



Monetary and Capital Markets Department
TECHNICAL ASSISTANCE HANDBOOK

Foreign Exchange Reference Rates

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THIS HANDBOOK

This handbook aims to distill, document, and make widely available the lessons learned from the Monetary and Capital Markets Department's (MCM) technical assistance (TA) over a long period while also incorporating lessons learned globally. It covers a wide range of central banking topics pertaining to governance and risk management, monetary policy, monetary and foreign exchange operations, and financial market development and infrastructures while highlighting, where relevant, specific issues for low-income, resource-rich countries. The handbook documents and promotes good practices and supports the consistency of advice over time. However, it stresses that one-size solutions cannot fit all, and all advice therefore needs to be tailored to country-specific circumstances. The handbook comprises self-contained, issue-specific chapters with cross-references on overlapping issues where needed. It is aimed at those who provide TA (both IMF and non-IMF personnel) and practitioners in central banks and other relevant institutions.

THIS CHAPTER: FOREIGN EXCHANGE REFERENCE RATES

This chapter of the Technical Assistance Handbook provides guidance to central banks on the development of robust frameworks for foreign exchange (FX) reference rate determination. It addresses key challenges commonly encountered in emerging market contexts, including limited data availability, market fragmentation, and varying degrees of market development. The chapter presents alternative methodological approaches for FX reference rate calculation, tailored to differing policy objectives and market conditions. It elaborates on key design elements, including the selection of eligible transactions, timing and sampling of data, and the choice of central tendency estimators. Additionally, it offers guidance on establishing data sufficiency thresholds and formulating contingency methodologies to ensure continuity in rate production. The chapter also emphasizes the importance of sound governance arrangements, clear accountability structures, and transparency practices in the provision of FX reference rates as public goods..

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I. Executive Summary

This TA Handbook on foreign exchange (FX) reference rates for the FX spot market provides comprehensive guidance on the design, implementation, and maintenance of robust FX reference rate frameworks. By addressing the challenges and incorporating best practices, central banks can enhance market integrity, support monetary policy transmission, and foster market development.

The key to achieving these objectives is to address the complexities and challenges in establishing robust and reliable foreign exchange (FX) reference rate frameworks. Key challenges include data quality and availability, market fragmentation, methodology selection, market manipulation risks, technological integration, and the need for ongoing maintenance and adaptation. These challenges are particularly pronounced in emerging and developing markets, where liquidity and data availability are often limited.

The handbook outlines four primary models for FX reference rate determination: central bank-managed fixing sessions, indicative quotes submitted by market makers, quotes (indicative or executable) observed on trading platforms, and the weighted average exchange rates of FX transactions. Each model's applicability depends on the market's level of development and the intended use of the reference rate. The handbook emphasizes the importance of robustness, representativeness, and replicability in designing these frameworks.

Effective governance structures are crucial for maintaining the integrity of FX reference rates. The central bank is often best positioned to play the key role in the FX benchmark governance framework, including fulfilling the role of administrator, because it is often responsible for implementing foreign exchange policy. Governance involves establishing oversight committees, ensuring transparency, and maintaining accountability through regular reviews and audits. The handbook also highlights the importance of engaging with market participants and adhering to international standards, such as the International Organization of Securities Commissions' *Principles for Financial Benchmarks* (IOSCO 2013).

Data sufficiency criteria are essential for ensuring that reference rates are based on competitive market transactions. The handbook provides guidelines for assessing data sufficiency and outlines contingency methods for calculating benchmarks when data is insufficient or not timely. These methods include using executable quotations, cross rates, previous day's benchmarks, and expert judgment.

As markets develop, FX benchmark methodologies may need to be adjusted. The handbook recommends a single-step transition to new benchmarks when possible but acknowledges that gradual transitions may be necessary in some cases. Effective communication and consultation with stakeholders are critical during transitions.

Transparency in the benchmark framework and adherence to international standards enhance credibility and market adoption. The handbook advises central banks to publish detailed methodology statements, disclose contingency methodology usage, and provide channels for stakeholder feedback.

II. Context and Issue

The primary purpose of well-designed FX reference rate frameworks is to provide the public with representative exchange rates. Such reference rates also contribute to market development by improving price discovery and transparency. While the administration and calculation can be performed by various entities—both private and public, including data providers, trade associations, regulated exchanges, and trading platforms—the central bank is best positioned to fulfill this role for FX benchmarks, given its central role in implementing FX policy.

The context of technical assistance (TA) requests on FX reference rates may encompass FX policy formulation, transitioning to a new exchange rate regime, pursuing market development objectives, and implementing international best practice, while also taking into account a member's obligations under Article VIII, Section 3. Policy formulation is related to exchange rate regimes and intervention frameworks consistent with those regimes. The methodology of computing the reference rate is important in representing market conditions and underlying volatility. This is often associated with regimes that are transitioning from fixed to floating exchange rates. Market development goals can include the modernization of market infrastructure, the revision of regulatory frameworks, and the realignment of market participants' incentives to allow them greater FX intermediation. Best practices around benchmark governance structures, calculation methodologies, and transparency ensure that the benchmark is representative, robust, relevant, and, over time, replicable. The reference rate becomes subject to the MCP policy when such rate is used by the authorities in actual exchange transactions, or when the authorities require its use in exchange transactions by authorized dealers.

The main challenges in establishing a robust FX reference rate framework are data quality and availability, market fragmentation, vulnerability to manipulation, technological integration, and ensuring that central bank FX policy is consistent with its mandate. Data from market agents in the wholesale market is often neither timely nor fully representative, with lower liquidity potentially compromising benchmark reliability—especially in emerging markets where data scarcity is common. Market fragmentation may occur when order flows concentrate among a few institutions that transact primarily with their own clients, potentially leading to a dysfunctional interbank market. The selection of the methodology—whether average prices, weighted prices, median prices, quotes, or transactions—is pivotal, as different approaches yield varying outcomes; the chosen method must balance accuracy, transparency, and market relevance, and must be applied consistently. In addition, weak institutional frameworks can expose benchmarks to manipulation, necessitating robust governance and oversight. Technological integration poses its own challenges, particularly for countries with limited resources, as the infrastructure for data collection, analysis, and dissemination must be both effective and scalable. Finally, once established, benchmarks require ongoing maintenance and periodic reviews to adapt to evolving market conditions, while central bank policy responses to exchange rate movements further underscore the need for transparent calculation methodologies.

III. Framework Design

A. Main Design Models

For the purpose of this chapter, we distinguish between four key models of FX reference rates. First, in cases of extreme market dysfunction, trading takes place in fixing sessions managed by the central bank, which plays a significant role in price formation by buying and selling—often to meet a specific exchange rate objective. In the second model, the fixing rate is set by the central bank as the simple arithmetic average of the FX spot quotes provided at a point in time by the most active domestic banks in the foreign exchange market. In the third model, the fixing rate is set by the central bank as the simple arithmetic average of the FX spot quotes

(indicative or executable) observed at a point in time or over a short time window on the most active trading platform. Finally, in the most sophisticated model, the fixing rate is set by the central bank as the weighted arithmetic average of the FX spot transactions observed over a short time window or the entire trading session on the most active trading platform.

First, central banks may organize official fixing sessions in countries where the interbank FX market is structurally absent. These sessions function similarly to interbank FX auctions. Their goal is to set the exchange rate for official transactions or the interbank market. During the fixing session, both the demand and supply of FX are determined endogenously. Unlike a standard FX auction, where the central bank controls the allocation of FX, the auction fixing allows for a more dynamic process. A fixing arrangement may involve the pre-submission of bids and offers, with live quotations received during the tender session. At the start of a fixing session, the organizer collects buying and selling orders to determine the opening rate. This rate may not represent an equilibrium rate, as it is based on available information and serves only to initiate the bidding process. Throughout the session, the live rate fluctuates in response to actual quotations, reflecting the imbalance between buying and selling orders. Ultimately, a market-clearing rate is established as a midpoint rate, with buy and sell rates calculated based on specified margins typically applied to executed orders. During fixing sessions, exchange rate quotations outside the sessions are not restricted. Occasionally, no trading occurs in a fixing session, in which case the rate may be established based on interbank quotations. (Kovanen 1994). This model is now rarely used in practice, as central banks in the absence of an interbank FX market typically rely on contributed quotes from a panel of banks or on banks' reported transactions with retail clients.

Second, using quotes submitted by a panel of banks fits a large variety of interbank FX markets. In such cases, the central bank will need to be sufficiently confident that the actual transactions' exchange rates are not significantly different from the panel of quotes submitted. At the same time, such an approach can be supportive of market functioning if the rate is computed from quotes early in the trading session, as this would provide helpful guidance on the market price in flexible exchange rate regimes. However, as the submitted quotes are, by construction, indicative, the representativeness of the resulting reference rate is not ensured. This might become problematic if large swings occur in the exchange rate after the publication of the reference rate. To help improve the representativeness of the reference rate, this model often involves trimming the lowest and highest values of the contributions before computing their simple arithmetic average. Still, because all contributions are treated equally—apart from filtering out extreme values—this approach may introduce bias compared to models that assign weights to exchange rates based on transaction size. Consequently, this model has seen limited use by central banks in recent years.

Third, calculating the reference rates based on a quasi-point-in-time observation of market conditions is suitable for markets with continuous trading activity throughout the trading session. Under such market conditions, the choice of the observation time is largely irrelevant, as transactions or firm quotes are observable at any time during the trading session. It is critical to observe the prices on a trading platform to ensure that tradable exchange rates are collected for the calculation, and not indicative rates. The market should be sufficiently deep, liquid, and heterogeneous with respect to participants' exchange rate exposure. Under such conditions, the risk of market manipulation is also lower. Otherwise, manipulative market participants may be able to influence observable exchange rates through a concerted and concentrated effort, which can result in a biased rate when observed at a point –in time. The key benefit of this model is that the reference rate can be published during the trading session, which is advantageous for price discovery and enables the effective use of benchmark orders or derivatives. This approach is widely used by central banks in emerging markets and by benchmark providers in advanced economies.

Finally, calculating the reference rates based on the observation of market conditions over the entire trading session is suitable for markets where intraday trading may be intermittent and market liquidity shallow. This group of markets includes most potential TA recipients. The main advantage of this approach is that it produces a reference rate that is robust to intraday fluctuations in liquidity and thereby potential

manipulation attempts that may arise in the previous model. However, the main drawback is that the earliest possible publication of the reference rate is after the end of the trading session, or the next business day. This can result in insufficient representativeness, as the exchange rate on the day of publication will not reflect prevailing market conditions. The use of such a lagged exchange rate can also be problematic with respect to the IMF's Guidance on Multiple Currency Practices.

Box 1. IMF Guidance for Official Exchange Rates under the Multiple Currency Practices Policy

In countries with less-developed FX markets, authorities often use—or require the use of—one-day-lagged official exchange rates for FX transactions. This practice arises when the necessary data for calculating current market exchange rates is unavailable during the day, preventing computation before the FX market closes. In such cases, the use of these lagged rates may be required.

Under certain conditions, using market exchange rates from the preceding business day to compute official exchange rates will not result in Multiple Currency Practices (MCP). The calculation must adhere to the following specific criteria. First, the lagged official exchange rate is determined as a weighted average of transaction exchange rates. When a wholesale FX market exists, the calculation is based on its transaction rates. If there is no wholesale FX market—or if its rates are not representative of the broader FX market—the rate should be computed using the weighted average of transaction exchange rates between intermediaries and their clients, or a combination of both. Second, the transactions included in the calculation must have occurred on the business day immediately preceding the day on which the official exchange rate is to be used.

For example, Country A's central bank uses the official exchange rate for government transactions (official action). The central bank announces the official exchange rate (R/USD) at 16:00 every trading day. The official exchange rate is determined by the weighted average interbank market exchange rates from 15:00 on the previous trading day (T) to 15:00 on the current trading day (T+1). The government trades with the central bank the next day (T+2) using this official rate calculated on the current day (T+1). Since the official exchange rate used on T+2 includes transaction information from two days before (the transactions between 15:00 and 17:00 on T), the calculation does not meet the criteria for a one-day-lagged exchange rate that would avoid giving rise to an MCP. Thus, the exchange rate would need to be monitored, since in this example it is used for government transactions.

Overall, the choice among the above models depends on the level of market development and the intended use of the reference rate. Central banks should always aim to use the model that results in the most robust and representative reference rate, given the degree of market development and their tolerance for resorting to contingency calculation methods if data is insufficient. At certain stages of market development, depending also on the institutional context, the combination of certain features of these main models can be used.

B. Key Principles

Robustness, representativeness, and replicability are the key principles that a state-of-the-art FX reference rate framework should follow. Robustness means that the reference rate is calculated and disseminated on every business day without significant operational risks, regardless of fluctuations in market conditions. This is the highest priority criterion, which must be met with a very high probability, even in the least developed markets. This can be achieved by addressing operational risks and putting in place effective contingency calculation methods. Representativeness means that the reference rate reflects the prevailing market conditions, where the price is formed by the competitive forces of demand and supply. To fully satisfy this criterion, only those transactions should be used to calculate the reference rate in which counterparties' bargaining power is sufficiently similar. Replicability means that market participants have a reasonable chance to execute FX transactions, on average, at rates sufficiently close to the reference rate without knowing its value in advance. Replicability can be facilitated by being transparent about the methodology and using market-based inputs only.

There is often a trade-off between robustness and representativeness. Including only larger transactions is detrimental from the perspective of robustness such trades tend to occur less frequently, which may result in insufficient data during periods of thin market liquidity. However, expanding eligibility to include dealer-to-customer transactions and smaller trade sizes undermines the representativeness.

Box 2. IOSCO Principles

The IOSCO *Principles for Financial Benchmarks*, published in July 2013, outline 19 principles for benchmark administrators to follow, grouped into four categories that aim to enhance the reliability, transparency, and integrity of financial benchmarks.

Governance: This category comprises five principles that ensure appropriate arrangements are in place to protect the integrity of the benchmark determination process. This includes addressing conflicts of interest and requiring Administrators to retain primary responsibility for all aspects of the benchmark determination process. Additionally, it establishes oversight functions to review and challenge the benchmark determination process, ensuring that benchmarks are administered in a transparent and accountable manner.

Quality of the Benchmark: The quality of the benchmark category comprises five principles that promote the quality and integrity of benchmark determinations. It emphasizes that benchmarks should be based on prices, rates, indices, or values formed by competitive market forces. This section also addresses data sufficiency and the hierarchy of data inputs, ensuring that benchmarks are robust and reliable. Furthermore, it ensures transparency of benchmark determinations, providing clarity on how benchmarks are calculated and disseminated.

Quality of the Methodology: The quality of the methodology category comprises five principles that focus on promoting the quality and integrity of methodologies used in benchmark determination. It requires the publication of minimum information about the methodology, ensuring transparency and understanding among stakeholders. This section also addresses procedures for material changes to the methodology, ensuring that any modifications are well-communicated and justified. Additionally, it establishes policies for benchmark transitions or cessations, providing a structured approach to handling changes in the benchmark lifecycle.

Accountability: The accountability category comprises four principles with mechanisms to ensure that benchmark Administrators are accountable for their actions. This includes establishing complaints procedures to handle disputes or concerns related to benchmark determinations. It also mandates audits and audit trails to maintain a record of all benchmark-related activities, enhancing transparency and compliance. Finally, it ensures cooperation with regulatory authorities, facilitating oversight and enforcement of these principles to maintain the integrity of financial benchmarks.

C. Objectives and Constraints at Various Levels of Market Development

The IOSCO *Principles for Financial Benchmarks* address the application of benchmarks to both active and illiquid markets.

Active markets: Generally described as markets with observable bona fide, arm's-length transactions with considerable size, liquidity, and many participants, or limited concentration. The Principles state that benchmarks should ideally be based on prices, rates, indices, or values formed by competitive forces of supply and demand, anchored by observable transactions conducted at arm's length between buyers and sellers. However, they clarify that individual benchmark determinations do not need to rely solely or predominantly on actual transactions. This allows for flexibility in how benchmarks are constructed, even in active markets, where observable data is more readily available.

Illiquid or fragmented markets: The Principles recognize potential limitations due to the lack of observable transactions. In such cases, benchmarks may rely on alternative data sources or methodologies, such as expert judgment or indicative quotes, provided these approaches are transparent and robust. The proportional application of the Principles ensures that benchmarks in illiquid markets are designed and governed

appropriately without imposing undue regulatory burdens. This approach balances the need for reliability with the practical challenges of limited liquidity.

This handbook chapter further considers the following factors in determining market maturity.

- **Interbank and Interdealer FX Market Activity:** Robust interbank trading and diverse dealer participation indicate a mature market.
- **Official Intervention:** The degree of official intervention in price formation is inversely related to market development; heavy intervention may lead to price distortions and parallel markets.
- **Dominance of Private FX Inflows:** The balance between official and private inflows reflects market maturity; deeper markets typically have more private flows.
- **Sophistication of Derivatives Markets:** The presence of forward contracts and complex hedging instruments suggests a more developed market; these are often lacking in less-developed markets.
- **Market Infrastructure and Capacity:** Established codes of conduct, efficient dealer systems, and capacity to handle large transaction volumes are essential indicators of market development.

The emphasis on each of the three dimensions in which a benchmark is assessed will depend significantly on the market's stage of development.

- **Nascent Markets:** The factors listed above are largely missing, and there is no active market for foreign exchange. Given the limited and sporadic liquidity and fragmentation in any of the observable markets, inputs for determining the benchmark are predominantly trades between banks and FX bureaus with their clients. This, together with a lack of adequate infrastructure affecting the sample universe and timing, means the benchmark is—calculated only once per day—based on deal flow across a full business day—and is made available on an ex-post basis, primarily for accounting purposes. In circumstances where official flows play a critical role in market functioning, the benchmark may alternatively be derived from official auctions or fixing sessions. The benchmark will be robust, moderately representative, but will lack replicability.
- **Emerging, Developing and Maturing Markets:** There are improvements in the maturity factors listed above and these markets may see the emergence of an active market. Transactions typically encompass interbank trades and wholesale deals executed by large bureaus with their clients and banks. The benchmark's role expands from mere accounting to include portfolio valuation and performance measurement, and the need for enhanced replicability becomes increasingly critical. Exchange rates are published at regular intervals during the day, capturing activity within specific time windows. Robustness and representativeness are maintained by including all transactions within each window and applying volume weighting, while additional indicators—such as firm quotes from dealers—may also be incorporated. Further improvements in market depth may be needed to establish benchmarks that are replicable.
- **Established or Mature Markets:** This group meets all the factors listed above and has active markets as defined. Market activity is primarily driven by interbank and interdealer trades, as well as the growing presence of electronic trading channels. The benchmark is computed over short, specific time windows—merging point-in-time data with a narrow window—to concentrate transactions at moments that facilitate replicability, and it typically include mechanisms to filter out outlier or unrepresentative transactions. This concentrated approach underpins the development of derivative hedging instruments,

index construction, portfolio valuation, and performance measurement, among other functions. Benchmarks strike a careful balance between replicability, representativeness, and robustness.

D. Timing, Sample Size, Number of Rates Published

Effective sample window sizing practices evolve alongside market sophistication to ensure that benchmarks accurately capture meaningful liquidity and trading activity. As markets deepen, the sample window can be narrowed to include only representative trades and data points from the most liquid currency pairs. Regulatory requirements that define business hours may also limit the overall window size. With increased market liquidity, central banks can identify shorter windows or specific point-in-time observation periods—such as market opening, midday, and closing rates—for the regular publication of benchmarks. Furthermore, as markets mature, specialized products based on specific fixings emerge, forming the basis for pricing a broad range of financial instruments and assets.

The length of the fixing window is the principal driver of both client transaction costs and dealer profitability. Longer windows reduce client execution costs by allowing hedging activity to be spread out, thereby minimizing price impact. However, this benefit comes at the cost of lower risk-adjusted profitability for dealers, especially for smaller trades, potentially undermining the commercial viability of benchmark execution services. In contrast, shorter windows increase dealer returns but can lead to prohibitively high costs for clients. Differences in the weighting function applied within the fixing window play a comparatively minor role. Robustness checks confirm that the dominant role of window length persists across a wide range of market parameters, including volatility and liquidity conditions. Administrators should weigh the trade-off between reducing client costs and ensuring dealer participation, tailoring fixing designs to market structure and transaction characteristics to promote fairness, efficiency, and resilience in FX benchmark use (Oomen and Muhle-Karbe, 2024).

Successful management of multiple exchange rates requires a framework that is market-driven, consistent, and transparent. The computation and publication of multiple rates should be guided by clear market needs, ensuring that different trading strategies are adequately captured while avoiding unnecessary complexity. To prevent confusion among market participants, the number of rates published for each objective should be limited—such as providing only one closing rate per day—and methodologies should be consistent, comparable, and fully documented. Typically, the central bank will offer a single official exchange rate for a specified period, complemented by additional indicative rates to support market requirements and economic analysis. Ultimately, it is the market that determines the appropriate use of these rates for valuation, financial contract referencing, and derivative contracts (Oomen and Muhle-Karbe, 2024).

Appropriate publication timing is critical for ensuring that benchmark exchange rates are accurate, relevant, and useful to all market participants. The benchmark exchange rate should be released at a time that best balances the needs of both the dealing community and the wider public. For instance, banks, foreign exchange cash offices, asset managers, and corporate treasurers may require higher-frequency indicative rates—such as opening, midday, and closing rates—to support timely decision-making. Conversely, the public may prefer on-demand indicative rates or simply the average and closing rates for the day. This balance in publication timing helps maintain the benchmark's integrity and maximizes its market utility.

In certain cases, the publication can only take place with a one-day lag, which requires careful framework design. Delays in data submission for the sample deemed appropriate for rate determination can lead to the rate being computed and published with a one-business-day lag. In these instances, the derived exchange rate should be used solely for accounting purposes, and it is essential that all communications clearly state this limitation. Although this delayed rate may be applied in official transactions with the government,

stakeholders must be fully informed of its accounting-only designation to avoid any misinterpretation as a real-time market indicator.

Effective participation in pricing submissions hinges on clearly defined data requirements, robust processes, and appropriate regulatory support. The central bank should specify the data requirements for the benchmark, identify the institutions responsible for submitting transactions, and ensure that the necessary infrastructure is available to support the exercise. The submissions should be governed by rules to protect the integrity of the benchmark and be consistent with IOSCO Principle 14 on submitter code of conduct. These measures are essential to producing a benchmark that is accurate, relevant, timely, and useful for the market. In some cases, it may be necessary to mandate data collection through regulatory requirements imposed on licensed market agents, with these obligations factored into the licensing process. It is important to distinguish between the submission of indicative quotes and the reporting of transactions. The latter often requires orders of magnitude greater infrastructure for data submission and monitoring, and more robust procedures to ensure high-quality data.

Publishing a single mid-rate as the official reference rate is a best practice that promotes clarity, transparency, and trust by reflecting the fair market value without embedded transaction costs. While there is merit in also disseminating buying and selling rates—given that these rates convey the costs of conversion, mark-ups, and market trading conditions—their roles must be clearly defined so that market participants understand their application. Buying and selling rates detail the costs associated with wholesale market transactions and offer insights into the indicative cost of entering and exiting positions, but these spreads typically do not apply to arm’s-length transactions involving non-dealer counterparts. In contrast, the mid-rate, free from mark-ups or margins, signals the official rate’s movement and underlying fair value, ensuring that the reference rate remains unbiased by costs. Consequently, while market agents are free to adjust their own prices and spreads in response to market conditions, the official rate should be published solely as a mid-rate to maintain its objectivity and market utility.

E. Eligible Transactions and Quotes

The eligibility criteria for transactions to be included in the reference rate are critical for the rate’s representativeness and robustness. To ensure representativeness, the transactions must involve the same financial instrument (i.e., FX spot transactions) and should ideally be sourced from a single marketplace where prices are formed by competitive forces of demand and supply (i.e., wholesale interbank transactions). To ensure both robustness and representativeness, these criteria may need to be relaxed under predefined contingency conditions. First, when the wholesale market is not active enough, the scope of eligible transactions should be expanded to dealer-to-customer trades. Second, the transaction amount threshold should be determined. Including very small retail transactions may undermine the representativeness of the benchmark, as the pricing of those trades is fundamentally different from that of interbank trades, which the reference rate is intended to represent. The minimum transaction amount threshold can be defined based on existing market practices, the minimum lots traded on electronic trading platforms, and historical data analysis for different threshold levels.

While including dealer-to-customer trades alongside wholesale transactions is appropriate, several considerations must be taken into account. First, most dealer-to-customer transactions occur with a spread to the wholesale market. This does not pose complications when there is a relative balance in the client’s supply and demand, resulting in a mid-rate close to the wholesale mid-market rate. However, when there is a substantial difference in supply and demand—often addressed by central bank interventions—the average dealer-to-customer rate may tilt towards either the purchase or sale rates, moving away from the mid-market rate. Second, while the central bank can access online data on wholesale transactions confirmed by both parties

through trading terminals or platforms, the reporting of dealer-to-customer transactions, which may be done manually in some cases, are prone to errors, corrections, and delays.

Data quality is typically better for interbank transactions. Operational difficulties in managing small transactions, along with their often relatively low share in terms of volume compared to wholesale transactions, provide further justification for excluding retail transactions from benchmark calculations. Additionally, in countries with strict capital controls, the price dynamics of retail transactions can substantially deviate from those in the wholesale market.

The choice of eligible transactions depends on market conventions, with spot (T+2) being the most commonly used. In some markets, however, T+0 or T+1 conventions may be more common. Typically, only one type of convention should define eligible transactions; however, using all three simultaneously is also possible. In such cases, complications arise, requiring other transactions to be recalculated into spot transactions using the interest rate differential for currency pairs, which may also vary across different banking segments. While measurement error from the interest rate differential can sometimes be neglected, a higher interest rate differential will increase that error.

Transactions between the central bank and market participants, as well as those between the central bank and government, should be excluded from eligible transactions because their prices are not determined by competitive forces of supply and demand. This holds true whether the central bank acts as a price taker or a price maker. Moreover, these transactions are often conducted at the previous day's official rate, which does not reflect market conditions on the transaction date. Additionally, excluding transactions with central banks may be justified due to their substantial share of total interbank activity—especially in countries with pegged regimes, which would not meet concentration thresholds.

For the volume-weighted average reference rate, very large transactions can have an outsized impact. Such transactions are sometimes related to government operations, state-owned enterprises (SOEs), or debt conversions. These transactions may occur at rates that do not reflect wholesale spot market conditions and may also be affected by reporting errors. One solution to address this issue would be to use the median volume-weighted rate instead of relying on professional judgment or applying a threshold to exclude very large transactions from benchmark calculations.

The spot legs of swap transactions should not be considered eligible transactions. Banks may incorporate risk-mitigating components when pricing the spot legs of derivative transactions. This would necessitate the establishment of proper reporting from commercial banks to distinguish between spot and derivative transactions.

F. Central Tendency Estimators

Selecting the appropriate measure of central tendency is critical in the design of a transaction-based FX benchmark, as it directly influences the benchmark's ability to reflect prevailing market conditions accurately and robustly. An unsuitable estimator—such as the simple mean in the presence of skewed data or outliers—can result in a benchmark rate that is biased or unrepresentative of actual trading activity. By contrast, using a weighted average, median, or trimmed mean—depending on market depth, distribution of transaction sizes, and susceptibility to manipulation—can enhance the benchmark's reliability, reduce distortion from extreme values, and ensure it remains both statistically sound and operationally defensible.

We compare two estimators—weighted median and weighted average—across five key features of statistical estimation: consistency, robustness, unbiasedness, parametric assumptions, and efficiency. Consistency refers to an estimator's convergence to the true parameter as sample size grows. Robustness

relates to how sensitive the estimator is to outliers or spurious values. An estimator is unbiased if its expected value equals the true parameter, while efficiency concerns the variance of the estimator among unbiased alternatives. It is also important whether an estimator relies on parametric assumptions—that is, whether it presumes a particular distributional form.

Table 1. Comparison of the Weighted Median and the Weighted Average			
Feature	Definition	Weighted Median	Weighted Average
Consistent	An estimator is consistent if it converges to the true value of the population parameter as the sample size increases.	Consistent	Consistent
Robust to outliers	Robustness refers to insensitivity to outliers or extreme values. Robust estimators are not significantly affected by anomalies in the data.	Highly robust	Not robust
Unbiased	An estimator is unbiased if its expected value equals the true population parameter. It does not systematically over- or underestimate the value.	Unbiased (under certain conditions)	Typically unbiased
Distribution assumptions	Refers to reliance on a specific distribution (e.g., normal) for the estimator to function optimally.	Less dependent on assumed distribution	More dependent on assumed distribution
Efficient	An estimator is efficient if it has the smallest possible variance or absolute deviation among unbiased estimators, meaning it uses data more effectively to estimate a parameter.	More efficient in terms of absolute deviation	More efficient in terms of variance
Source: IMF staff construction.			

Under these criteria, the weighted median is superior to the weighted average across most features.

Both the weighted median and the weighted average are deemed consistent. However, while the weighted median is highly robust—less influenced by extreme values—the weighted average is not, making it more vulnerable to outliers. If weights are correctly specified, the average is always unbiased, while the unbiasedness of sample median estimator is not so evident and might require additional properties of the distribution. The weighted mean is a parametric estimator that is optimal (i.e., efficient and unbiased) when the underlying data follow the assumed distribution. The weighted median, by contrast, is less dependent on such strict parametric assumptions and is generally more robust to deviations from the assumed distribution (such as skewness or the presence of outliers). However, this robustness can come at the cost of reduced efficiency when the assumed distribution (e.g., normal) is indeed correct. Finally, regarding efficiency, it depends on the loss function which estimator is superior. the mean minimizes the quadratic variance (making it efficient by construction), while the median minimizes absolute deviation.

G. Data Sufficiency Criteria and Contingency Calculation Methods

Data sufficiency criteria can be derived from the principle that requires prices to be driven by the competitive forces of demand and supply formulated in arms-length transactions. Data will be insufficient if it fails to meet these criteria, the quantification of which must be calibrated for each country to reflect the central bank's preferences between the competing priorities of robustness and representativeness. The tradeoff is that in developing markets such transactions are often scarce. Therefore, central banks often need to rely on less representative data (e.g., dealer-to-customer transactions instead of interbank trades) in order to calculate the reference rate every day. To ensure robustness, these criteria must be observable on a daily basis to enable the use of contingency calculation methods when not met.

While data insufficiency is more common in developing markets, it is important to recognize that even well-developed markets can exhibit episodes of insufficient data during periods of financial stress. In such cases, the normal functioning of the interbank FX market may be temporarily impaired, leading to a sharp decline in transaction volumes or a concentration of trades that do not reflect competitive pricing. These episodes underscore the importance of designing data sufficiency criteria that are resilient not only to structural limitations but also to cyclical disruptions in market functioning.

The first step is to define the central bank's tolerance for insufficient data expressed in the percentage of trading days on which data is expected to be insufficient. This can be estimated using at least one year of historical data to account for seasonality in market activity. It is expected that as markets develop over time, data insufficiency will occur less frequently. Therefore, it is good practice to re-estimate the data sufficiency thresholds annually and change them if significant changes are observed.

To assess market activity and decide whether to apply contingency measures, the central bank can employ data insufficiency triggers. First, the number of transacting banks on a given trading day falls below a set threshold; second, daily volume is less than a specified percentage of the average daily volume; and third, a high concentration of transactions where a few banks account for a substantial share of turnover. These triggers should be defined based on a thorough analysis of the FX interbank market and discussed ex ante in the calculation methodology for the benchmark.

To help implement this, we present some rules of thumb to assess data sufficiency. First, the percentage of trading days with highly concentrated market turnover—defined as days when the top three banks account for more than 80 percent of turnover—should be lower to indicate greater robustness. Second, the percentage of trading days with zero or near-zero trading volume should ideally be as close to zero as possible. Third, the percentage of trading days with very few active market participants (i.e., fewer than five banks) serves as another important metric. When the interbank market is active, the determination process should rely solely on interbank transactions, although bank-client transactions may be considered to enhance robustness. Conversely, if the market is inactive, these requirements should be relaxed under predefined contingency conditions.

If the data insufficiency test indicates that the interbank market is inactive, the central bank should rely on additional alternative data sources for benchmark contingency computation. The following hierarchy of data inputs can be used:

- **Dealer-to-customer trades:** If this data is not already used alongside wholesale transactions as eligible transactions.

- **Request for Quote (RFQ),¹ or executable or indicative quotations:** The central bank can use fixings based on snapshots at a specific time of day or obtain quotations multiple times during trading hours. The latter option improves data quality by capturing market conditions over a longer period, better representing the overall market situation, and reducing the potential risk of manipulation.
- **Transactions with different currency pairs:** The central bank must use clear, pre-determined guidance on how to recalculate cross rates into the relevant benchmark rate.
- **Previous day's benchmark:** If data remains insufficient, the central bank could use the previous day's benchmark as an input for benchmark determination.
- **Expert judgment:** While IOSCO principles (Principle 8) allow flexibility and reliance on expert judgment in low-liquidity markets, the use of professional judgment could undermine benchmark credibility and make automatic calculation impossible.

It is important to note that these alternative data sources are used to supplement the available (though insufficient) data on eligible transactions, not to replace it. Alternative data sources are used until sufficient data is available, following a top-down approach based on the input hierarchy.

H. Transition

Central banks can choose to adjust their calculation methodology or the entire benchmark setting framework for various reasons. The most natural rationale is when the degree of market development has reached a higher level. This may enable the transition from a panel of contributors to the observation of trading activity over the entire trading session.

Ideally, the transition should be executed in a single step. Conceptually, a single-step adjustment is better as it is consistent with the notion that a legacy benchmark is no longer appropriate. Then, the only credible move from the central bank is to immediately transition to a new benchmark. To further enhance the credibility of the benchmark framework, the new benchmark would be calculated retroactively.² However, in practice, the unavailability of the underlying data for the new methodology for the past period prevents such a retroactive benchmark calculation.

Nevertheless, many central banks prefer to change their calculation methods gradually. Many central banks are concerned about inducing excessive, though temporary volatility, revaluation effects, and potential impacts on economic agents' expectations resulting from the introduction of a new benchmark that has a significantly different value from the previous one. Consequently, a gradual transition from the legacy benchmark to the new one is often seen as a good compromise, especially in jurisdictions with a history of managed exchange rate regimes.

When a gradual transition process is chosen, the pace of change should be calibrated carefully. A relatively straightforward approach throughout the transition period is to compute the weighted average of the legacy rate and the new rate with gradually drifting weights. At the start of the transition, the legacy rate is assigned a weight of 1 (by design) and the new rate a weight of 0; by the end, the weights will be reversed.

¹ RFQ is a standard process used in trading systems, including Bloomberg and Refinitiv, where a buyer requests price quotes from multiple sellers for a specific financial instrument. RFQ can be sent simultaneously to multiple liquidity providers or dealers, who then respond with their quotes for the requested quantity and terms. This can help identify the best available price for execution.

² This approach is similar to the one applied in the process of abandoning the LIBOR interest rate benchmarks.

I. Governance

While the role of administrator and other key roles within the benchmark governance framework can be performed by various entities—both private and public, including data providers, trade associations, regulated exchanges, and trading platforms—the central bank is best positioned to fulfill these roles for FX benchmarks. This provides the following benefits:

- **Avoiding Conflicts of Interest:** Central banks can administer benchmarks independently, eliminating potential conflicts that arise when private entities manage benchmarks while also offering financial products linked to them.
- **Enhanced FX Market Functioning:** Central banks have an interest in improving FX market functioning, including the FX derivatives market, which supports better monetary policy transmission.
- **Credibility and Market Insight:** As a credible government institution, the central bank has a deep understanding of actual market conditions. FX benchmarks administered by the central bank are trusted and utilized by various entities, including government institutions, for purposes such as debt operations, export-import transactions, and balance sheet revaluations.

Box 3. IOSCO Benchmark Governance Framework

The IOSCO principles distinguish several key roles within the benchmark governance framework:

Administrator:

The Administrator is responsible for managing the overall benchmark process. This role includes ensuring the integrity of the benchmark and facilitating communication with stakeholders.

Administrator Oversight Function:

The Oversight Function involves an independent committee that establishes and reviews the benchmark's methodology, monitors the benchmark governance process, and addresses any potential conflicts of interest. This function plays a critical role in maintaining the credibility and integrity of the benchmark.

Calculating Agent:

The Calculating Agent is tasked with the accurate calculation of benchmark values based on the provided data. This includes processing and analyzing the collected data in accordance with the established methodology.

Publishing Agent:

The Publishing Agent disseminates the calculated benchmark values to the public and relevant stakeholders. This role ensures that the published information is accurate, timely, and compliant with the defined standards.

Audit Function:

The Audit Function is responsible for reviewing and assessing the processes and methodologies used in benchmark calculation and governance. This includes ensuring that the benchmarks are calculated accurately and transparently, and that the relevant procedures are followed.

The roles of the calculating agent, publishing agent, and audit may be fulfilled by entities other than the administrator and its oversight function.

Within the central bank's role as administrator, responsibility for all aspects of the benchmark determination process—establishing the governance framework, and implementing accountability procedures—can be assigned to a functional unit that operates in the FX market or possesses up-to-date information on market developments and intelligence. This unit can initiate the benchmark establishment process, communicate with market participants and central bank management, coordinate internal processes, and prepare internal and external documents and regulations.

The central bank is responsible for establishing an oversight function, such as the Oversight Committee (OC), which plays a crucial role in identifying, mitigating, and managing conflicts of interest. The central bank must develop and maintain appropriate procedures and documents regulating OC activities. This includes the OC's terms of reference, criteria for selecting and electing OC members, their head and deputy, their replacements, and declarations of any conflicts of interest by OC members.

The OC may also be tasked with developing the benchmark methodology and recommending it for approval by the central bank's decision-making body, such as the Governing Board. To ensure the credibility of the benchmark, it is advisable for the central bank to engage with market participants prior to its introduction. The OC should include representatives from the FX market community, selected by professional FX traders' associations, such as ACI,³ or directly by the treasuries of licensed banks. While the OC will not have decision-making power, it is recommended that the central bank maintain a majority in the OC's composition, with a representative from the central bank as the head.

Once the benchmark methodology is established, the OC is responsible for reviewing and overseeing all aspects of the benchmark determination process. The following tasks are involved:

- Periodic review and assessment of whether the existing benchmark definition or methodology accurately reflects the underlying market. The structure of the underlying market might change, for example, when market volume shifts to a different settlement convention (e.g., from tom/next to spot) or to a different currency pair, and the existing benchmark definition or methodology does not capture these changes.
- If changes in market structure necessitate amendments to the methodology, the OC will review proposed changes and ensure that necessary remedial actions are implemented.
- Review and recommend procedures for the termination of the benchmark to the central bank's decision-making body.
- To ensure the integrity and effectiveness of the control framework, the OC should verify adherence to the existing methodology, consider audit results, and monitor the implementation of remedial actions.
- In case of non-standard procedures for benchmark production, including using expert judgment or contingency conditions, the OC must review the cases in which the central bank exercised it.
- Review and address complaints received by the central bank regarding benchmarks.

Within the central bank, the daily benchmark determination process must be separated among business areas. While the central bank is in charge of data collection, validation, and conducting the data insufficiency test, other structural units will fulfill the roles of Calculation and Publishing Agents. This separation helps prevent the concentration of all roles within one area and mitigates potential conflicts of interest. It is also good practice for the units performing the roles of Administrator and Calculation Agent to come from different business areas and report to different deputy governors.

Benchmark calculations should preferably be performed automatically using an internal application and without discretion. When using contingency methodology, a predefined methodology must be applied, ensuring that management approval is obtained before benchmark dissemination. The procedure for contingency calculation should ensure that additional data, such as firm quotes that may complement actual transactions used for standard calculation, is received in a timely manner.

³ Association Cambiste Internationale.

J. Accountability and Transparency

Transparency regarding the benchmark framework, along with adherence to IOSCO principles, allows the central bank to meet the demand for accountability, improve the credibility of the benchmark, and stimulate wider adoption by market participants. The central bank should provide the following benchmark disclosures on its website:

- A methodology statement that includes the benchmark definition, publication time, standard and contingency computation methodologies, data insufficiency triggers, and error handling.
- Disclosure of cases when the contingency methodology is used.
- The central bank should indicate a contact email for complaints regarding the benchmark methodology. Such complaints can be considered during periodic reviews of the benchmark methodology. Complaints regarding market conduct should be escalated to the relevant authority.

An internal or external auditor should be appointed to periodically review and report on the central bank's adherence to its methodology. Given the size, level of market development, and cost considerations, it is sufficient for many emerging markets' central banks to appoint an internal auditor for this task. Additionally, the central bank might consider publishing a statement of compliance with "IOSCO principles for Financial Benchmarks" and appointing an external auditor to provide periodic assurances on this compliance statement.

The publication of the reference rate could be complemented with aggregated indicators on the market turnover. This would help reference rate users assess its representativeness. Furthermore, it would provide critical information to banks' clients about the market's liquidity, which can help them scale their FX orders to sizes that are consistent with the market turnover.

K. Prevention of Market Manipulation

In the spot foreign exchange market, economic agents' increasing awareness about transaction costs, best execution and the emergence of passive asset management strategies have given prominence to fixing orders: currency conversions initiated by banks' clients to be executed at a certain benchmark exchange rate (fixing). Accepting fixing orders results in open positions on banks' FX books and provides them with non-public information on potentially market-moving flows, which may create incentives and provide capabilities to attempt market manipulation. If the benchmark calculation methodology is not robust to concentrated market activity (i.e. point-in-time observation instead of a time window), the fixing rate can be distorted even without malicious activity.

Depending on the framework of the benchmark and the structure of the FX market, one can detect benchmark manipulation using supervisory methods or observatory methods. Supervisory methods are generally the privilege of law enforcement agencies and aim at collecting evidence on market participants' collusion activity (e.g. monitoring bilateral communication channels). Observatory methods refer to the analysis of the outcome of a possible collusion: trades (volatility and trading volume), quotes (volatility), contributions (distribution). When observing, it is difficult to distinguish between elevated market activity and market manipulation. Selecting sensitive dates (month-end, quarter-end, year-end) and times (data release/ announcement schedule) is crucial. In addition, monitoring market participants' response to changes in the benchmark design is essential for assessing whether the policy action to prevent manipulation was successful or not.

Aligning the benchmark's design and its usage is the most effective way of preventing manipulation. Either the benchmark should be made robust to manipulation efforts or market participants' motivation or

capability to manipulate it should be eliminated. Motivation for manipulation can be curbed by forcing banks to cease accepting fixing orders. This requires effective intervention in market participants' business models which can be achieved by moral suasion or regulation. Market participants' capability to manipulate can be undermined by modifying the benchmark design in ways that make manipulation infeasible, such as by lengthening the observation window.

L. Cross Rates

We define cross rates as exchange rates between two currencies not involving the dominant currency pair, which is typically against the U.S. dollar as the base currency under direct quotation. In the context of this handbook, the cross rate is the value of the local currency against another that is not the dominant currency pair and is therefore not readily available from those that are frequently traded in the domestic market. While the standard description suggests these rates help determine the value of one currency in terms of another currency directly, without involving the U.S. dollar (USD) as an intermediary, the derivation makes use of an exchange rate of a common currency, which is typically the USD. These rates are beneficial for facilitating international transactions without the USD, supporting investment decisions, managing currency risk, and identifying arbitrage opportunities.

Typically, the currency pairs of the globally convertible currency are derived from fixings in the international foreign exchange market. The most prominent example is the WM⁴/Reuters 4 pm London Fix. The currency pairs for other currencies are the official exchange rates published by the authorities in their respective jurisdictions. Care should be taken when monitoring the conventions between direct and indirect quotations when buy and sell rates are provided.

Given the illiquidity in these currency pairs, the cross rates are often only indicative rates for information, as the central bank does not trade at those rates. These rates may also be used for valuation and accounting purposes. In this case, it may be beneficial to only show the mid-rate as a guide to the level of the cross rate and as an indication of the pricing of final transactions, not for buying and selling cross rates. This communication around the cross rates should contain the methodology used, including the timings and relevance of these rates.

IV. TA Approach

Technical assistance on FX reference rates must consider the specific features of each environment. There needs to be a clear understanding of the central bank's exchange rate regime and foreign exchange, the level of market development, and any relevant regulations. The following strategy can be followed:

- Map out the relevant objectives and constraints.
- Determine the design parameters of the methodology.
- Design a data collection process, if needed.
- Draft a public policy document.

⁴ World Markets Company, which was later acquired by Thomson Reuters.

A. Map Out the Relevant Objectives and Constraints

The first task of the technical assistance mission should be to perform a quantitative and qualitative evaluation of the foreign exchange market's development. Quantitative assessment should be based on granular, ideally transaction-level data. The objective is to assess the importance of various market segments (foreign exchange bureaus, dealer-to-customer segment, and the interdealer segment) in determining the market clearing price. In addition, it is pivotal to gain a clear picture of the parallel market—its volume, exchange rate spread, and participants. This is often only possible by a qualitative assessment based on surveys or anecdotal evidence. Established market participants (both market makers and their clients) need to be surveyed too. This survey should cover the indicators (qualitative and quantitative) of market functioning.

The next task of the mission should be to explore the potential and actual use of the reference rates. This process should start with the review of the legal and regulatory framework. This effort should be supported by interviewing the central bank's subject matter experts. Then, to understand the actual usage of the reference rate, the representatives of all relevant stakeholders should also be interviewed. In addition, targeted questions should be included in the surveys mentioned above.

Based on the assessed level of market development and the actual and potential use of the reference rate, the objectives and constraints of the reference rate framework should be set. This should result in the proportionate interpretation and appropriate prioritization of the key principles of representativeness, reliability, and replicability. This will eventually inform the design of the methodology and other key elements of the framework.

B. Determine the Design Parameters of the Methodology

The starting point for framework design is the selection of a reference rate model, as outlined in Section III.A. In principle, central banks should seek to adopt the model that delivers the most robust and representative rate, considering the prevailing market conditions and their willingness to rely on contingency methodologies in cases of insufficient data. The fixing session model is appropriate where interbank FX markets are structurally absent, and price discovery must be actively facilitated by the central bank through organized trading sessions. The panel-based quote model is suitable for markets with some interbank activity but limited transaction data, where central banks can rely on a panel of banks for indicative quotes, particularly early in the trading session to support price discovery. The point-in-time observation model is best suited to markets with continuous and liquid trading throughout the day, where reliable and executable prices can be observed on trading platforms at any moment without significant risk of manipulation. The full-day transaction-weighted model is most appropriate for markets with intermittent or shallow liquidity, where capturing the full range of transactions across the trading session helps mitigate the impact of intraday volatility and manipulation. In some cases, particularly at intermediate stages of market development, a hybrid approach that combines elements of different models may be warranted, subject to institutional capacity and operational feasibility.

The foundation of designing the various parameters is to back-test historical data. This should cover the scope of eligible transactions, any transaction size thresholds, the sample window, the central tendency estimators, as well as the choice between publishing only a single mid-rate or also publishing buying and selling rates. This approach should also apply to setting the data sufficiency criteria and the prioritization of contingency calculation methods. The objective is not to choose the setting that results in the most stable reference rate but to strike the right balance between representativeness, robustness, and replicability.

C. Design Data Collection Process If Needed

Reliable data quality is a common requirement for all frameworks, but it is especially important in relatively illiquid markets. In these markets, it is often necessary to collect and manage granular data from entities with limited technological capacity and vulnerable infrastructure. To help achieve a sufficient degree of standardization, a common reporting template should be used across all reporting entities. This reporting template should be granular enough to enable the filtering and cross-checking of the reported data. Appendix I provides an example of such a reporting template.

As many central banks operate in an institutional environment that may give rise to outside pressure or internal conflict between policy priorities, the risk of internal exchange rate manipulation must be eliminated. The robustness of the internal data management procedure is also pivotal in this. To this end, the data management process must include access control, audit trail, and data retention arrangements. This way, legitimate data cleaning or error handling can be distinguished from potential manipulation attempts during regular internal audits.

D. Produce a Public Policy Document

The credibility of the framework can be best supported by transparency and accountability on the part of the central bank. A public policy document outlining the governance and methodological arrangements is a powerful tool to achieve this. Such a document should explain how the main decision-making body exercises its responsibility to keep the methodology appropriate and to ensure that it is implemented by the central bank's operational functions. The methodology should be comprehensive and detailed enough to enable an effective audit of the process. The document should also include error handling and communication procedures as well as consultation arrangements with stakeholders.

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Appendix I. Calculation of Various Central Tendency Estimators

The below Python code calculates various central tendencies on historical FX transaction data.

```
import pandas as pd

def central_tendencies(data):
    # Sort data by price
    data = data.sort_values(by='price')

    # Simple average
    simple_avg = data['price'].mean()

    # Trimmed Simple average (remove top and bottom 25%)
    trimmed_data = data.iloc[int(len(data)*0.25):int(len(data)*0.75)]
    trimmed_simple_avg = trimmed_data['price'].mean()

    # Weighted average
    total_weight = data['weight'].sum()
    weighted_avg = (data['price'] * data['weight']).sum() / total_weight

    # Trimmed weighted average
    trimmed_weight = trimmed_data['weight'].sum()
    trimmed_weighted_avg = (trimmed_data['price'] * trimmed_data['weight']).sum() /
    trimmed_weight

    # Weighted median
    cumulative_weight = 0
    for index, row in data.iterrows():
        cumulative_weight += row['weight']
        if cumulative_weight >= total_weight / 2:
            weighted_median = row['price']
            break
    return pd.Series({
        'simple_avg': simple_avg,
        'trimmed_simple_avg': trimmed_simple_avg,
        'weighted_avg': weighted_avg,
        'trimmed_weighted_avg': trimmed_weighted_avg,
        'weighted_median': weighted_median
    })

# Import data from CSV file. Assume the CSV file is named "input_data.csv" and has
columns "date", "price", and "weight"
data = pd.read_csv('input_data.csv')

# Group data by date and apply central_tendencies function
result = data.groupby('date').apply(central_tendencies).reset_index()

# Export the result to a new CSV file. The resulting file will be named
"output_central_tendencies.csv"
result.to_csv('output_central_tendencies.csv', index=False)
```

Appendix II. An Example for an FX Transaction Reporting Template

Reporting Requirements. Provide historical data (for the last three months). Going forward, please submit new data on a daily basis, by noon on the working day following the trade date.

- **Trade date:** the date of the trade.
- **Transaction time:** the time of the transaction (hour, minute, second)
- **Value date:** the settlement date of the trade, in the case of a swap trade, the settlement date of the initial leg of the trade.
- **Transaction type:** the type of transactions reported.
 - SP: spot conversions concluded by the reporting entity,
 - FW: forward transactions concluded by the reporting entity,
 - SW: swap transactions concluded by the reporting entity.
- **Name of reporting entity**
- **Counterparty ID:** a unique ID of the counterparty that includes the following.
 - the counterparty's residency
 - resident
 - non-resident
 - the counterparty's sector
 - banks,
 - foreign exchange bureaus,
 - NBFIs,
 - non-financial corporates,
 - others.
- **Purchased currency:** the ISO code of the purchased currency, in the case of a swap trade, the currency of the initial leg's buy side.
- **Purchase amount:** the amount of the purchased currency, in the case of a swap trade, the purchased amount at the initial leg.
- **Sold currency:** the ISO code of the sold currency, in the case of a swap trade, the currency of the initial leg's sell side.
- **Sold amount:** the amount of the currency sold, in the case of a swap transaction, the amount sold at the initial leg.
- **Swap forward value date:** the settlement date of the forward leg of the swap transaction.
- **Swap forward purchase amount:** the purchase amount of the forward leg of the swap transaction.
- **Swap forward sale amount:** the sale amount of the forward leg of the swap transaction.