Consultation paper on proposed reforms to the TMA USD/HKD and USD/CNY(HK) spot fixings

About this document

1. This paper is published by Treasury Markets Association (TMA) and seeks to consult the market on proposals for reforming TMA's spot foreign exchange (FX) USD/HKD and USD/CNY(HK) fixings.

2. Interested parties are invited to respond to the consultation questions using the *pro forma* at the attachment – **Response to consultation**. Comments should be submitted in writing to the TMA Secretariat no later than **30 June 2015** by ***any one*** of the following means –

   (1) By mail
   TMA Secretariat
   55/F, Two International Finance Centre
   8 Finance Street, Central, Hong Kong

   (2) By fax
   +852 2878 7297

   (3) By email
   dkltsui@hkma.gov.hk ***AND*** hlam@hkma.gov.hk

3. After considering the consultation submissions received, the TMA will refine the proposal, and will release a response.

4. Any person submitting comments on behalf of any organisation is requested to provide details of the organisation they represent.

5. Submissions will be received on the basis that the TMA may freely reproduce and publish them, in whole or in part, in any form; and may use, adapt or develop any proposal put forward without seeking permission from or providing acknowledgement to the party making the proposal.

6. Please note that the names of respondents, their affiliation(s) and the contents of their submissions may be published or reproduced by the TMA. ***If you do not wish*** your name, affiliation(s) and/or submissions to be disclosed, please state this clearly when making your submissions.

7. Any personal data submitted will only be used for purposes which are directly related to this consultation. Such data may be transferred to other parties for the same purposes. For access to or correction of personal data contained in your submissions please contact by email to: dkltsui@hkma.gov.hk ***AND*** hlam@hkma.gov.hk.

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1. EXECUTIVE SUMMARY

1.1. Financial benchmarks, especially the interest rate and FX benchmarks, are referenced to in many financial contracts. Their robustness is crucial to the well-functioning of the financial market. Since 2012, there have been reports that certain banks manipulated their contributions to, or trades in respect of, some of the most widely used global financial benchmarks to their own advantage. Regulators subsequently conducted investigations and took supervisory actions on those banks found to have committed misconduct. In parallel, various international bodies considered measures to enhance the transparency and robustness of those widely used global financial benchmarks, and have recently made recommendations.

1.2. The main thrust is that financial benchmarks (including FX benchmarks) should be anchored by observable *bona fide* arm's length transactions rather than merely from expert-judgement based contributions if market conditions permit. At present, the FX benchmarks of Hong Kong, i.e. the TMA Spot USD/HKD and USD/CNY(HK) fixings (collectively the "Spot FX Fixings") are calculated from expert-judgement based contributions.

1.3. While the international recommendations are mostly related to the global financial benchmarks and do not directly apply to Hong Kong, given our role as an international financial centre, Hong Kong has been reviewing the need and feasibility in reforming our financial benchmarks alongside the international recommendations, having regard to local market conditions.

1.4. As the administrator of the Spot FX Fixings, the TMA has been involved in such work, and has sought assistance from the Hong Kong Monetary Authority (HKMA) to assess the market conditions in Hong Kong, particularly on whether there are sufficient transactions to support a more transaction-based fixing mechanism having regard to international recommendations.

1.5. The assessment, which is summarised in section 4 of this document, suggests that there should be scope to move to a more transaction-based fixing mechanism for the Spot FX Fixings along the proposed methodology outlined in the table below.

Summary of proposed calculation methodology	
Transactions used to calculate a fixing	All spot USD/HKD (USD/CNY(HK)) trades that – (i) have a transacted amount of at least US$1 million; and (ii) are routed through all approved money brokers in Hong Kong.
Time period for which transactions made during the period will be used to calculate a fix	10:45:00 am to 11:15:00 am Hong Kong time
Method used to average the transactions to calculate a fix	Volume-weighted median
Fall-back arrangement if there were no eligible transactions within the stated period	No fix **<u>OR</u>** use last fix (no expiry time limit)
Transition arrangement	An announced overnight change with a three-month notice period

1.6. The TMA would like to invite market's views on the proposed changes contained in this consultation paper. We will take into account the comments received before announcing any plans for transition.

2. INTERNATIONAL RECOMMENDATIONS

2.1. Since 2012, cases of attempted manipulations to some of the most widely used global financial benchmarks have led to investigations by regulators in the UK, the US, Europe, and elsewhere. The investigations, which were first released in June 2012, revealed cases of certain global banks trying to profit from rigging the benchmark rates. Supervisory actions have been taken to those banks concerned.

2.2. Insofar as Hong Kong's FX benchmarks (i.e. the Spot FX Fixings) are concerned, the HKMA announced in December 2014 that it had conducted investigations into several banks for any rigging behaviours. Using the same rigorous methodology that was adopted in similar benchmark investigations overseas, the HKMA found no evidence of collusion amongst the banks investigated and no evidence of any rigging of the Spot FX Fixings.

2.3. In view of the incidents of benchmark manipulations, various international bodies considered measures to enhance the transparency and robustness of those benchmarks that are widely used in the global financial markets.

2.4. In July 2013, the International Organization of Securities Commissions (IOSCO) promulgated an overarching framework of recommended principles for financial benchmarks in general. They addressed four major aspects, namely, governance, quality of benchmark design, methodology and accountability.[1] In particular, the IOSCO recommended that benchmarks should be based on prices that are formed by competitive forces of supply and demand, and anchored by observable *bona fide* arm's length transactions.

2.5. The Financial Stability Board (FSB) also set up the Foreign Exchange Benchmark Group (FXBG) to review and reform the FX benchmark that is the most widely used in the global financial market, namely, the WM/Reuters 4 pm London fix (the "WMR

[1] Principles for Financial Benchmarks: Final Report, IOSCO [Link].

Fix”). In September 2014, the FXBG issued a report[2], making a number of recommendations regarding the way forward in reforming the WMR Fix. In gist, regarding calculation methodology, the report recommended that –

i. the fix should be calculated based on actual transactions collected from a wide range of FX trading platforms;
ii. the “fixing window”, i.e. the period in which transactions made will be used to calculate the fix, should be widened from one minute to five minutes, with a view to increasing the difficulties in manipulating the fix; and
iii. the calculation methodology should not create adverse incentives for potential manipulative abuses.

2.6. **The main thrust is that if market conditions permit, financial benchmarks should be *<u>anchored by observable bona fide arm's length transactions</u>*.** In implementing the relevant recommendations, both IOSCO and FSB recognised that there is not a *one-size-fits-all* method. In particular, the application and implementation of the recommendations should be proportional to the size and risks posed by each benchmark and the benchmark-setting process. Accordingly, relevant jurisdictions have been moving ahead to make changes to the respective financial benchmarks along the international recommendations.

2.7. Apart from recommending changes to the calculation methodology, the FXBG report also made recommendations on changing the behaviours of market participants around the time of the major FX benchmarks (primarily the WMR Fix). The key ones were –

i. supports the development of industry-led initiatives to create independent netting and execution facilities for transacting fix orders;
ii. fixing transactions should be priced in a manner that was transparent and consistent with the risk borne in accepting such transactions, e.g. by applying bid-offer, or through a clearly communicated and documented fee structure;

[2] Foreign Exchange Benchmarks Final Report, FSB [Link].

iii. banks should establish and enforce internal guidelines and procedures for collecting and executing fixing orders, including separate processes for handling such orders;

iv. market-makers should not share information with each other about their trading positions, and should not pass on private information to clients or to other counterparties that might enable them to anticipate flows of others;

v. codes of conducts that describe best practices should detail more precisely and explicitly the extent to which information sharing between market-makers was or was not allowed; and

vi. there should be stronger demonstration by market participants of compliance with the relevant industry codes, as well as their internal codes of conduct.

2.8. Mark Carney, Chair of the FSB, recently sent a letter to all the Global FX Committees (including the TMA), seeking assistance to monitor market participants' progress in implementing the behaviour-related recommendations. The Global FX Committees were asked to report the implementation status in their respective markets (as at 30 June 2015) by 31 July 2015.[3] The TMA has been engaging the market separately in this regard.

3. THE EXISTING ARRANGEMENTS FOR FIXINGS

3.1. At present, the Spot FX Fixings are calculated from expert-judgement based contributions. Specifically, 19 banks are appointed to contribute their **estimated** market exchange rate of US dollar against Hong Kong dollar at 11 am for calculating the USD/HKD fix, and 18 banks are appointed to contribute their **estimated** exchange rate of USD against offshore renminbi in Hong Kong at 11 am for calculating the USD/CNY(HK) fix. The fixings are then calculated as a trimmed mean of these contributions (removing the highest and lowest three contributions in both cases), and published at around 11:15 am on each trading day.

[3] A copy of the letter is posted on the TMA website [Link].

3.2. Administration of the Spot FX Fixings is conducted by TMA. The administration framework was established in September 2013, drawing reference from the relevant recommendations made by IOSCO. In particular, a surveillance mechanism has been put in place to identify anomalies in the benchmark-setting process. Dedicated staff have been appointed to conduct daily surveillance in accordance with the surveillance mechanism. An independent Surveillance and Governance Committee has also been formed within the TMA to oversee the administrative work, with responsibilities including handling complaints and whistleblower reports received, and making report to the HKMA.

3.3. The TMA has conducted an internal assessment on the methodology and governance of the Spot FX Fixings, and concluded that while the administration process is largely in line with international best practices, **as the Spot FX Fixings *<u>are calculated from expert-judgement based contributions</u>* at the moment, they are not considered to fully comply with the latest international recommendations**, especially those in relation to anchoring the benchmark-setting process based on observable *bona fide* arm's length transactions**.**

3.4. In this connection, the Market Practices Committee (MPC) of the TMA sought assistance from the HKMA to conduct a feasibility study on the scope of having a more transaction-based fixing mechanism for the Spot FX Fixings.

4. FEASIBILITY STUDY

4.1. The study was conducted using daily transaction-level data collecting from major approved money brokers in Hong Kong[4] which met the following criteria –

i. spot USD/HKD and USD/CNY(HK) transactions that had a transaction size of at least US$1 million (i.e. usually considered

4 Nine out of the fifteen approved money brokers in Hong Kong provided relevant data for the exercise. Market sources indicated that these nine brokers collectively accounted for a large majority of the brokered spot FX market in Hong Kong.

as the threshold of "wholesale transactions", as well as the minimum transaction size that brokers in Hong Kong would normally accept); and

ii. traded from July 2013 to June 2014.

4.2. It is worth-noting that banks' bilateral trades were ***excluded***. First, given the homogeneity of spot FX trades, the MPC agreed that brokers had the critical mass of spot FX trades. Secondly, the MPC noted that many of the bilateral trades conducted between banks were relationship-based, and hence could not be demonstrated as *bona fide* arm's length transactions, i.e. not fulfilling the IOSCO principles. The WMR Fix is calculated from transactions routed through broker platforms too.

4.3. During the studied period, the average daily turnover and number of the collected transactions of USD/HKD were around US$2.2 billion and 720, while that of USD/CNY(HK) were around US$5.1 billion and 1,800. When analysing the data in detail, the MPC noted that should the Spot FX Fixings be calculated using the same "fixing window" of the WMR Fix around the current fixing time of 11:00 am (i.e. +/- 2.5 minutes around 11:00 am), the average turnover and number of collected transactions were around US$19 million and 5 for USD/HKD, and around US$55 million and 15 for USD/CNY(HK). The MPC considered that the "window" should be wider to cover more transactions.

4.4. Meanwhile, by widening the window to 30 minutes (+/- 15 minutes around 11:00 am), the average turnover and number of collected transactions for USD/HKD were around US$100 million and 20, and those for USD/CNY(HK) were around US$300 million and 90. The MPC considered that it would be more reasonable to calculate a fix based on such volume of market transactions. The MPC also noted that the volumes and number of transactions were not affected even when adverse weather were affecting Hong Kong (e.g. typhoon signal number 8), and on the days with the lowest number of transactions, there were at least one eligible trade for USD/HKD and two eligible trades for USD/CNY(HK), thus still enabling the Spot FX Fixings to be calculated.

4.5. The MPC reviewed the above, and considered that the fixing time should remain at 11 am as of now. It also considered that there should be sufficient market conditions to support a more transactions-based fixing mechanism on every trading day. In particular, the MPC noted that following the launch of Shanghai-Hong Kong Stock Connect (i.e. after the survey), turnover in both currency pairs had further increased.

Question 1
Given the reported volume and number of transactions, do you agree that there are sufficient conditions to calculate the Spot FX Fixings using ***actual transactions*** *for every trading day?*

5. PROPOSED PARAMETERS OF CHANGES

5.1. The MPC also considered the following issues having regard to international recommendations and local market conditions, with a view to recommending a suitable calculating framework for transaction-based Spot FX Fixings –

i. the sources of transactions to be collected;
ii. the “width” and “position” of the fixing window;
iii. the methodology to average the transactions to calculate a fix;
iv. the fall-back arrangement if there were no eligible trades within the fixing window; and
v. the transition arrangement to a transaction-based mechanism.

5.2. The recommendations of the MPC are discussed in greater details in the ensuing paragraphs. The MPC considered it crucial to consult the market about the recommendations before finalising the transition arrangement.

Recommendation 1: Calculate the Spot FX Fixings using spot transactions routed through approved money brokers

5.3. In view of the considerations discussed in 4.2 above, the MPC suggested that only transactions routed through approved money brokers should be used to calculate the future transaction-based Spot FX Fixings.

Question 2
*Given the need to anchor a benchmark based on observable bona fide arm's length transactions, do you agree that **only transactions that are routed through approved money brokers** should be used? If not, what other types of transactions should be included, and how will such transactions meet the international recommendations?*

Recommendation 2: Include trades from both Electronic Brokers (EBs) and Voice Brokers (VBs)

5.4. The MPC further noted that brokers were broadly categorised as EBs and VBs, and that EBs accounted for a large share of the brokered FX spot market in Hong Kong.[5] Notwithstanding, the MPC saw merits in calculating the Spot FX Fixings using transactions routed through ***both*** EBs and VBs, as doing otherwise might undesirably result in market players being able to intentionally include/exclude their trades in fixing calculation by routing their trades through either the EBs or VBs.

5.5. In making this recommendation, the MPC was mindful of a possibility that VBs might not be as ready as EBs in sending relevant transactions to an external party for calculating a benchmark (i.e. the calculating agent). The MPC however noted from experiences of other markets which adopted a transaction-based fixing mechanism using ***all*** broker trades that such concerns were largely technical, and solutions were readily available. The MPC further noted that no problems or security breaches had been reported.

Question 3
*Do you agree that we should **collect trades from both EBs and VBs** in calculating a transaction-based spot fixing? Are there other types of transactions that we should take into account?*

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5 Based on the data collected, on average, around 60% of the USD/HKD trades and 70% of the USD/CNY(HK) trades were routed through EBs.

Question 4

*Do you agree that the **same types of transactions should be used in calculating both USD/HKD and USD/CNY(HK) fixes**? If not, why and how should they be different?*

Recommendation 3: A fixing window of +/- 15 minutes around 11 am

5.6. The MPC also considered that a balance should be struck in setting a fixing window that should be sufficiently wide to cover a reasonably large number of transactions under different market conditions, and yet sufficiently narrow so that market players who had contracts based on the fix could hedge their positions (i.e. to replicate the fix).

5.7. Having considered several back-testing results, experiences of FX markets that had a similar size as Hong Kong, and the fact that the existing fixings were calculated from around 20 contributions, the **MPC considered that a *30-minute fixing window* would be appropriate.** As reported earlier, the number of transactions for USD/HKD and USD/CNY(HK) would then be around 20 and 90 respectively, while the volume of transactions would be around US$100 million and US$300 million. In deliberating, the MPC noted that if the fixing window was widened/narrowed, the number of trades captured would broadly increase/decrease proportionately.

Question 5

*Do you agree that a **30-minute fixing window** strikes the right balance in incorporating a reasonably large number of transactions to calculate a fix and in allowing market players to replicate it? If not, what is your preferred fixing window duration, and why and how is it more suitable?*

5.8. Meanwhile, in determining the position of the fixing window, the MPC noted that the existing Spot FX Fixings were calculated from contributions submitted between 11:00 am and 11:10 am, i.e. ten minutes after the fixing time. In moving to a transaction-based fixing, the MPC saw merits in following the practice adopted by the WMR Fix and agreed by the FXBG, which was positioning the fixing time at the mid-point of the fixing window (i.e. 10:45 am to

11:15 am). The MPC believed that calculating the fix using trades that were executed ***both*** before and after the fixing time would capture more pricing information than including trades that were executed ***either*** before or after the fixing time only.

5.9. In view of a 30-minute fixing window that ends at 11:15 am, our dialogues with potential calculating agents indicated that the earliest time that a fix could be published would be around 11:30 am, i.e. 15 minutes later than the existing 11:15 am.

Question 6

*Do you agree that we should follow the WMR Fix approach to **have the fixing time at the mid-point of fixing window**? If not, what is your preference, and why and how is it more suitable?*

Question 7

*Do you agree that both USD/HKD and USD/CNY(HK) fixes should have the **same duration** as the fixing window, and adopt the **same approach** in having the fixing time at the mid-point of the fixing window?*

Recommendation 4: Calculate the fix as the volume-weighted median of the collected transactions

5.10. The MPC considered various averaging methodologies having regard to the FXBG report and approaches adopted in other transaction-based spot fixings.[6] An illustration of various averaging methodologies considered by the MPC, as well as the respective pros and cons, are at the **Annex**. In considering the various methodologies, the MPC agreed that a suitable calculation arrangement should strike a balance in the following –

i. *Not to create undue incentives for benchmark manipulative abuses:* While no averaging method is immune to manipulative abuses, certain averaging method might result in a fix that would be less "costly" to manipulate, and the associated activities might be less identifiable.

[6] The WMR Fix and Singapore USD/SGD fix are calculated as the non-weighted median and the volume-weighted mean of relevant trades, respectively.

ii. *Seek to measure the same underlying market*: To maximise market acceptance, the chosen methodology should exhibit similar dynamics as the existing contribution-based fixing.

iii. *Appropriately volume-weighted*: While larger volume trades should carry heavier weights than smaller trades, there were many instances where the market clearing price had been relatively stable, got pushed up/down significantly due to a large trade, but then reverted to the previous level shortly afterwards. On top of taking into account the volume of trades, the appropriate averaging method should also take into account how many trades had been executed at relevant price levels (i.e. the number of occurrences within the fixing window), and should not be easily affected by such outliers.

5.11. After deliberation, the MPC considered ***volume-weighted median*** to be the most suitable averaging method. Specifically –

i. *Not to create undue incentives for benchmark manipulative abuses:* With volume-weighted median, to manipulate a fix, a trader would need to execute a large volume trade at off market-price, which should be easily identifiable.

ii. *Seek to measure the same underlying market*: Using the volume-weighted median method, the calculated fix for the subject period would be statistically closer to the existing Spot FX Fixings as compared to some other methodologies[7], especially for USD/CNY(HK) fix.

iii. *Appropriately volume-weighted*: a volume-weighted median would take into account both the volume and the number of occurrences. Also, unlike mean (volume-weighted or not), the averaging outcome of median would not be affected by outliers.

[7] The average and maximum discrepancies (both in *absolute values*) for various methods are –

		Median	Volume-weighted median	Mean	Volume-weighted mean
		(basis point)			
USD/HKD	Average	0.4	0.6	0.5	0.6
	Maximum	6.5	8.0	6.5	7.3
USD/CNY(HK)	Average	1.6	1.7	2.6	4.4
	Maximum	28	28	119	397

Question 8

*Do you agree that **volume-weighted median** is the suitable averaging method? If not, what other method should be used, and why is it more suitable?*

Question 9

*Do you agree that the **same averaging method** should be used for both USD/HKD and USD/CNY(HK) fixes?*

Recommendation 5: Arrangement if there is no transaction within the fixing window – Either no fixing or use the last fix

5.12. While there were no trading days with no eligible transactions during the fixing window in the subject period, it was considered prudent to have a "***fall-back arrangement***" in place. At present, no fix would be published should there be insufficient number of contributions.[8] Given the deep FX market, the MPC generally agreed that if there were no transactions, the underlying problem should be beyond technical, i.e. tended to be long-lasting.

5.13. The MPC considered a number of options, but had not come to a definitive view on whether "no fix" or "use the last fix (no expiry time limit)" would be preferred[9], and suggested seeking views from the market –

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[8] The minimum number of contributions required is number of contributors minus four.

[9] Other options being explored by the MPC, and why they were considered not suitable, are –

i. *Widen the fixing window*: Most MPC Members agreed that it would be extremely difficult to widen the fixing window within a very short lead time, after it was found that there were no eligible transactions within the original window. Some of the cited complications include (i) how and who should decide the new "width"; and (ii) fixings calculated for different days might then be based on transactions captured within different periods, and hence not directly comparable.

ii. *Defer to executable market quotes*: Given the deep FX spot market, if there were no trades executed within the fixing window, there would unlikely have any executable quotes either. Even if there were, these quotes would be at very off-market levels, i.e. not representative of the prevailing market prices.

iii. *Defer to bank contributions*: It was considered impractical to ask banks to contribute within a very short notice, or to ask them to continue to contribute daily for contingency only.

iv. *Use the last fix, but only up to a limited number of days (e.g. two days, and then discontinue publication)*: It was unclear as to where the line should be drawn. As mentioned in 5.12, if there were no transactions within the fixing window, it would most likely be due to long-lasting issues. Thus, the decided number of days (e.g. two days) would likely be "too short" (i.e. irrelevant).

i. *No fix (i.e. the existing arrangement)*: Some MPC Members considered that the existing arrangement should be maintained. In particular, some Members considered that using the last fix would not be acceptable given market volatility, especially for the USD/CNY(HK) pair. Hence, if there were no trades, parties should be allowed to trigger the contingent arrangement of the contracts that made reference to the Spot FX Fixings, which would generally not be possible if a fix was still being published by the TMA.

ii. *Use the last fix (no expiry time limit)*: Some viewed that not all existing contracts had contingent arrangements, and by having the TMA publish the last fix as today's fix, smooth market operation could be maintained. The MPC also noted that the WMR Fix used this approach. However, some considered that by keep publishing a dated fix, parties in contracts might not have the option to trigger the contingent arrangement even if doing so was more appropriate.

Question 10
*Do you consider "**no fix**" or "**use the last fix (no expiry time limit)**" more suitable as the fall-back arrangement in case there were no transactions during the fixing window, and what are the reasons behind?*

Question 11
*Do you consider **any other fall-back option** more suitable? If so, why?*

Question 12
*Do you agree that **the same fall-back arrangement** should apply to both USD/HKD and USD/CNY(HK) fixes?*

Recommendation 6: A three-month notice period for a planned overnight change in calculation methodology

5.14. The MPC considered a three-month notice period appropriate for the market to prepare for the transition and to make arrangements as required.

5.15. The MPC also agreed that a planned overnight change in the calculation methodology on a specific date (e.g. announce that the fixing methodology would change in three months' time[10]). Such an overnight change would be more appropriate than publishing both contribution- and transaction-based fixings in parallel for certain period before discontinuing the contribution-based later on, as the latter approach might be confusing and prone to "cherry-picking", e.g. use the fix that is more beneficial to one side of the contracting party.

> ***Question 13***
> *Do you agree with a* ***<u>three-month notice period</u>*** *for transition?*
>
> ***Question 14***
> *Do you agree with a* ***<u>planned overnight change</u>*** *in the calculation methodology? If not, why?*
>
> ***Question 15***
> *Do you agree that the* ***<u>same transition arrangement</u>*** *should apply to both USD/HKD and USD/CNY(HK) fixes?*

6. Next steps

6.1. As part of the consultation process, the TMA intends to meet key stakeholders and relevant industry associations. Those parties will be directly contacted. Following the consultation period, the TMA will provide a summary of comments received along with a response, and a detailed implementation timeline for changes.

Treasury Markets Association Secretariat
May 2015

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[10] In other words, the USD/HKD and USD/CNY(HK) fixes will be calculated based on actual transactions three months after the announcement date, and be published under the existing names of TMA USD/HKD and USD/CNY(HK) fixes.

Abbreviations

EBs	Electronic Brokers
FSB	Financial Stability Board
FX	Foreign Exchange
FXBG	Foreign Exchange Benchmark Group
HKMA	Hong Kong Monetary Authority
IOSCO	International Organization of Securities Commission
MPC	Market Practices Committee of the TMA
Spot FX Fixings	The TMA Spot USD/HKD and USD/CNY(HK) fixings
TMA	Treasury Markets Association
VBs	Voice Brokers
WMR Fix	The WM/Reuters 4 pm London fix, calculated by the WM Company

Annex

Example of the averaging methodologies considered

Time	Transaction
10:46	*US$10 million at $7.7900*
11:00	*US$2 million at $7.7901*
11:05	*US$3 million at $7.7903*

Median

Data point	Price
1	7.7900
2#	7.7901
3	7.7903
#Median of 3 data points	**7.7901**

Volume-weighted Median

Data point	Price
1	7.7900
2	7.7900
3	7.7900
4	7.7900
5	7.7900
6	7.7900
7	7.7900
8*	7.7900
9	7.7900
10	7.7900
11	7.7901
12	7.7901
13	7.7903
14	7.7903
15	7.7903
***Median of 15 data points**	**7.7900**

Mean

Data point	Price
1	7.7900
2	7.7901
3	7.7903
Mean of 3 data points	**(7.7900+ 7.7901+ 7.7903)/ 3 =7.7901**

Volume-weighted mean

Data point	Price	Volume	Volume-weighted price
1	7.7900	10	7.7900×10 = 77.9000
2	7.7901	2	7.7901×2 = 15.5802
3	7.7903	3	7.7903×3 = 23.3709
Volume-weighted median of 3 data points			**(77.9000+ 15.5802+ 23.3709)/ (10+2+3) = 7.7901**

	Median	*Volume-weighted Median*	*Mean*	*Volume-weighted mean*
Calculated fixing	**7.7901**	**7.7900**	**7.7901**	**7.7901**

	Median	***Volume-weighted Median***	***Mean***	***Volume-weighted mean***
Pros	Easy to calculate Not affected by outliers	Takes volume of trades into account Not affected by outliers	Easy to calculate	Takes volume of trades into account
Cons	Does not take volume of trades into account	Less intuitive More difficult to compute	Does not take volume of trades into account More affected by outliers	More affected by outliers More difficult to compute