between 2007 and 2018. The second study, *Gold's performance during February-April 2020's asset liquidation event*, takes a closer look at last year asset liquidation event as the COVID-19 pandemic started to unfold. Both studies are included for reference.

1 Gold's performance during February-April 2020's asset liquidation event

The analysis was conducted on intraday data covering 3 February to 30 April 2020[8] using a variety of market efficiency metrics: volumes, transaction costs, volatility, depth of liquidity and market falls. We highlight findings from the analysis that compare spot and futures gold market metrics to those of spot and futures US 30-year Treasury metrics (considered HQLA) as well as spot gold and the most liquid gold ETF to the most liquid stocks traded on NYSE.

- The gold spot price experienced about half the drawdown of the spot 30-year US Treasury bond price during the period of February to April 2020 (Table 1). Although NEX gold spot prices represent a smaller sample of total spot market trading, futures volumes for both instruments are similar.
- Mean quoted spreads in gold spot were below those of 30-year US Treasuries during normal UK-US trading hours across the period (Table 2a). Median quoted spreads for gold spot were below those of 30-year US Treasuries at any hour over the period (Table 2b).
- Mean and median effective spreads in gold spot were higher than those of 30-year US Treasuries, but mean and median effective spreads in gold futures were lower than those of US 30-year Treasury futures and the top 5 stocks in all periods.
- Gold spot experienced both lower intraday and Parkinsons volatility during the liquidity event in March 2020 than either spot US 30-year Treasuries or the top 5 stocks (Table 3).
- Gold spot experienced slightly more seller bias (traded value order imbalance) during March 2020 than spot US Treasuries, with similar levels across the period (Table 4). CME gold futures experienced no such bias vis-à-vis US 30-year Treasury futures during the March liquidity event.
- Gold spot so no significant price declines (<-5%) as monitored by the Bank of International Settlements in spot or futures markets during the period, unlike US 30-year Treasuries where end-of-day prices recorded falls of at least 5% on 3 days. The top 5 stocks experienced a higher instance of significant falls still (Table 5).

[4] World Gold Council, *The relevance of gold as a strategic asset*, February 2021.
[5] See Trading volumes section of Goldhub.com
[6] See LBMA Trade Data.
[7] The Rozetta Institute, formerly known as Capital Markets Consulting, is a financial markets think tank based in Australia with renown expertise on financial market infrastructure and efficiency.
[8] Spot gold trading data is difficult to obtain and only 1% of reported top-level volume reported by the LBMA-i was captured.

2 Market Quality: Gold

We find that across a number of market quality measures, trading in gold is similar or better vis-à-vis top 20 NYSE firms. Relative to bonds, we confirm as expected that US treasury bonds are the most liquid, however relative to corporate bonds, gold is of a higher ranking. These results hold across the periods assessed and regions.

Market Stress Periods

Events	Start	End	No. of months
Global financial crisis start	**2007-07-01**	**2009-05-31**	**23**
Key events			
Bear Stearns halts redemptions from two of its funds	2007-07-17		
Run on the repo market starts	2007-08-09		
Fed announces Term Auction Facility (TAF)	2007-12-12		
TSLF and PDCF initiated; Bear Steams sold	2008-03-01		
AIG announces imminent bankruptcy, gets bailed out	2008-09-16		
Lehmann Brothers declares bankruptcy	2008-09-14		
Congress passes Troubled Asset Relief Program (TARP)	2008-10-03		
Term Asset-backed Securities Facility (TALF) announced	2008-11-25		
Treasury department announces stress tests	2009-02-10		
US bank stress test results released	2009-05-07		
Euro zone crisis	**2010-08-01**	**2011-12-31**	**17**
Key events			
Greece admits deficit-to-GDP ratio of 12 percent	2009-10-18		
First Eurozone-IMF rescue plan completed	2010-05-02		
European FSB cleared to purchase soverign bonds	2011-07-01		
China stock market turbulence	**2015-07-01**	**2016-02-28**	**7**
Key events			
SSE halted over 1,400 companies, spread to international stock markets	2015-07-08		
Sharp sell-off; circuit break, triggered Dow Jones plunge	2016-01-04		
US-China trade war	**2018-03-01**	**2018-12-31**	**10**
Key events			
President Trump imposed tariffs of 25% on steel and 10% on aluminum	2018-03-01		
China responded by imposing tariffs on 128 products it imports from the US	2018-04-02		
The White House announced that it would impose a 25% tariff on $50 billion of Chinese goods with "industrially significant technology"	2018-05-29		
US tariffs on $34 billion of Chinese goods came into effect	2018-07-06		
China filed a complaint with the World Trade Organization (WTO)	2018-08-14		
Total			**57**

- Analysis covering a longer period of 57 months from 2007 to 2019 during market turbulent periods shows that gold spot futures and ETF (GLD) volumes have exceeded that of the top 20 NYSE traded stocks. Quoted and Effective spreads have been in line or lower than those of stocks, volatility considerably lower, order imbalance less negative and significant price falls far fewer (Tables 6 to 10).
- Gold daily volumes considerably exceeded daily volumes of the top 20 traded stocks at NYSE.
- Gold spreads (in bps) through COMEX were tighter than the top 20 traded stocks at NYSE.
- Gold's intraday volatility was considerably lower than that of the top 20 traded stocks.
- Gold prices had de minimis proportion of downward movements greater 5% during the Global Financial Crisis and did not experience any downward movements greater than 10% over the period; the topmost traded stocks at NYSE experienced considerable pullbacks over the periods under consideration.
- US treasury has a narrower inside spread, however the advantage decreases if one compares 10-year bonds and gold.
- Small trades in corporate bonds incur the highest transaction costs, considerably higher than gold.

2020 March Market Liquidation Event Analysis

Table 1. Volumes

		Max Return	Min Return	Total
Markets	*Instruments*			
Gold	NEX Gold Small	6.11	-4.51	7.21
	XAU NEX UK/US*			
	ETF-GLD	4.85	-3.99	7.04
	CME Gold	5.95	-4.63	7.07
Stocks	Top 5 stocks			
Treasury bonds	30YR Treasury	8.11	-8.43	14.55
	CME 30Y Treasury	3.47	-4.11	10.53

Mean Daily Trading Value (US$ Mn)			
February	*March*	*April*	*Period*
397	689	669	593
239	513	452	408
2,039	3,111	1,971	2,397
58,728	52,860	30,479	47,078
6,953	10,143	7,560	8,290
12,832	18,916	13,522	15,224
64,198	73,854	34,100	57,430

Table 2a and 2b. Transaction Costs

		Mean Quoted spreads (bps)			
Markets	*Instruments*	*February*	*March*	*April*	*Period*
Gold	NEX Gold Small	1.60	8.69	12.16	7.69
	XAU NEX UK/US*	1.41	7.75	11.50	7.07
	ETF-GLD	0.69	1.53	0.98	1.08
	CME Gold	0.70	1.51	1.21	1.16
Stocks	Top 5 stocks	2.26	4.91	2.91	3.42
Treasury bonds	30YR Treasury	3.24	12.99	5.49	7.46
	CME 30Y Treasury	1.94	2.19	1.85	2.00

Mean Effective spreads (bps)			
February	*March*	*April*	*Period*
0.96	6.29	7.13	4.94
1.01	6.34	6.90	4.89
0.76	1.23	0.90	0.97
0.85	1.84	1.54	1.43
1.50	2.91	1.82	2.11
2.08	5.78	2.71	3.61
1.95	2.13	1.82	1.97

		Median Quoted spreads (bps)			
Markets	*Instruments*	*February*	*March*	*April*	*Period*
Gold	NEX Gold Small	1.39	3.98	12.07	4.29
	XAU NEX UK/US*	1.34	3.41	11.81	3.74
	ETF-GLD	0.67	1.41	0.92	0.86
	CME Gold	0.69	1.55	1.22	1.08
Stocks	Top 5 stocks	1.88	4.54	2.81	2.89
Treasury bonds	30YR Treasury	3.20	12.56	5.20	5.04
	CME 30Y Treasury	1.94	2.15	1.85	1.92

Median Effective spreads (bps)			
February	*March*	*April*	*Period*
0.81	3.69	6.49	3.87
0.81	3.74	6.76	4.00
0.70	1.19	0.86	0.86
0.80	1.83	1.46	1.36
1.26	2.78	1.78	1.88
2.04	6.29	2.65	2.65
1.94	2.04	1.83	1.93

Table 3. Volatility

		Mean Intraday Volatility (5min)			
Markets	*Instruments*	*February*	*March*	*April*	*Period*
Gold	NEX Gold Small	0.14	0.24	0.11	0.16
	XAU NEX UK/US*	0.16	0.16	0.10	0.14
	ETF-GLD	0.07	0.17	0.10	0.12
	CME Gold	0.05	0.15	0.10	0.10
Stocks	Top 5 stocks	0.17	0.44	0.20	0.28
Treasury bonds	30YR Treasury	0.09	0.30	0.09	0.16
	CME 30Y Treasury	0.05	0.14	0.05	0.08

Mean Parkinsons Volatility (5min)			
February	*March*	*April*	*Period*
0.81	1.95	1.14	1.32
0.61	1.41	0.79	0.96
0.92	2.43	1.52	1.66
1.46	3.38	1.77	2.24
0.90	3.47	1.18	1.91
0.57	1.87	0.64	1.06

Table 4. Depth of Liquidity

		Order Imbalance on Traded Value (bps)			
Markets	*Instruments*	*February*	*March*	*April*	*Period*
Gold	NEX Gold Small	0.0086	-0.0461	0.0489	0.0028
	XAU NEX UK/US*	0.0001	-0.0354	0.1362	0.0336
	ETF-GLD	0.0021	-0.0201	-0.0016	-0.0070
	CME Gold	0.0032	0.0009	-0.0044	-0.0002
Stocks	Top 5 stocks	-0.0124	-0.0003	0.0077	-0.0013
Treasury bonds	30YR Treasury	-0.0112	-0.0128	-0.0143	-0.0128
	CME 30Y Treasury	-0.0035	-0.0011	0.0008	-0.0012

Order Imbalance on Quoted Depth Value (bps)			
February	*March*	*April*	*Period*
0.0308	-0.0019	0.0798	0.0358
0.0368	0.0014	0.0786	0.0384
-0.0596	-0.0404	-0.0962	-0.0652
-0.0053	-0.0134	-0.0030	-0.0074
-0.0204	-0.0064	-0.0251	-0.0170
-0.0031	0.0059	0.0065	0.0033
0.0013	-0.0065	0.0002	-0.0018

Table 5. Significant Price Falls

		Instance of Significant Price Falls (<-5%)			
Markets	*Instruments*	*February*	*March*	*April*	*Period*
Gold	NEX Gold Small	0.00	0.000	0.000	0.000
	XAU NEX UK/US*				
	ETF-GLD	0.000	0.000	0.000	0.000
	CME Gold	0.000	0.000	0.000	0.000
Stocks	Top 5 stocks	0.242	2.791	3.029	2.090
Treasury bonds	30YR Treasury	0.526	2.136	1.571	1.452
	CME 30Y Treasury	0.000	0.000	0.000	0.000

Table 6. Volumes

		Mean Daily Trading Value (US$ Mn)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	1,134.4	405.9	-	-	821.3
	NEX Gold Small	-	217.2	247.0	206.5	220.8
	CME Gold	8,098.3	20,242.5	14,604.1	30,822.2	16,494.0
	ETF-GLD	1,108.5	2,453.2	813.6	868.4	1,425.3
Stocks	NYSE top 20	982.6	749.0	772.7	871.2	865.6

Table 7. Transaction Costs

		Weighted Daily Quoted Spread (bps)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	13.78	6.87	-	-	10.81
	NEX Gold Small	-	4.66	2.76	1.84	3.43
	CME Gold	2.52	1.20	1.14	0.83	1.65
	ETF-GLD	1.59	0.93	0.97	0.84	1.18
Stocks	NYSE top 20	3.37	2.55	2.26	2.19	2.77

		Weighted Daily Effective Spread (bps)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	4.82	5.17	-	-	4.97
	NEX Gold Small	-	2.99	1.60	0.85	2.07
	CME Gold	2.87	1.81	1.83	1.06	2.10
	ETF-GLD	3.25	3.43	2.76	2.80	3.16
Stocks	NYSE top 20	6.16	3.37	2.58	2.29	4.18

Table 8. Volatility

		Average Intraday Volatility (5 min)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	0.149	0.124	-	-	0.138
	NEX Gold Small	-	0.088	0.072	0.048	0.073
	CME Gold	0.097	0.070	0.054	0.036	0.073
	ETF-GLD	0.126	0.084	0.060	0.041	0.090
Stocks	NYSE top 20	0.275	0.137	0.134	0.117	0.188

		Average Parkinson Volatility (5 min)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	1.630	1.086	-	-	1.399
	NEX Gold Small	-	1.238	0.891	0.589	0.985
	CME Gold	1.685	1.131	0.929	0.649	1.239
	ETF-GLD	1.247	0.794	0.532	0.384	0.867
Stocks	NYSE top 20	2.596	1.322	1.292	1.139	1.789

Table 9. Depth of Liquidity

		Order Imbalance on Traded Value (bps)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	0.006	-0.065	-	-	-0.024
	NEX Gold Small	-	-0.014	-0.009	0.023	-0.002
	CME Gold	-0.006	0.001	-0.003	-0.003	-0.003
	ETF-GLD	0.013	-0.003	-0.014	0.007	0.003
Stocks	NYSE top 20	-0.015	-0.013	-0.008	-0.025	-0.015

		Order Imbalance on Quoted Value (bps)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	-0.001	0.011	-	-	0.004
	NEX Gold Small	-	0.012	0.002	0.002	0.007
	CME Gold	-0.002	-0.008	-0.002	-0.002	-0.004
	ETF-GLD	-0.018	-0.039	0.001	-0.005	-0.019
Stocks	NYSE top 20	0.006	-0.004	-0.004	0.004	0.001

Table 10. Significant Price Falls

		Significant price falls (<-5%)				
Markets	*Instruments*	*global financial crisis start*	*eurozone crisis*	*China stock market turbulence*	*US - China trade war*	*57 months*
Gold	NEX Gold Big	0.193	0.088	-	-	0.149
	NEX Gold Small	-	0.088	0.000	0.000	0.045
	CME Gold	0.124	0.167	0.000	0.000	0.098
	ETF-GLD	0.248	0.084	0.000	0.000	0.123
Stocks	NYSE top 20	1.483	0.343	0.195	0.102	0.731

ANNEX 2

Gold's performance during February-April 2020's asset liquidation event

Report for the World Gold Council

22 June 2020

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Gold's performance during February to April 2020 asset liquidation event

June 2020

Executive summary

Gold is often considered a safe haven that typically benefits from flight-to-quality flows during periods of financial stress. While it has no credit risk and trades with high volumes in both over-the-counter and listed markets around the world,[9] it is not formally considered a high-quality liquid asset (HQLA) for purposes of the Liquidity Coverage Ratio (LCR) requirements of Basel III. Additionally, the Net Stable Funding Ratio (NSFR) assigns gold a Required Stable Funding (RSF) factor of 85% which stands in stark contrast to both Level 1 HQLA such as sovereign bonds (RSF factor of 5%) and Level 2 HQLA such as lower quality corporate bonds and common equity shares (RSF factor of 50%).

The recent and significant liquidation events that occurred in March are an opportune time to study the relative liquidity of gold compared to stocks and other assets considered HQLAs such as US Treasuries, which sold off sharply as the impact of the COVID-19 pandemic came to light. Longer-term US Treasury prices fell sharply despite a dramatic and unscheduled cut to the Fed funds rate on 15 March, underscoring the stress experienced by various asset classes.

We examined a variety of intra-day market efficiency metrics – including trading volumes, spreads, depth of book, among others – for gold, Treasury bonds, high liquidity stocks, and oil during February and March of 2020.

Our analysis shows that:

- Gold spot and futures have tighter spreads than those recorded for 30-year US Treasury. Gold also does not experience any significant price decline as monitored by the Bank for International Settlements, unlike US Treasury where end of day prices records falls of 5% on 3 days.
- Gold performed much better than the most liquid stocks traded in NYSE during the studied period, including the asset liquidation events in March. Spreads are lower in spot and futures gold products vis-a vis spreads in US equities. US equities also experience falls of 5 and 10%, which is not observed in gold products.
- Liquidity in US Treasury bonds is not consistent across maturities.
- There are indications that gold spot in the over-the-counter (OTC) market performs well compared to longer-term spot Treasuries throughout most of the studied period. While the same cannot be shown for the late March, this underperformance is likely caused by sample bias in the NEX tick data which only captures 1% of the reported top-level daily volume by LBMA-i. This bias does not affect Treasury data since BrokerTech captures 70-80% of all trades.
- Trading in futures does not suffer a sample selection bias and we report smaller spreads in gold futures vis-a-vis 30-year US Treasury futures.

Our analysis indicates that gold appears to exhibit the attributes and behaviour of well-established HQLAs such as long-term US Treasuries or, at least, warrant a less punitive treatment than stocks for purposes of the LQR and NSFR requirements of Basel III. However, the lack of comprehensive tick-level data for the OTC gold market prevents us from reaching a more definitive conclusion.

[9] LBMA-i data indicates that gold trades between $50 billion and $60 billion a day in the over-the-counter market, with an additional $65 billion to $80 billion in COMEX and various other exchanges around the world.

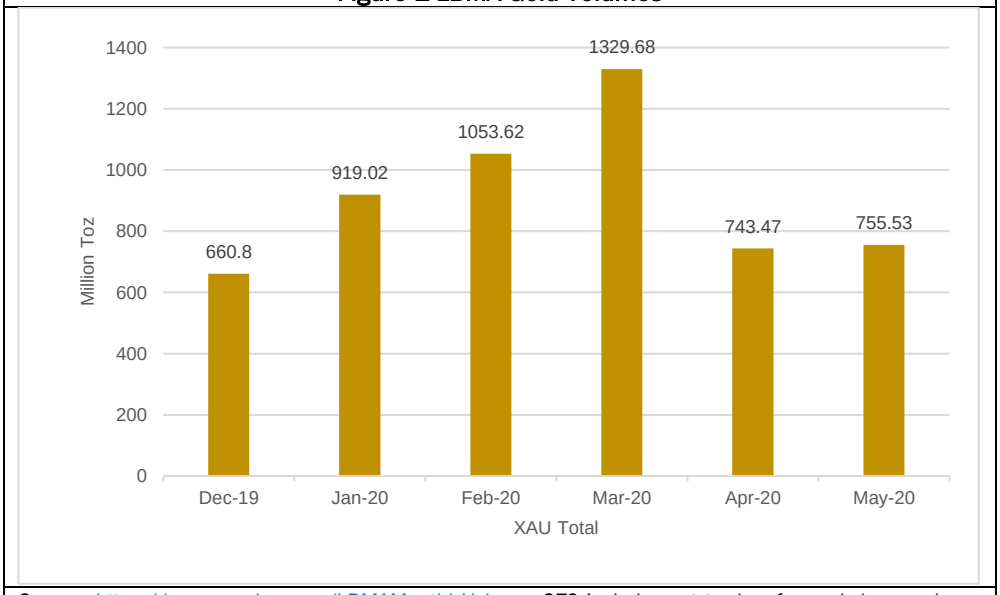
Introduction

We analyse the exogenous shock of the COVID-19 pandemic to evaluate the liquidity performance of gold, oil, stocks and Treasuries during the months of February and March 2020. This period was associated with a more than 50-fold increase in the number of reported COVID-19 cases, sending financial markets into a period of turmoil leading to a number of stabilising market interventions by central banks and the implementation of lockdowns across the globe.

Liquidity is a key element in the proper functioning of markets and plays a central role in financial stability. It measures how easily market participants can buy or sell a security without affecting its price. This is particularly relevant during challenging economic environments or when market sentiment drive liquidity towards markets where investors are best able to convert securities into cash.

Figure 1 shows that the LMBA reported increasing volumes in OTC gold traded during Q1 2020 relative to December 2019, highlighting the liquidity available in gold markets during this period of market stress. At the start of Q2 2020 a revision in volumes is reported however 12-14% higher than pre-COVID19 volumes.

Figure 1 LBMA Gold Volumes



Source: https://www.nasdaq.com/LBMAMonthlyVolume. OTC include spot trades; forwards/swaps, lease and option trades executed OTC.

Markets and Financial Instrument Selected

The markets[10] selected for the current study include:

- NYSE, owned by the Intercontinental Exchange is the world's largest market by market capitalisation.
- COMEX, part of the CME Group is the primary futures and options market for trading of precious metals and other commodities in the US.
- NEX, a subsidiary of the CME Group. Trading data is sourced directly from LBMA Market Makers and some of the LBMA Full Members. Based on trading volumes in February, March and April NEX transacted 22.53M troy ounces of gold equivalent to approximately US $36.76bn. NEX is one of several platforms offering market participants spot trading in gold and is used here as a benchmark for trading in gold across the universe of spot trading platforms.[11]
- BrokerTec facilitates the majority share of daily US Treasury electronic trading volumes, with estimates between 70-80%.

[10] We define markets as the venue of exchange
[11] We estimate NEX to represent less than 1% of daily trading volumes in London, but is our best source of intra-day data we have access to.

Securities

The gold instruments selected for analysis include:

- XAU=EBS (995), is the physical spot exchange rate of gold against the US dollar. The security has a contract size of 100 troy ounces. Trading takes place between 10pm (t-1) -9pm (t) GMT. The minimum price increment of negotiation is $0.10/troy ounce.
- GC traded on COMEX, is the leading benchmark futures contract for gold prices. The security has a contract size of 100 Troy ounces with the option of exchange for physical. Trading takes places 11pm (t-1)-10pm (t) GMT. The minimum price increment of negotiation is also $0.10/troy ounce.
- GLD, listed on the NYSE is the SPDR Gold Shares exchange traded fund managed by State Street Global Advisors. 10 shares of GLD is equivalent to 1 Troy ounce of gold, and the minimum lot size is 100 shares. Trading takes place 1.30pm-8pm GMT. The minimum price increment of negotiation is $0.01/troy ounce.

For spot market comparisons we identify the following securities:

- Top 5 equity firms by index weight. This includes Microsoft, Apple, Amazon, Facebook and Berkshire Hathaway (B-share);
- The SPDR S&P 500 ETF, designed to track the S&P 500 stock market index; and
- US Treasury bonds across six different maturities (2, 3, 5, 7, 10 & 30-year) traded via BrokerTec, which.

For futures comparisons we use the following "active"[12] contracts:

- E-mini S&P500, which represents one-fifth of the standard S&P futures and tracks the underlying S&P500 stock index;
- WTI Crude Oil Futures, the world's most liquid crude oil contract;
- 2,5,10, & 30-year US Treasury Futures; and
- VIX futures, which provide market participants with the ability to trade a liquid volatility product.

Table 1 identifies the 20 securities assessed and shows the total returns over the period, and maximum and minimum daily returns. The asset with the largest gains was the VIX futures (89%), followed by the recovery in equities (14.55%) and 30-year Treasuries (10.53%). The biggest loser was oil (-62.40%) followed by the e-mini futures (-10.57).

Table 1

	Max Return	Mini Return	Total
Panel A Spot Markets			
NEX Gold Small	6.11	-4.51	7.21
ETF-GLD	4.85	-3.99	7.04
ETF-SPY	9.06	-10.94	-10.38
30YSpot	8.11	-8.43	14.55
10YSpot	8.50	-8.72	10.12
7YSpot	2.91	-2.98	6.03

[12] At any one point in time, multiple contract expiries trade contemporaneously, we chain together the most actively traded contracts to form one sequential time series. It should be noted the most active is typically the nearest to maturity contract

5YSpot	1.97	-2.20	-0.54
3YSpot	1.24	-2.95	-0.05
2YSpot	0.57	-2.49	-0.47
Panel B Futures Markets			
CME Gold	5.95	-4.63	7.07
CME Emini-S&P500	9.80	-10.78	-10.57
CME 30Y Treasury	3.47	-4.11	10.53
CME 10Y Treasury	1.24	-1.51	5.69
CME 5Y Treasury	0.78	-0.77	4.37
CME 2Y Treasury	0.36	-0.26	1.94
CME Crude Oil	28.49	-43.37	-62.40
CBOE VIX Futures	34.74	-19.63	89.01

Results

Using top-of-book[13] intraday data, the reports summarises 8 measures of market quality including trade value, quoted and effective bid ask spreads, quoted depth and volatility. See Appendix A for technical details of each measure and source of data.

Trading Value

Table 2 reports trading values in the spot markets examined. As expected, US Treasury are the most actively securities traded, however there is considerable difference across maturities and across the sample period. 5- and 10-year US Treasury on average trade approximately $53bn and $58bn daily across the three months, however 30-year bonds are less active, averaging $156bn per day over the sample period. The next most actively traded security is the ETF SPY, averaging $48bn per day. SPY experienced an almost 100% increase in average trading value between February and March, reverting in April. The level of trading in the SPY is in stark contrast to that reported for the 5 largest securities which on average trade $8.29bn per day.

ETF GLD shows a 52.57% increase in average trade value between February and March, and 36.64% fall between March and April with an average trade values of $2.3bn. Spot gold also experiences a surge in trading activity from February to March (77%), with similar volumes reported in March and April..

Table 2 Mean Daily Trading Value in Spot Markets (US Million)

Security	February	March	April	Period
XAU NEX	396.51	688.78	669.48	592.68
XAU NEX UK/US*	239.15	512.70	451.74	408.22
GLD	2,039.11	3,111.07	1,971.25	2,396.50
SPY	35,513.31	70,829.75	36,753.65	48,465.07

[13] Top of book refers to the best bid and ask quotes in the order book. We do not have access to prices below level 1 quotes.

Top 5 stocks	6,952.73	10,142.88	7,559.61	8,290.27
30YR Treasury	12,832.44	18,915.66	13,521.61	15,224.43
10YR Treasury	45,534.10	60,561.13	51,394.83	52,851.36
7YR Treasury	14,510.35	19,175.32	10,420.89	14,780.52
5YR Treasury	54,577.34	66,585.46	52,257.48	58,052.53
3YR Treasury	20,138.44	26,818.96	20,748.71	22,715.65
2YR Treasury	26,566.47	34,367.50	26,459.72	29,298.42

*XAU NEX UK/US, only considers trading activity between 3amCT (ie 9am London) -4pmCT (ie 5pm New York when the CME closes),

Unlike OTC spot markets where data is incomplete due to market fragmentation, the futures markets provide a comprehensive overview of trading activity. Table 3 highlights the dominance of the e-mini S&P index futures trading, outpacing US Treasury futures. For US Treasury futures we also observe differences in trading activity across tenors as identified in spot markets. The 10-yr contract is the most active and 30-year contract the least active. Gold is the next most active contract, turning over volumes very similar to 30-year US Treasury futures.[14]

Table 3 Mean Daily Trading Value in Futures Markets (US Million)

Security	February	March	April	Period
CME Gold	58,728.45	52,860.10	30,479.20	47,077.83
CME E-mini	373,141.31	359,695.21	240,535.44	323,455.22
CME 30Y T	64,197.91	73,854.22	34,099.81	57,429.83
CME 10Y T	292,488.91	285,288.87	141,453.67	238,776.96
CME 5Y T	119,325.31	164,187.57	69,516.21	118,373.35
CME 2Y T	124,939.75	164,097.08	67,751.91	119,464.21
CME Oil	32,653.76	22,548.54	13,365.63	22,534.96
CME VIX	3,419.59	6,524.74	1,614.44	3,947.63

[14] If one considers futures trading in oil across all contract matures in February this would be$74.8bn versus 67.4bn for gold, and in March 61.bn versus 75. 2bn in gold. Our analysis focuses only on the most active contract in a given month.

Extant literature has identified that trading activity is a significant determinant of liquidity in equity and futures markets. Consequently, we compare gold securities to securities in spot and futures markets with similar trading activity, specifically 30-year Treasury, equites and the like for like comparison in the ETFs. For completeness, Appendix B reports summary results across all asset classes, respectively.

Market Quality: Gold vs US Treasury

Figure 2 compares the futures contracts for gold and 30-year Treasury bonds. Relative to spot markets, traders in futures markets incur lower quoted and effective spreads. We observe that gold futures have lower spreads than 30-year Treasury futures, and we identify a change in spread measures post March 9 consistent with increased volatility in the market. Interestingly, if we were to compare spreads in 10-year US Treasury futures to gold futures, quoted spreads are lower in gold contracts for all of February vis 10-year Treasury bond futures. Post March 9, we observe a change in spread measures for both 30-year and gold futures, reaching similar levels. In April however we see a reversion with spreads in gold futures below those reported for 30-year US Treasury futures.

Figure 2 Futures Gold and 30-year Treasury

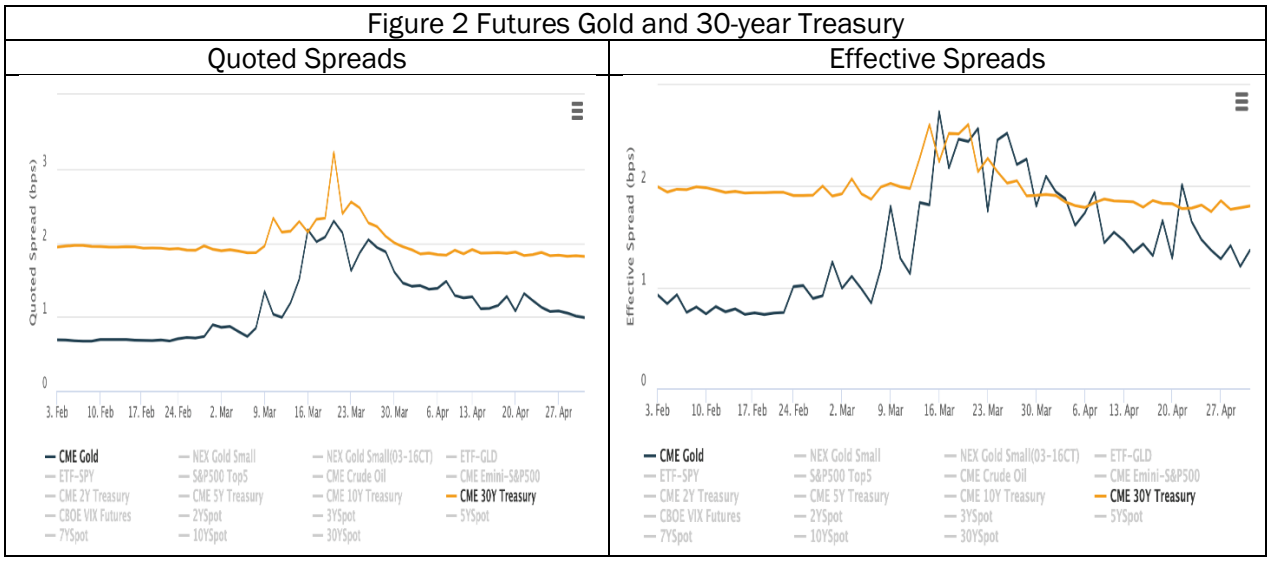
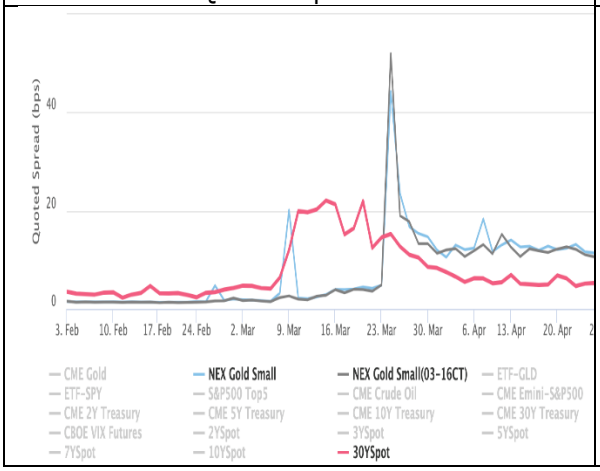


Figure 3 highlights, that, for 53% of the sample period, quoted bid-ask spreads in 30-year Treasury bonds traded on BrokerTec are larger than those faced by traders of gold on NEX. We observe two days with abnormal increases in quoted spreads for gold prior March 10, compared to a structural increase in quoted spreads for 30-year Treasury bonds. To control for the possible effects of reduced trading activity outside of UK and US normal trading hours, we sample trading during 3am USCT (ie. 9am GMT) and 4pm (USCT) and do not observe the two spikes suggesting they are due to reduced quoting activity outside of US-UK hours.

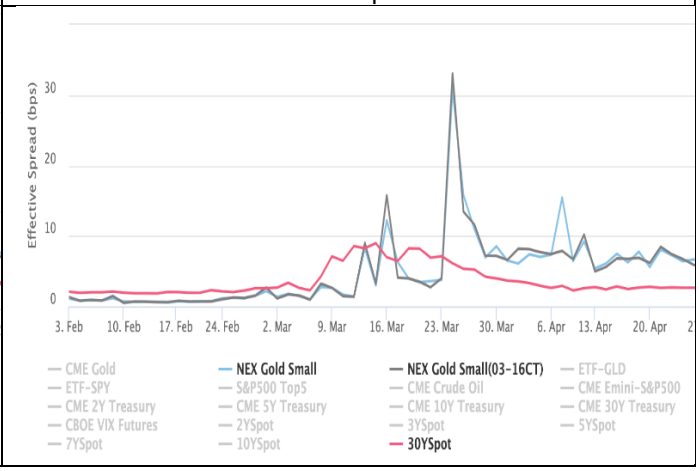
From March 10, spreads in 30-year Treasury bonds increase from approximately 3bps to an average of 12bps in late March corresponding to the triggering of market wide circuit breakers in equity markets and intervention by the Federal Reserve. In the final week of March, gold records a sharp increase in spreads, which quickly reverts to a new level of apprixiamtley12bps that is sustained through April. Figure 3 also depicts the trend in effective spreads during the period. Results closely resemble those for quoted spreads. This highlights the limitation of using NEX data as we are unable to determine if the spike we observe is due to data availability or market behaviour.

Figure 3: Spot Gold and 30-year Treasury

Quoted Spreads



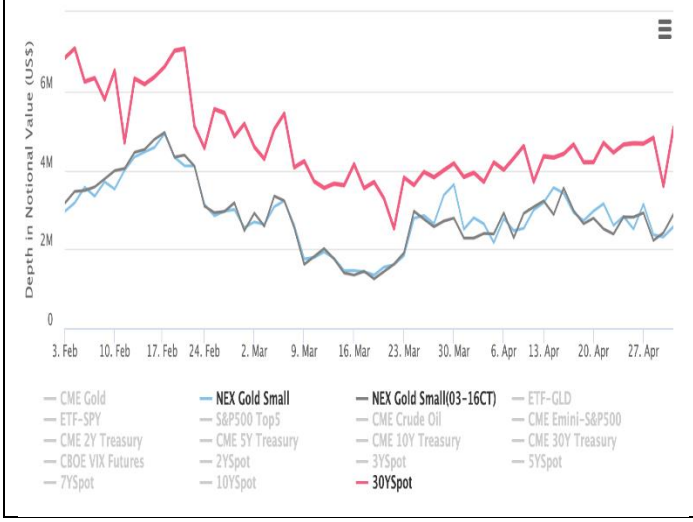
Effective Spreads



Turning to depth in the market, Figure 4 shows that available depth is larger in 30-year US Treasury vis-à-vis gold, in both spot and futures markets. This is not unexpected given the differences in contract specification and typical trade size which is significantly smaller in gold. Consistent with academic literature, we observe a negative relationship between depth and spreads. During the period of assessment, quoted depth in spot gold and 30-year Treasury is trending down, and closely track one another. Quoted depth in US treasury futures is significantly impacted in March, falling by almost 85%, while gold futures experience falls of 68% on average. In April, we observe steady increase in available depth in 30-year US Treasury futures , however significantly below levels in February 2020.

Figure 4 Quoted Depth

Spot Markets



Futures Markets

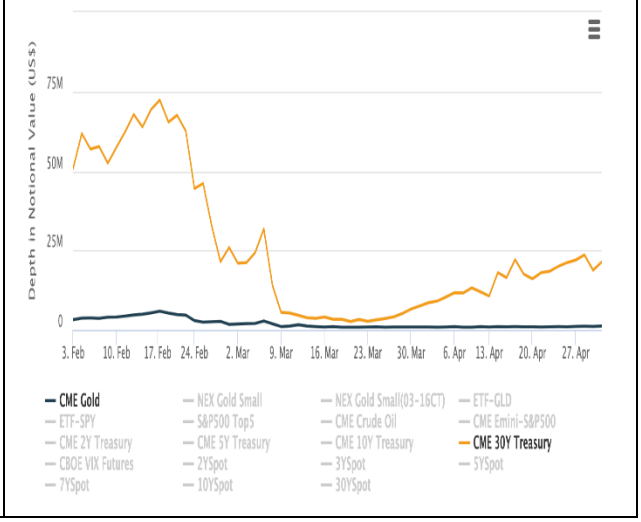
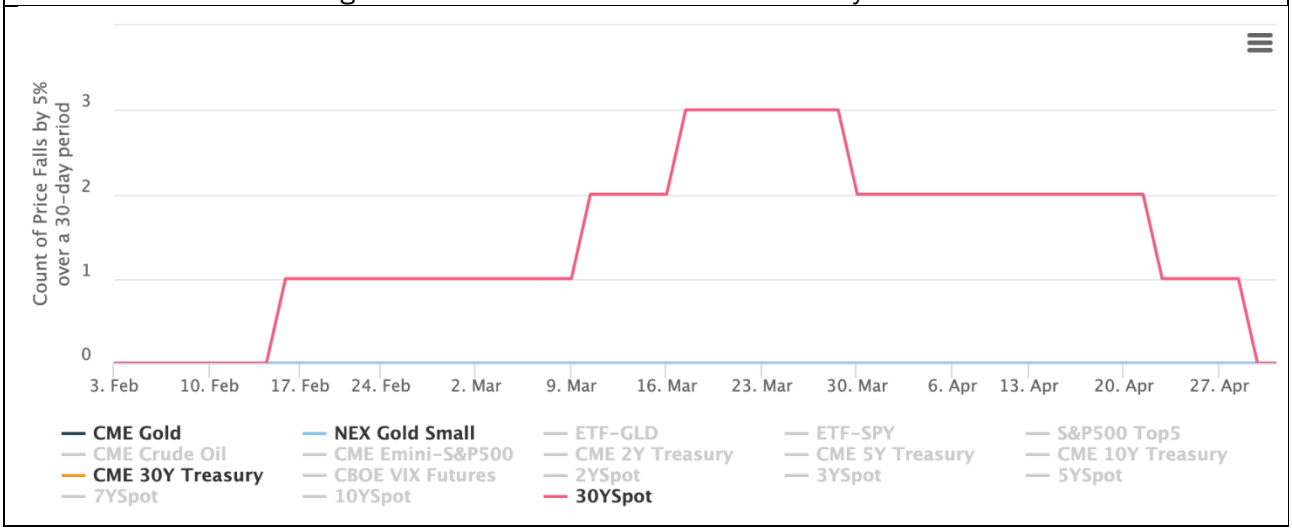


Figure 5 tracks the instances of price falls in end of day prices monitored by the BIS as part of consideration of HQLAs. For gold, we identify no prices declines of 5% during the period February to April. For 30-year Treasury however we do report a fall of 5% on Feb 14, followed by another on March 10, and March 16. Neither asset class experiences a fall of 10% or more during the period.

Figure 5: Price Falls in Gold and US Treasury Markets

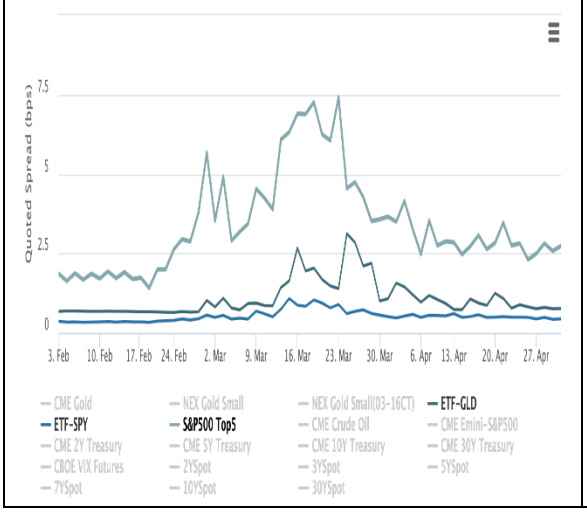


Market Quality: Gold ETF vs US Equities/ETF

Figure 6, shows the quoted and effective spreads for ETF of Gold (GLD) compared to the top 5 US equites and S&P 500 ETF, SPY. Both ETFs exhibit lower spreads than that reported for the top 5 US equities. The top 5 securities experience greater variation in spreads and also and sharp increase as early as February 21. Spreads in the ETF are very similar, however SPY reports lower quoted and effective vis-a-vis GLD.

Figure 6 Spot Gold and Top 5 US Equities

Quoted Spreads



Effective Spreads

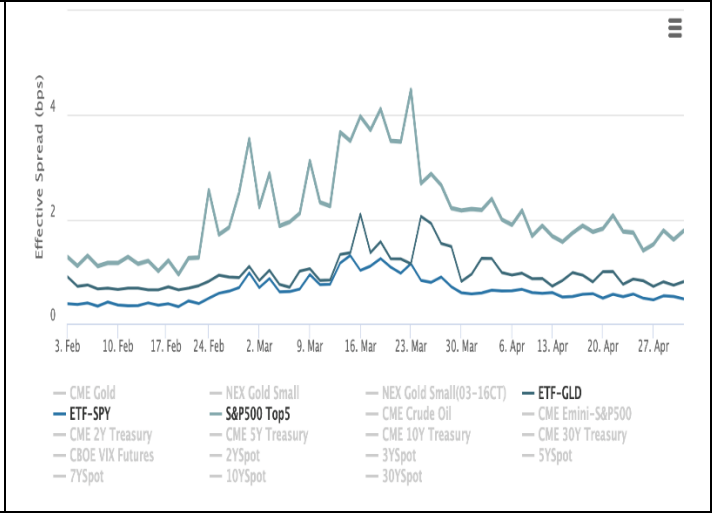
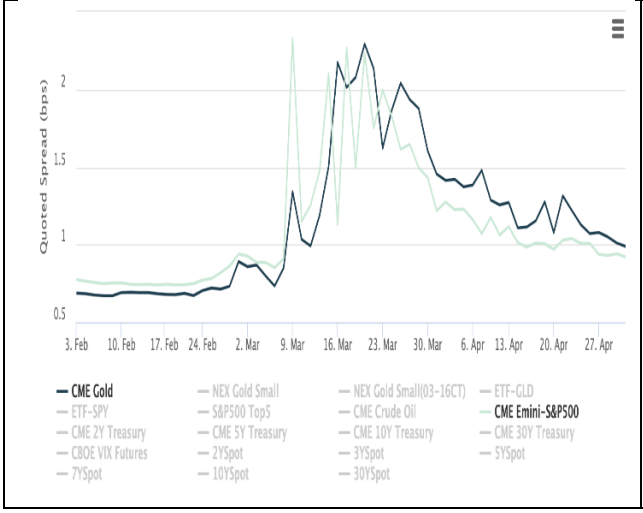


Figure 7, shows spreads measures for gold and e-mini futures.[15] On average quoted and effective spreads in gold futures are similar those reported for e-mini futures. Quoted spreads in the e-mini average 1.12bps vis-à-vis 1.16bs for gold futures, over the sample period. Similarly, effective spreads in the e-mini average 1.42bps vis-à-vis- 1.43bs for gold futures, over the sample period.

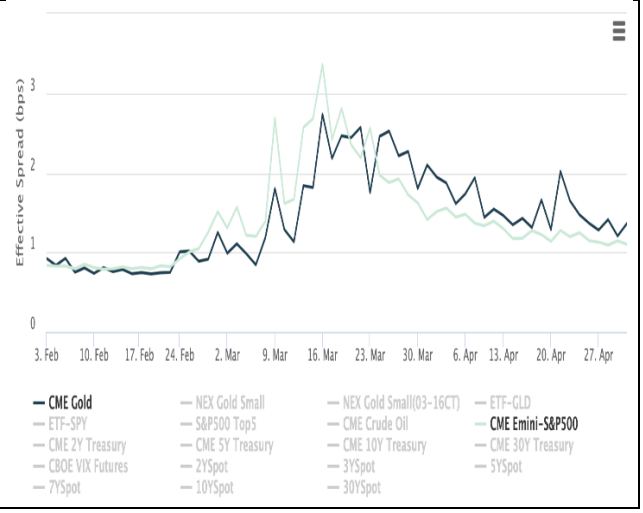
[15] We do not examine any trading in single stock futures or options.

Figure 7 Futures Gold and e-mini

Quoted Spreads



Effective Spreads

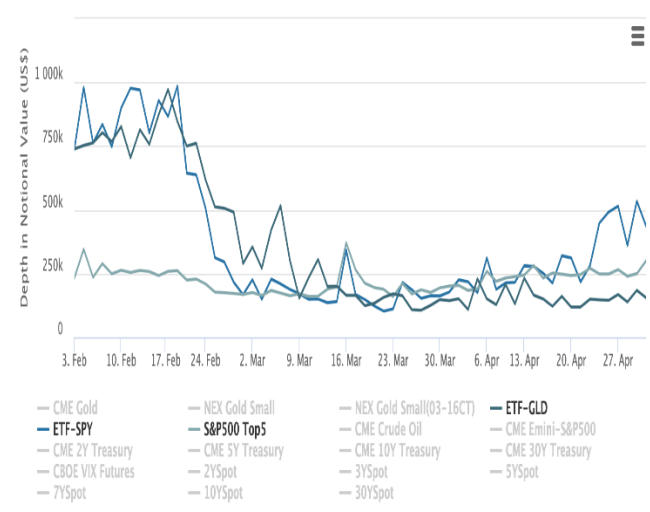


Despite the larger trading activity of the SPY, Figure 8, reports the depth across the two ETFs are very similar. In February, depth in the ETF is significantly larger than that reported for the top 5 securities, particularly during the first 3 weeks of February. Post February 20, we observe a significant decline in posted depth posted in the two ETFs. On average between February and March, average quoted depth decreased by more than 70% in the ETFs, while in the top 5 securities a decrease of 18% is reported.

In futures markets the reverse is true, with available depth in the e-mini significantly larger than that available in gold. However, available depth in the e-mini is extremely volatile during the sample period. Available depth in early February appears to sustain typical levels of approximately $20m, however this quickly falls away towards the end of February by almost 80%. Depth then spikes significantly on March 9, 16 and 18 where we see sellers flood the ask side of the book. In April, depth falls to an average or approximately $4.5m. By comparison depth in the gold futures fall from an average of 3.9m in February, to 1.2m in March and 0.97 in April.

Figure 8 Quoted Depth

Spot Markets



Futures Markets

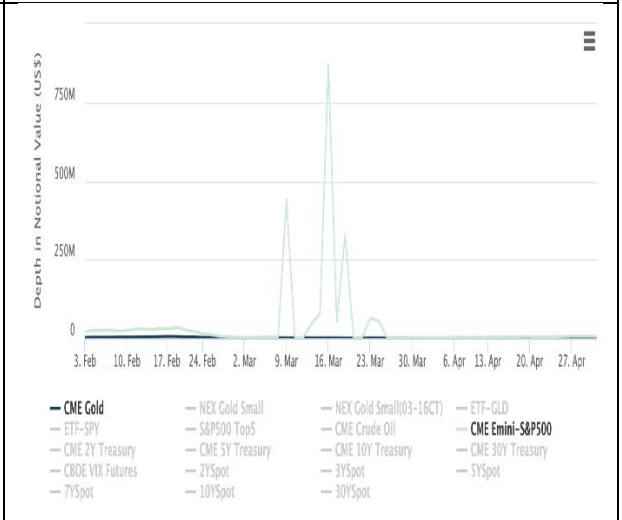
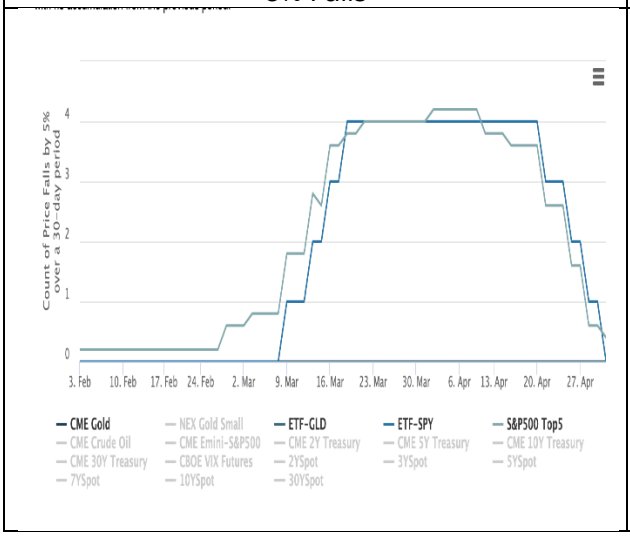
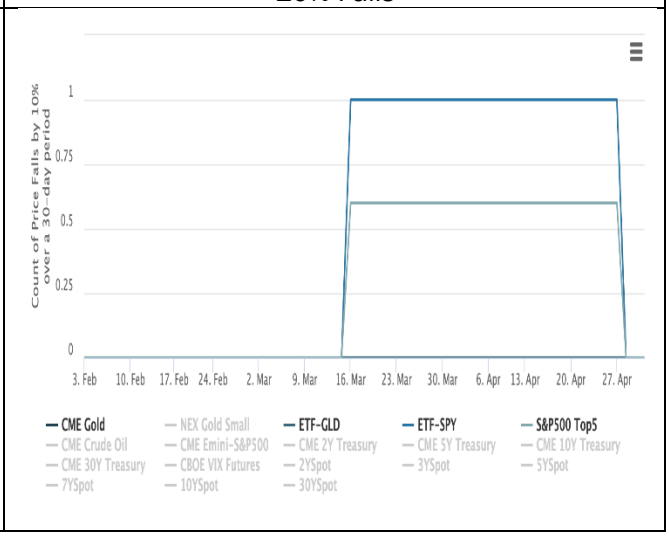


Figure 9 shows that the top 5 securities and the SPY recorded prices falls of 5% and 10% during the period contributing to its overall loss of -20.48% between February and March. No such falls are observed in GLD of gold futures.

Figure 9 Instance of Significant Price Falls

5% Falls	10% Falls
	

Conclusion

Periods of market stress are synonymous with large movements in price, fleeting liquidity and government intervention. Historically gold has performed well during these periods, and also experienced mini-episodes of perplexity, possibly due to profit taking or portfolio re-weighting. This analysis shows trading activity in gold is similar in certain dimensions to long dated US Treasury bonds considered HQLA. Specifically, it shows that during the exponential increase in cases of COVID-19, trading in OTC spot gold was associated with lower bid-ask spreads and more stable prices as no significant (ie 5%) price falls are recorded in end of day prices. Similarly spreads in gold are lower than those reported for some of the largest US stocks.

Appendix A: Data and Variable Definitions

Data

Data for XAU=EBS is obtained directly from NEX and US Treasury bond data is obtained directly from BrokerTec. All other intraday trade and quote data for is sourced from Thomson Reuters Tick History. The source data include price and volume data for all completed trades and top of book best bid and ask prices and volumes, as updated throughout the trading session.

Tick level data from the three data sources are processed using the Market Quality Dashboard. The platform ingests level-1 trade and quote data and derives end of day security measures of market quality.

Given the quantity and complexity of the data, a number of filters are applied to control for outliers. Excluded from any of the subsequent analysis are data printed during trading holidays (ie Presidents Day) or half trading days.

With respect to trading data for futures contracts, the MQD identifies for each day the relevant contract with the greatest volume. Given that, at any one point in time, multiple contract expiries trade contemporaneously, MQD chains together the most active contracts to form one sequential time series. It should be noted the most active is typically the nearest to maturity contract.

Market Activity

The first set of measures permits assessment of the general level of market activity. To account for differences in traded currency and contract specifications across the gold securities all summary measures have been standardised into Troy ounces of Gold or US dollars. The greater the trading activity the greater is the ability of traders to react to new information and therefore prices to reflect the information. Conversely, in less active or small markets, it is easier for large traders to distort prices or create imbalance in order flow, thus impeding market quality.

Transaction Costs

The second set of measures permit evaluation of round-trip transactions costs and quote quality. To measure transaction costs, we apply (1) quoted spread, or half-spread, to measure the cost of completing a trade if trades are executed at the quoted prices; and (2) effective spread, measured as the difference between the trade execution price and the underlying value of the security (ie. midquote), provides an estimate of the execution cost actually paid by the liquidity taker and the gross revenue earned by the liquidity provider. We calculate quoted spread$QS_{i,d}$,, effective spread $ES_{i,d}$, of each security-day as follows:

$$QS_{i,d} = \sum \frac{ask_{i,d,t} - bid_{i,d,t}}{m_{i,d,t}} * \frac{d_{i,d,t}}{\sum d_{i,d}} \quad (1)$$

$$ES_{i,d} = \sum s_{i,d,t} * \frac{2 * \left(p_{i,d,t} - m_{i,d,t}\right)}{m_{i,d,t}} \quad (2)$$

where $p_{i,d,t}$ and $m_{i,d,t}$ are the trade price of the i^{th} stock at time t in day d and the midpoint price of the best bid and ask quote immediately before the trade, respectively; $s_{i,d,t}$ is the signed direction of trade (Lee and Ready, 1991) identifying if the trade is buy-initiated ($s_{i,d,t}$=1) or sell-initiated ($s_{i,d,t} = -1$).

Demand and Supply Schedules

The second set of measures calculated seek to proxy the depth of liquidity available or demanded in the market. We measure Quoted Depth available at the top of the book and Order Imbalance. Effectively, quoted depth reflects the resiliency of the order book and available liquidity in the market. Increased quoted depth is associated with improved liquidity and resiliency. Order imbalance is calculated as the difference between the average daily buyer-initiated trade volume/quote activity and the average daily seller-initiated trade/quote volume divided by the total trade volume/quote activity. Order imbalance provides additional power to explain trading activity besides volumes and is significantly associated with liquidity and market returns (Chordia and Subrahmanyam, 2004). First, a high order imbalance can have an effect on returns because market makers have to work harder to adjust their inventories. Secondly, order imbalances signal excessive trading demand. Possibly due to increased asymmetric information or large trades such as inventory rebalances.

We calculate quoted depth and order imbalance as follows:

$$QDepth_{i,d} = \frac{\sum asksize_{i,d,t} * ad_{i,d,t} + \sum bidsize_{i,d,t} * bd_{i,d,t}}{timeactive_{i,d}} \quad (1)$$

$$Trade\ Order\ Imbalance_{i,t} = \frac{\sum BuyerInitiatedTrade_{i,t} - \sum SellerInitiatedTrade_{i,t}}{Total\ Trade_{i,t}} \quad (2)$$

$$Quote\ Order\ Imbalance_{i,t} = \frac{\sum BidQuoteSize_{i,t} - \sum AskQuoteSize_{i,t}}{QuoteSize_{i,t}} \quad (2)$$

where $asksize_{i,d,t}$, $bidsize_{i,d,t}$, $ad_{i,d,t}$, $bd_{i,d,t}$, and $timeactive_{i,d}$ is the national level best ask/bid size, the duration of this best level best ask/bid before between quote improvements. Trade initiation is determined as per the Lee and ready (1991) algorithm.

Price Stability

The third set of measures permits assessment of the volatility of prices. We calculate intraday Parkinson Volatility as follows:

$$Parkinson\ Volatility_{jt} = \sqrt{\frac{1}{n} x \sum_{t=1}^{n} \frac{1}{4xln(2)} xHL_{j,y}^2} \quad (1)$$

where $High_{j,t}$ is the maximum price for security j on day t; $Low_{j,t}$ is the minimum price for security j on day t,

With respect to price stability, we follow the Bank of International Settlements (BIS) methodology and track the instances of significant price declines (5,10,20%) over a 30-day period during the period assessed. In addition, we identify high-impact events that create sharp discontinuities in price returns—jumps. Jumps are identified in historical data based on: sampling frequency, benchmark parameters and distribution assumptions as developed in Lee and Mykland (2008).

Appendix B: Summary Measures of Market Quality

A1: Mean Quoted Spreads (bps)

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	1.6032	8.6948	12.1570	7.6942
Gold US-UK	1.4072	7.7488	11.4955	7.0744
GLD	0.6873	1.5259	0.9783	1.0834
SPY	0.3733	0.6823	0.5045	0.5274
Equities	2.2586	4.9120	2.9084	3.4203
30YR T	3.2384	12.9892	5.4900	7.4610
10YR T	1.6507	2.4318	1.7226	1.9522
7YR T	1.7408	2.7650	1.9735	2.1830
5YR T	0.8533	1.3093	0.9158	1.0363
3YR T	0.8647	1.1534	0.8896	0.9756
2YSpot	0.4392	0.7065	0.4617	0.5416
Panel B Futures Markets				
CME Gold	0.7006	1.5116	1.2129	1.1619
CME Emini	0.7722	1.4942	1.0527	1.1234
CME 30Y T	1.9356	2.1924	1.8530	1.9988
CME 10Y T	1.1883	1.1826	1.1309	1.1669
CME 5Y T	0.6628	0.6861	0.6371	0.6624
CME 2Y T	0.3753	0.3886	0.3665	0.3770
CME Oil	2.0313	4.1400	6.2658	4.2138
CME VIX	29.8229	20.8246	16.9276	22.3497

A2: Mean Effective Spreads (bps)

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	0.9613	6.2861	7.1308	4.9404
Gold US-UK	1.0077	6.3419	6.8958	4.8948
GLD	0.7565	1.2325	0.8964	0.9728
SPY	0.4497	0.8766	0.5549	0.6368
Equities	1.5047	2.9100	1.8245	2.1117
30YR T	2.0832	5.7809	2.7096	3.6074
10YR T	1.5812	1.9227	1.4305	1.6513
7YR T	1.5788	1.8576	1.5613	1.6718
5YR T	0.8033	0.9305	0.7640	0.8351
3YR T	0.7868	0.8375	0.7417	0.7895
2YSpot	0.3983	0.4478	0.3711	0.4066
Panel B Futures Markets				
CME Gold	0.8481	1.8406	1.5405	1.4348
CME Emini	0.9021	2.0052	1.2717	1.4187
CME 30Y T	1.9475	2.1332	1.8212	1.9706
CME 10Y T	1.2150	1.2789	1.1491	1.2154
CME 5Y T	0.6645	0.7210	0.6347	0.6745
CME 2Y T	0.3701	0.3883	0.3590	0.3728
CME Oil	2.2649	4.7910	7.9857	5.0989
CME VIX	29.5091	23.8298	17.6117	23.5600

A3: Average Quoted Depth ($000s)

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	3,661.554	2,269.000	2,790.064	2,872.240
Gold US-UK	3,768.099	2,193.182	2,725.027	2,855.959
GLD	712.950	211.898	155.145	346.223
SPY	698.352	172.513	308.466	379.705
Equities	236.905	193.776	242.515	223.501
30YR T	5,985.297	3,934.299	4,342.615	4,701.131
10YR T	56,677.108	13,838.986	28,414.227	31,903.573
7YR T	43,276.140	12,185.096	26,582.137	26,589.414
5YR T	61,329.124	15,804.811	35,788.677	36,524.539
3YR T	91,815.587	18,648.455	44,193.099	49,722.859
2YSpot	90,290.830	20,426.791	53,587.001	53,068.422
Panel B Futures Markets				
CME Gold	3,908.642	1,234.128	965.991	1,962.916
CME Emini	21,934.724	89,612.587	4,479.987	40,037.361
CME 30Y T	54,674.220	8,368.287	16,207.185	25,213.926
CME 10Y T	336,775.079	55,774.787	144,789.263	172,037.844
CME 5Y T	150,757.269	31,291.939	81,427.635	84,883.728
CME 2Y T	473,282.196	78,097.144	293,146.750	272,041.623
CME Oil	2,316.724	598.038	349.551	1,040.567
CME VIX	7,865.319	1,320.991	1,303.792	3,353.749

A4: Average Trade Imbalance ($000s)

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	0.0086	-0.0461	0.0489	0.0028
Gold US-UK	0.0001	-0.0354	0.1362	0.0336
GLD	0.0021	-0.0201	-0.0016	-0.0070
SPY	0.0104	0.0440	-0.0188	0.0124
Equities	-0.0124	-0.0003	0.0077	-0.0013
30YR T	-0.0112	-0.0128	-0.0143	-0.0128
10YR T	0.0027	-0.0123	0.0033	-0.0024
7YR T	-0.0148	-0.0042	-0.0257	-0.0147
5YR T	-0.0085	-0.0059	-0.0150	-0.0098
3YR T	0.0217	0.0142	0.0030	0.0127
2YSpot	0.0121	-0.0045	-0.0037	0.0009
Panel B Futures Markets				
CME Gold	0.0032	0.0009	-0.0044	-0.0002
CME Emini	0.0029	0.0057	0.0035	0.0041
CME 30Y T	-0.0035	-0.0011	0.0008	-0.0012
CME 10Y T	-0.0035	-0.0039	-0.0017	-0.0030
CME 5Y T	-0.0031	0.0023	-0.0064	-0.0023
CME 2Y T	-0.0044	-0.0021	-0.0108	-0.0057
CME Oil	-0.0047	-0.0085	-0.0060	-0.0065
CME VIX	-0.0550	-0.0102	-0.0267	-0.0296

A5: Average Quote Imbalance ($000s)

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	0.0308	-0.0019	0.0798	0.0358
Gold US-UK	0.0368	0.0014	0.0786	0.0384
GLD	-0.0596	-0.0404	-0.0962	-0.0652
SPY	-0.0231	-0.0180	-0.0137	-0.0181
Equities	-0.0204	-0.0064	-0.0251	-0.0170
30YR T	-0.0031	0.0059	0.0065	0.0033
10YR T	-0.0026	0.0022	0.0099	0.0033
7YR T	-0.0142	-0.0026	-0.0053	-0.0071
5YR T	0.0056	0.0111	-0.0007	0.0054
3YR T	-0.0102	0.0053	0.0027	-0.0003
2YSpot	0.0005	0.0096	-0.0161	-0.0019
Panel B Futures Markets				
CME Gold	-0.0053	-0.0134	-0.0030	-0.0074
CME Emini	-0.0063	-0.0968	-0.0110	-0.0400
CME 30Y T	0.0013	-0.0065	0.0002	-0.0018
CME 10Y T	-0.0016	-0.0061	0.0037	-0.0014
CME 5Y T	-0.0055	-0.0054	-0.0051	-0.0053
CME 2Y T	-0.0111	-0.0012	-0.0258	-0.0126
CME Oil	-0.0002	-0.0008	0.0023	0.0004
CME VIX	0.0244	-0.0211	-0.0030	-0.0010

A6: Volatility

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
Gold	0.0081	0.0195	0.0114	0.0132
GLD	0.0061	0.0141	0.0079	0.0096
SPY	0.0093	0.0320	0.0162	0.0197
Equities	0.0146	0.0338	0.0177	0.0224
30YR T	0.0090	0.0347	0.0118	0.0191
10YR T	0.0039	0.0113	0.0040	0.0066
7YR T	0.0029	0.0080	0.0026	0.0046
5YR T	0.0021	0.0050	0.0016	0.0030
3YR T	0.0012	0.0026	0.0007	0.0015
2YSpot	0.0008	0.0016	0.0004	0.0009
Panel B Futures Markets				
CME Gold	0.0092	0.0243	0.0152	0.0166
CME Emini	0.0117	0.0457	0.0215	0.0271
CME 30Y T	0.0057	0.0187	0.0064	0.0106
CME 10Y T	0.0031	0.0078	0.0026	0.0046
CME 5Y T	0.0020	0.0043	0.0014	0.0026
CME 2Y T	0.0008	0.0015	0.0004	0.0009
CME Oil	0.0220	0.0789	0.1491	0.0852
CME VIX	0.0570	0.1414	0.0526	0.0860

A7 Count of Price Fall

	5%	10%	20%
Panel A Spot Markets			
NEX Gold Small	0	0	0
ETF-GLD	0	0	0
ETF-SPY	1.935	0.484	0
S&P500 Top5	2.09	0.29	0
30YSpot	1.452	0	0
10YSpot	0	0	0
7YSpot	0	0	0
5YSpot	0	0	0
3YSpot	0	0	0
2YSpot	0	0	0
Panel B Futures Markets			
CME Gold	0	0	0
CME Emini-S&P500	1.452	0.484	0
CME 30Y Treasury	0	0	0
CME 10Y Treasury	0	0	0
CME 5Y Treasury	0	0	0
CME 2Y Treasury	0	0	0
CME Crude Oil	5.016	2.468	1.161
CBOE VIX Futures	6.607	1.328	0

A8 Jumps

Security	February 2020	March 2020	April 2020	Total
Panel A Spot Markets				
NEX Gold Small	32	24	15	71
ETF-GLD	16	14	12	42
ETF-SPY	13	13	12	38
SP500TOP5-AAPL	39	27	50	116
30YSpot	10	12	8	30
10YSpot	10	12	7	29
7YSpot	13	15	10	38
5YSpot	12	9	6	27
3YSpot	13	20	8	41
2YSpot	15	12	7	34
Panel B Futures Markets				
CME Gold	12	15	8	35
CME Emini-S&P500	11	17	10	38
CME 30Y Treasury	9	8	8	25
CME 10Y Treasury	10	9	6	25
CME 5Y Treasury	12	6	6	24
CME 2Y Treasury	13	7	10	30
CME Crude Oil	5	14	27	46
CBOE VIX Futures	11	13	9	33

ANNEX 3

MARKET QUALITY: GOLD

1. Introduction

Market liquidity is a measure of how easily traders can buy or sell a security in a market without affecting its price. Liquidity is a key element in the proper functioning of markets and plays a central role in financial stability. Changes in economic environment and or sentiment drives change such that liquidity gravitates to markets where traders are able to convert securities into cash.

The following seeks to assess the market quality of Gold across the various forms it is traded during periods of market stress. The forms of gold assessed include physical spot, futures and ETF, across multiple trading venues including the US and China.

In 2013 the European Banking Authority released Report 413 which compared a number of securities including gold for the purposes of identifying High Quality Liquid Assets. While the study covered a period 2009 to 2012, the study had limited data with respect to the trading of gold. This study seeks to overcome these shortfalls to provide a comprehensive view of liquidity in gold products utilising trade and quote data, that was not utilised in Report 413.

Both the Bank of International Settlements and EBA set forth a number of attributes of high-quality liquidity assets, however no universal measure of quality is accepted. For example the BIS points to low risk, ease and certainty of valuation, active and sizeable market, while the EBA incorporates measure such as bid-ask spread and price stability. Many of these measures are widely cited or developed in the academic discipline of market microstructure which seeking to assess market quality in light of the operation of financial markets (O'Hara 2013). In this study we assess 13 measures and compare the performance of gold to top 20 firms traded on the NYSE and fixed income securities issued by US government and firms.

Rather than undertaking a continuous time series analysis of market quality, this study focuses on periods of market stress identified by widening of two interbank spread rates, specifically LIBOR—T-bill and EURIBOR—OIS spreads over the period 2007 to 2019. Four major events are identified including the Global Financial Crisis of 2007-2009; the Euro zone crisis of 2010 and 2011; China's stock market turbulence and the US-China. In total 57 months are evaluated.

We find that across a number of market quality measures, trading in gold is similar or better vis-à-vis top 20 NYSE firms. Relative to bonds, we confirm as expected that US treasury bonds are the most liquid, however relative to corporate bonds, gold is of a higher ranking. These results hold across the periods assessed and regions.

2. Data and Method

2.1 Financial Instrument Trading Gold

Multiple financial instruments listed on multiple platforms permit trading of gold in physical or a deferred/financial basis. The markets selected for the current study include:

- NEX, an electronic platform headquartered in London UK and a subsidiary of the CME Group.
- Shanghai Gold Exchange (SGE), established in 2002 provides trading, clearing, delivery and vaulting services of gold, silver and platinum. Trading products include physical trading, deferred trading, forward, swap, option and leasing.
- COMEX, part of the CME Group of exchanges is the primary futures and options market for trading of precious metals.
- Shanghai Futures Exchange (SFE), operating under the supervision of the China Securities Regulatory Commission lists 18 futures contracts and 3 commodity options including precious metals, oil and rubber.
- NYSE, owned by the Intercontinental Exchange is the world's largest market by market capitalisation.

The instruments selected for analysis include:

- XAU=EBS (995), traded on NEX is the physical spot exchange rate of gold against the US dollar index. Initially the NEX set the contract size for 1000 troy ounces, however in 2010 a smaller contract size of 100 troy ounces was introduced. For a period of time the two contacts traded concurrently, however this ceased to be the case in our post 2011 sample period.
- AU99.99 traded on the SGE is physically bullions produced by SGE certified gold producers and meet SGEB1-2002 quality standards, or produced by qualified producers certified by London Bullion Market Association (LBMA).
- Au(T+D) traded on the SGE is the margin traded and daily settled of gold ingot-fineness no less than 99.99%.
- GC traded on COMEX, is the leading benchmark futures contract for gold prices.
- AU traded on the SGE is the monthly expiry contract representing 1kg of gold with physical delivery.
- GLD, listed on the NYSE is the SPDR Gold Shares exchange traded fund managed by State Street Global Advisors.

Each of the gold instruments vary with respect to contract specifications. Table 1 reports details of contract size, tick increments, trading hours, lot size, and delivery. In the subsequent analysis that follows. To facilitate a comparison across the various gold contracts, all market quality measures are adjusted for contact size and trading currency. For example all quantity metrics are expressed in Troy ounces of gold and US dollars.

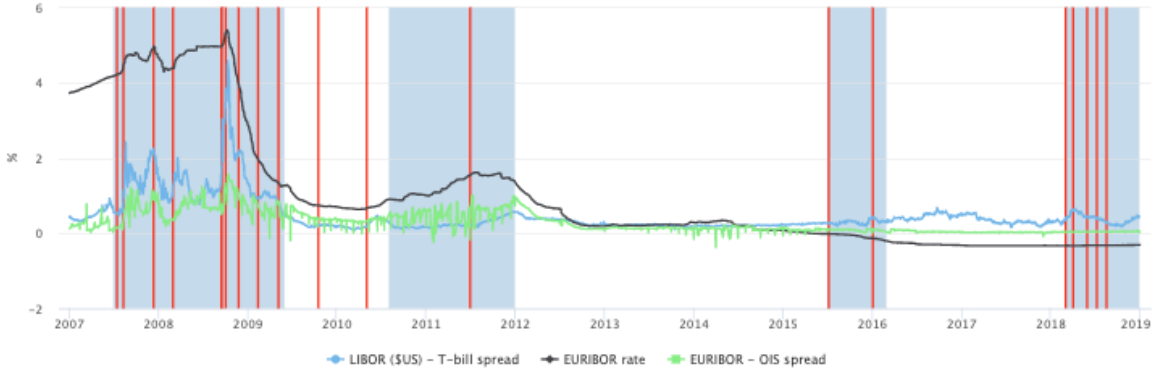
Table 1: Contract Specification of Spot, Futures and ETF Gold Securities

	NEX	SGE Spot	SGE Deferred	CME	Shanghai Future Exchange	NYSE ETF
Name	Spot Gold to USD (XAU=EBS (995))	Spot Gold 99.99 (Au99.99)	Deferred Gold 99.99 (Au(T+D))	Gold Futures	Gold Futures	SPDR Gold Shares ETF Symbol: GLD
Contract size	100(small)/1000(big) troy ounce	1kg gold ingot; Fineness no less than 99.99%	3kg gold ingot-fineness no less than 99.95%*Replacement:1kg gold ingots-fineness no less than 99.99%	100 troy ounces	1 kg	10shares/troy ounce
Tick size	$0.10/troy ounce	0.01 yuan/g	0.01 yuan/g	$0.10/troy ounce	0.05 yuan/gram	$0.01
Local trading hours	10pm - 9pm (GMT)	Day Session: 9am-11:30am; 1:30pm -3:30pm; Night Session: 7:50pm -02:30am (GMT +8)	Day Session: 9am-11:30am; 1:30pm -3:30pm; Night Session: 7:50pm -02:30am (GMT +8)	6pm-5pm (GMT-5)	Day Session 9am-11:30am; 1:30pm-3:00pm; Night Session: 9pm-2:30pm (GMT+8)	9:30am-4pm (GMT-4)
UTC trading hours	10pm - 9pm (GMT)	Day Session 1am-3:30am and 5:30am-7:00am; Night Session 11:50pm-6:30pm (GMT)	Day Session 1am-3:30am and 5:30am-7:00am; Night Session 11:50pm-6:30pm (GMT)	11pm-10pm (GMT)	Day Session 1am-3:30am and 5:30am-7:00am; Night Session 1pm-6:30pm (GMT)	1:30pm-8pm (GMT)
Exchange	EBS	SGE	SGE	COMEX	SHFE	NYSEArca
Lot size	100(small)/1000(big) troy ounce	10g	1kg	100 troy ounces	1kg	100
Delivery	Physical	Physical	Physical/Tending for Delivery	Physical/Deliverable	Physical	-

2.2 Sample Period and Data Sources

Figure 1 reports the TED Spread, the difference between the LIBOR and US Treasury Bill and the OIS LIBOR spread, the difference between the LIBOR and Overnight Index Swap rate for the period 2007 to 2019. Both measures have become ubiquitous proxies of market stability and leading indicators of economic downturn.

Figure 1: TED and EURIBOR-OIS Spreads



Shaded regions in Figure 1, highlight exacerbations in the two spread measures that align with significant historical events of market stress such as the Global Financial Crisis, the subsequent Euro Zone Crisis, volatility in China's markets and more recently the US-China Trade War. During each of these episodes a number of key dates can be identified such as the introduction of relief programs and bailouts to significant sell offs, halting of trading and imposition of tariffs that affect global market conditions. Table 2 identifies the periods of interest examined in this report. Specifically, the 23 months surrounding the

GFC, 17 months of the Euro zone crisis, 7 months of turbulence in China's equity markets and 10 months of US China trade wars, providing a sample period of 57 months with which to evaluate the market quality of gold securities during periods of market stress.

Table 2: Market Stress Periods

Events	Start	End	No. of months
Global financial crisis start	**2007-07-01**	**2009-05-31**	**23**
Key events			
Bear Stearns halts redemptions from two of its funds	2007-07-17		
Run on the repo market starts	2007-08-09		
Fed announces Term Auction Facility (TAF)	2007-12-12		
TSLF and PDCF initiated; Bear Steams sold	2008-03-01		
AIG announces imminent bankruptcy, gets bailed out	2008-09-16		
Lehmann Brothers declares bankruptcy	2008-09-14		
Congress passes Troubled Asset Relief Program (TARP)	2008-10-03		
Term Asset-backed Securities Facility (TALF) announced	2008-11-25		
Treasury department announces stress tests	2009-02-10		
US bank stress test results released	2009-05-07		
Euro zone crisis	**2010-08-01**	**2011-12-31**	**17**
Key events			
Greece admits deficit-to-GDP ratio of 12 percent	2009-10-18		
First Eurozone-IMF rescue plan completed	2010-05-02		
European FSB cleared to purchase soverign bonds	2011-07-01		
China stock market turbulence	**2015-07-01**	**2016-02-28**	**7**
Key events			
SSE halted over 1,400 companies, spread to international stock markets	2015-07-08		
Sharp sell-off; circuit break, triggered Dow Jones plunge	2016-01-04		
US-China trade war	**2018-03-01**	**2018-12-31**	**10**
Key events			
President Trump imposed tariffs of 25% on steel and 10% on aluminum	2018-03-01		
China responded by imposing tariffs on 128 products it imports from the US	2018-04-02		
The White House announced that it would impose a 25% tariff on $50 billion of Chinese goods with "industrially significant technology"	2018-05-29		
US tariffs on $34 billion of Chinese goods came into effect	2018-07-06		
China filed a complaint with the World Trade Organization (WTO)	2018-08-14		
Total			**57**

2.3 Data Sources

With the exception of XAU=EBS which is obtained directly from NEX, all other intraday trade and quote level data for is sourced from Thomson Reuters Tick History. The source data include price and volume data for all completed trades and top of book best bid and ask prices and volumes, as updated throughout the trading session. All data is collected from electronic trading platforms listed in Section 2.1.

2.3 Data Management

Tick level data from Thomson Reuters and NEX are processed using the Rozetta Institute Market Quality Dashboard. The platform ingests level-1 trade and quote data and derives end of day security measures of market quality.

Given the quantity and complexity of the data, a number of filters are applied to control for outliers. Excluded from any of the subsequent analysis are data printed during trading holidays or half trading days. A parsimonious data filter is also applied such that any price that is a multiple of 8 relative to previous prices are ignored. The aim of this filter is to remove erroneous data points as opposed to volatile trading.

With respect to trading data for futures contracts, the MQD identifies for each day the relevant expiry contract with the greatest volume. Given at any one point in time multiple contract expiries trade contemporaneously, MQD chains together the most active contracts to form one sequential time series. It should be noted the most active is typically the nearest to maturity contract.

In addition to trade and quote data for gold securities, we also ingest equity trading data from the NYSE. In order to benchmark the performance of gold to equites, we identify the population of firms listed on the NYSE which are active during the 57-month sample period. This is done so as to achieve a consistent sample of firms through time. For each identified market stress period (ie GFC, Eurozone Crisis, China Market Turmoil, and US-China Trade War) we first measure the average daily trading value for each firm and rank firms to identify the top 20 actively traded firms).

2.4 Market Quality Measures

2.4.1 Market Activity

The first set of measures permits assessment of the general level of market activity, specifically trading volume, frequency and size. To account for differences in traded currency and contract specifications across the gold securities all summary measures have been standardised into Troy ounces of Gold or US dollars. The greater the trading activity the greater is the ability of traders to react to new information and therefore prices to reflect the information. Conversely, in less active or small markets, it is easier for large traders to distort prices or create imbalance in order flow, thus impeding market quality.

2.4.2 Transaction Costs

The second set of measures permit evaluation of round-trip transactions costs and quote quality. To measure transaction costs, we apply (1) quoted spread, or half-spread, to measure the cost of completing a trade if trades are executed at the quoted prices (2) effective spread, measured as the difference between the trade execution price and the underlying value of the security, provides an estimate of the execution cost actually paid by the liquidity taker and the gross revenue earned by the liquidity provider; (3) realised spread, a proxy of transaction costs net of informational adverse selection costs and hence the profits of liquidity maker; and (4) price impact, a proxy of informational adverse selection costs. We calculate quoted spread$QS_{i,d}$,, effective spread $ES_{i,d}$, realised spread $RS_{i,d}$, and price impact $PI_{i,d}$ of each security-day as follows:

$$QS_{i,d} = \sum \frac{ask_{i,d,t} - bid_{i,d,t}}{m_{i,d,t}} * \frac{d_{i,d,t}}{\sum d_{i,d}} \quad (1)$$

$$ES_{i,d} = \sum s_{i,d,t} * \frac{2 * \left(p_{i,d,t} - m_{i,d,t}\right)}{m_{i,d,t}} \quad (2)$$

$$RS_{i,d} = \sum s_{i,d,t} * \frac{2 * \left(p_{i,d,t} - m_{i,d,t+r}\right)}{m_{i,d,t}} \quad (3)$$

$$PI_{i,d} = \sum s_{i,d,t} * \frac{2 * \left(m_{i,d,t+r} - m_{i,d,t}\right)}{m_{i,d,t}} \quad (4)$$

where $p_{i,d,t}$ and $m_{i,d,t}$ are the trade price of the i^{th} stock at time t in day d and the midpoint price of the best bid and ask quote immediately before the trade, respectively. $m_{i,d,t+r}$ is the trade price of the i^{th} stock at time t in day d and the midpoint price of the best bid and ask quote after the trade execution in r seconds; $s_{i,d,t}$ is the signed direction of trade (Lee and Ready, 1991) identifying if the trade is buy-initiated ($s_{i,d,t}$=1) or sell-initiated ($s_{i,d,t} = -1$).

2.4.3 Price Stability

The third set of measures permits assessment of the volatility and efficiency of prices. Two volatility measures are adopted. First, intraday volatility of mid-quote returns measured at 5-minute intervals. Second, Parkinson (1980) extreme volatility measure. We calculate intraday volatility and Parkinson Volatility as follows:

$$Intraday\ Volatiliity_{j,\mathrm{t}} = \sqrt{\sum_{i=1}^{n} \frac{(r_{j,i} - m_{jt})^2}{n-1}} \quad (1)$$

$$HL_{jt} = \ln\left(\frac{High_{j,t}}{Low_{j,t}}\right)$$

$$Parkinson\ Volatility_{jt} = \sqrt{\frac{1}{n} x \sum_{t=1}^{n} \frac{1}{4xln(2)} xHL_{j,y}^2} \quad (2)$$

where $r_{j,i}$ is the return in midpoint prices at 5-minute intervals, m_{jt} is the mean return for security j on day t; $High_{j,t}$ is the maximum price for security j on day t; $Low_{j,t}$ is the minimum price for security j on day t,

With respect to price stability and efficiency, we utilise two proxies, first Price Fall and secondly Variance Ratios. Following the Bank of International Settlements (BIS) we track the instances of significant price declines (5,10,20%) over a 30-day period during the 57-months identified.

The variance ratio (see Lo and MacKinlay, 1988) captures that, in an efficient market, prices should approximate a random walk. If a securities price follows a random walk, the variance of its returns is a linear function of the measurement frequency. The variance ratio exploits this property to measure inefficiency as a price series' deviation from the characteristics that would be expected under a random walk. We calculate variance ratios for each stock-day at multiple intra-day frequencies as follows:

$$Variance\ Ratio_{k,\mathrm{l}} = |\frac{\sigma_{k,l}^2}{k\sigma_l^2} - 1| \quad (1)$$

2.4.4 Demand and Supply Schedules

The final measures calculated seek to proxy the depth of liquidity available or demanded in the market. We measure Quoted Depth available at the top of the book and Order Imbalance. Effectively, quoted depth reflects to an extent the resiliency of the order book and available liquidity in the market. Increased quoted depth is associated with improved liquidity. Order imbalance is calculated as the difference between the average daily buyer-initiated trade volume/quote activity and the average daily seller-initiated trade/quote volume divided by the total trade volume/quote activity. Order imbalance provides additional power to explain trading activity besides volumes and is significantly associated with liquidity and market returns (Chordia and Subrahmanyam, 2004). First, a high order imbalance can have an effect on returns because market makers have to work harder to adjust their inventories. Secondly, order imbalances signal excessive trading demand. Possibly due to increased asymmetric information or large trades such as inventory rebalances.

We calculate quoted depth and order imbalance as follows:

$$QDepth_{i,d} = \frac{\sum asksize_{i,d,t} * ad_{i,d,t} + \sum bidsize_{i,d,t} * bd_{i,d,t}}{timeactive_{i,d}} \quad (1)$$

$$Trade\ Order\ Imbalance_{i,t} = \frac{\sum BuyerInitiatedTrade_{i,t} - \sum SellerInitiatedTrade_{i,t}}{Total\ Trade_{i,t}} \quad (2)$$

$$Quote\ Order\ Imbalance_{i,t} = \frac{\sum BidQuoteSize_{i,t} - \sum AskQuoteSize_{i,t}}{QuoteSize_{i,t}} \quad (2)$$

where $asksize_{i,d,t}$, $bidsize_{i,d,t}$, $ad_{i,d,t}$, $bd_{i,d,t}$, and $timeactive_{i,d}$ is the national level best ask/bid size, the duration of this best level best ask/bid before between quote improvements. Trade initiation is determined as per the Lee and ready (1991) algorithm.

3. Results

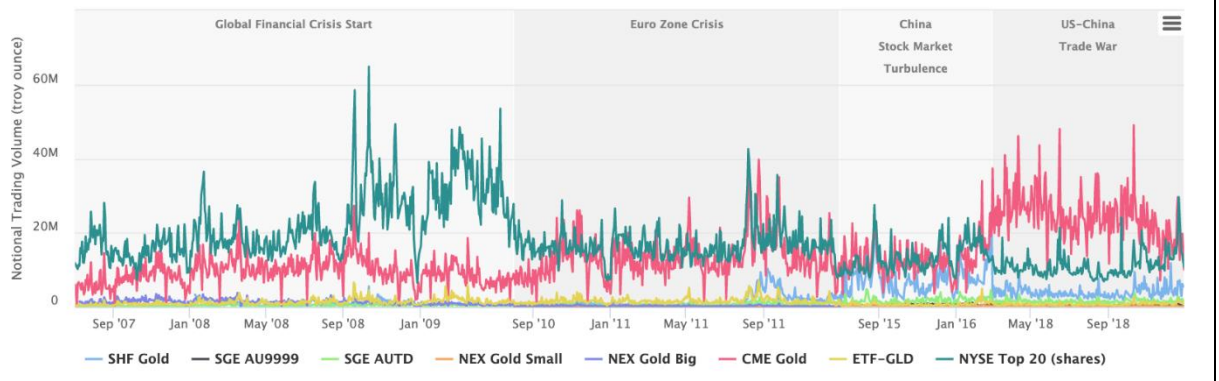
3.1 Gold and US Equity Markets

Notional Trade Volume and Value

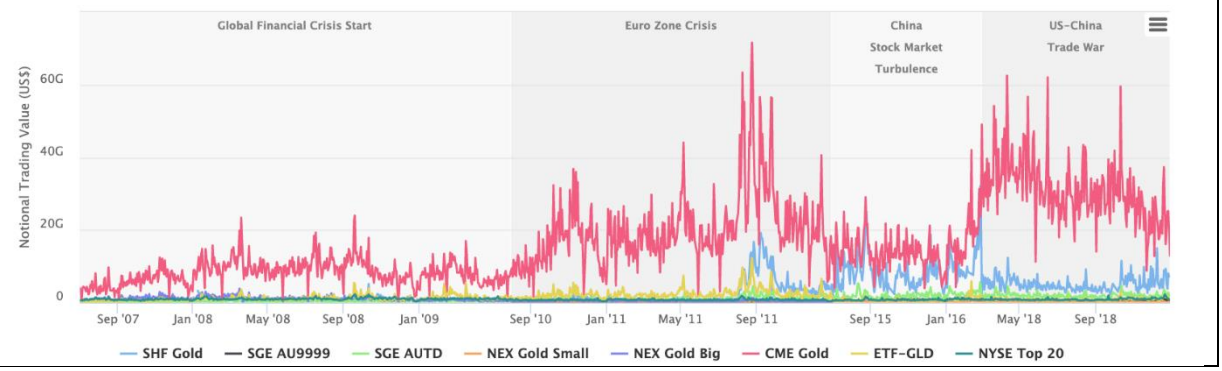
Figure 2 reports daily trading volume measure across the 57-months. As expected, the dominant market place for the trading of gold is futures markets followed by ETF and spot markets, respectively.

Figure 2: Trade Volume in Troy Ounces and US dollars

Panel A: Troy Ounces



Panel B: Dollars



CME Trading volumes are moderately increasing, with significant shifts reported during the US-China trade war and August 2011. This temporal pattern in trading activity is also observed in other gold securities and markets.

In China, the futures contact is similarly the predominant contract relative to spot trading, experiencing a significant uplift in trading post August 2001. AU(T+D), has become the major contract of SGE. Despite

the contract being traded on margin, exhibiting the characters of futures, it is backed by physical delivery every day. Data for SGE 9999 is not available pre 2010.

ETF, GLD is very active trading $813m to $2.45bn on a daily basis.

NEX contract EBS originally listed a 'big' contract for 1000 troy ounces of gold. This was the only contract available during the GFC and experienced trading volumes in excess of $1m per day. Subsequently a small contact was listed (ie 'small' for 100 ounces). We observe a downward shift in quantity and value in the big contract following the switch by NEX to the small contract, which trades anywhere from $207 to $247 per day during the four periods assessed.

In comparison during the 57 months of data analysed, the typically NYSE top 20 firms on average traded $865M per day. Table 3 reports mean trading volume and value across the four periods and over the 57 months.

Table 3 Trading Activity

Panel A Notional Trading Volume (troy ounce) in Million

Security / Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20 (shares)	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	9.447	1.298	1.344	-	22.709	-	0.32	0.866
Euro zone crisis	13.27	1.651	0.275	0.144	16.837	0.064	0.656	1.486
China stock market turbulence	12.949	0.747	-	0.219	13.45	0.64	1.806	7.647
US-China trade war	24.41	0.731	-	0.164	11.039	0.438	1.534	3.975
57 months	13.641	1.229	0.884	0.166	17.695	0.302	0.832	2.715

Panel B Notional Trading Value (US$) in Million

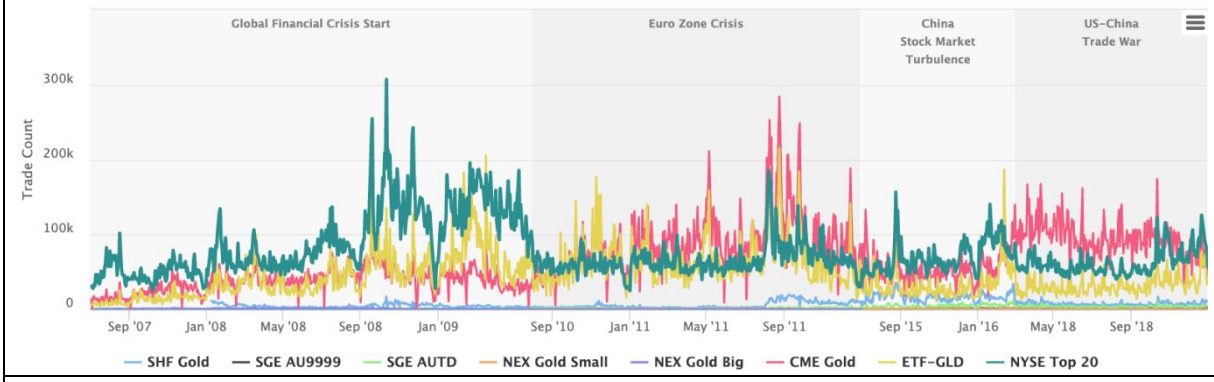
Security / Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	8098.3	1108.49	1134.4	-	982.632	-	277.02	755.643
Euro zone crisis	20242.5	2453.23	405.859	217.199	749.005	98.435	1018.49	2473.63
China stock market turbulence	14604.1	813.6	-	246.97	772.74	717.436	2028.21	8689.98
US-China trade war	30822.2	868.45	-	206.507	871.243	553.55	1938.92	5084.05
57 months	16494	1425.32	821.321	220.846	865.623	369.213	1022.64	3382.5

Trade Count and Notional Trade Size

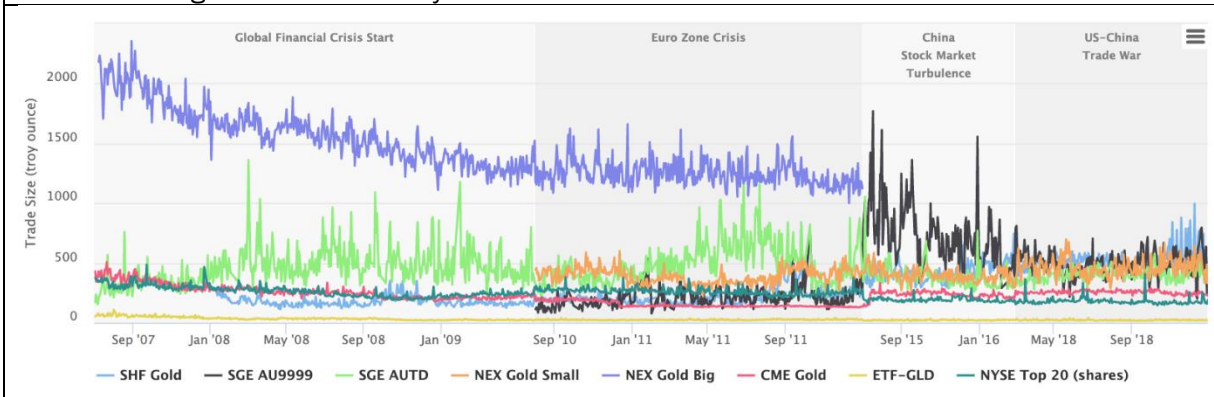
Figure 3 reports daily trading count, trade size and trade value during the the 57-months.

Figure 3

Panel A: Trade Count



Panel B Average Trade Size in Troy Ounces



Panel C Average Trade Value

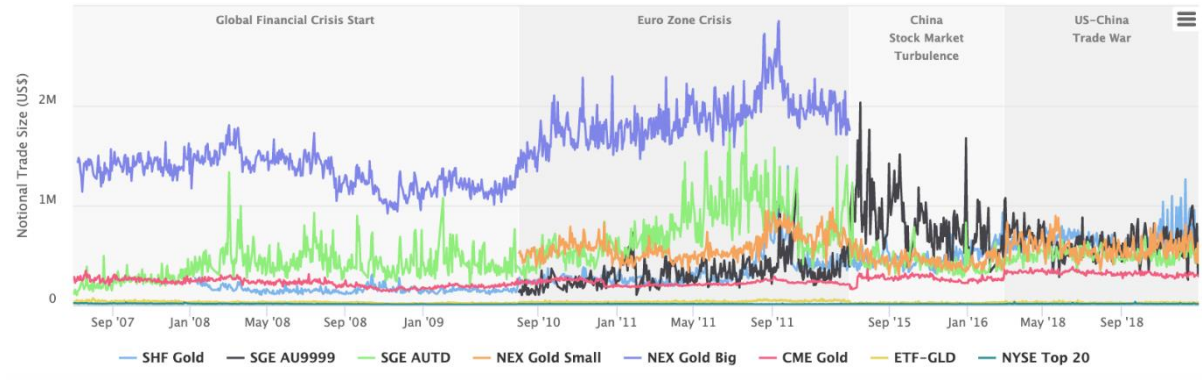


Table 4 reports average trade size and trade value during across each of the four periods of market stress and over the 57-months examined.

Table 4

Panel A Trade Count in thousands

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	37.454	42.7	0.83	-	91.475	0.172	0.655	4.596
Euro zone crisis	89.927	65.127	0.217	0.376	65.333	0.304	1.404	5.58
China stock market turbulence	55.543	33.288	-	0.542	70.617	0.962	4.895	16.828
US-China trade war	95.013	32.395	-	0.353	62.155	0.897	3.885	7.572
57 months	65.325	46.285	0.567	0.407	75.83	0.444	2.015	7.371

Panel B Trade Size in Troy Ounces

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20 (shares)	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	265.438	35.984	1589.73	-	263.029	-	459.13	176.279
Euro zone crisis	151.055	25.212	1247.53	391.343	260.616	210.786	493.914	218.385
China stock market turbulence	236.437	21.915	-	399.124	191.591	735.033	381.239	434.317
US-China trade war	255.562	22.476	-	462.13	178.639	497.028	400.191	521.335
57 months	226.118	28.546	1442.68	413.236	238.025	411.412	448.47	297.286

Panel C Trade Value

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20 (shares)	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	265.438	35.984	1589.73	-	263.029	-	459.13	176.279
Euro zone crisis	151.055	25.212	1247.53	391.343	260.616	210.786	493.914	218.385
China stock market turbulence	236.437	21.915	-	399.124	191.591	735.033	381.239	434.317
US-China trade war	255.562	22.476	-	462.13	178.639	497.028	400.191	521.335
57 months	226.118	28.546	1442.68	413.236	238.025	411.412	448.47	297.286

During the period, on average an NYSE top 20 firm by trade volume would experience over 75,000 trades, outpacing the number of trades in CME Gold futures (GLD) by approximately 10,000 trades (30,000).

In value terms, however, the average typical trade in a COMEX futures contract is over $200,000 and Shanghai where each trade would represent between 5 to 16 contracts each comprising 1gk of gold and valued at over $520,000. This compares the trades in NYSE top 20 firms where the average trade ranged between $11,100 and $14,100 over the 4 periods considered.

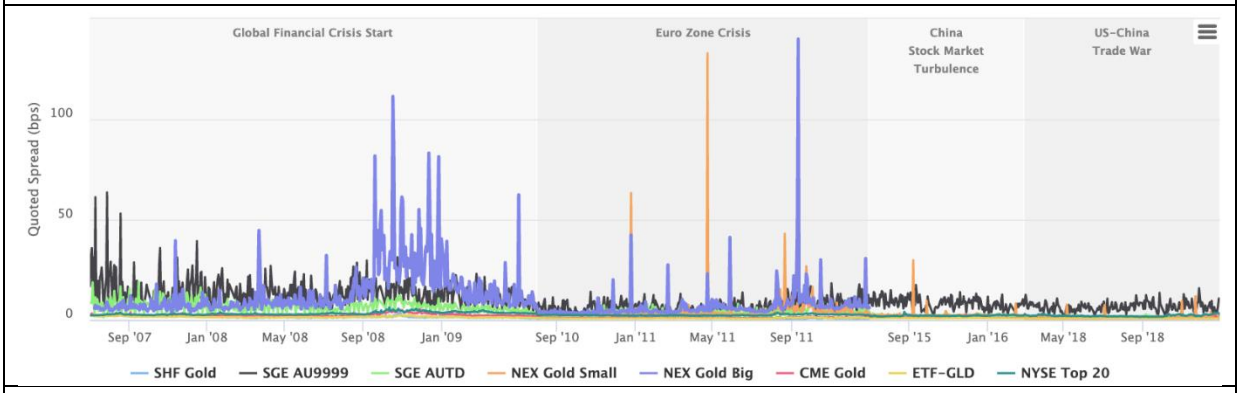
With respect to spot markets the typical trade size is equal to the contract value for the big NEX, however it is on average 3-5 in the small contract, representing a trade of $1.56M and $553,000, respectively.

Quoted Spread

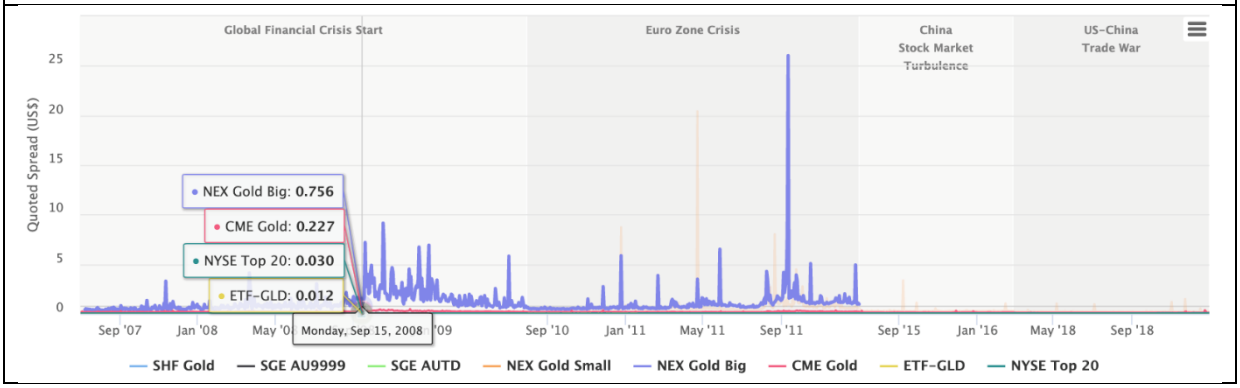
Figure 4 reports daily quoted spreads in basis point and dollar terms.

Figure 4 Quoted Spreads

Panel A



Panel B



Results for quoted spread report that Spot gold markets have the largest bid-ask spread in percentage terms and dollars. It is important to note that quoted spreads are measured over all quote updates including trades, cancelations and modification. This is distinct from effective spreads that are measured relative to completed trades. Spot markets are typically open for trade almost 24-hours a day however their trading activity is concentrated during certain times, resulting in stale quotes, typically at wider spreads.

Table 5 highlights quoted spreads in exchange traded securities are on average 1-1.6bps bps highlighting the liquidity in the ETF products, and on average 1-3.5 bps in futures markets. This compares to the 20-most actively traded securties on the NYSE which have quoted spreads on average of 2.5-3.4bps depending on market stress event.

Quoted spreads in gold securities traded in China are typically larger than US counterparts, this is true of spot AU9999.

Table 5

Panel A Quoted Spread bps

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	2.516	1.587	13.78	-	3.374	13.865	6.933	1.497
Euro zone crisis	1.197	0.929	6.872	4.66	2.548	6.958	3.941	1.03
China stock market turbulence	1.145	0.971	-	2.76	2.258	8.526	2.288	2.243
US-China trade war	0.833	0.842	-	1.838	2.192	6.727	1.732	1.911
57 months	1.649	1.18	10.811	3.43	2.773	9.866	4.516	1.538

Panel B Quoted Spreads Dollars

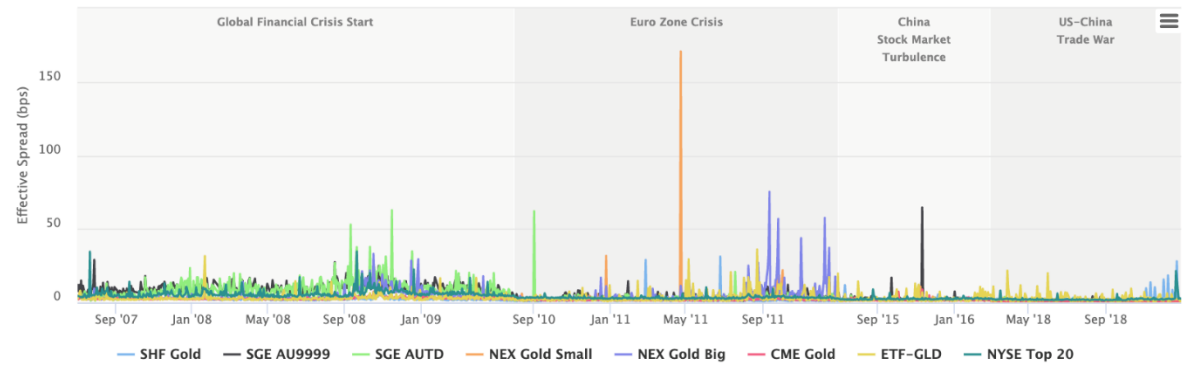
Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	0.211	0.013	1.162	-	0.022	0.037	0.018	0.004
Euro zone crisis	0.18	0.014	1.076	0.718	0.013	0.034	0.019	0.005
China stock market turbulence	0.128	0.01	-	0.31	0.016	0.031	0.008	0.008
US-China trade war	0.105	0.01	-	0.231	0.026	0.027	0.007	0.008
57 months	0.172	0.012	1.125	0.487	0.019	0.034	0.015	0.006

Effective Spread

Figure 5 reports daily effective spreads in basis point and dollar terms.

Figure 5 Effective Spreads

Panel A Basis Points



Panel B Dollars

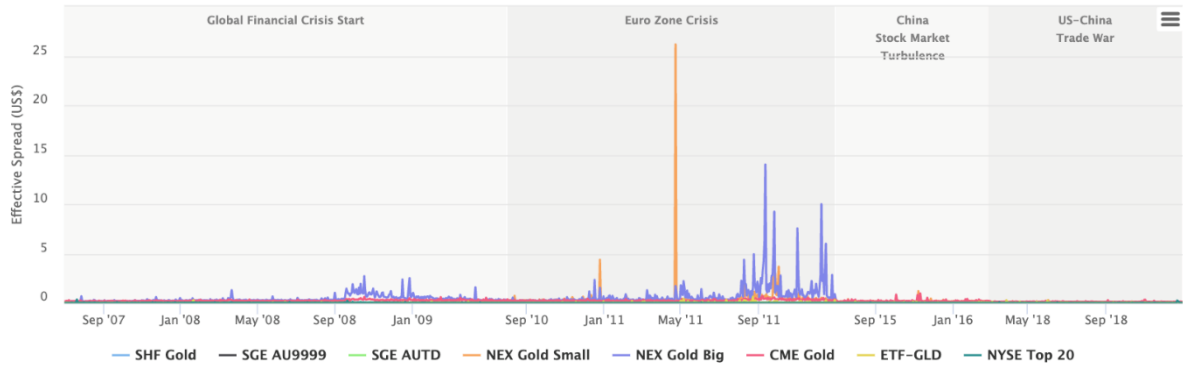


Table 6 reports average effective spreads (in basis points and dollar terms) across each of the four periods of market stress and over the 57-months examined.

Table 6

Panel A Effective Spread bps

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	2.869	3.255	4.822	-	6.161	9.9	9.621	2.421
Euro zone crisis	1.811	3.434	5.166	2.994	3.372	4.025	3.436	1.685
China stock market turbulence	1.826	2.758	-	1.603	2.582	2.748	2.04	2.754
US-China trade war	1.064	2.804	-	0.854	2.288	1.586	1.41	2.638
57 months	2.103	3.162	4.97	2.072	4.179	5.752	5.342	2.271

Panel B Effective Spreads Dollars

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	0.242	0.027	0.406	-	0.037	0.027	0.026	0.007
Euro zone crisis	0.274	0.052	0.829	0.458	0.018	0.02	0.017	0.008
China stock market turbulence	0.204	0.03	-	0.18	0.018	0.01	0.007	0.01
US-China trade war	0.134	0.034	-	0.107	0.025	0.006	0.006	0.011
57 months	0.227	0.036	0.588	0.295	0.027	0.019	0.017	0.009

During the GFC traders incurred effective spreads on average of 6.161bps in NYSE top 20 firms as identified by trading volume, this compares to the lower cost—2.869bps in CME futures, 3.255-3.77bps for ETFs and 4.822 in spot markets. Gold futures in China, similarly, report lower effective spreads, however spot markets report spreads closer to 10bps (it should be noted however the trading volumes in China's markets are significantly lower relative to US equivalents). This pattern of top 20 NYSE firms being associated with higher effective spreads relative to mature US gold markets permeates during the four main periods of analysis.

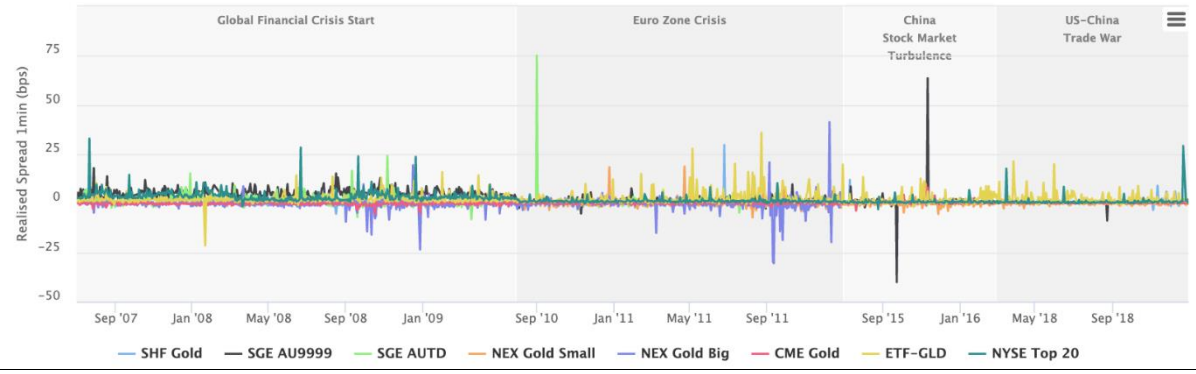
There are a number of days, where effective spreads are higher, for example on the passing of TARP and post August 2011 during the Euro zone crisis.

Summary: Realised Spread

Figure 6 and Table 7, report realised spreads or the temporary price impact associated with trades, reflecting the net revenues earned by liquidity providers. Relative to effective spreads, realised spreads are smaller. On the NYSE, both in ETF and top 20 firms we see these are larger than for rest of gold, this is most likely driven by the liquidity fees or rebates exchanges charge liquidity demanders and suppliers.

Figure 6

Panel A Basis Points



Panel B Dollars

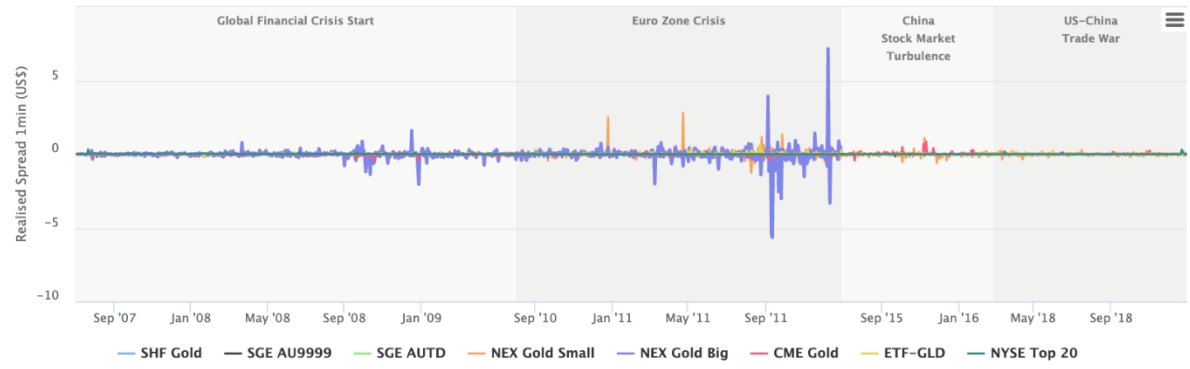


Table 7

Panel A Basis Points

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.192	2.08	-0.115	-	3.655	4.905	1.373	-0.207
Euro zone crisis	0.012	2.581	-0.101	0.046	1.162	1.354	0.93	0.015
China stock market turbulence	0.408	1.81	-	-0.12	0.72	1.03	0.304	0.656
US-China trade war	0.177	2.051	-	-0.014	0.878	0.396	0.366	0.556
57 months	0.014	2.187	-0.109	-0.008	2.038	2.549	0.922	0.149

Panel B Dollars

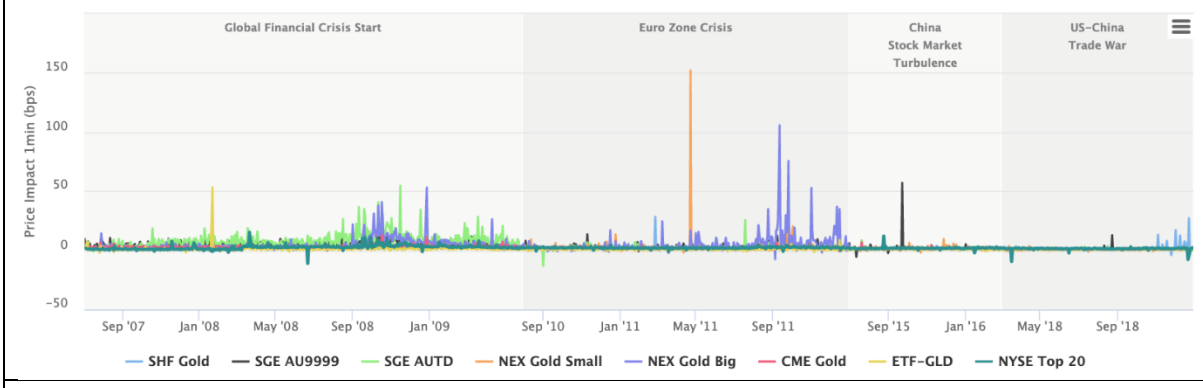
Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.016	0.017	-0.009	-	0.023	0.013	0.004	-0.001
Euro zone crisis	0.001	0.039	-0.021	0.007	0.007	0.007	0.004	0
China stock market turbulence	0.046	0.02	-	-0.013	0.005	0.004	0.001	0.002
US-China trade war	0.022	0.025	-	-0.002	0.01	0.002	0.001	0.002
57 months	0.004	0.025	-0.014	0	0.014	0.008	0.003	0.001

Price Impact

Figure 7 Table 8 report the average price impact of trades or the permanent effect. Price impact is frequently used to measure the extent of information asymmetry in the market, as spreads will widen with the presence of informed traders. Average price impacts are very similar to effective spreads, indicative of spreads being set to control against adverse inventory effect.

Figure 7

Panel A Basis Points



Panel B Dollars

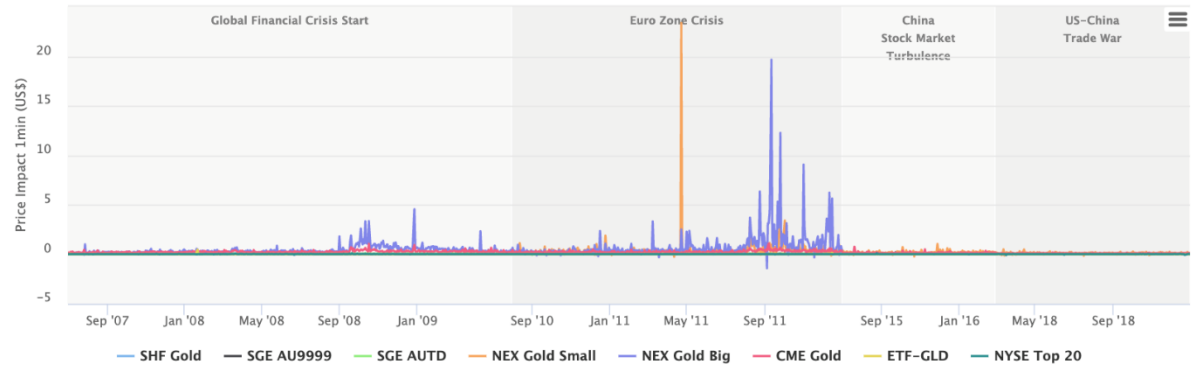


Table 8

Panel A Basis Points

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	3.062	1.175	4.937	-	2.506	4.996	8.247	2.628
Euro zone crisis	1.799	0.853	5.267	2.948	2.209	2.671	2.506	1.671
China stock market turbulence	1.417	0.948	-	1.723	1.862	1.718	1.737	2.098
US-China trade war	0.888	0.753	-	0.868	1.41	1.19	1.045	2.082
57 months	2.089	0.976	5.079	2.081	2.141	3.203	4.42	2.122

Panel B Dollars

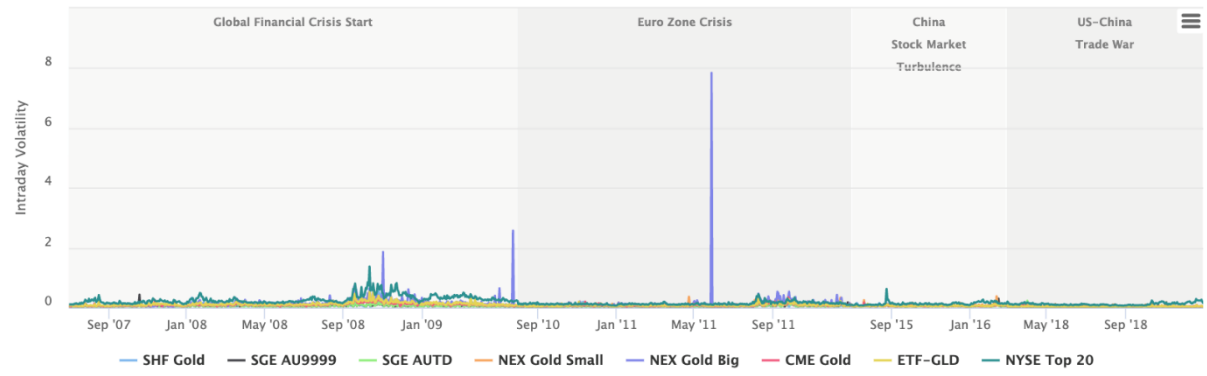
Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	0.258	0.01	0.415	-	0.014	0.014	0.023	0.007
Euro zone crisis	0.273	0.012	0.85	0.451	0.011	0.013	0.012	0.008
China stock market turbulence	0.159	0.01	-	0.192	0.013	0.006	0.006	0.008
US-China trade war	0.112	0.009	-	0.109	0.015	0.005	0.004	0.009
57 months	0.223	0.011	0.602	0.295	0.013	0.011	0.014	0.008

Volatility

Figure 8 and Table 9 report results for the two volatility metrics estimated. Figure 8 Panel A highlights the intraday volatility of mid-quote returns measured at 5-minute for equities is higher relative to gold securities. Equities experienced the greatest volatility during the GFC, highlighting the significance of the event. During the other remaining market events volatility is relatively similar.

Figure 8

Panel A Intraday



Panel B Parkinson

Spot and derivative gold products experience similar intraday volatility as expected given the connectedness between the two markets. This is the case for both US and China.

The Parkinson measure of extreme volatility, reported in Panel B identifies a similar pattern. US equities exhibit higher volatility, again most evident during the GFC.

Table 9

Panel A Intraday

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	0.097	0.126	0.149	-	0.275	0.06	0.059	0.085
Euro zone crisis	0.07	0.084	0.124	0.088	0.137	0.042	0.046	0.054
China stock market turbulence	0.054	0.06	-	0.072	0.134	0.045	0.047	0.06
US-China trade war	0.036	0.041	-	0.048	0.117	0.022	0.024	0.028
57 months	0.073	0.09	0.138	0.073	0.188	0.046	0.047	0.059

Panel B Parkinson

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	1.685	1.247	1.63	-	2.596	1.03	0.995	0.745
Euro zone crisis	1.131	0.794	1.086	1.238	1.322	0.837	0.764	0.56
China stock market turbulence	0.929	0.532	-	0.891	1.292	1.317	0.767	0.858
US-China trade war	0.649	0.384	-	0.589	1.139	0.432	0.356	0.345
57 months	1.239	0.867	1.399	0.985	1.789	0.908	0.785	0.62

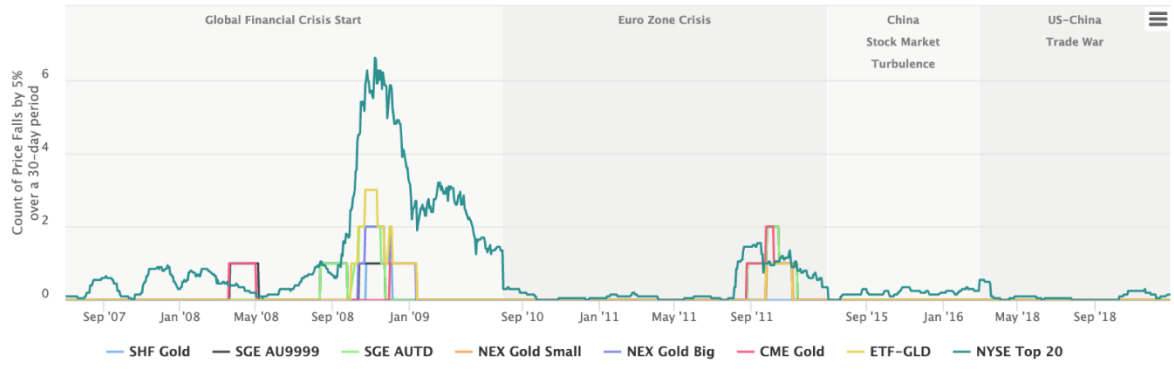
Price Falls

Figure 9 and Table 10 reports the instances of prices falls 5,10 and 20% over a rolling 30-day window. End of day price returns indicate that gold does not experience falls of 10% or greater in any of the four stress periods. This is compared to NYSE top 20 firms which are associated with price falls of 5%, 10%, and 20%.

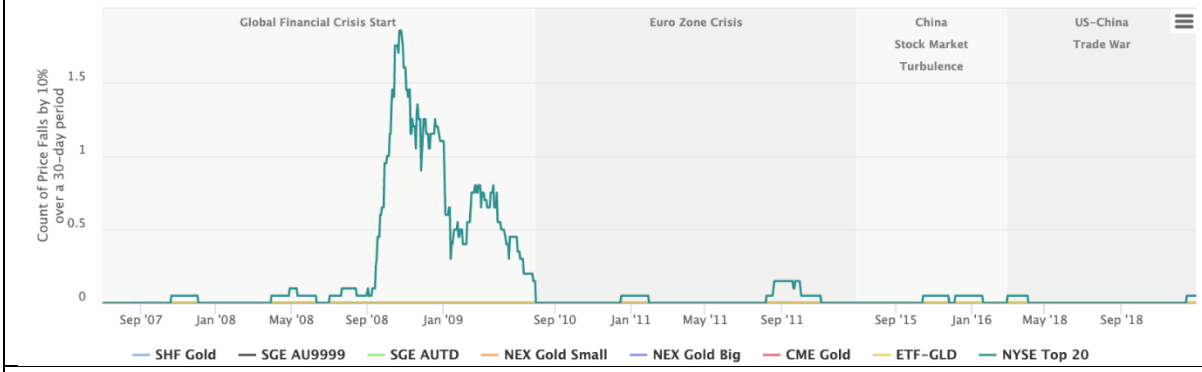
While price fall of up to 5% are identified in gold, they only appear during the Global Financial Crisis and Eurozone crisis. The percentage of times this is observed over a 30-day rolling window however is substantially below that observed for equities.

Figure 9

Panel A 5% Falls



Panel B 10% Falls



Panel B 20% Falls

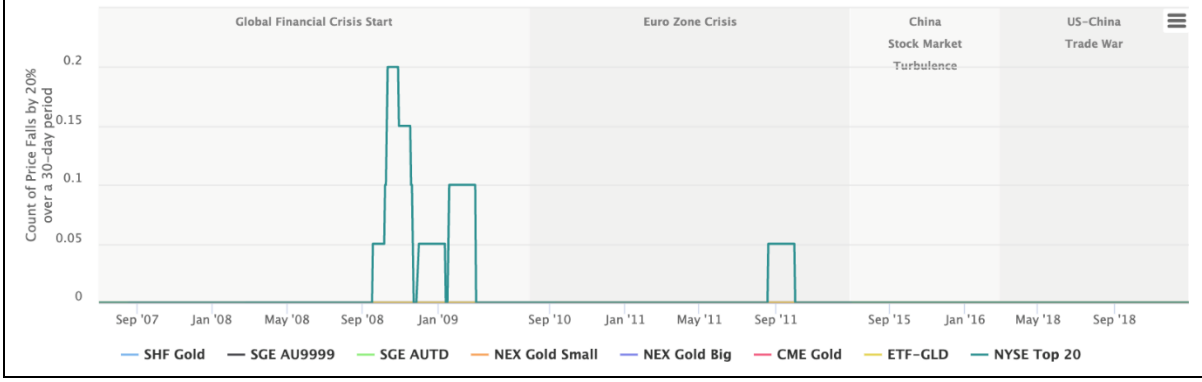


Table 10

Period	Security / Price Drop	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	**5%**	0.124	0.248	0.193	-	1.483	0.193	0.193	0.292
	10%	0	0	0	-	0.313	0	0	0
	20%	0	0	0	-	0.022	0	0	0
Euro zone crisis	**5%**	0.167	0.084	0.088	0.088	0.343	0.173	0.173	0
	10%	0	0	0	0	0.021	0	0	0
	20%	0	0	0	0	0.004	0	0	0
China stock market turbulence	**5%**	0	0	-	0	0.195	0	0	0
	10%	0	0	-	0	0.018	0	0	0
	20%	0	0	-	0	0	0	0	0
US-China trade war	**5%**	0	0	-	0	0.102	0	0	0
	10%	0	0	-	0	0.008	0	0	0
	20%	0	0	-	0	0	0	0	0
57 months	**5%**	0.098	0.123	0.149	0.045	0.731	0.127	0.127	0.088
	10%	0	0	0	0	0.134	0	0	0
	20%	0	0	0	0	0.01	0	0	0

Variance Ratio

Variance ratios highlight the relative efficiency of each of the securities, gold and US equities. Values are closer to zero, suggesting prices are efficient and these results hold across the time periods considered.

Figure 10 reports daily variance ratios, and Table 11 reports mean variance ratios across the four periods of market stress.

Figure 10

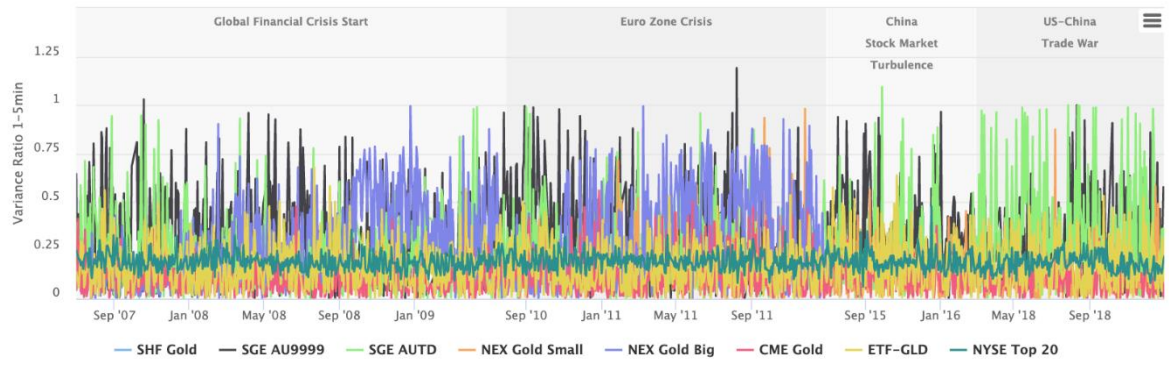


Table 11

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD
Global financial crisis start	0.11	0.166	0.262	-	0.19	0.312	0.218
Euro zone crisis	0.13	0.167	0.316	0.147	0.195	0.325	0.228
China stock market turbulence	0.126	0.195	-	0.117	0.193	0.34	0.218
US-China trade war	0.104	0.189	-	0.093	0.184	0.3	0.345
57 months	0.117	0.174	0.285	0.125	0.191	0.318	0.243

Quoted Depth

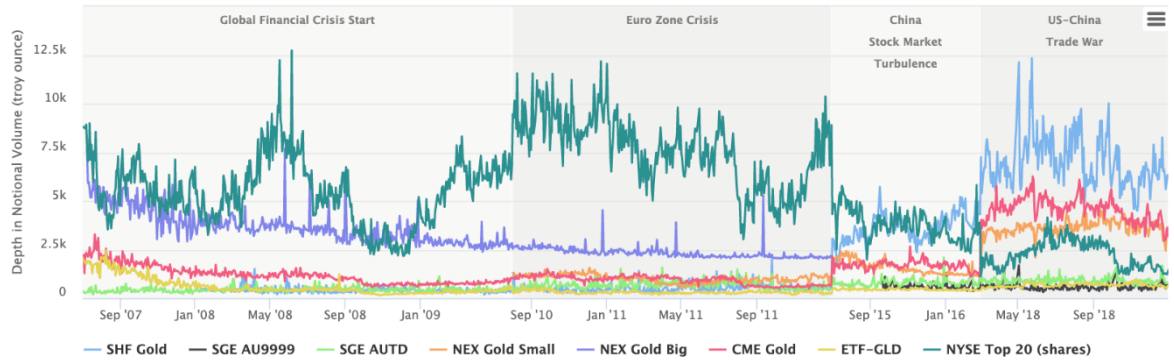
Figure 11 and Table 12 report quoted depth at the top of book. Results reported for depth portray an interesting evolution in gold securities. During the GFC, top 20 NYSE firm quoted depth typically represented $179,000, while for gold it ranges from $165,000 to $3.0M. Gold spot markets had the largest depth, however this is somewhat explained by the minimum contract size set at 1000 troy ounces. US futures on average also post $1m worth of contracts for trade in the first level of the book. It is important to note that the volume represents available volume on electronic markets. The CME suspended its floor trading in 2015 (and these activities were not reflected/merged with electronic order books). In China, the typical available depth in gold securities averaged greater than $360,000 in futures and spot markets.

During the Euro crisis similar result hold with the exception of ETF IAU and trading in China's markets. While available depth increases beyond $5m, possibly in response to the 10:1 split, the increase in quoted depth is not associated a corresponding increase in trading volume, with GLD remaining the most active ETF by a significant margin. In contrast the increase or doubling in quote depth on China's markets it associated with a significant uplift in trading volume. Similar results ae observed during the China stock market turbulence period of 2015 and 2016. The Shanghai futures markets reports a significant increase, over 4 times, relative to the 2010 &2011 periods.

In the more recent period, we see that the futures markets of CME and Shanghai have available the greatest depth in the market, in addition to observing the increase in depth of gold available via IAU, which however remain significantly below trading volumes in GLD.

Figure 11

Panel A Troy Ounces



Panel B Value

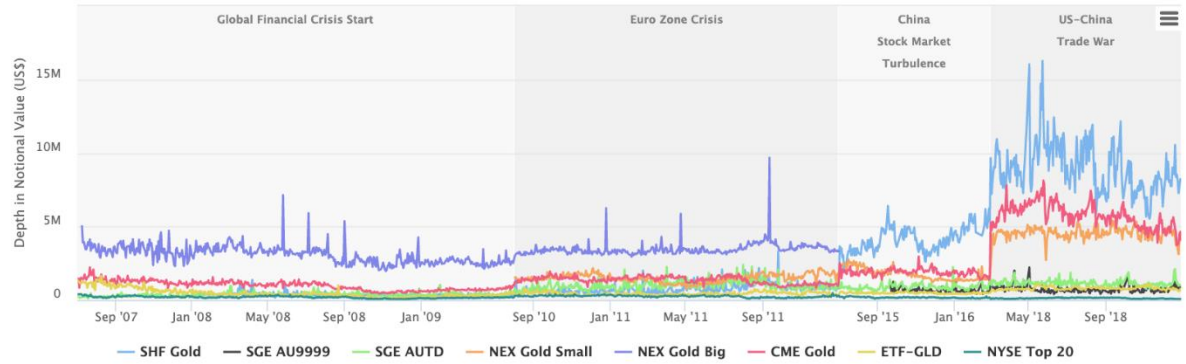


Table 12

Panel A Troy Ounces Thousand

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20 (shares)	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	1.197	0.612	3.694	-	5.484	-	0.442	0.409
Euro zone crisis	0.928	0.307	2.326	1.003	7.557	-	0.673	0.51
China stock market turbulence	1.693	0.45	-	1.561	3.762	0.604	0.791	3.628
US-China trade war	4.567	0.677	-	3.645	2.267	0.585	0.906	7.015
57 months	1.769	0.511	3.106	1.88	5.309	0.591	0.638	2.238

Panel B Dollars

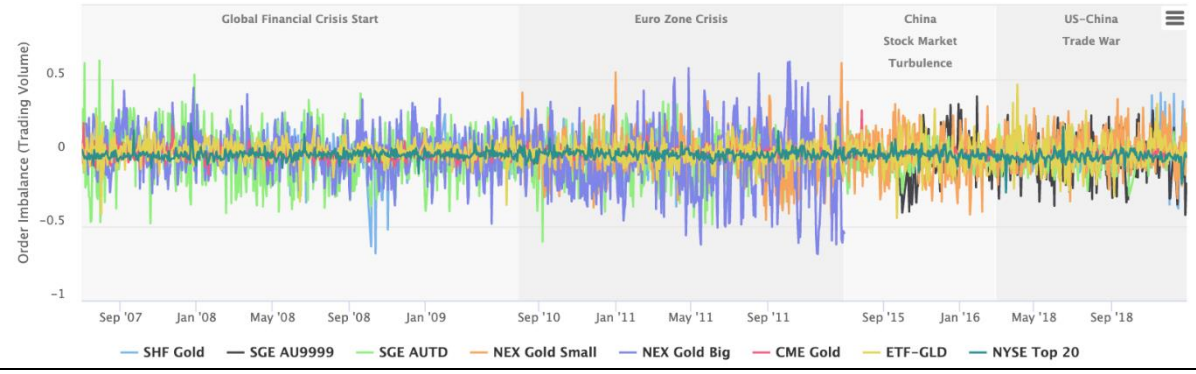
Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	990.096	481.81	3082.71	-	193.148	-	375.88	362.113
Euro zone crisis	1356.89	445.048	3459.28	1490.55	258.342	-	1013.21	779.024
China stock market turbulence	1894.61	483.224	-	1751.85	175.11	675.024	886.845	4109.57
US-China trade war	5755.21	803.007	-	4569.89	128.08	739.896	1143.54	8962.24
57 months	2046.63	526.554	3244.53	2425.57	198.776	718.132	766.387	2769.26

Summary: Order Imbalance (traded volume)

A positive order imbalance is consistent with a greater proportion of buyers in the market, conversely a negative order imbalance is consistent with a greater proportion of seller. During the crisis periods assessed, we do observe a greater number of sellers for the majority of contracts, however the order imbalance is close to zero for most other periods as reported in Figure 12 and Table 13.

Figure 12

Panel A Basis Points



Panel B Dollars

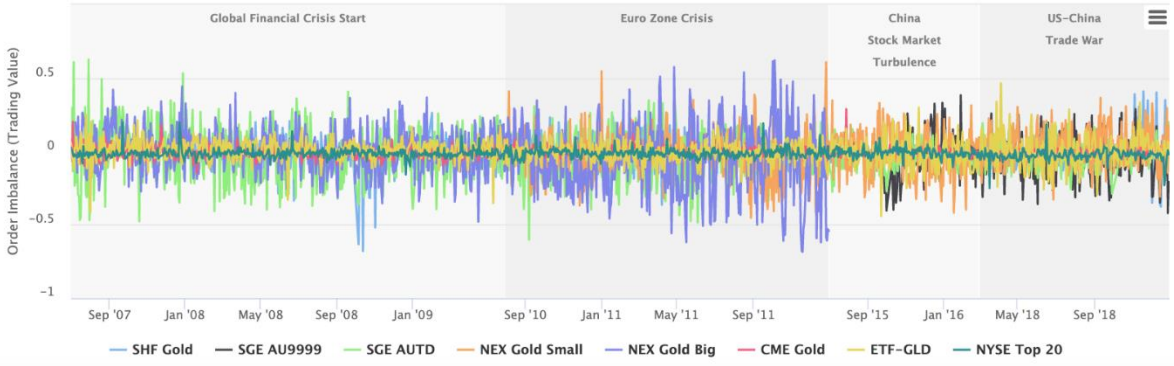


Table 13

Panel A Basis Points

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.006	0.012	0.006	-	-0.014	-	-0.019	-0.016
Euro zone crisis	0.001	-0.003	-0.065	-0.014	-0.009	-	-0.037	-0.008
China stock market turbulence	-0.003	-0.014	-	-0.009	-0.007	-0.012	-0.034	0
US-China trade war	-0.003	0.007	-	0.023	-0.026	-0.041	-0.022	-0.004
57 months	-0.003	0.003	-0.025	-0.002	-0.014	-0.031	-0.027	-0.009

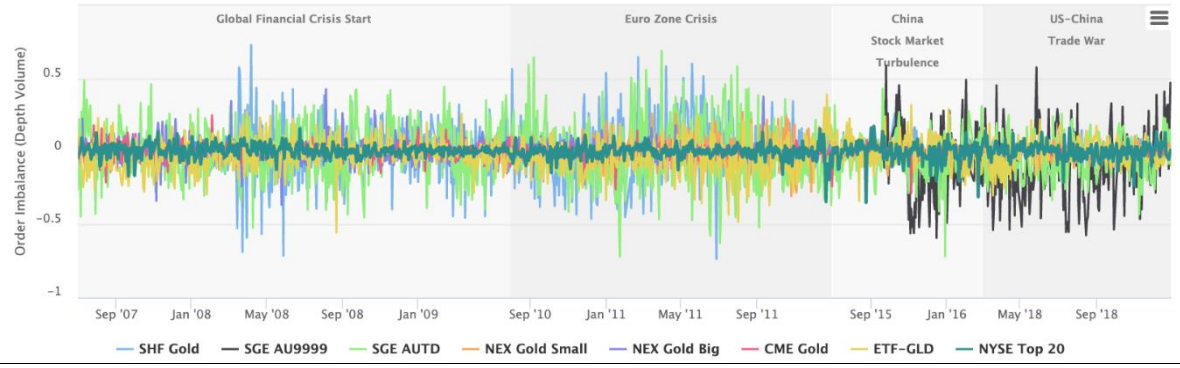
Panel B Dollars

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.006	0.013	0.006	-	-0.015	-	-0.018	-0.016
Euro zone crisis	0.001	-0.003	-0.065	-0.014	-0.013	-	-0.036	-0.008
China stock market turbulence	-0.003	-0.014	-	-0.009	-0.008	-0.012	-0.034	0
US-China trade war	-0.003	0.007	-	0.023	-0.025	-0.041	-0.022	-0.004
57 months	-0.003	0.003	-0.024	-0.002	-0.015	-0.031	-0.026	-0.009

Figure 13 and Table 14, report order imbalance summary measures using bid and ask quotes. Analysis of whether the top of the book is weighted more to one side of the book. Again, we do find a greater proportion of sellers, however the order imbalance measured in quotes remains close to zero.

Figure 13

Panel A



Panel B

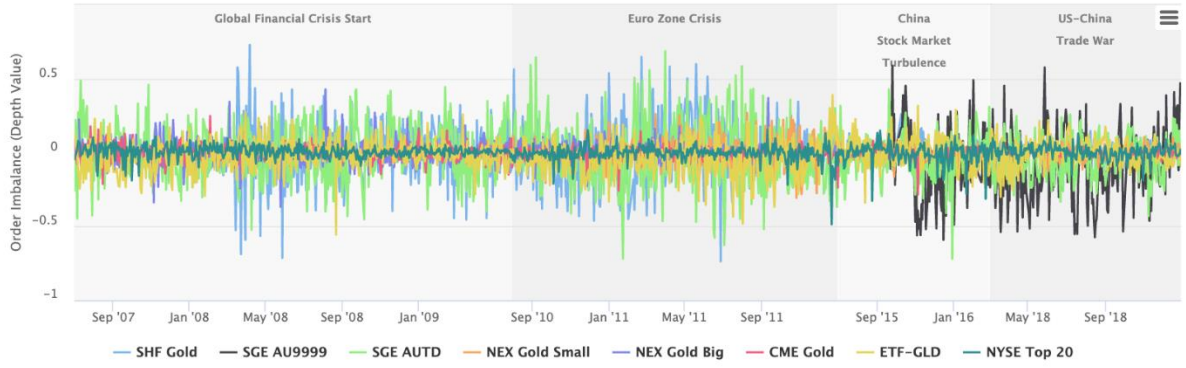


Table 14

Panel A

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.002	-0.018	0	-	0.007	-	0.011	0.002
Euro zone crisis	-0.008	-0.039	0.012	0.012	-0.003	-	-0.009	0.02
China stock market turbulence	-0.002	0.002	-	0.002	-0.004	-0.079	-0.034	0.01
US-China trade war	-0.002	-0.005	-	0.002	0.002	-0.096	-0.041	-0.001
57 months	-0.004	-0.019	0.005	0.007	0.002	-0.091	-0.01	0.008

Panel B

Security Period	CME Gold	ETF-GLD	NEX Gold Big	NEX Gold Small	NYSE Top 20	SGE AU9999	SGE AUTD	SHF Gold
Global financial crisis start	-0.002	-0.018	-0.001	-	0.006	-	0.011	0.002
Euro zone crisis	-0.008	-0.039	0.011	0.012	-0.004	-	-0.009	0.02
China stock market turbulence	-0.002	0.001	-	0.002	-0.004	-0.079	-0.034	0.01
US-China trade war	-0.002	-0.005	-	0.002	0.004	-0.096	-0.041	-0.001
57 months	-0.004	-0.019	0.004	0.007	0.001	-0.091	-0.01	0.008

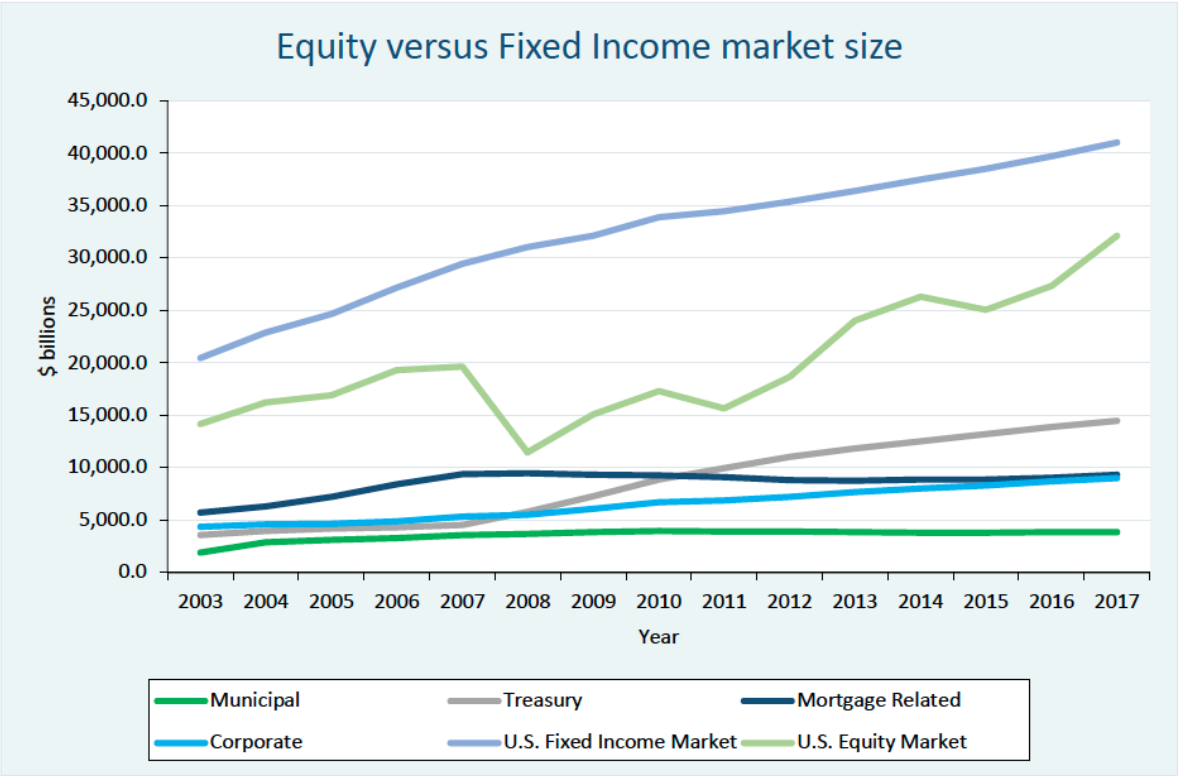
3.2 Fixed Income

In this section we seek to rely on the results published in the academic literature pertaining to market quality measures in fixed income. The majority of fixed-income instruments are traded in dealer-oriented over-the-counter (OTC) search markets that differ significantly from for example equity markets, which are predominantly organised electronic limit order markets. With respect to fixed income, with the exception of U.S. Treasury instruments relatively little fixed-income trading occurs on electronic platforms and is mostly facilitated via requests for quote (RFQ) services.

Bessembinder et al (2020) utilise data provided by the Securities Industry and Financial markets Association (SIFMA) to compare the size of fixed income markets relative to equity markets for the period 2003 to 2017. Reproduced in Figure 14, they demonstrate the size of US fixed income markets is significantly larger than US equity markets.

Figure 14: Size of Fixed Income Markets

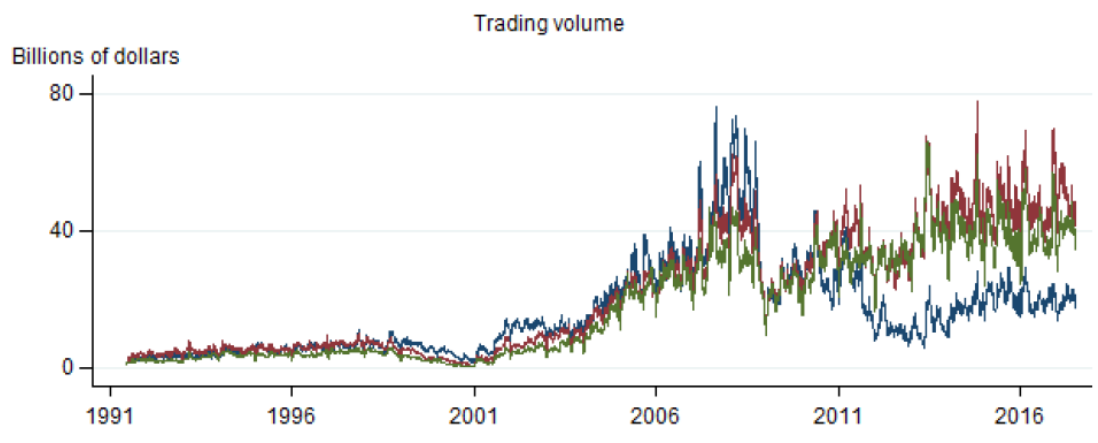
Source: Author calculations based on data provided by Securities Industry and Financial Markets Association (SIFMA).



Bessembinder et al (2020) note while there have been advances in the available data sources for fixed income data, estimation of transaction costs remains problematic, given that many quotes posted in fixed income markets are indicative and hence not executable. This is not the case for US treasury trading. A number of measures have been developed to overcome the data limitations (eg dealer round-trip and signed regression models) however these rely on completed transactions which may not reflect total requested trades which remain incomplete due to insufficient liquidity.

Relying on orderbook and transaction data from GovPX and BrokerTec, Adrian et al (2017) analyse liquidity in US Treasury. Figure 15 reports daily trading volume of 2, 5 and 10-year US treasury bonds, with a significant uptrend post 2001. Between 1991-2000 typical daily volume of trade was in the vicinity of 3 to 5 billion depending on tenure. Post 2001 this increased 22-30 billion per day.

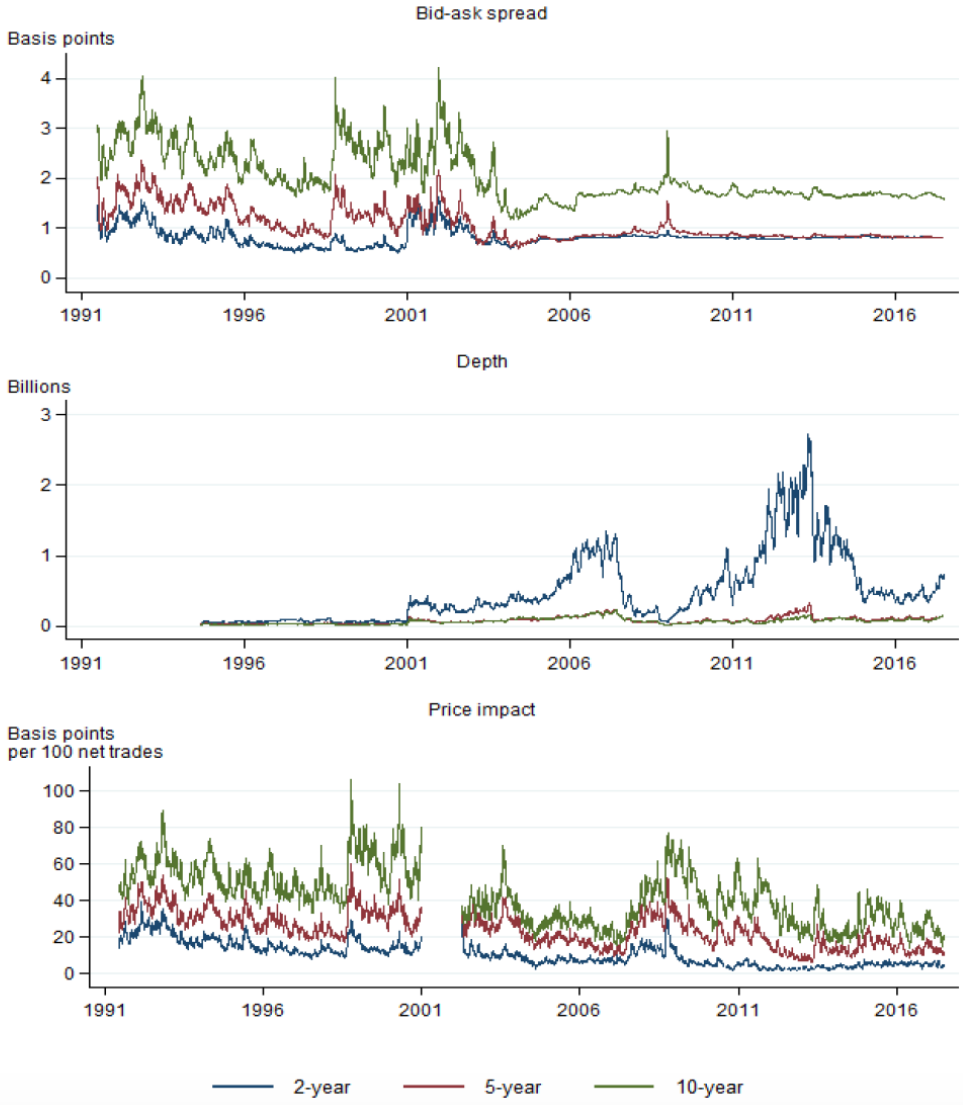
Figure 15 Trading Volume



With respect to bid-ask spreads and depth Adrian et al (2017) Figure 16 demonstrates variability in bid-ask spreads in earlier periods and also across tenure. Short term expiry bonds have the smallest bid-ask spreads (0.8) bps) and increase monotonically with tenure (2.46bys 10-year) pre 2000. Post 2001 2-year and 5-year bonds experience relatively similar bid-ask spreads, with 10-year being a multiple of 2. During the GFC a significant increase in bid-ask spreads is observed, particularly for 5 and 10-year bonds. Relative to gold figures reported above, Adrian et al (2017) results would suggest US treasury have a narrower inside spread, however the advantage decreases if one compares 10-year bonds and gold.

In Figure 16 Adrian et al (2017) demonstrate depth in bonds is concentrated in short term bonds, averaging over 650 million between 2001-2017 while depth in 5-year and 10-year measure 100 and 87 million respectively. Depth is US Treasury is

Figure 16



Bessembinder et al (2018) utilise Trade Reporting and Compliance Engine (TRACE) of US corporate bonds trade made available by the Finance Industry Regulation Authority (FINRA) evaluate liquidity in the corporate bond market between 2006 and 2016. Reproduced in Table 15 Bessembinder et al (2018) demonstrate the size of the corporate bond market with respect to trading and amount outstanding.

Table 15

Year	Trading Volume (Billions)	Corporate Bond Outstanding Amount (Billions)	# of Corporate Bonds Outstanding	Trading Volume Relative to Amount Outstanding	TRACE Reported Volume (Billions)	Volume Not Disseminated on TRACE (Billions)
2006	3,141	3,331	8,050	0.94	2,770	372
2007	2,956	3,577	8,069	0.83	2,542	414
2008	2,309	3,658	7,567	0.63	2,095	215
2009	3,297	4,327	8,259	0.76	2,928	369
2010	3,752	4,820	8,996	0.78	3,133	620
2011	3,722	5,171	9,371	0.72	3,070	652
2012	3,851	5,723	10,052	0.67	3,115	737
2013	4,217	6,199	10,721	0.68	3,364	853
2014	4,227	6,557	10,967	0.64	3,801	426
2015	4,402	7,147	11,289	0.62	4,402	0
2016 (10 months)	3,723	6,726	10,291	0.55	3,723	0

Due to data constraints around quote level data, Bessembinder et al (2018) employ indicator variable regressions to measure trading costs. The model regresses the change in price between trades on changes in direction of trading activity. The slope coefficient is interpreted as half the difference between the price at which dealers will sell a bond to a customer and the price at which they will purchase the bond from a customer. Assessing market costs pre GFC, post GFC and around regulatory changes associated with Dodd-Frank, Vockler and Basel Accords, Bessembinder et al (2018) show during the GFC crisis spreads increased 25bps to 65bps, and remained at these levels until June 2010. Following Dodd Frank and Basel Accords, spreads reduced to 47bps and further to 42bps post the implementation of Vockler on April 1, 2014

Bessembinder also report costs across trade size bands and bond grade/characteristics. They show consistent with previous literature that small trades in corporate bonds incur the highest transaction costs, while block trades (ie greater than $10m) incur the lowest transaction costs, ranging between 16bps and 29bps depending on period of interest.

Table 16

	January 2006 to June 2007	July 2007 to April 2009	May 2009 to June 2010	July 2010 to March 2014	April 2014 to October 2016
	Precrisis	Crisis	Postcrisis	Regulatory	Volcker
Aggregate Market Sample	0.40%	0.65%	0.63%	0.47%	0.42%
Top 70% Sample	0.24%	0.45%	0.35%	0.26%	0.25%
Constant Dealer Sample	0.31%	0.56%	0.54%	0.43%	0.39%
By Trade Size: Aggregate Market Sample					
Transaction Cost (%): ≤$100K	0.61%	0.89%	0.87%	0.69%	0.62%
% of Total Volume	*1%*	*2%*	*2%*	*2%*	*2%*
Transaction Cost (%): >$100K & ≤$1M	0.25%	0.47%	0.42%	0.31%	0.29%
% of Total Volume	*7%*	*9%*	*9%*	*9%*	*10%*
Transaction Cost (%): >$1M & ≤$10M	0.19%	0.33%	0.28%	0.21%	0.20%
% of Total Volume	*60%*	*60%*	*58%*	*61%*	*61%*
Transaction Cost (%): > $10M	0.16%	0.29%	0.23%	0.18%	0.16%
% of Total Volume	*32%*	*29%*	*31%*	*28%*	*27%*
By Bond Characteristics: Aggregate Market Sample					
Transaction Cost (%): Investment Grade	0.36%	0.71%	0.65%	0.45%	0.38%
% of Total Volume	*58%*	*64%*	*68%*	*63%*	*69%*
Transaction Cost (%): High Yield	0.46%	0.50%	0.56%	0.51%	0.51%

% of Total Volume	*42%*	*36%*	*32%*	*37%*	*31%*
Transaction Cost (%): Large Issue Size	0.36%	0.68%	0.57%	0.38%	0.33%
% of Total Volume	*37%*	*47%*	*49%*	*48%*	*52%*
Transaction Cost (%): Medium Issue Size	0.38%	0.64%	0.67%	0.48%	0.45%
% of Total Volume	*29%*	*29%*	*28%*	*32%*	*32%*
Transaction Cost (%): Small Issue Size	0.45%	0.59%	0.70%	0.64%	0.58%
% of Total Volume	*34%*	*24%*	*23%*	*20%*	*16%*
Transaction Cost (%): Young bonds	0.23%	0.50%	0.39%	0.31%	0.27%
% of Total Volume	*36%*	*36%*	*41%*	*42%*	*36%*
Transaction Cost (%): Old bonds	0.44%	0.69%	0.70%	0.53%	0.46%
% of Total Volume	*64%*	*64%*	*59%*	*58%*	*64%*
Transaction Cost (%): Clicking Trades	0.30%	0.66%	0.40%	0.32%	0.26%
% of Total Volume	*2%*	*5%*	*5%*	*5%*	*7%*
Transaction Cost (%): Calling Trades	0.41%	0.65%	0.65%	0.48%	0.44%
% of Total Volume	*98%*	*95%*	*95%*	*95%*	*93%*

Bessembinder et al (2018) in assessing liquidity show that while liquidity costs increased during the GFC, that they have returned to pre-crisis levels. Their data however permits investigation into how much support exist in the market due to dealer commitments. They show that dealer commitments have reduced since the GFC despite transaction costs returning to pre-crisis levels, possibly due to the rise in ETFs, increased electric trading and introduction of regulation.

Conclusion

TBD

References

CME Gold

- Price quote: per troy ounce in USD
- Contract size: 100 troy ounce
- Notional Volume = volume from data * 100
- Notional Value = price * volume from data * 100

SHF Gold:

- Price quote: per gram in CNY
- Contract size: 1kg
- Notional Volume = volume from data * 1000 * 0.0321507 (gram to troy ounce)
- Notional Value = price * volume from data * 1000 * currency ratio of USD/CNY

SGE AU9999

- Price quote: per gram in CNY
- Trading unit: 10g
- Notional Volume = volume from data * 10 * 0.0321507 (gram to troy ounce)
- Notional Value = price * volume from data * 10 * currency ratio of USD/CNY

WGCPlot-Slide_20191212SGE AUTD

- Price quote: per gram in CNY
- Trading unit: 1kg
- Notional Volume = volume from data * 1000 * 0.0321507 (gram to troy ounce)
- Notional Value = price * volume from data * 1000 * currency ratio of USD/CNY

NEX Gold big

- Price quote: per troy ounce in USD
- Contract size: 1000 troy ounce
- Notional Volume = volume from data * 1000
- Notional Value = price * volume from data * 1000

NEX Gold small

- Price quote: per troy ounce in USD
- Contract size: 100 troy ounce
- Notional Volume = volume from data * 100
- Notional Value = price * volume from data * 100

ETF AAAU:

- Price quote: 100 shares per troy ounce in USD
- Notional Volume = volume from data * 0.01
- Notional Value no need to adjust

ETF BAR/SGOL/GLD:

- Price quote: 10 shares per troy ounce in USD
- Notional Volume = volume from data * 0.1
- Notional Value no need to adjust

- Price quote:
  - 10 shares per troy ounce in USD before 2010-06-24
  - 100 shares per troy ounce in USD from 2010-06-24
  - https://www.splithistory.com/?symbol=IAU
- Notional Volume:
  - before 2010-06-24: volume from data * 0.1
  - from 2010-06-24: volume from data * 0.01
- Notional Value no need to adjust

*** SGOL and BAR also had stock split but in 2019 which is outside our sample periods.