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Reforming LIBOR and Other Financial Market Benchmarks

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In the spring of 2008, LIBOR moved from the fine print of interest-rate contracts to the headlines of newspapers (for example, Mollenkamp 2008; Mollenkamp and Whitehouse 2008). LIBOR is the London Interbank Offered Rate: a measure of the interest rate at which large banks can borrow from one another on an unsecured basis. LIBOR is often used as a benchmark rate—meaning that the interest rates that consumers and businesses pay on trillions of dollars in loans adjust up and down contractually based on movements in LIBOR. Investors also rely on the difference between LIBOR and various risk-free interest rates as a gauge of stress in the banking system. Benchmarks such as LIBOR therefore play a central role in modern financial markets.

Thus, the 2008 news reports revealing widespread manipulation of LIBOR threatened the integrity of this benchmark and lowered trust in financial markets. LIBOR is determined each day—or "fixed"—based not on actual transactions between banks but rather on a poll of a group of banks, each of which is asked to make a judgment-based estimate of the rate at which it could borrow. Banks had incentives to announce biased interest rates, for two reasons. First, in times of economic stress, reporting a lower interest rate would signal that the bank is more creditworthy, all else equal. Second, some of the bank's trading positions would be more profitable if LIBOR could be pushed one way or the other, depending on the position taken.

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These problems with LIBOR raised more general issues about benchmarks. Along with LIBOR, there are other "IBORs," including EURIBOR, which is the interbank offered rate at which large banks in the European Union lend to each other, and TIBOR, the Tokyo Interbank Offered Rate, at which large Japanese banks lend to each other. In addition, benchmarks for foreign exchange rates and certain commodity prices appear in many contracts.

The two of us recently contributed to a pair of reports commissioned by the Financial Stability Board that recommend how to make benchmark rates such as LIBOR and other interbank offered rates less vulnerable to manipulation.[1] While these reports cover many technical issues, they are based on two overarching principles.

First, benchmarks should be based—to the greatest practical extent—not on judgments submitted by market participants, but on actual transactions. Anchoring benchmarks in transactions is a key recommendation of several previous policy groups (for example, see International Organization of Securities Commissions 2013). But a tough problem confronts a shift to transaction-based IBOR benchmarks. Remember, the "I" in IBOR stands for "interbank." The daily fixing of LIBOR is supposed to be an estimate of the rate at which major banks can borrow *from each other*. However, there are surprisingly few actual loan transactions between banks that could be used to fix most of the IBORs, including those for the 3- and 6-month maturities that are so widely used as benchmark rates. The thinness of the underlying interbank markets has made it difficult to come up with reliable daily fixings that are transactions-based.

The solution proposed in the policy reports of our groups is to fix the IBORs using a much wider set of unsecured bank-borrowing transactions, not just those in the interbank market. This approach would include rates on "wholesale" (that is, large-denomination) certificates of deposit as well as commercial paper issued by banks to a wide range of nonbank investors.

Second, the reform process should strongly encourage heavier use of alternative benchmark reference rates. The original purpose of the IBORs was to measure average bank borrowing costs, which include a spread component for bank credit risk. Particularly with the enormous boom in interest-rate derivatives trading since the 1980s, IBORs have been heavily used in contracts whose purpose is to transfer risk related to fluctuations in general market-wide interest rates. The motives for these "rates trading" applications generally have little to do with the component of the IBORs that reflects the spread between bank credit and a risk-free interest rate. However, it is a self-reinforcing choice by market participants to trade in more liquid high-volume markets, all else equal. In part through an accident of history, this desire to belong to the high-liquidity club has led to a massive agglomeration of trade based on the IBOR benchmarks.

[1] Duffie chaired a Market Participants Group on Reforming Interest Rate Benchmarks (or the Market Participants Group on Reference Rate Reform). Stein co-chaired (along with Martin Wheatley, head of the UK's Financial Conduct Authority) an Official Sector Steering Group on the same topic, while serving as a member of the Federal Reserve Board of Governors. Both groups were established by the Financial Stability Board. These reports are Market Participants Group (2014) and Official Sector Steering Group (2014).

While such an agglomeration effect is beneficial from the standpoint of liquidity, it increases incentives for market manipulation. The deep and liquid IBOR-based derivatives markets can accommodate extremely large derivatives positions. A trader with a sufficiently large position can profit significantly from even tiny distortions in IBOR fixings, on the order of one basis point (that is, 0.01 percent). In 2008, reporting on the LIBOR scandal revealed that manipulators had arranged for dishonest judgment-based reports of bank borrowing rates. With a transactions-based benchmark, a manipulator might attempt to distort actual transactions. Either way, the message is the same: a thin underlying bank borrowing market cannot be a robust foundation for a multi-hundred-trillion dollar derivatives "rates" market, even with substantial improvements to the IBOR-fixing methodology.

Fortunately, many of the interest-rate trading applications currently served by the IBORs could be as well or better served by risk-free or near-risk-free benchmarks that are not tied to banks' costs of funds. In the United States, for example, interest rates based on Treasury bills or other rates that we will discuss later in this paper (such as general collateral repo rates) would be adequate or preferred for many rates-trading applications.

We do not underestimate the difficulty of getting market participants to opt for alternative reference rates so long as IBOR-based markets are so liquid. Precisely because everybody prefers to be in the high-liquidity club, there is a coordination problem. No individual actor may be willing to switch to an alternative benchmark, even if a world in which many switched would be less vulnerable to manipulation and offer investors a menu of reference rates with a better fit for purpose. Hence, there may be an important role for policymakers to guide markets in the desired direction.

The remainder of this paper is organized as follows. We begin with a discussion of the economic role of benchmarks in reducing market frictions. We explain how manipulation occurs in practice, and illustrate how benchmark definitions and fixing methods can mitigate manipulation. We then turn to an overall policy approach for reducing the susceptibility of LIBOR to manipulation, before focusing on the practical problem of how to make an orderly transition to alternative reference rates, without raising undue legal risks.

The Economics of Benchmarks

Why Use Benchmarks?

Financial market participants rely on benchmarks for a range of purposes that are primarily related to reducing asymmetric information regarding the value of the underlying traded financial instrument.

Consider for illustration a forward contract for gold, committing a buyer to pay the difference between the agreed forward price and the spot price of gold at the future contract settlement date. Without recourse to an independently announced gold price benchmark, the counterparties could easily disagree about the net payment due at the time of settlement. Indeed, the two parties have

precisely opposite incentives regarding how to measure the spot price of gold. Thus, without a benchmark, they might expend extra effort to settle their contract. They might avoid contracting based on price, and instead use the more costly (but less manipulation-prone) settlement method of physical delivery of gold. Or in light of the anticipated settlement costs, the two parties might just fail to agree on a contract in the first place, thus losing their gain from trade. Even if a benchmark exists, costs may arise to the extent that the benchmark is not reliably measured or can be manipulated. Indeed, there have been recent allegations of manipulation of gold benchmarks (Vaughn 2014). Clearly, if one of the counterparties to a trade also plays a role in the fixing method that determines the announced benchmark price, the incentive to manipulate is especially severe. This moral hazard may lead to lower market participation or even a market breakdown.

Reliable benchmarks also reduce search costs in bilateral over-the-counter markets, where, in the absence of a centralized exchange, benchmarks can improve matching efficiency and increase participation by less-informed agents. For example, with the publication of an interest rate benchmark such as LIBOR, bank customers are better able to judge whether a loan rate is competitive. Without a benchmark, intermediaries can take greater advantage of market opaqueness and of the cost to customers of searching for alternative quotes. Before the advent of LIBOR in the United States, banks commonly quoted variable-rate loans at some spread above a "prime rate," but each bank decided on its own prime rate, and while these rates moved in relatively close tandem across banks, sophisticated borrowers understood the benefit of shopping around.

In this sort of setting, benchmarks offer financial intermediaries a tradeoff: on one side, benchmarks tend to reduce profit margins; on the other side, this disadvantage can potentially be more than offset through increased volume of trade (Duffie, Dworczak, and Zhu 2014). Thus, intermediaries may find it advantageous to introduce a benchmark. Indeed, in 1969 a consortium of London-based banks led by Manufacturers Hanover introduced LIBOR in order to entice international borrowers such as the Shah of Iran to borrow from them (for a brief history, see Ridley and Jones 2012). By 1984, LIBOR became an official benchmark of the British Bankers Association.

A further transparency benefit of benchmarks applies when investors delegate their trading decisions to agents, who may not always make their best efforts to obtain good trade execution on behalf of their clients. Suppose an investor selling euros for dollars is told by her broker, "We obtained an excellent price of $1.3500 for your Euros." Absent a benchmark, the investor could not easily validate the broker's claim and may be suspicious of the potential for dishonest service. However, if there is a nearly simultaneous published benchmark fixing of an exchange rate of one euro for $1.3501, then the broker's claim of good execution is easily verified. Less-informed investors who delegate their trade execution to agents are thus more willing to participate in markets when incentives for good execution are supported by the existence of reliable benchmarks. The recent report of the Financial Stability Board on foreign exchange benchmarks confirms that the least-sophisticated investors are the most likely to prefer that their foreign exchange trades be executed at

the precise time at which the benchmark is fixed (Foreign Exchange Benchmark Group 2014).[2]

In the special case of interbank offered rates, there is an important additional motive for introducing a benchmark. Suppose a bank wishes to hedge the risk of a change in its borrowing cost. However, because the bank is known to have private information about its idiosyncratic credit quality, it might find that no counterparty is eager to hedge this risk. This problem of adverse selection can make it hard for the bank to negotiate a contract that is based on its own future credit spread. This market breakdown might be overcome to some extent with hedging contracts that are instead linked to market-wide, rather than bank-specific, credit spreads. In this case, a benchmark based on the interbank offered rate allows banks to hedge at least the common component of their borrowing costs.

Agglomeration of Trade around Benchmarks

Once a benchmark has been established, it can become a powerful "basin of attraction" for related trades, based on two types of agglomeration effects. To see why, suppose that a spectrum of possible non-benchmark trades could be substituted with a benchmark trade. These alternative types of trades are differentiated by their risk attributes and other characteristics, such as time of execution (relative to the time at which the benchmark is fixed).

One force driving agglomeration is the incentive for market participants to reap the information-related benefits of a benchmark that we described in the previous section, including lower search costs, higher market participation, better matching efficiency, and lower moral hazard in delegated execution. In order to obtain these benefits, market participants or their agents will often choose to substitute their "best-fit-for-purpose" trade with a benchmark trade. For example, a foreign-exchange trade that, absent benchmark effects, would optimally be executed at 5 pm London time could be shifted to match the extremely popular WM/Reuters benchmark, produced by the WM Company, which has a 4 pm London fixing time. Similarly, an investor who is interested in taking a hedging or speculative position in risk-free interest rates might shift toward a LIBOR-based financial instrument, even though the bank-credit-spread component of LIBOR is somewhat undesirable.

The second force for agglomeration is the incentive to lower trading costs that are associated with illiquidity. A high volume of trade in a financial instrument is typically associated with a smaller bid–ask spread, shorter execution delays, lower search costs, and a lower price impact for large trades. Once trading in a benchmark-related instrument is active, there is an incentive to substitute from

[2] Indeed, less-sophisticated investors in foreign exchange markets commonly request "fix trades," by which they contract with a dealer to buy or sell at the benchmark price itself, without a fee or bid–ask spread. The dealer absorbs the risk of laying off the position acquired from its clients at a different price, and thus a potential loss. The dealer may be compensated in part, however, by the common practice in this market of "front running" by dealers, who may trade on their own behalf a few seconds before the fixing, thus causing a price impact to the fixing that can benefit the dealer at the expense of its clients. Whether malicious or not, the report commissioned by the Financial Stability Board recommends that this practice be curtailed.

less-actively traded instruments toward instruments that reference the benchmark (McCauley 2001). This liquidity incentive can easily dominate any mildly undesirable investment characteristics of a non-benchmark instrument.

Once a benchmark is established, its basin of attraction can thus become larger and larger, given the positive feedback effects of informational transparency and liquidity. In the next section, we provide some statistics that illustrate the extent to which LIBOR has become the overwhelmingly popular interest-rate benchmark.

Once liquidity in LIBOR-linked contracts became firmly established in the 1980s, dealers and derivatives exchanges had the incentive to introduce a wide range of LIBOR-based hedging instruments, including exchange-traded eurodollar futures and options available from Chicago Mercantile Exchange Group, and over-the-counter derivatives including caps, floors, and swaptions (that is, an option to engage in a swap contract). The availability of risk transfer in these related instruments further increased the magnetic qualities of LIBOR-based trading.

Manipulation and Manipulation-Resistant Fixing Methods

During the financial crisis of 2007–2009, no bank wished to appear to be less creditworthy than others, as concerns over their creditworthiness might have raised their costs of funding, or in the extreme case, caused a run. When banks were polled to produce LIBOR, the rates reported by each bank were listed individually. As a result, some banks started "low-balling"—that is, understating their true borrowing costs when submitting to the LIBOR poll. The unrealistically tight bunching among banks of their reported borrowing rates is part of what led to the news reports of likely manipulation. Subsequent research revealed a substantial downward and persistent bias in LIBOR relative to actual bank borrowing rates (Abrantes-Metz, Kraten, Metz, and Seow 2012; Snider and Youle 2012; Kuo, Skeie, and Vickery 2012; for an overview, see Hou and Skeie 2013).

The second basic motive for manipulating benchmarks is a desire to profit on positions in derivative financial instruments that are contractually linked to the benchmark. In the case of interbank offered rates, some derivatives traders asked bank officials that were charged with providing rate submissions to the LIBOR poll to bias their reports. Figure 1 offers some examples of emails between traders that later emerged in an investigation of Barclays Bank. Sometimes these requests would be relayed by another trader, often located at another bank. In some instances, more significant distortions were achieved through collusion that coordinated the misreporting among several banks.

Clearly, if traders are able to benefit their swap positions by causing a benchmark to move one way or the other, the least ethical of them may attempt to do so. The extent to which a fixing can be distorted will always be a source of incentive to manipulate. However, an additional incentive is the ease with which very large positions in LIBOR-linked derivatives can be established, given the extremely high volumes and liquidity in this market.

In order to mitigate manipulation, tighter governance and regulatory monitoring of the fixing process may be somewhat effective, especially for those benchmarks that are set by judgment-based reporting (United Kingdom Financial

Figure 1
Some Emails and Text Messages from Swaps Traders at Barclays

1) "WE HAVE TO GET KICKED OUT OF THE FIXINGS TOMORROW!! We need a 4.17 fix in 1m (low fix) We need a 4.41 fix in 3m (high fix)" (November 22, 2005, Senior Trader in New York to Trader in London).

2) "You need to take a close look at the reset ladder. We need 3M to stay low for the next 3 sets and then I think that we will be completely out of our 3M position. Then it's on. [Submitter] has to go crazy with raising 3M Libor." (February 1, 2006, Trader in New York to Trader in London).

3) "Your annoying colleague again. … Would love to get a high 1m Also if poss a low 3m … if poss. … thanks" (February 3, 2006, Trader in London to Submitter).

4) "This is the [book's] risk. We need low 1M and 3M libor. PIs ask [submitter] to get 1M set to 82. That would help a lot" (March 27, 2006, Trader in New York to Trader in London).

5) "We have another big fixing tom[orrow] and with the market move I was hoping we could set the 1M and 3M Libors as high as possible" (May 31, 2006, Trader in New York to Submitter).

Source: From the investigation of Barclays by the US Commodity Futures Trading Commission, http://www.cftc.gov/ucm/groups/public/@lrenforcementactions/documents/legalpleading/enfbarclaysorder062712.pdf.
Notes: The references to 3m or 1m refer to three-month or one-month LIBOR estimates. The term "fix" refers to the actual LIBOR announcement on a given day.

Conduct Authority 2012). But the first line of defense is having a benchmark definition and a fixing methodology that are more difficult to manipulate.

All else equal, it is better to have the benchmark fixing based on a large volume of transactions so that it is difficult for individual manipulated trades or reports to have much influence on the fixing and so that it is easier to detect when trades and reports are distortionary. This can be achieved in part by widening the time window over which rates or prices are averaged to determine the benchmark and by broadening the set of instruments or types of trades that are used. Specific recommendations for broadening the data collected to fix benchmarks have been made for the interbank offered rates (Market Participants Group on Reforming Interest Rate Benchmarks 2014; Official Sector Steering Group 2014; Duffie, Skeie, and Vickery 2013) and for the foreign exchange benchmarks (Foreign Exchange Benchmark Group 2014).

A key tradeoff is that broadening the data collected to fix a benchmark can increase the heterogeneity of the proxies used for the item being measured, whether through timing or quality differences. This heterogeneity can be mitigated with statistical methods, but in the end the benchmark may be more robust to manipulation but not very specific to the trading interests of market participants. One way to do better is to weight the data strategically so as to produce a fixing that efficiently trades off the incentive to manipulate against measurement error. For example, smaller trades (those whose prices are most easily distorted) are optimally downweighted (Duffie and Dworczak 2014).

Table 1
US Dollar LIBOR Market Footprint by Asset Class and Tenor

Asset class	*Volume (billions of dollars)*	*% LIBOR-related*	*Most common tenors (in months)*
Loans			
Syndicated loans	~3,400	97%	1m and 3m
Corporate business loans	1,650	30-50%	1m and 3m
Noncorporate business loans	1,252	30–50%	1m and 3m
Commercial real estate/Commercial mortgages	3,583	30–50%	3m
Retail mortgages	9,608	15%	6m
Credit cards	846	Low	
Auto loans	810	Low	
Consumer loans	139	Low	
Student loans	1,131	7%	1m and 3m
Bonds			
Floating/Variable Rate Notes	1,470	84%	1m and 3m
Securitizations			
Residential Mortgage-Backed Securities (RMBS)	~7,500	24%	1m (83%)
Commercial Mortgage-Backed Securities (CMBS)	~636	4%	1m (75%)
Asset-Backed Securities (ABS)	~1,400	37%	1m (76%)
Collateralized Loan Obligations (CLO)	~300	71%	3m (82%)
Over-the-counter derivatives			
Interest-rate swaps	106,681	65%	3m (90%)
Forward Rate Agreements (FRAs)	29,044	65%	3m (90%)
Interest-rate options	12,950	65%	3m (90%)
Cross-currency swaps	22,471	65%	3m (90%)
Exchange-traded derivatives			
Interest-rate options	20,600	98%	3m
Interest-rate futures	12,297	82%	3m

Source: This table is adapted from *Market Participants Group on Reforming Interest Rate Benchmarks, Final Report*, March 2014.

Reforming LIBOR

How is LIBOR Used?

With this general framework in mind, we now turn to the specific problem of reforming LIBOR. Most of the issues that we will discuss pertain to all of the LIBOR currencies—US dollar, British pound, euro, Swiss franc, and Japanese yen—as well as to the other IBORs, namely EURIBOR and TIBOR. For concreteness, we focus on the case of the US dollar LIBOR.

Table 1 presents some facts concerning the major applications of US dollar LIBOR, drawn from Market Participants Group on Reference Rate Reform (2014). The table covers four broad categories of financial instruments: loans, bonds, securitizations, and derivatives—both over-the-counter and exchange-traded. Several points stand out. First, across a range of applications, a majority of contracts tend to be linked to either the 1-month or 3-month LIBOR rate. Second, LIBOR is the dominant interest-rate benchmark for trillions of dollars of conventional loans,

many of which are retained on the balance sheets of banks and other intermediaries. For example, 97 percent of the $3.4 trillion syndicated loan market is tied to LIBOR. Among other business loans and commercial real estate loans, which collectively add up to nearly $6.5 trillion, somewhere between 30 and 50 percent are linked to LIBOR. Of the $9.6 trillion of nonsecuritized residential mortgages, about 15 percent have adjustable interest rates that are LIBOR-based.

For lending applications that appear on bank balance sheets, it is easy to understand the appeal of an interest-rate benchmark like LIBOR that embeds an element of bank credit risk. If a commercial bank makes a long-term floating-rate business loan or commercial real estate loan, and funds the loan by borrowing short-term in the wholesale unsecured market, the bank's funding costs are exposed to movements in both the general level of interest rates as well as the bank's credit spreads. Thus, if the floating-rate loan is tied to an index based on a riskless rate, like the Treasury bill rate, then the bank has hedged only the component of its funding costs that is related to riskless rate. If credit spreads for the banking industry widen *relative to the riskless rate*, the bank's net interest margin will suffer. Indeed, during the 2007–2009 crisis, LIBOR rates went up several percentage points, whereas Treasury rates declined! If the floating-rate loan is instead linked to LIBOR, then the bank will at least be hedged with respect to the market-wide component of bank credit spreads, albeit not to idiosyncratic movements in its own credit spread. As discussed earlier, this motive for hedging risks that appear on bank balance sheets helps to explain why early efforts at creating interest-rate benchmarks in the 1970s gravitated toward a rate like LIBOR that was intended to capture bank credit risk.

But sizable and important as these bank-related lending applications are, the most striking fact in Table 1 is how they are now utterly dwarfed by trade in interest-rate derivatives tied to LIBOR. For example, the dollar-based over-the counter interest-rate swap market alone is estimated to be on the order of $107 trillion in gross notional value, of which 65 percent is linked to LIBOR. (In this market, an investor who prefers to pay a fixed interest rate rather than a variable rate such as 3-month LIBOR can enter a swap that exchanges the difference between these rates, for a given number of years, with another market participant that has the opposite preference.) Roughly another $100 trillion in interest-rate derivatives—including futures, cross-currency swaps, and both over-the-counter and exchange-traded options—are heavily LIBOR-dependent.

In contrast to the use of LIBOR for hedging a bank's loan funding costs, it is improbable that many users of interest-rate derivatives have an intrinsic economic reason to be exposed to the changes in bank credit spreads that are included in LIBOR. Rather, the majority are likely using these derivatives either to hedge an exposure to the general level of interest rates, to make a speculative bet on market-wide interest rates, or to intermediate such trades. For these "rates traders," the fact that LIBOR incorporates a bank credit risk component is, if anything, a bit of a nuisance. This inconvenience is apparently more than offset by the liquidity advantages of trading in the tremendously deep LIBOR-based derivatives market, as discussed earlier.

Costs of Excessive Agglomeration around the LIBOR Benchmark

In the narrative that we have in mind, bank-hedging motives were the seed that originally made LIBOR an attractive benchmark. From this seed, and given the strong agglomeration effects associated with liquidity and transparency externalities, the market for interest-rate-linked products has grown exponentially, while the benchmark has remained "stuck" on LIBOR. This is so despite the fact that much of the subsequent demand for referencing an interest-rate benchmark has come from users—most notably derivatives traders—who care a great deal about liquidity and transparency but who may have no particular desire for exposure to the bank-credit-risk component of LIBOR.

If this story is correct, it suggests that two distinct costs are associated with the pileup of so much trading on LIBOR-linked contracts. First, LIBOR may offer a less-than-ideal fit for the purposes of the majority of derivatives users. That is, even if most derivatives users would prefer to have their contracts tied to another benchmark without a bank credit risk component (for example, Treasury bills), once LIBOR has become the dominant benchmark, it is very difficult for the market to switch to this new equilibrium on its own. The result of these liquidity externalities can be that markets suffer a coordination failure and become stuck at an inferior equilibrium.

Second, the incentives for manipulation are heightened when a large derivatives market is indexed to a benchmark rate that is set in a primary market where trading activity is orders of magnitude smaller. What is striking about many of the documented cases of LIBOR manipulation is that they involved only very small rate distortions, with the guilty parties often misstating their borrowing costs by just a few basis points. Even such tiny distortions in LIBOR fixings can be potentially very profitable for a manipulator who has accumulated a large enough position in derivatives whose payments are contractually based on the LIBOR fixing. Thus the relative scales of the two markets—the derivatives market versus the primary market which ultimately determines the reference rate—play a key role in manipulation incentives.

Moreover, this manipulation problem is not resolved merely by improving the design of the LIBOR fixing methodology, despite the importance of making these improvements. In the past, manipulators arranged for dishonest judgment-based reports of bank borrowing rates. But even with a fully transactions-based benchmark, a manipulator might attempt to distort actual transactions in the underlying bank funding markets. A thin underlying borrowing market cannot be expected to provide a robust foundation for a multi-hundred-trillion dollar derivatives market, even with substantial improvements to the LIBOR fixing methodology.

The Basic Idea of a Two-Benchmark Approach

If we were starting from scratch, what might a more efficient and resilient set of arrangements for interest-rate benchmarking look like? The above discussion suggests that there could be considerable appeal in a "two-rate approach," that is, two distinct types of interest-rate benchmarks. One of these, an improved version of LIBOR itself, would continue to be based on banks' wholesale unsecured funding

costs and would be appropriate for applications that rest on that credit risk component, such as hedging the revenues of balance-sheet lenders. This banking-oriented benchmark would be reformed so as to be transactions-based and subject to a tougher monitoring regime, and hence less subject to manipulation.

The second benchmark would be based on a riskless or near-riskless rate that is established in a broad and deep market. The goal here would be to give pure interest rate traders—potentially a large fraction of the derivatives market—something that fits their risk-transfer needs well, while at the same time reducing the manipulation incentives that arise when so much rates-trading is tied to a rate like LIBOR that is based on the much thinner underlying market for unsecured bank borrowing.

For the two-rate approach to be more fully articulated, three questions need to be addressed. First, how does one most effectively design an improved version of LIBOR, which we will call LIBOR+, so that it is based to the maximum extent possible on actual market transactions, rather than on banks' discretionary reports of their funding costs? Second, what is the appropriate riskless or near-riskless rate to use for pure rates-trading applications? Third, and perhaps most challenging, given that we are not actually starting from scratch, and given the large obstacles posed both by legacy contracts and liquidity-driven coordination problems, how can policymakers help to break the stranglehold of existing LIBOR and pave the way for transition to a two-rate regime? In what follows, we consider each of these questions in turn.

The Design of LIBOR+

The various policymaking groups that have studied the manipulation problems associated with LIBOR have all concluded that it would be desirable to move away from the current practice of fixing LIBOR rates based on judgmental submissions from a panel of banks and shift to a fixing methodology that is more anchored in observable, verifiable market transactions. In addition to whatever benefits such a switch might bring in terms of reduced manipulability, if the fixing methodology is entirely algorithmic, it would also eliminate a potential threat to financial stability—namely that, because of legal risks, member banks might decide to defect from the LIBOR panels, making it impossible to calculate a reliable reference rate under the poll-based methodology. In the case of EURIBOR, the euro-based interbank offered rate, there has already been a notable exodus from the panel of reporting banks, which had dropped from a high of 44 to only 26 banks by June 2014 (Brundsen 2014). With an algorithmic approach to fixing, there is no need for banks to decide whether they will contribute to a LIBOR panel.

Although a transactions-based approach has clear appeal, it is more difficult to implement than one might first think. For example, 3-month LIBOR is meant to reflect the typical rate at which large banks borrow on an unsecured basis for a 3-month term *from other banks*. But the volume of borrowing in the interbank market is small and has been secularly trending downward. Some of the secular decline in interbank borrowing is likely due to the extraordinary monetary policies of the last several years, which have left banks glutted with reserves and therefore less dependent on interbank borrowing to manage their liquidity positions. There is

Table 2
Transactions Data on Unsecured Bank Borrowing

		Number of Trades					Numbers of Issuers					Volume ($mn)				
		O/N	1W	1M	3M	6M	O/N	1W	1M	3M	6M	O/N	1W	1M	3M	6M
Daily Avg	2014	468	74	21	19	18	15	9	7	8	7	20,223	3,204	888	706	718
	2013	511	95	18	25	13	16	9	6	8	6	22,312	4,157	702	1,006	474
	2012	344	62	24	31	13	17	10	8	9	5	14,889	2,637	888	1,211	452
	2011	435	79	38	34	18	21	15	14	11	5	18,945	3,356	1,407	1,331	706
Daily Max	2014	538	127	42	45	40	17	13	10	12	11	23,853	5,460	1,869	1,903	1,861
	2013	878	280	78	126	76	20	18	13	17	15	39,722	13,043	3,479	5,904	2,892
	2012	521	225	80	112	55	24	20	19	19	13	22,985	10,007	3,613	4,539	2,140
	2011	666	263	113	107	112	27	25	32	24	15	30,015	11,686	4,982	4,642	4,985
Daily Min	2014	406	31	3	8	2	14	5	3	4	2	16,998	1,279	77	222	50
	2013	187	7	1	1	1	13	3	1	1	1	6,910	204	5	1	1
	2012	33	4	0	2	0	7	2	0	1	0	1,399	124	0	64	0
	2011	235	10	3	3	0	17	4	1	1	0	9,608	242	75	24	0

Source: Market Participants Group, *Final Report*, March 2014.
Notes: This table displays daily average, maxima, and minima for number of trades, number of issuers, and dollar volume of unsecured bank borrowing transactions in the commercial paper (CP) and certificate-of-deposit (CD) markets based on a sample from a unit of J.P. Morgan over the period 2011 through January 2014. Maturity buckets are defined as follows: O/N = 1 day to 4 days, 1W = 6 days to 8 days, 1M = 28 days to 32 days, 3M = 85 days to 95 days, 6M = 175 days to 185 days. "$mn" means "millions of dollars."

also a significant reduction in interbank unsecured borrowing during periods of market stress. This tendency is especially pronounced at longer maturities (Gorton, Metrick, and Xie 2014). The paucity of interbank lending is especially severe in Japanese yen and Swiss francs (Market Participants Group on Reforming Interest Rate Benchmarks 2014).

Simply put, most banks don't borrow at longer maturities from other banks on most days. This is an obvious challenge to any attempt to measure term interbank borrowing rates on a daily basis, be it judgment-based or transactions-based. If LIBOR is to serve as an effective benchmark, its fixing should be broadened so as to be based on unsecured bank borrowings *from all wholesale sources*—not just other banks, but nonbank investors in bank commercial paper and large-denomination certificates of deposit (CDs). This is a key recommendation for LIBOR+ in the Market Participants Group (2014) report. Indeed, this report conducted a pilot study of LIBOR+ using proprietary data from a unit of J.P. Morgan that covers approximately 40 to 45 percent of the overall market for unsecured bank borrowing. Table 2 gives some details on the density of transactions at various tenors (that is, lengths of borrowing period) in this data set. For example, over the period from 2011 to early 2014, there were roughly 25 to 30 transactions at the 3-month tenor on a typical day, for an average total daily dollar volume of about $1 billion. However, on the lowest-volume days, there were only a handful of transactions, numbering on the order of three to eight.

With these data in hand, the Market Participants Group (2014) built a prototype LIBOR+ fixing algorithm. Their basic methodology is as follows. On any given day t, for any given bank i, and for any tenor of interest, if bank i has an available transaction, the rate on that transaction is entered with a weight of unity into the index. If bank i does not have an available transaction, the algorithm goes back

to the nearest prior date $t - k$ when there is a transaction, and enters the rate on that transaction into the index with a reduced weight—one that gets smaller as the distance k from the present gets larger. Thus the algorithm includes noncontemporaneous data to compensate for the low density of transactions on any given day, but downweights the older data in light of its staleness (Duffie, Skeie, and Vickrey 2013).

The results of this exercise are plotted in Figure 2, which compares the constructed LIBOR+ to actual LIBOR for each of the 1-, 3- and 6-month tenors. As can be seen, while LIBOR+ is always more volatile on a day-to-day basis than LIBOR—which is not surprising given the opinion-based nature of LIBOR—the levels of the two time series track each other reasonably closely at both the 1-month and 3-month tenors. At the 6-month tenor, the fit is considerably less good. Some of this deterioration in fit is due to the paucity of transactions at 6-month terms. But some of it is due to a particular form of sample selection—the fact that during a period of market stress, only the highest credit-quality banks find it economically sensible to issue at a 6-month maturity. This selection effect tends to make the transactions-based LIBOR+ lower than the judgmentally reported LIBOR during stressful periods in the banking sector. Nevertheless, given that the vast majority of contracts in dollar LIBOR reference the 1- and 3-month tenors, the LIBOR+ methodology holds considerable practical promise, especially if the interbank loan data supporting it can eventually be augmented to capture the entire universe of certificate-of-deposit and commercial paper transactions.

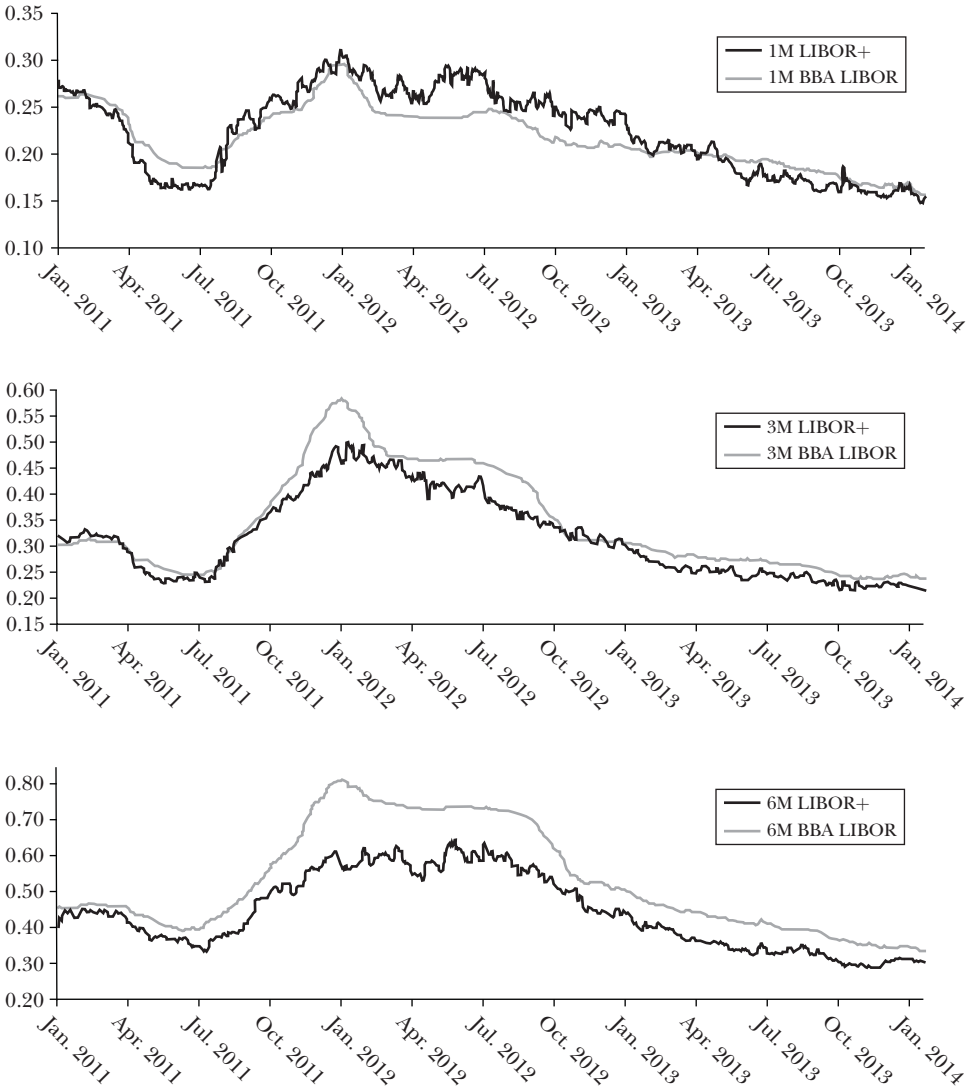
However, even if a transactions-based LIBOR+ methodology can be made to work well from an economic perspective, there remains the crucial question of whether it also "works" legally. In other words, for the large stock of existing legacy contracts that reference LIBOR, is it possible to seamlessly substitute a fixing along the lines of LIBOR+ without causing private litigants to challenge this substitution? We will return to this question later.

What is a Suitable Riskless Interest Rate Benchmark?

Despite the potential promise of LIBOR+ for certain bank-based transactions, we believe that it would be a mistake for such a benchmark to shoulder the burden of being the primary reference rate for the entire interest-rate derivatives market. To understand why, compare the magnitudes in Tables 1 and 2. At the commonly used 3-month tenor, transactions in the underlying market for unsecured bank funding are roughly on the order of $1 billion dollars on a typical day, while the volume of gross notional outstanding in the swap market that references LIBOR at this tenor is on the order of $100 trillion, or *100,000 times larger.*[3] As we have been emphasizing, this divergence leaves a strong incentive for a trader with a large derivatives position to manipulate even a transactions-based LIBOR+, for example

[3] This compares a flow with a stock, but the difference remains striking. The daily volume of US dollar LIBOR-based derivatives has an order of magnitude of around $1.15 trillion (Bank for International Settlements 2013, table 3). This is roughly a factor of 1,000 times the volume of trade determining 3-month US dollar LIBOR. Moreover, payments on the much larger stock of outstanding derivatives are exposed to daily LIBOR fixings.

Figure 2
Comparison of Transactions-Based LIBOR+ to Actual British Banker's Association (BBA) LIBOR



Source: Market Participants Group (2014).

by borrowing or lending (or by arranging for someone else to borrow or lend) more or less aggressively in the markets for interbank loans, commercial paper, or certificates of deposit.

In our view, a key to reforming interest rate benchmarks is therefore to encourage the transition of a large fraction of derivatives trading to a more robust benchmark based on interest rates that are risk-free, or nearly so. There are several

possibilities for such a benchmark: an interest rate administered by the central bank, the rate on short-term Treasury bills, general collateral repo rates, and overnight index swap (OIS) rates. We consider each of these in turn.

The Federal Reserve sets certain interest rates directly. For example, it sets the rate that it pays to banks on their excess reserves. It also sets the "overnight reverse repurchase rate," which is the rate paid by the Fed to a wider range of market participants on overnight reverse repurchase agreements, whereby the Fed effectively borrows on a collateralized basis against its holdings of government securities. Indeed, the Fed has announced that it plans to use its control of these two rates as tools to implement changes in monetary policy going forward.

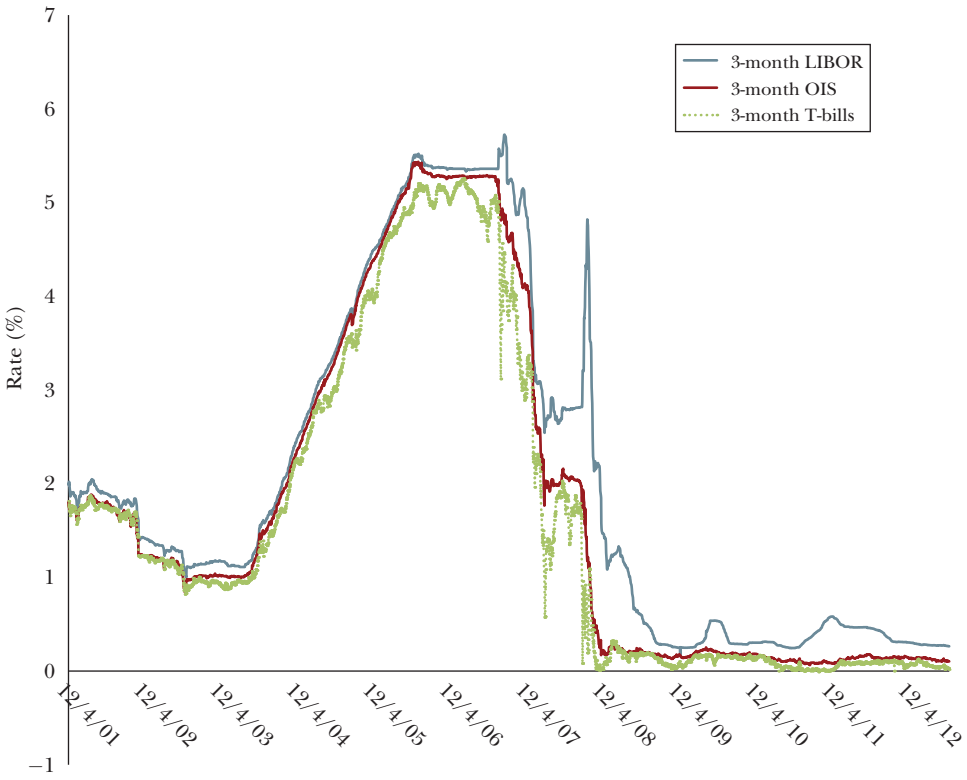
Because these two rates are directly administered by the Fed, as opposed to being set in the market, they are immune from manipulation. However, the appeal to market participants of using these administered rates as benchmarks will depend on the details of how the Fed uses them to implement monetary policy. For example, the Fed may decide to leave a relatively large spread between the rate on excess reserves and the reverse repurchase rate, with market-determined short-term rates bouncing between these two administered rates. In that case, neither of the two rates would be a tight proxy for the market risk that investors are most anxious to transfer. A secondary concern is whether an overnight interest rate like that on the reverse repurchase facility would be attractive for the settlement of floating-rate contracts that have traditionally been based on longer maturities such as three months.

The rate on short-term Treasury bills is another natural candidate for a riskless reference rate. While this market is not manipulation-proof, it is certainly much deeper and more active than the market for unsecured bank borrowing. Moreover, in January 2014, the US Treasury began to issue floating interest rate notes linked to auction-determined rates on 13-week Treasury bills. The Treasury's presence in the floating-rate note market may help to boost liquidity in contracts that use Treasury bill interest rates as a benchmark.

The Market Participants Group (2014) report received input from a wide range of market participants regarding their desire to use Treasury bill rates as a reference rate for derivatives contracts. The responses indicated a general lack of enthusiasm for this option. One reason for this skepticism is that during periods of market stress, "flight-to-quality" or "safe-haven" demands tend to lower the rates on Treasury bills relative to those on other relatively safe instruments. This phenomenon is illustrated in Figure 3, which plots the rate on 3-month Treasury bills along with the 3-month overnight index swap (OIS) rate, another often-used proxy for a near-riskless rate (which will be discussed further later in this section), as well as 3-month LIBOR. Several downward spikes of the Treasury bills rate relative to the OIS rate during the financial crisis are readily apparent. To the extent that investors are seeking to hedge or speculate on the general level of rates without taking a view on movements in these Treasury-bill-specific safe-haven premiums, these spikes can make the interest rate on Treasury bills less appealing as a reference rate.

Nevertheless, we think it is easy to exaggerate this concern. Over the sample period December 2001 to July 2013 shown in Figure 3, the correlation between 3-month Treasury bill rates and 3-month OIS rates is 0.995 in levels and 0.560 in

Figure 3
3-Month LIBOR, Overnight Index Swap (OIS), and Treasury Bills



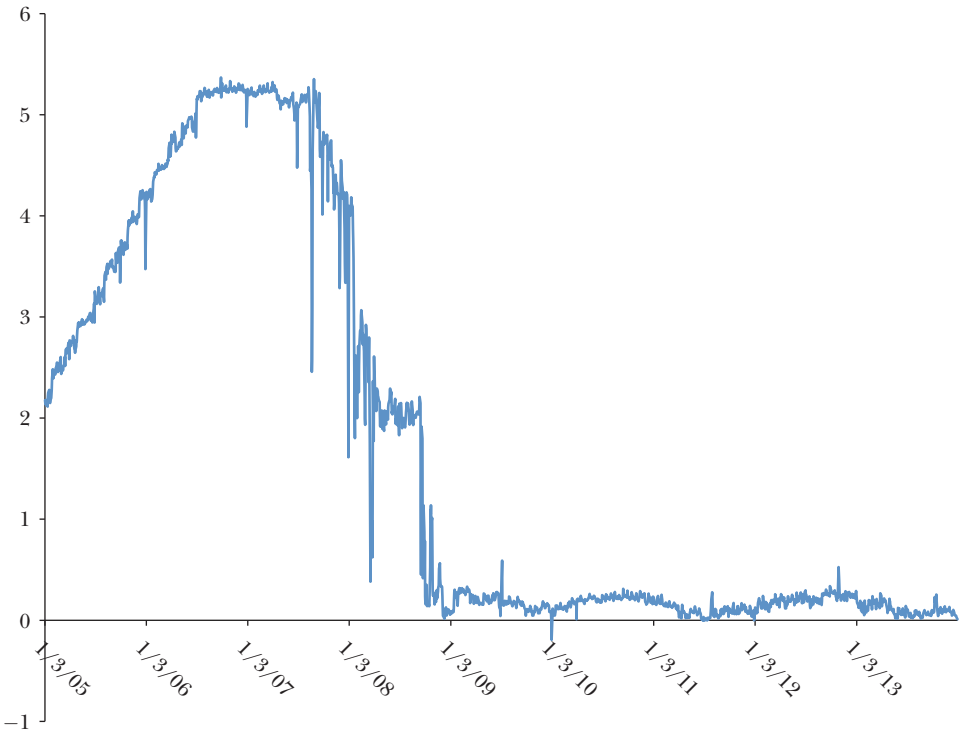
Source: Data is from Bloomberg.

weekly changes. The basis risk here is notable mainly in tail events. Given the other obvious merits of using Treasury bills as a reference rate, our view is that this option should be given careful consideration.

Another near-riskless rate is the so-called "Treasury general collateral repo rate." A "general collateral" repurchase agreement is signed without specifying a particular security that will be sold and repurchased, but instead just specifying that the lender of funds will accept anything from the general class of Treasury and other related securities as collateral. Thus, the general collateral repo rate is effectively the average rate at which dealers obtain overnight financing secured by Treasury securities. This market is highly liquid; recently, about $590 billion of Treasuries are financed this way on a typical day.[4] Hence, like Treasury bill rates, one would expect general collateral repo rates to be relatively robust to manipulation.

[4] The Federal Reserve Bank of New York provides the amounts of securities financed in the tri-party repo market on the seventh business day of each month. For July 2014, see http://www.newyorkfed.org/banking/pdf/jul14_tpr_stats.pdf.

Figure 4
Overnight Treasury General Collateral Repo Rate



Source: The data is from Boomberg.
Notes: The data in the figure is for the Treasury General Collateral Finance (GCF) rate, which is published by the Depository Trust and Clearing Corporation. The GCF rate is based on a subset of transactions (approximately 20 percent) in the broader tri-party general collateral repo market.

Although there is currently no official general collateral repo rate, Figure 4 plots a close proxy, the "Treasury General Collateral Finance" rate, which is published by a company called the Depository Trust and Clearing Corporation. This rate is based on a subset of about 20 percent of all transactions in the broader general collateral repo market. As shown, general collateral repo rates, like Treasury bill rates, tend to spike downward during periods of market stress, reflecting a safe-haven property. Some of the volatility of the general collateral repo rate is also due to the one-day maturity of this rate. That is, unlike the 3-month Treasury bill rate, there is no "averaging out" of the impact of short-lived supply and demand shocks. A further disadvantage of the general collateral repo rate is that the underlying market is not very active at maturities beyond one week, whereas LIBOR is most actively referenced at the 1-month and 3-month maturities.

Motivated by these limitations with the general collateral repo rate, a more novel benchmark design discussed in the Market Participants Group (2014) report is the compounded interest rate implied by the overnight general-collateral

rates over (say) the three months leading up to settlement date.[5] This 3-month-lagged compounded daily rate is clearly an implementable benchmark. This rate is extremely robust to manipulation because, as we have discussed, the underlying general collateral repo rate is itself robust, and the averaging inherent in this formula makes manipulation all the more difficult. On the other side of the ledger, a potential drawback of this compounded-daily-rate benchmark is its backward-looking nature. Still, while some market participants might prefer to know their next floating-rate interest payment well in advance of the due date rather than waiting until very shortly before the payment is due, this wait-and-see payment method is more familiar to most wholesale market participants such as swaps traders. Even retail financial consumers are familiar with the idea of having their latest floating-rate mortgage payments reported to them after the fact in their bank statements, in the same manner as their utility payments.

Our final candidate for a low-risk interest rate benchmark, as we mentioned earlier, is the overnight index swap (OIS) rate. The 3-month OIS rate is the interest rate on a so-called overnight index swap, which pays a predetermined fixed interest rate in exchange for receiving the compounded daily federal funds rate over the 3-month term of the contract.[6] Thus, the 3-month OIS rate can be thought of as the market's forward-looking expectation for the average federal funds rate that will prevail over the upcoming three months. (Because of compounding and also because of risk aversion to uncertain changes in future daily federal funds rates, this "expectation" is slightly biased.) To the extent that federal funds interest rate transactions—which are overnight unsecured borrowings by banks—are themselves close to riskless, the 3-month OIS rate is a reasonable proxy for a 3-month riskless rate. An advantage of OIS is that it does not incorporate the same kind of safe-haven premium as Treasury bills.

The potential appeal of the overnight index swap rate as a standardized low-risk rate is evident in Figure 3. During periods of market stress, there are no upward spikes associated with jumps in term credit risk premiums, and no downward spikes associated with flight to a Treasury-like safe haven. Some researchers and many market practitioners therefore rely on OIS rates as a relatively clean and transparent proxy for the "true" riskless rate.

However, it is less clear that the overnight index swap rate is ready for the more demanding task of serving as a benchmark for payments on many trillions of dollars of interest-rate derivatives. Importantly, the OIS market itself is a derivatives market that is not yet heavily traded. For example, Fleming, Jackson, Li, Sarkar, and Sobel (2012) report that between June and August 2010 there were an average of only 31 transactions a day in US dollar OIS, representing a notional volume of about $30 billion. It is not clear that one should attempt to shift volume from a LIBOR

[5] For example, the contractually agreed floating-rate payment due at the end of a 90-day contract period would be $P = (1 + r_1)(1 + r_2)\ldots(1 + r_{T-1})$, where $T = 90$ and where r_k is the overnight general collateral repo rate.

[6] More generally, by entering an overnight index swap position as a fixed-rate payer, one agrees to pay at maturity in T days the notional principal amount plus interest on this amount at the contractually agreed

benchmark on the premise that the underlying bank-borrowing market is so thin, and then substitute with another rate such as OIS that is also set in a relatively thinly traded market.

None of the alternative reference rates that we have discussed is perfect for all applications, but they are feasible and relatively effective substitutes for many applications currently served by LIBOR. None of these alternative rates include a significant component for bank credit risk, which is an advantage over LIBOR for most "rates trading" applications. All of these alternatives, with the exception of the overnight index swap rate (whose market is currently relatively thin), are far less subject to manipulation than LIBOR. If the OIS market were to grow sufficiently, perhaps boosted by support from the official sector, it too might someday become an effective substitute for a significant amount of LIBOR-based derivatives trading, though in our judgment it is not currently up to the task.

Can We Get There from Here? Transition Challenges

To summarize the discussion to this point: We have argued that if we could start the world from scratch, we would aim for a two-rate model, with a transactions-based LIBOR+ serving as the reference rate for most on-balance-sheet bank lending contracts, and with some low-credit-risk reference rate—such as the Treasury bill rate, the 3-month lagged compounding of daily general collateral repo rates, or perhaps eventually the overnight index swap rate—serving as the reference rate for the majority of interest-rate derivatives. However, given the large stock of legacy contracts already tied to LIBOR, as well as the strong liquidity-driven network effects that we have discussed, getting from here to there presents formidable challenges. In what follows, we lay out a transition strategy that we think has the best shot of addressing these challenges. We acknowledge, however, that even this best-case strategy faces a number of daunting uncertainties.

A "Seamless" Transition from LIBOR to LIBOR+ for Legacy Contracts

The first element in our idealized transition strategy is a "seamless" transition from LIBOR to LIBOR+ for legacy contracts. At some future date, the LIBOR administrator would stop publishing LIBOR based on its current fixing methodology, and would begin publishing LIBOR+ in its place. The current administrator for LIBOR is ICE Benchmark Administration, which took over from the British Bankers' Association (BBA) in early 2014. Contracts would not need to be rewritten to change the stated "LIBOR" reference rate; merely the fixing would change.

The key risk associated with this approach is that it may provoke legal challenges, in which one party to a contract claims that his obligations should be

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OIS rate R, in exchange for a floating-rate payment from the counterparty. The floating-rate payment per dollar of notional is the compounded overnight amount, that is, $(1 + r_1)(1 + r_2)\ldots(1 + r_{T-1})$, where r_k is the stipulated benchmark overnight interest rate on day k.

discharged based on the doctrine of "contract frustration." The Market Participants Group (2014) report contains a detailed analysis of this issue. Although it is hard to be definitive, the report suggests that contract-frustration risks are likely to be mitigated if: 1) the conceptual basis for LIBOR+ (as a rate representative of unsecured bank borrowing costs) is close to that for existing LIBOR; and 2) the two rates have similar levels as of the transition date, as well as similar statistical properties, thereby minimizing any value reallocation associated with the switch. The report concludes, based on legal consultations as well as the sort of pilot-testing of LIBOR+ shown in Figure 2, that a "seamless transition can be achieved for US dollar LIBOR at the popular 1-month and 3-month tenors without raising undue risk of legal contractual frustration risk" (p. 25). However, the report does not reach a final conclusion about whether to attempt a seamless transition from LIBOR to LIBOR+ at the somewhat less-popular 6-month maturity.

Pushing Newly Written Derivatives to a Riskless Reference Rate

While a seamless transition appears to be a promising approach for moving contracts from LIBOR to LIBOR+, it is unlikely to be viable for moving contracts from LIBOR to an alternative low-credit-risk rate of the sort we have discussed, for example the Treasury bill rate. The differences between LIBOR and these other alternatives are too substantial, both in concept and in statistical behavior, for such a switch to avoid legal challenges based on contract frustration. Instead, if the goal is to move a major fraction of derivatives trades to a riskless rate, this must be accomplished differently. We propose the following steps.

First, the majority of already-existing derivatives contracts would not be altered, but rather could simply be allowed to roll off over time. An analysis of the maturity distribution of these contracts suggests that a substantial "roll-off" can occur over a five-year horizon. Specifically, for the different categories of over-the-counter and exchange-traded derivatives displayed in Table 1, about 65 percent of over-the-counter interest-rate swaps will roll off over five years, as would approximately 100 percent of floating-rate agreements, 74 percent of over-the-counter interest-rate options, 76 percent of cross-currency swaps, 100 percent of exchange-traded interest-rate options, and 99 percent of exchange-traded interest-rate futures (Market Participants Group 2014, p. 309).

Second, regulators would use a variety of tools to encourage newly written derivatives contracts to reference a riskless rate, rather than LIBOR (or LIBOR+). For example, bank regulators could, for the firms that fall under their authority, increase the effective capital charges that apply to derivatives based on LIBOR relative to those based on a riskless rate. In addition to mitigating manipulation incentives, we believe that there is a legitimate safety-and-soundness rationale for doing so. As noted above, the survey-based nature of current LIBOR creates the risk of defections from the bank reporting panels, with the attendant dangers of market-wide disruptions if the LIBOR rate cannot be produced. To the extent that a transition from LIBOR to LIBOR+ takes a long time or is subject to uncertainty, beginning the process of moving derivatives to an alternative reference rate would have the added benefit of reducing this type of risk to financial stability.

It is difficult to say just how much regulatory pressure would need to be applied to substantially change contracting practices in the derivatives market, or how much force it would be appropriate to apply. On the one hand, as we have argued above, there are elements of a pure coordination problem here. It may be that many derivatives users would actually prefer to be in an equilibrium in which there were highly liquid contracts that referenced a riskless rate, as opposed to an equilibrium in which the benchmark contains a significant spread component for bank credit risk. In this case, a strong regulatory hand that pushes the outcome towards this new equilibrium would be seen as socially desirable. On the other hand, there is undoubtedly significant heterogeneity among derivatives users, and it is far from clear that all would prefer the new equilibrium. As a result, any strong push by regulators would likely create losers as well as winners, which cuts against an overly aggressive use of regulatory authority such as a highly punitive capital charge on derivatives that remain linked to LIBOR or LIBOR+. Striking the right balance on this dimension seems to us to be one of the most challenging aspects of the reform process.

Conclusion

Rather than restating our arguments, we close by highlighting a fundamental limitation of our analytical approach. From the outset, we have taken as given two policy objectives: 1) that it is desirable to maintain large, deep, and liquid interest-rate derivatives markets; and 2) that it is also desirable to design markets in a way that leans against manipulation. But as we have seen, there is a fundamental tension between these two objectives: the deeper and more liquid a derivatives market becomes, the more tempting it is for market participants to manipulate the underlying benchmark referenced by these derivatives.

This suggests that even the best market design can only go so far, and that if one wishes to support the existence of a very large derivatives market, some equilibrium level of manipulation may be an inevitable cost of doing business. This is an uncomfortable prospect for policymakers to acknowledge, but it is nevertheless important to be candid on this score. The last thing one wants is to embark on a costly and time-consuming set of reforms while overpromising what they can deliver. On a more constructive note, acknowledging the limits of market-design policies, such as those suggested here, underscores the need for a complementary attack on the manipulation problem from a legal (rules and enforcement) angle. Given that one cannot count on market design as a panacea for preventing manipulation, vigorous enforcement of the civil and criminal statutes against market manipulation will continue to play an important role no matter what other reforms are undertaken.

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