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Could Transaction-Based Financial Benchmarks be Susceptible to Collusive Behavior?

Lilian Muchimba

Abstract: Prior to the series of manipulation scandals, financial benchmarks were perceived as a competitive and objective reflection of underlying money markets. For example, the manipulation of the London Interbank Offered Rate (LIBOR), underpinning financial contracts worth trillions of dollars was unthinkable. To prevent manipulation, financial market regulators around the world have recommended a paradigm shift from estimation-based to transaction-based financial benchmarks. This shift is based on the mainstream economic view that financial benchmarks anchored on actual transactions are not susceptible to anticompetitive behavior. However, unlike auction markets, underlying interbank money markets have unique features. As most activity takes place over the counter, they are opaque and are governed by conventions, trust, and reciprocity. This complicates the achievement of competitive pricing. Using a novel dataset from Bank of Zambia, this article makes an empirical investigation into transaction-based benchmarks' susceptibility to anticompetitive behavior. Additionally, it contributes to the theoretical understanding of transaction-based financial market benchmarks. The study reflects on financial market regulators' recommendation to transit from estimation-based to transaction-based financial market benchmarks. Further, the study is of interest to central bankers, as short-term interbank rates are the first stage of the monetary transmission mechanism..

Keywords: Bank of Zambia, banks, collusion, LIBOR, monetary transmission mechanism, reference rates

JEL Classification Codes: B52, E43, E52, G15, G28

The publication of the London Interbank Offered Rate (LIBOR), the most widely referenced benchmark[1] is not guaranteed beyond December 31, 2021. The cessation follows the manipulation of the LIBOR in 2012 and structural changes in underlying money markets during the 2007/2008 global financial crisis. In 2014, the Federal Reserve Board and the New York Fed convened the Alternative Reference Rates Committee (ARRC) charged with the responsibility to identify a more robust transaction-based benchmark to replace the United States Dollar LIBOR. The effort to transit to an alternative rate accelerated in 2017, when the United Kingdom regulator, the Financial Conduct Authority announced that banks will not be compelled to submit LIBOR rates beyond December 31, 2021.

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[1] As at mid-2018, LIBOR underpinned approximately US$ 400 trillion worth of financial contracts (Schrimf and Sushko 2019).

In June 2017, the ARRC identified the Secured Overnight Financing Rate (SOFR) as an alternative to the U.S. Dollar LIBOR (Alternative Reference Rate Committee 2019). The SOFR is a transaction-based rate that measures "the cost of borrowing cash overnight collateralized by Treasury securities." (Federal Reserve Bank of New York 2021a). Similarly, efforts are underway in several jurisdictions to shift to alternative transaction-based rates. For example, UK, Switzerland, Europe, and Japan are shifting to Sterling Overnight Index Average (SONIA), Swiss Average Rate Overnight (SARON), Euro Short-term Rate (€STR), and Tokyo Overnight Average Rate (TONAR), respectively. The efforts in various jurisdictions demonstrate the critical role of financial benchmarks in the economy.

First, reference rates provide a standardized way of pricing financial products and thereby lower transaction costs and promote liquidity (Federal Reserve Bank of New York 2021b). Second, they facilitate risk management through pricing of other financial instruments such as student loans, mortgages, and derivatives. Specifically, to manage funding risk, banks peg some of their financial products to interbank rates. This is because they are assumed to represent a significant source and cost of banks' funding (BIS 2013). Third, reference rates give an indication of investment performance.

Fourth, from a policy perspective, short-term interbank rates are the first step of central banks' monetary transmission mechanism. This is the process by which central banks achieve their economic output and inflation objectives. Central banks achieve this through their direct influence on interest rates given their monopoly power as issuers of money (European Central Bank 2021). Most central banks especially inflation-targeting economies have institutionalized this logic in their monetary policy making (Muchimba and Stenfors 2021).

Prior to the series of manipulation scandals in 2012, reference rates were perceived as an objective reflection of competitive conditions in underlying money markets (Stenfors and Lindo 2018). Therefore, manipulation of the LIBOR and similar benchmarks was unthinkable. However, banks were "low balling" rates to signal their creditworthiness and profit from their large derivative positions (Duffie and Stein 2015).

This led to various banks and brokers being fined penalties around the world. For example, Barclays was fined $200 million by the U.S. Commodities Futures Trading Commission, £59.5 million by the U.K. Financial Services Authority and $160 million by the U.S. Department of Justice for manipulation of interest rate benchmarks (United States Commodities Future Trading Commission 2012; Financial Services Authority 2012; United States Department of Justice 2012). Further, the Swiss Competition Commission imposed total fines of approximately Swiss Franc (CHF) 45.3 million on Barclays and Deutsche, Société Générale, and Royal Bank of Scotland for unlawful collusion between derivatives traders that may have influenced the Euribor (Swiss Competition Commission 2016).

To understand how financial benchmarks were manipulated, it is fundamental to highlight their calculation methodology. Up until recently, most interbank rates employed estimation-based methodologies which involved contributors submitting rates they "perceived" representative of competitive underlying market conditions. For instance, LIBOR was calculated by Thomson Reuters on behalf of the British Bankers Association, as a trimmed arithmetic mean of rates submitted by banks based on the criteria: "The rate at which an individual contributor panel bank could borrow funds, were it to do so by asking for and then accepting interbank offers in reasonable market size, just prior to 11.00am London time" (British Bankers Association 2012). This provided a window for selected panel banks to submit manipulated rates. Therefore, the reliability of the LIBOR was questioned.

Consequently, the new international paradigm points towards adoption of transaction-based benchmarks that meet attributes of a good benchmark: reliability, robustness and resilience, usability, transparency and representativeness (IOSCO 2013). Specifically, the "reliability" attribute entails that benchmarks should not be susceptible manipulation and/or collusion.

Theoretical Perspective of Price Fixing Conspiracies and the LIBOR Manipulation Evidence

The paradigm shift from estimation-based to transaction-based benchmarks is based on the mainstream economic view that the latter are reflective of competitive underlying money market conditions. However, according to Adam Smith, "the father of economics," price fixing conspiracies (collusion) can arise because: "People of the same trade seldom meet together even for merriment and diversion, but the conversation ends in a conspiracy against the public or contrivance to raise prices" (Adam Smith [1776] 1976, 145).

This view supports the recent evidence of interest rate benchmark manipulation scandals across the world. Manipulation of the LIBOR and similar benchmarks was achieved through internal (within panel banks) and external (between panel banks and brokers) communication. Internally, derivatives traders communicated with submitters of money market information, to submit rates favorable to their derivative positions. For example, according to the Financial Services Authority (2012), the Barclays evidence revealed that on March 13, 2006, the following email exchange took place internally between a derivatives trader and submitter of money market information:

> *Derivatives Trader: The big day [has] arrived . . . My NYK are screaming at me about an unchanged 3m libor. As always, any help wd be greatly appreciated. What do you think you'll go for 3m?*
>
> *Submitter: I am going 90 altho 91 is what I should be posting.*
>
> *Derivatives Trader: [...] when I retire and write a book about this business your name will be written in golden letters [. . .].*
>
> *Submitter: I would prefer this [to] not be in any book!*

And externally, according to the Final Notice (2012) on October 26, 2006, an external trader requested Barclays for a lower three-month U.S. LIBOR submission. The external trader stated in an email to Trader G at Barclays "If it comes in unchanged I'm a dead man." Trader G responded that he would "have a chat." Barclays' submission (three-month US dollar LIBOR) on that day was half-basis point lower than the day before, rather than being unchanged. The external trader appreciated Trader G for Barclays' LIBOR submission later that day: "Dude. I owe you big time! Come over one day after work and I'm opening a bottle of Bollinger."

Whereas this evidence applies to estimation-based benchmarks, communication to conspire against prices can still be achieved in actual money markets. The unique features of underlying money markets make actual rates susceptible to collusion and/or manipulation.

Unique Features of Money Markets

Underlying money markets possess unique features. First, they are governed by conventions where trust and reciprocity are critical. Money market dealers share trading floors or dealing rooms with foreign exchange dealers. As deals are executed over the counter (OTC), they are governed by the Association Cambiste Internationale (ACI) or the Financial Markets Association Model code. The model code published since 1955 plays a significant role in organization of interbank trading and liquidity provision (Stenfors 2020). These rules have been passed on from previous generations of market makers and thus are a product of past processes (Veblen [1899] 1957, 190–191).

The ACI Model Code (Financial Markets Association 2015, 103–104) states that:

> Bilateral reciprocal dealing relationships are common in the OTC markets and often extend to unwritten understandings between Dealers to quote firm two-way dealing prices. These usually evolve as a result of regular business in specific products.

This reality is in line with the Post Keynesian theoretical perspective which underscores the role of uncertainty in decision making. As John Maynard Keynes (1936, 162–163) states, "human decisions affecting the future [. . .] cannot depend on strict mathematical expectation." This characteristic of the money market makes it susceptible to manipulation. Further, these conventions have been institutionalized and play a fundamental role in the price determination process of in OTC markets (Stenfors 2018).

Second, unlike auction markets, interbank money markets are opaque and have limited transparency. As trades are bilateral, information is confidential and not often available to the public. When published, it is often aggregated and published with a lag. This limits the amount of information available to banks to price the funds competitively.

These unique features lead to a testable hypothesis that: "transaction-based benchmarks are also susceptible to anti-competitive behavior (manipulation)." While this hypothesis is critical, studies based on "real rates" are limited. This is not surprising given the scarcity of this data due to the OTC nature and confidentiality issues surrounding it.

Data and Methodology

This study takes advantage of novel actual transactions data from Bank of Zambia (BOZ) to test this hypothesis. Daily unsecured overnight interbank data comprising of interest rates, counterparties, and interest rates is used. As the case in other markets, there is concentration of liquidity in the overnight (O/N) tenor. To this effect, the study uses the Zambian Kwacha (ZMW) O/N maturity category for the period April 4, 2012 to December 31, 2020.

The Zambian interbank money market is a miniscule relative to other markets. However, the structure is similar other markets (Muchimba and Stenfors 2021). Like other OTC markets, it benefits from spillover regulation (ACI Global Code) from the foreign exchange market (Chipili et al. 2019). Second, similar to other inflation targeting economies, Zambia has institutionalized the monetary transmission mechanism in its policy making process. Zambia revised its monetary operational framework and shifted from monetary targeting to interest rate targeting in April 2012 (Bank of Zambia 2012).

To empirically test the susceptibility of the data to anticompetitive behavior, the study employed Benford's Law, a mathematical screening methodology employed by anti-trust authorities to screen data for anomalies. In a recent study, Rosa Abrantes-Metz, Sofia

Villas-Boas, and George Judge (2011) recommend and apply Benford's Law[2] Second Digit distribution to detect anticompetitive behavior on the USD 1-month LIBOR.

Given a random dataset, the general intuition is that the probability of digits 1 and 9 belonging to the set d = {1, 2, … ,9} occurring is (1/9) or 11.11%. However, according to Frank Benford (1938), the probability of the lower first digits, for example, digits 1 and 2 occurring are higher. For example, the probability of the first lower digit 1 occurring is 30% while the probability of the subsequent digits is lower. Benford tested various datasets including areas of lakes, lengths of rivers and molecular weights of pounds, and found that these datasets complied with Benford's Law. This study applies Benford's second and third digits probability distributions given by equations (1) and (2) below:[3]

$$Prob(D_2 = d_2) = \sum_{k=1}^{9} log_{10}\left[1+\left(10k+\frac{1}{d_2}\right)\right]: d_2 \in \{0,1,2,\ldots 9\} \quad (1)$$

The expected distribution for all subsequent digits (nth position when n >1), the probability to observe a digit is given below:

$$Prob = (D_n = d) = \sum_{k=10^{n-2}}^{10^{n-1}-1} log_{10}\left[1+\frac{1}{10k+d}\right]: d \in \{0,1,2,\ldots,9\} \quad (2)$$

To deal with the stickiness of interbank rates due to central bank influence, deviations from the BOZ Policy rate (Target rate) are used. Further, in line with Mark Nigrini (2012), empirical tests on positive and negative deviations are seperated. A violation of Benford's Law[4] implies that the data could have been tampered with, and therefore the susceptibility to anticompetitive behavior (manipulation).

Susceptibility to Anticompetitive Behavior

Table 1 below shows that the empirical distribution (positive deviations from the BOZ Policy Rate) deviates significantly from the expected second digit distribution (Benford's Law).

Table 1. Second Digit Expected and Empirical Distributions for the Unsecured ZMW O/N Positive Interest Rate Deviations, April 4, 2012–December 31, 2020

Digit	Benford's Law	Bank A	Bank C	Bank D	Bank E	Bank F	Bank H	Bank I	Bank J	Bank N	Bank O
0	11.97%	0.00%	14.29%	37.14%	24.07%	31.46%	18.13%	25.86%	38.92%	12.79%	11.54%
1	11.39%	25.00%	0.00%	5.71%	4.56%	21.00%	8.75%	14.66%	4.32%	17.44%	15.38%
2	10.88%	16.67%	65.71%	34.29%	19.92%	12.42%	20.63%	15.23%	14.59%	18.02%	16.67%
3	10.43%	2.78%	0.00%	0.00%	7.88%	2.95%	9.38%	6.32%	3.78%	15.12%	1.28%
4	10.03%	0.00%	0.00%	0.00%	5.39%	7.15%	7.50%	4.89%	2.16%	8.72%	14.10%
5	9.67%	11.11%	2.86%	11.43%	12.86%	12.96%	9.38%	6.03%	31.89%	15.70%	6.41%
6	9.34%	0.00%	0.00%	0.00%	0.83%	1.70%	1.25%	4.89%	1.62%	2.91%	12.82%
7	9.04%	5.56%	17.14%	11.43%	11.62%	6.43%	21.25%	8.33%	1.62%	4.07%	11.54%
8	8.76%	5.56%	0.00%	0.00%	4.98%	2.32%	2.50%	8.33%	0.00%	1.16%	7.69%
9	8.50%	5.56%	0.00%	0.00%	7.88%	1.61%	1.25%	5.46%	1.08%	4.07%	2.56%
Obs		36	35	35	241	1,119	160	348	185	172	78
x^2		24.82	121.54	53.95	91.12	723.92	75.89	96.45	287.73	51.68	16.8

Source: Bank of Zambia and author's calculations
Notes: Obs=Observations x^2 =Chi-Square

[2] This method has been used in various field to detect suspicious behavior (Varian 1972; Giles 2007)

[3] The study uses the second and third digits as interbank market data is sticky and therefore unlikely to follow Benford's Law. This is because they are highly influenced by central bank actions (Stenfors 2018)

[4] To allow for accurate comparisons between the expected and empirical distributions, a chis-square value is calculated and compared to critical values of 21.67, 16.92, ad 14.68 at 1%, 5% and 10%, respectively. If the chi-square value > critical value, then the hypothesis that the empirical and expected distributions are similar is rejected.

Similarly, third digit distributions of the positive spreads from the BOZ Policy Rate do not comply with Benford's Law, as shown in table 2 below.

Table 2. Third Digit Expected and Empirical Distributions for the Unsecured ZMW O/N Positive Interest Rate Deviations, April 4, 2012–December 31, 2020

Digit	Benford's Law	Bank A	Bank C	Bank D	Bank E	Bank F	Bank H	Bank I	Bank J	Bank N	Bank O
0	10.18%	61.11%	17.14%	51.43%	49.18%	55.38%	57.93%	45.56%	70.09%	40.46%	58.23%
1	10.14%	5.56%	0.00%	0.00%	3.28%	2.56%	3.05%	1.68%	6.70%	11.56%	2.53%
2	10.10%	0.00%	0.00%	0.00%	0.41%	1.19%	0.61%	0.72%	0.00%	5.78%	1.27%
3	10.06%	0.00%	0.00%	0.00%	1.23%	1.11%	0.61%	0.96%	0.00%	0.58%	3.80%
4	10.02%	0.00%	0.00%	0.00%	0.00%	1.19%	0.61%	3.12%	0.00%	1.16%	2.53%
5	9.98%	22.22%	82.86%	45.71%	40.16%	29.10%	34.76%	39.09%	17.86%	28.90%	22.78%
6	9.94%	11.11%	0.00%	2.86%	5.74%	5.29%	1.22%	6.71%	1.79%	5.78%	1.27%
7	9.90%	0.00%	0.00%	0.00%	0.00%	1.37%	0.61%	1.20%	1.79%	1.16%	1.27%
8	9.86%	0.00%	0.00%	0.00%	0.00%	2.05%	0.61%	0.96%	1.34%	3.47%	0.00%
9	9.83%	0.00%	0.00%	0.00%	0.00%	0.77%	0.00%	0.00%	0.45%	1.16%	6.33%
Obs		36	35	35	244	1,172	164	417	224	173	79
x^2		119.48	215.9	129.54	750.62	3,570.34	591.79	1,329.10	1,147.03	288.99	233.98

Source: Bank of Zambia and author's calculations
Notes: Obs=Observations x^2 =Chi-Square.

Considering the negative deviations from the BOZ Policy rate, table 3 below shows non-compliance of the second digit empirical distribution with Benford's Law.

Table 3. Second Digit Expected and Empirical Distributions for the Unsecured ZMWO/N Negative Interest Rate Deviations, April 4, 2012–December 31, 2020

Digit	Benford's Law	Bank C	Bank E	Bank F	Bank H	Bank I	Bank J	Bank N
0	11.97%	7.81%	15.42%	15.72%	17.24%	15.09%	22.41%	41.46%
1	11.39%	0.00%	10.45%	5.69%	10.34%	8.49%	6.90%	4.88%
2	10.88%	46.88%	18.91%	29.54%	23.28%	16.98%	6.90%	17.07%
3	10.43%	0.00%	7.96%	8.94%	10.34%	3.77%	5.17%	2.44%
4	10.03%	1.56%	8.96%	2.98%	6.90%	7.55%	1.72%	0.00%
5	9.67%	25.00%	18.41%	14.63%	17.24%	21.70%	31.03%	9.76%
6	9.34%	0.00%	4.98%	5.69%	0.86%	4.72%	5.17%	0.00%
7	9.04%	18.75%	10.45%	12.74%	8.62%	8.49%	10.34%	21.95%
8	8.76%	0.00%	2.49%	4.07%	3.45%	8.49%	6.90%	2.44%
9	8.50%	0.00%	1.99%	0.00%	1.72%	4.72%	3.45%	0.00%
Obs		64	201	369	116	106	58	41
x^2		134.92	54.93	212.87	46.14	30.55	43.24	56.15

Source: Bank of Zambia and author's calculations
Notes: Obs=Observations x^2 =Chi-Square.

Similarly, the third digit empirical distribution (negative deviations) does not comply with Benford's Law as shown in table 4 below.

Table 4. Third Digit Expected and Empirical Distributions for the Unsecured ZMW O/N Negative Interest Rate Deviations, April 4, 2012–December 31, 2020

Digit	Benford's Law	Bank C	Bank E	Bank F	Bank H	Bank I	Bank J	Bank N
0	10.18%	34.38%	50.75%	35.50%	64.10%	58.49%	72.58%	39.02%
1	10.14%	0.00%	6.97%	7.05%	8.55%	8.49%	0.00%	2.44%
2	10.10%	0.00%	0.50%	0.54%	0.00%	0.00%	0.00%	2.44%
3	10.06%	0.00%	0.00%	0.81%	0.85%	0.00%	0.00%	0.00%
4	10.02%	0.00%	0.00%	0.81%	0.00%	0.00%	0.00%	0.00%
5	9.98%	65.63%	36.82%	47.43%	22.22%	27.36%	24.19%	34.15%
6	9.94%	0.00%	4.48%	7.05%	4.27%	3.77%	0.00%	19.51%
7	9.90%	0.00%	0.00%	0.27%	0.00%	0.94%	3.23%	0.00%
8	9.86%	0.00%	0.00%	0.00%	0.00%	0.94%	0.00%	0.00%
9	9.83%	0.00%	0.50%	0.54%	0.00%	0.00%	0.00%	2.44%
Obs		64	201	369	117	106	62	41
x^2		286.51	594.34	956.86	427.59	339.05	316.6	84.69

Source: Bank of Zambia and author's calculations
Notes: Obs=Observations x^2=Chi-Square.

Conclusion and Policy Implications

Contrary to the mainstream economic view that actual interbank rates are reflective of underlying money market conditions, empirical results show non-compliance of actual overnight interbank data with Benford's Law (second and third digit distributions). While this is not evidence of actual manipulation, it shows that the data does not reflect competitive conditions in underlying markets, and is therefore susceptible to collusion and/or manipulation. This evidence demonstrates the challenges of achieving competitive prices due to the unique features of money markets. The informal rules governing these markets encourage trust and reciprocity. In line with Alexis Stenfors (2018), while conventions are critical in maintaining liquidity in the market, there is a trade-off between liquidity provision and the achievement of competitive pricing. Further, the opaqueness of interbank markets presents challenges in the achievement of competitive pricing. Since trades are agreed bilaterally, and thereby confidential, there is limited information available to achieve competitive pricing in the market.

From a policy perspective, countries normally adopt international best practice. Currently, the international paradigm shift points to transaction-based financial benchmarks, as seen by the U.S. adoption of the SOFR. While this is a good step towards a more robust financial benchmark, it is critical for policy makers and regulators around the world to remain vigilant on the transaction-based financial benchmarks. Consequences of undetected collusion and/or manipulation could lead to transmitting unintended signals to the rest of the economy.

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