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Interbank rate fixings during the recent turmoil[1]

The turmoil in global interbank markets in the second half of 2007 raises questions about the robustness of interbank rate fixings. A comparison of alternative fixings for similar interest rates confirms that they diverged to an unusual extent. Nevertheless, the design of fixing mechanisms worked as intended to moderate the influence of strategic behaviour and changing perceptions of credit quality.

JEL classification: F30, G12, G15.

The evaporation of liquidity in the term segment of major interbank markets in the second half of 2007 raises questions about the reliability of rate fixings purported to represent conditions in these markets. Financing for terms of more than a few days was reportedly not readily available at some commonly referenced interest rates, such as the London interbank offered rate (Libor). A comparison of alternative fixings for similar interest rates confirms that, during the recent turbulence, Libor diverged from other reference rates to an unusual extent. A deterioration in market liquidity, an increase in interest rate volatility and differences in the composition of the contributor panels were the main causes of the divergence. Nevertheless, the design of the fixing mechanism moderated the influence of extreme quotes from contributor banks, as intended.

Below, we first discuss the role of money market benchmarks in financial markets. The following section compares the design of different interbank fixings and considers the incentives banks face to contribute accurate quotes. We then examine the influences on fixings during the market turmoil in the second half of 2007. The final section concludes.

The role of money market benchmarks

Money market rates are referenced in many financial contracts

Short-term interest rates are referenced in a wide variety of financial contracts. Well established benchmarks are therefore critical to the efficient functioning of markets in these instruments. However, the importance of benchmarks for

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short-term interest rates goes well beyond their use in contracts. They anchor the short end of the yield curve, thereby conveying information about expected future policy rates and other macroeconomic fundamentals.

The use of money market rates to price other financial instruments dates back to at least the 1970s. The pickup as well as the variability in inflation at the time made long-term fixed rate securities unattractive to investors. In response, floating rate bonds were introduced with coupon payments linked to money market rates plus a credit spread. The syndicated loan market, which began to grow around the same time, adopted a similar pricing mechanism (Gadanecz (2004)).

The terms of many financial derivatives also make explicit reference to money market rates. Futures contracts on money market rates were the first to emerge. Their over-the-counter equivalent, forward rate agreements, were developed in the early 1980s, along with interest rate swaps (Stigum and Crescenzi (2007)). Numerous other derivatives linked to money market rates followed, including swaptions, cross-currency swaps and asset swaps.

Even for instruments not contractually linked to them, money market rates have an important impact on market functioning. For example, forward foreign exchange contracts are priced off of money market rates. The discount rates used in a wide variety of cash flow models, such as those used to estimate the fair value of bonds or equities, are typically based on money market rates.

There are a range of money market rates that could serve as references, including Treasury bill, interbank, repo and commercial paper rates. Typically only one will be elevated to the status of benchmark, and that will tend to be the rate with the most stable relationship to the prices of other securities. A key requirement of a benchmark is that it be liquid. Movements in benchmark yields should not be driven by order imbalances but rather should exclusively reflect new information about fundamentals (Wooldridge (2001)). Benchmark yields need not be risk-free rates. Indeed, interest rates with a small credit risk premium might be more effective hedging and positioning vehicles because they are closer approximations of the rates faced by financial institutions. However, the risk premia in benchmark yields need to be predictable if the yields are to be a stable reference for pricing.

Benchmark status is gained through competition

Benchmark status is gained through competition; it is not conferred. Therefore, it can also be lost. Persistent pricing anomalies limit the usefulness of a benchmark as a hedging or positioning vehicle. This may result in a switch to an alternative reference rate. Each participant who switches subtracts liquidity from the established benchmark and adds liquidity to its competitor. In the self-reinforcing process whereby liquid markets become more liquid, this makes it more attractive for others to do likewise.

Such a process of benchmark tipping occurred in the US dollar money market in the mid-1980s (McCauley (2001)). US Treasury bills were once the pre-eminent short-term reference rate. When derivatives based on offshore interbank rates were introduced, financial institutions found that their prices more closely approximated their own borrowing costs. Periodic large changes in the supply of Treasury bills and associated breakdowns in normal pricing relationships strengthened the incentive for market participants to re-examine

their risk management practices. By the late 1980s, three-month Libor was well established as the benchmark rate in the US dollar money market.

The design of interbank rate fixings

Libor is the best known fixing arrangement

An interbank rate is the rate of interest paid on a loan from one bank to another. Typically the market rate is estimated through a "fixing" arrangement, wherein an average rate is calculated from quotes contributed by a panel of banks. The best known fixing arrangement is that for Libor. Compiled by the British Bankers' Association (BBA), Libor refers to the interest rate at which banks in London offer to lend funds to each other just prior to 11:00 local time.[2] The BBA collects quotes from a panel of banks. Quotes are ranked in order, the top and bottom quartiles are disregarded, and the middle two quartiles are averaged to compute Libor. At present, Libor is fixed for 15 different maturities, from overnight to 12 months, in 10 international currencies.[3]

Similar fixing arrangements exist in markets around the world (Table 1). Although these copy many features of Libor, there are some important differences: the liquidity of the market, the composition of the contributor panel, the type of rate quoted and the design of incentives to contribute accurate quotes. These differences influence the representativeness of the fixing and can result in systematic discrepancies between rate fixings in the same currency.

Market liquidity

Liquidity is arguably the most important determinant of whether rate fixings accurately represent conditions in money markets. In countries where other segments are more liquid than the interbank market, interbank fixings have struggled to emerge as money market benchmarks. That said, the advantages of referencing an interest rate based on banks' borrowing costs are such that in most cases the alternative is a close substitute for an interbank loan.

One simple indicator of market participants' perceptions of the most liquid segment in money markets is the reference rate in interest rate swaps (IRSs). Whereas IRSs for US dollars and most other major currencies reference interbank fixings, those for a number of Asia-Pacific currencies reference other rates (Table 1). In Australian dollar IRSs, the floating rate leg is linked to banks' expectations of where bank bills will trade. In most Philippine peso, Singapore dollar and Thai baht IRSs, the floating rate leg is linked to the interest rate implied by foreign exchange swaps. Chinese renminbi IRSs typically reference the onshore seven-day repo rate.

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[2] The current instructions from the BBA state: "An individual BBA Libor Contributor Panel Bank will contribute the rate at which it could borrow funds, were it to do so by asking for and then accepting inter-bank offers in reasonable market size just prior to 1100".

[3] The Australian dollar, the Canadian dollar, the Danish krone, the euro, the Japanese yen, the New Zealand dollar, the pound sterling, the Swedish krona, the Swiss franc and the US dollar.

Features of selected money market fixings

Currency	Fixing	Onshore/ offshore rate?	Panel composition		Average	Type of quote	Bench-mark tenor[3]	IRS reference rate?[4]
			Size[1]	Foreign banks[2]				
AUD	Libor	Offshore	8	6	Trimmed	Non-binding	3-month	No
	Bank bills	Onshore	14	8	Trimmed	Non-binding	3-month	Yes
CAD	Libor	Offshore	12	9	Trimmed	Non-binding	3-month	Yes
	Bank bills	Onshore	9	3	Trimmed	Non-binding	3-month	No
CNY	Chibor	Onshore	. . .	. . .	. . .	Transacted	7-day	No
	Shibor	Onshore	16	3	Untrimmed	Non-binding	7-day	No
	Repo	Onshore	. . .	. . .	Untrimmed	Non-binding	7-day	Yes
DKK	Libor	Offshore	8	8	Trimmed	Non-binding	3-month	No
	Cibor	Onshore	12	5	Trimmed	Non-binding	6-month	Yes
EUR	Libor	Offshore	16	11	Trimmed	Non-binding	3-month	No
	Euribor	Onshore	45	–	Trimmed	Non-binding	6-month	Yes
HKD	Hibor	Onshore	20	14	Trimmed	Non-binding	3-month	Yes
IDR	Jibor	Onshore	18	7	Untrimmed	Non-binding	3-month	No
INR	Mibor	Onshore	33	7	Trimmed	Non-binding	Overnight	Yes
JPY	Libor	Offshore	16	12	Trimmed	Non-binding	6-month	Yes
	Tibor	Onshore	16	1	Trimmed	Non-binding	3-month	No
KRW	Koribor	Onshore	14	4	Trimmed	Non-binding	3-month	No
	CD rate	Onshore	10	. . .	Trimmed	Transacted	3-month	No
MYR	Klibor	Onshore	11	6	Untrimmed	Non-binding	3-month	Yes
NZD	Libor	Offshore	8	8	Trimmed	Non-binding	3-month	No
	Bank bills	Onshore	7	7	Trimmed	Non-binding	3-month	Yes
PHP	PHIREF	Offshore	. . .	. . .	Untrimmed	Transacted	3-month	Yes
	Phibor	Onshore	17	8	Untrimmed	Non-binding	3-month	No
SGD	Sibor	Onshore	13	10	Trimmed	Non-binding	6-month	No
	SOR	Onshore	. . .	. . .	Trimmed	Non-binding	6-month	Yes
THB	THBFIX	Offshore	13	14	Trimmed	Non-binding	6-month	Yes
	Bibor	Onshore	16	7	Trimmed	Non-binding	3-month	No
USD	Libor	Offshore	16	13	Trimmed	Non-binding	3-month	Yes
	Sibor	Offshore	15	12	Trimmed	Non-binding	3-month	No
	H.15	Offshore	Broker prices		. . .	Binding	3-month	No

Libor = London interbank offered rate (IBOR); AUD bank bills = bank bill swap reference rate; CAD bank bills = bankers' acceptance rate; Chibor = China IBOR; Shibor = Shanghai IBOR; Cibor = Copenhagen IBOR; Euribor = euro IBOR; Hibor = Hong Kong IBOR; Jibor = Jakarta IBOR; Mibor = Mumbai IBOR; Tibor = Tokyo IBOR; Koribor = Korea IBOR; KRW CD rate = 90-day CD rate published by the Korean Securities Dealers Association; Klibor = Kuala Lumpur IBOR; NZD bank bills = 90-day bank bill reference rate; PHIREF = PHP interest rate derived from USD/PHP foreign exchange swaps; Phibor = Philippine IBOR; Sibor = Singapore IBOR; SOR = swap offer rate implied by USD/SGD foreign exchange swaps; THBFIX = THB interest rate implied by USD/THB foreign exchange swaps; Bibor = Bangkok IBOR; H.15 = offered rate for offshore certificates of deposit published by the US Federal Reserve.

[1] Total number of contributor banks. [2] Number of contributor banks headquartered outside the currency's home country. [3] Most widely referenced maturity. [4] Floating rate leg typically referenced in interest rate swap contracts.

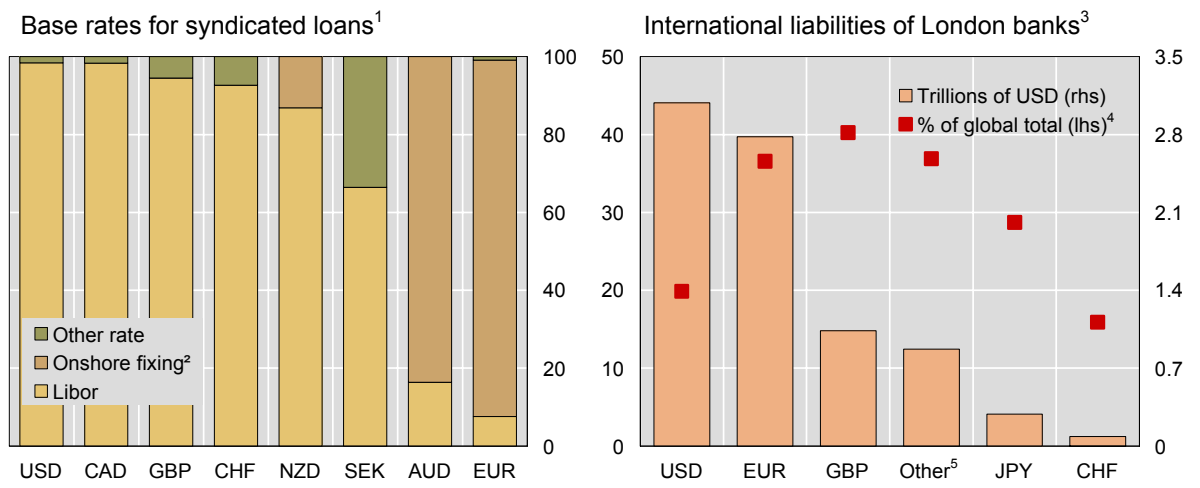
Sources: BBA; Bloomberg; Reuters. Table 1

In those markets where interbank rate fixings serve as a benchmark, offshore rates are frequently preferred to onshore ones. Most fixings, other than those in London and Singapore, refer to domestic, onshore interest rates. In contrast, Libor is an offshore rate for all currencies except sterling. Even though there are comparable onshore fixings, Libor is widely referenced in the Canadian dollar, New Zealand dollar, Swedish krona, Swiss franc and US dollar markets. For example, it is the base rate for a large share of syndicated loans denominated in these currencies (Graph 1, left-hand panel).

One reason for preferring offshore rate fixings as benchmarks is that they are less likely to be distorted by regulations. Capital controls can lead to a wedge between on- and offshore rates by preventing banks from taking advantage of arbitrage opportunities. Even in fully integrated markets, reserve requirements, deposit insurance premiums and other regulations affecting banks' domestic operations tend to reduce onshore rates relative to offshore ones because offshore banks can offer higher rates on wholesale deposits not subject to such regulations (Kreicher (1982)).

Another reason is that offshore markets are often as liquid, and in some cases more so, than onshore markets. This is especially true of London, where a large share of international banking activity is transacted (Graph 1, right-hand panel). Singapore too has liquid international interbank and foreign exchange markets, upon which rate fixings in US dollars and a few other currencies are based. The diversity of market participants is often greater in offshore markets, which helps to boost activity. In particular, barriers to entry and exit are typically lower in offshore markets, making them less vulnerable than onshore markets to the actions of a few large institutions. Indeed, the Swiss National Bank targets Libor instead of an onshore rate because the former is less affected by short-term imbalances in activity (Gehrig (1999)).

Use of Libor as a reference rate



[1] Percentage of international syndicated credit facilities signed in 2007 that are based on the specified rate; excludes loans where no base rate is specified by Dealogic Loanware. [2] For AUD and NZD, bank bills rate; for EUR, Euribor. [3] Liabilities to non-residents in all currencies plus residents in foreign currencies, of banks domiciled in the United Kingdom, at end-June 2007; includes inter-office positions. [4] As a percentage of the international liabilities of all banks in the BIS reporting area; for EUR, the global total excludes euro area banks' cross-border liabilities to euro area residents. [5] Liabilities denominated in currencies other than the five specified.

Sources: Dealogic Loanware; BIS; authors' calculations. Graph 1

Composition of the contributor panel

Rate fixings based on a large sample of banks are likely to be more representative of market conditions than those derived from a small sample. There is a trade-off, however, because banks are not equally active. A few banks might account for a disproportionately large volume of transactions, and so a panel of many small banks might be less representative of overall activity than a panel of a few large banks.[4]

The majority of fixing panels have 12 to 16 contributor banks (Table 1). Libor has as few as eight for currencies other than the US dollar, euro and yen, for which it has 16. Contributing banks are selected based on their reputation, credit quality and activity in London, and the composition of the panel is reviewed at least once a year. The euro interbank offered rate (Euribor) is based on quotes from as many as 45 banks, from every country in the euro area.

Differences between fixings may reflect the panel composition ...

In addition to the number of banks, contributor panels differ in the kinds of banks included. Foreign banks – in particular large, internationally active ones – dominate the Libor panels but are in the minority on most others. For example, 15 of the 16 banks on the Tokyo panel and 13 of the 16 banks on the Shanghai panel are domestic banks, headquartered in the country. The credit quality and business models of these banks are often different from those of foreign banks.

Even with 12 to 16 banks, the average can be unduly influenced by unusually high or low quotes. Therefore, fixings are typically based on a trimmed average. Most fixings follow Libor and exclude the top and bottom 25% of contributed quotes. Euribor excludes the top and bottom 15%. The Mumbai interbank offered rate (Mibor) identifies outliers using a statistical bootstrapping method. A few fixings, including those in Jakarta and Kuala Lumpur, include all submitted quotes and, consequently, are likely to be more affected by extreme quotes.

Types of quotes

... the type of quote ...

Fixings obtained from transactions or transactable quotes by definition capture market conditions, at least in part of the market. Indices based on interbank transactions are available in several markets, but usually only for overnight interest rates. Examples include the federal funds effective rate in the US dollar market and the European overnight index average (EONIA) in the euro market. The compilation of these indices is either done or assisted by the central bank because it has privileged information on transactions in what is otherwise a private, bilateral market.

Indices based on binding quotes or transactions can also be constructed from brokers' systems and electronic trading platforms. One example is the eurodollar interest rate published in the US Federal Reserve's H.15 statistical release. This series is based on the best offered rate on offshore US dollar

[4] Banks are asked to contribute quotes for a "standard" transaction size, which is likely to be different for large and small institutions.

certificates of deposit brokered by ICAP at around 09:30 in New York. A weakness of such rates is that the broker or platform may not have a large presence in the market, so the sample of transactions might not be representative.

Incentives to contribute accurate quotes

Most fixings, however, are based on non-binding quotes; contributing banks are not obliged to transact at the interest rates they submit. Therefore, the reliability of such fixings as measures of market conditions depends on the willingness of contributing banks to reveal their true, transactable quotes. In particular, it depends on the incentives given to market participants to reveal private information truthfully. Processes which achieve this objective are said to be "incentive compatible" (Hurwicz (1972), Royal Swedish Academy of Sciences (2007)).

One way in which fixings seek to be incentive compatible is by publishing individual banks' contributed interest rates. Transparency exposes the banks to reputational risk because their customers will penalise them for transacting at rates significantly different from their submitted rates.

However, transparency raises questions about the information signalled by contributing banks through their quotes. There may be circumstances in which contributing banks deliberately choose to disclose biased quotes. If there is uncertainty about the liquidity position of a contributing bank, the bank will be wary of revealing any information that might add to this uncertainty for fear of increasing its borrowing costs (Spence (1973)). Therefore, for the purposes of the fixing, the bank has an incentive to quote a lower interest rate publicly than it might be prepared to pay in a private transaction.

The widespread use of fixings as reference rates also gives contributing banks an incentive to misquote. The costs of manipulating a given rate might be outweighed by the potential profit from positions based on those rates (Ewerhart et al (2007)). For example, market participants with large positions in derivative contracts referencing a rate fixing might seek to move the fixing higher or lower by contributing biased quotes. Alternatively, they might indirectly influence the accuracy of the fixing by choosing not to join the contributor panel.

... and strategic behaviour by banks

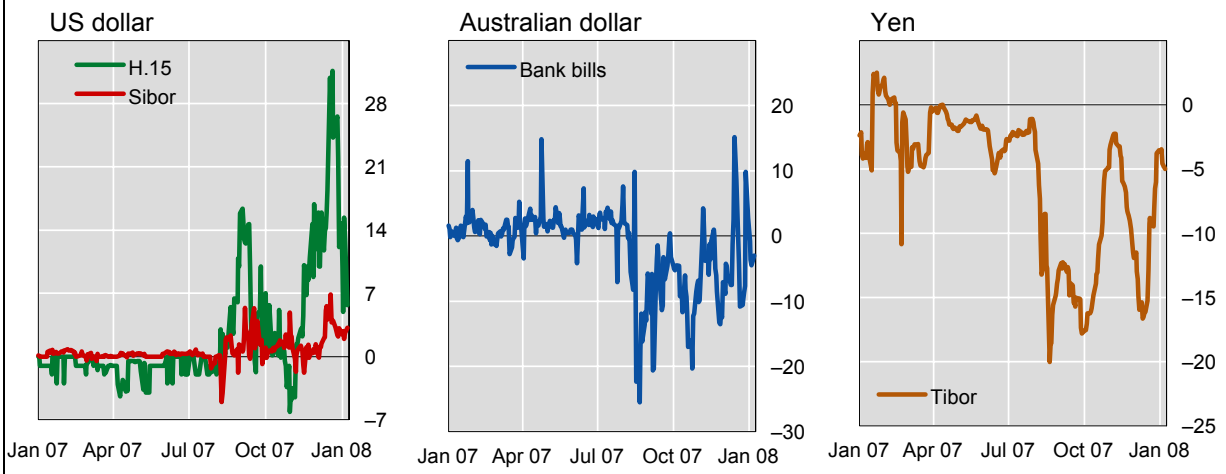
The scope for such strategic behaviour to influence the fixing can to some extent be limited by trimming, in which biased or extreme quotes are disregarded. However, even trimmed means can be manipulated if contributor banks collude or if a sufficient number change their behaviour.

Fixings during the recent turmoil

The turbulence in global interbank markets in the second half of 2007 saw the normally low and stable spread between similar rate fixings widen markedly (Graph 2). Below, we consider the impact of the factors discussed in the previous section on the spread between similar fixings and, by extension, on the representativeness of different rate fixings.

Spreads over Libor

In basis points



Sources: Bloomberg; authors' calculations.

Graph 2

Change in spreads over Libor

We focus on currencies for which more than one fixing is available. For the Australian dollar, Canadian dollar, Danish krone, euro and yen, one fixing refers to an offshore rate (Libor) and the other to an onshore rate. For the US dollar, all refer to offshore rates but each is fixed at a different time during the day: first in Singapore (Sibor), then in London (Libor) and finally in New York (H.15). Spreads and correlations between various fixings and Libor are shown in Table 2. Two periods are distinguished: a normal period, from 1 January to 8 August 2007, and a stress period, from 9 August 2007 to 30 January 2008.

Spreads between fixings in the same currency widened ...

The US dollar market stands out for being the one market where Libor rose by substantially less than similar fixings during the stress period. The average spread between Sibor and Libor widened from about zero in the normal period to 2 basis points in the stress period, and the spread between

Spreads and correlations between interbank fixings

Currency	Fixing rate[1]	Average spread over Libor[2]			Correlation[3]	
		1 Jan–8 Aug 07	9 Aug 07–30 Jan 08	Change	1 Jan–8 Aug 07	9 Aug 07–30 Jan 08
AUD	Bank bills	1.7*	–6.4*	–8.1*	0.24	0.44
CAD	Bank bills	7.4*	–8.4*	–15.8*	0.15	0.61
DKK	Cibor	–0.3*	0.1*	0.4*	0.53	0.89
EUR	Euribor	0.1*	–0.0*	–0.1	0.75	0.99
JPY	Tibor	–2.1*	–10.0*	–7.9*	0.11	0.14
USD	Sibor	0.2*	1.8*	1.6*	0.21	0.98
USD	H.15	–1.0*	6.7*	7.7*	0.09	0.89

[1] Three-month interest rates. [2] In basis points; * indicates that the mean is significantly different from zero at the 1% level based on a t-test. [3] Mean of the August–January period minus mean of the January–August period. [3] Correlation of daily yield changes corrected for the increase in volatility following Loretan and English (2000).

Sources: Bloomberg; authors' calculations.

Table 2

H.15 and Libor widened from –1 to 7 basis points.

In the Australian dollar and Canadian dollar markets, the average spread of onshore rates over Libor turned from positive during the normal period to negative during the stress period. The change in the spread between the two periods was as much as –16 basis points in the case of Canadian dollar rates. In the yen market too, the average spread between the onshore rate and Libor fell sharply between the two periods, by 8 basis points.

In the euro market, there was no change in the Euribor–Libor spread between the normal and stress periods. A similar pattern was seen in the market for the Danish krone, which is pegged to the euro.

Panel composition

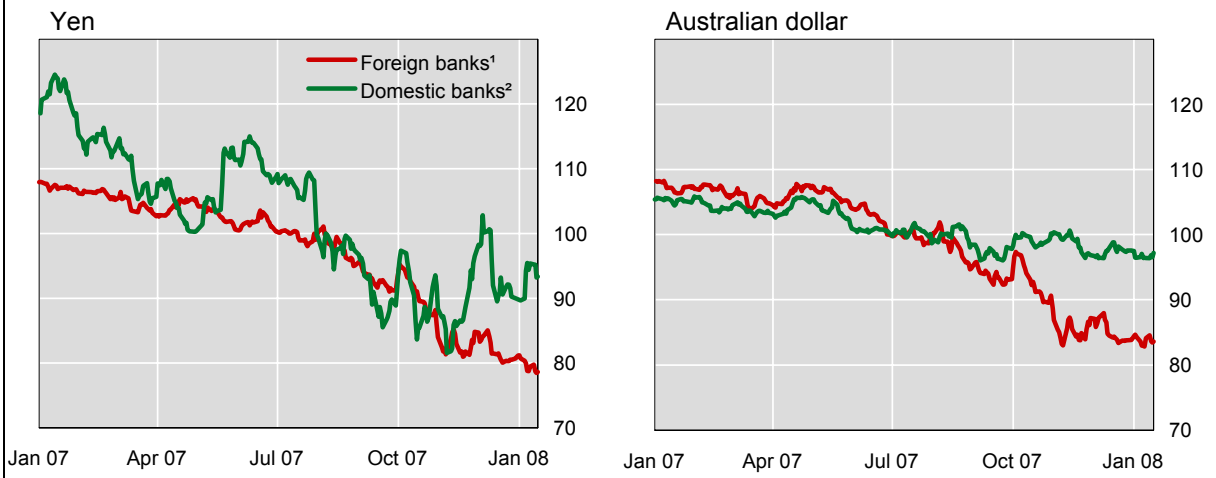
... because domestic banks were less exposed to structured credit than foreign banks ...

The widening of spreads between similar fixings was driven in part by differences in panel composition. The large, international banks which dominate Libor panels had larger exposures to subprime mortgages and structured investment vehicles than many of the domestic banks which dominate onshore panels. Consequently, the perceived credit quality and funding needs of Libor contributor banks deteriorated by more than those of domestic banks, putting greater upward pressure on Libor than on onshore rate fixings.

During periods of calm, panel composition is usually not an important source of volatility in rate fixings because most contributor banks have a high credit standing. The credit rating of banks in almost all Libor panels averages AA. So too does the rating of banks in Australia's bank bills swap reference rate panel and the Cibor panel. Among the fixings considered in Table 2, Tibor has the lowest-rated panel, averaging A+. However, credit ratings tend to lag changes in credit quality; therefore, during periods of uncertainty differences in panel composition become more important.

Contributor banks' equity prices

Relative to domestic equity market indices; 9 August 2007 = 100



[1] Banks headquartered outside the currency's home country and included in the Libor panel. [2] Banks headquartered inside the currency's home country and included in the Libor panel.

Sources: Bloomberg; authors' calculations. Graph 3

One indication that credit and funding concerns played a part in the recent divergence of rate fixings comes from equity prices for foreign versus domestic banks. As shown in Graph 3, Australian and Japanese banks did better relative to their respective equity markets than foreign banks did relative to their equity markets. In particular, in November 2007 Japanese banks in the Tibor panel outperformed the Tokyo equity market, whereas foreign banks in the yen Libor panel underperformed their home equity markets. The equity prices of Australian banks in the onshore fixing panel matched the Sydney market, whereas foreign banks in the Australian dollar Libor panel underperformed.

For Australian dollar and yen fixings, correlations between changes in rates are also consistent with panel composition being an important explanation for the widening of spreads between similar fixings. The correlation between Tibor and yen Libor remained very low during the normal and stress periods, indicating that factors unique to each fixing had a significant influence on daily yield changes (Table 2). For Australian dollars, the correlation between the onshore fixing rate and Libor rose during the stress period, but only to 0.4.

In the Canadian dollar, euro and US dollar markets, panel composition was not as important an explanation for the divergence in rate fixings. Many of the banks in these panels were perceived to have significant exposure to structured credit products. Nevertheless, in the Canadian dollar market, the deterioration in Canadian banks' credit quality was not fully reflected in the onshore rate because the fixing is based on bankers' acceptances. The payment of bankers' acceptances is jointly guaranteed by the accepting bank and the ultimate borrower, thereby diversifying investors' credit risk exposure.

Liquidity and volatility

Another factor which contributed to the widening of the spreads between similar rate fixings was a deterioration in market liquidity. In less liquid markets, imbalances in order flow are more common and prices are consequently more prone to jumps. Changes in interest rate volatility and correlations between the normal and stress periods are consistent with a deterioration in liquidity, especially in the US dollar and euro markets.

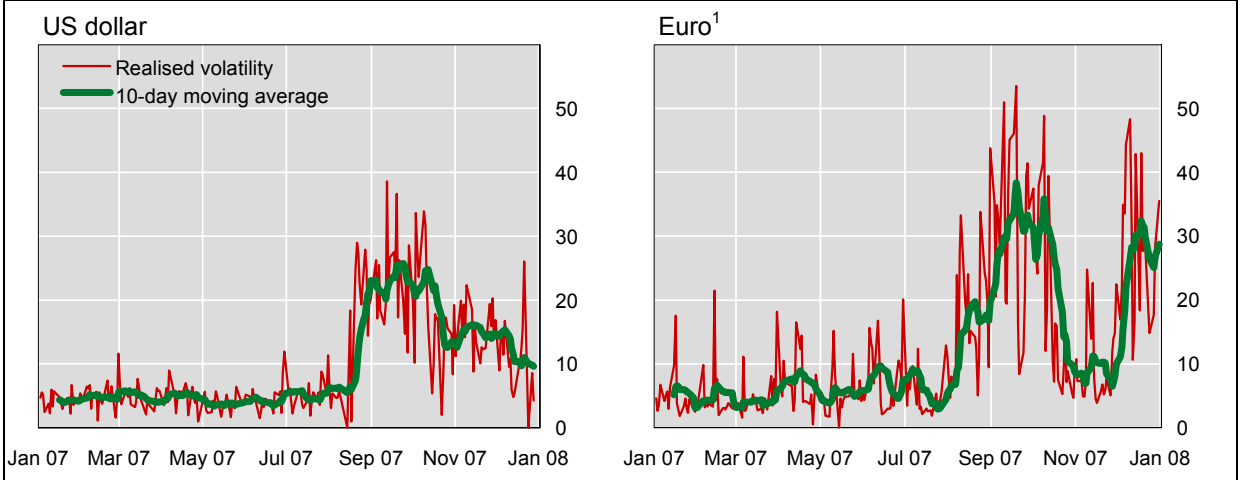
... and volatility increased

The volatility of money market rates increased many times over during the recent period of turmoil. Graph 4 plots the realised volatility of overnight interbank rates for the US dollar and the euro. Greater uncertainty about future economic conditions and banks' creditworthiness was responsible for part of the increase. Volatility tends to be highest around macroeconomic announcements (Andersen et al (2005)). Considering that most news is announced during onshore trading hours, greater uncertainty probably had a larger impact on fixings that took place during those hours. This might explain part of the increase in the spread of the H.15 rate over US dollar Libor.

That said, our estimate of volatility is based on overnight rates, so arguably only a small part of the increase was driven by greater uncertainty about the future. A deterioration in liquidity was most likely responsible for the larger part of the increase. Consistent with this interpretation, correlations between daily changes in different US dollar, euro and Danish krone rate fixings rose to almost 1 during the stress period (Table 2). This indicates that

Volatility of overnight interest rates[1]

In basis points



[1] Based on interest rates for overnight interbank loans sampled intraday at 30-minute intervals; estimation procedure follows Andersen et al (2003).

Sources: e-Mid; authors' calculations. Graph 4

the changes were driven by factors common to the different fixings. Whereas the composition of the contributor panel, and therefore counterparty credit risk, differs across fixings in the same currency, liquidity premia are likely to be similar. Indeed, Michaud and Upper (in this issue) find that at daily frequencies liquidity considerations were a more important driver of US dollar, euro and sterling Libor than credit risk.

An open question is whether central banks' operations in money markets accentuated differences between rate fixings by bolstering liquidity in onshore markets. During the stress period, central banks adjusted their operating procedures to facilitate the distribution of liquidity (Borio and Nelson in this issue). If banks in offshore markets do not have access to central banks' distribution channels, then central banks' operations might have caused spreads between on- and offshore rates to widen, at least temporarily. In the euro and Danish krone markets, there is no evidence of segmentation: on- and offshore rates were almost the same on average during the stress period. For other currencies, asynchronous polling times make it difficult to test this proposition.

Strategic behaviour and trimming

Finally, we consider whether strategic behaviour contributed to the widening of spreads between similar rate fixings. As previously discussed, during periods of turmoil banks are likely to behave in a more strategic manner. They might seek to signal information about their credit quality or liquidity needs through their quotes, or they might quote in a way that benefits their positions in instruments which reference the fixing. However, if there were any attempts to manipulate fixings during the recent turbulence, trimming procedures appear to have minimised their impact.

Trimming procedures were clearly much more important during the turmoil period. In the normal period, the difference between the maximum and minimum contributor banks' rates ranged between 1 and 2 basis points in the US dollar Libor panel and 2 and 3 basis points in the euro Libor panel (Graph 5). The maximum–minimum range was wider in the yen Libor panel because of larger differences in contributor banks' credit quality. However, during the stress period, the range between the maximum and minimum contributor banks' rates in all panels widened markedly. If this was because a few banks engaged in manipulative behaviour, then the trimming procedure ensured that their rates were not used to calculate the rate fixing.

Trimming is more important during periods of turmoil

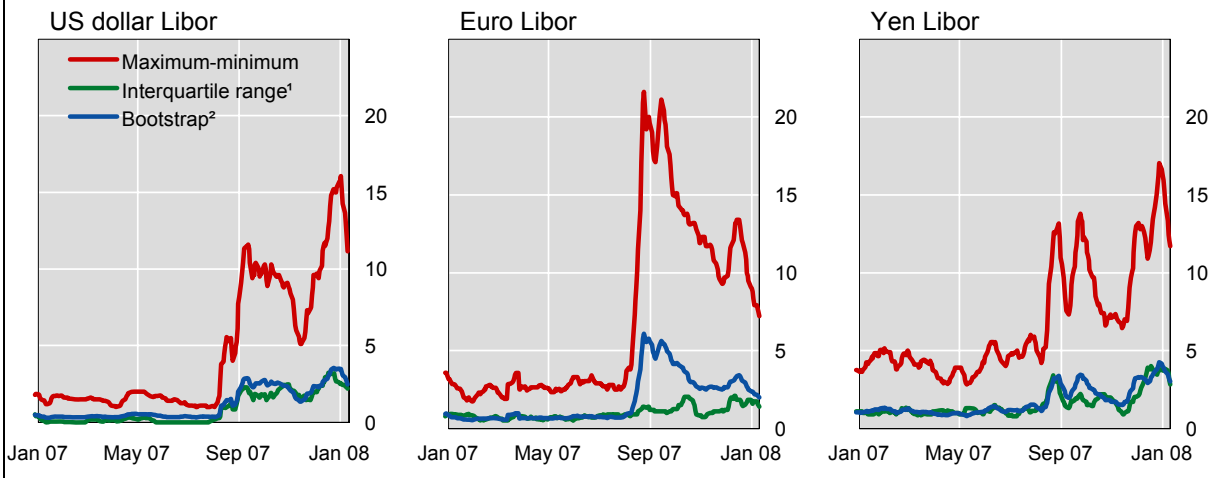
If a majority of banks engaged in strategic behaviour, then trimming alone would not have mitigated the impact on the fixing. That said, there is little evidence that this was the case. In the US dollar market, the widening of Sibor and H.15 spreads over Libor is consistent with signalling by Libor contributor banks. However, many of the banks on the US dollar Libor panel are also on the euro Libor panel, and there are no signs that signalling distorted the latter fixing. Likewise, available data do not support the hypothesis that contributor banks manipulated their quotes to profit from positions based on fixings. Eurodollar futures contracts traded on the Chicago Mercantile Exchange indicate that commercial traders – a category which includes banks and other market participants that might seek to hedge their business activities in the futures market – had a larger than normal net open short position in the third quarter of 2007. To the extent that futures positions are representative of their overall exposure, banks would have gained by submitting low quotes to move Libor below the true market rate. In fact, Libor moved in the opposite direction: it rose in early August.

Little evidence of manipulation

Supplementing this anecdotal evidence, alternative methods of estimating Libor also give no indication that fixings were manipulated. If rates were polled

Dispersion in contributor banks' rates

Libor panel; 10-day average range, in basis points



[1] Third minus first quartile. [2] Confidence interval of 95% for the mean of sampled rates; based on 5,000 daily panel samples from actual rates contributed by panel banks.

Sources: Bloomberg; BIS calculations. Graph 5

from an unrepresentative sample of banks, then even a trimmed mean would be biased. Furthermore, trimming procedures might not produce the best estimate of the mean because information in the highest and lowest quotes is disregarded. To test the robustness of trimming procedures, we re-estimated the mean of the US dollar, euro and yen Libor panels using a bootstrap technique. This technique minimises the influence of non-random observations and outliers on the mean without disregarding any quotes (Efron and Tibshirani (1994)). The bootstrapped mean is not significantly different from Libor for any of the panels considered.

Moreover, the 95% confidence interval around the bootstrapped mean loosely corresponds to the interquartile range in the Libor panel (Graph 5). In other words, the bootstrap technique indicates that 19 days out of 20, the design of the Libor fixing produces an estimate that is close to the true interbank rate. This is the case even during the stress period. Only for euro Libor is the bootstrapped confidence interval noticeably wider than the interquartile range during the stress period, reflecting the wider dispersion of polled rates.

Conclusions

A comparison of different fixings in the same currency reveals that interbank rates diverged to an unusual extent in the second half of 2007. This divergence was not caused by shortcomings in the design of the fixing mechanism. Rather, it reflected the dislocation in the underlying interbank markets. Changes in the credit quality of contributor banks and a deterioration in liquidity affected fixings to varying degrees. Credit quality appears to have had an especially large impact on offshore fixings, dominated by foreign banks. Liquidity was a significant factor in US dollar and euro fixings.

Design of fixings worked as intended to minimise the influence of outliers

A number of lessons regarding the design and use of fixings can be drawn from these developments. First, the representativeness of rate fixings depends critically on the mechanisms used to minimise the influence of outliers. Banks' quotes are determined by strategic behaviour as well as credit quality and funding needs. Transparency and trimming are important ways to lower, albeit not eliminate, the vulnerability of fixings to sampling noise and manipulation. Transparency strengthens banks' incentive to contribute accurate quotes, while trimming procedures limit the scope for individual banks to distort the fixing.

Second, the confidence interval around rate fixings – even trimmed fixings – is wider during periods of uncertainty. In other words, fixings are likely to be less representative when market conditions are volatile. During calm periods there is usually very little dispersion in polled rates. By contrast, during volatile periods there can be significant dispersion because of greater uncertainty about credit quality and greater incentives to engage in strategic behaviour.

Finally, rate fixings measure conditions in a given market segment. Differences in market participants, liquidity and regulations can lead to deviations between fixings and conditions in closely related markets. If these deviations persist, they might undermine the role of a particular fixing as a

pricing reference, which could ultimately lead market participants to switch to a new benchmark.

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