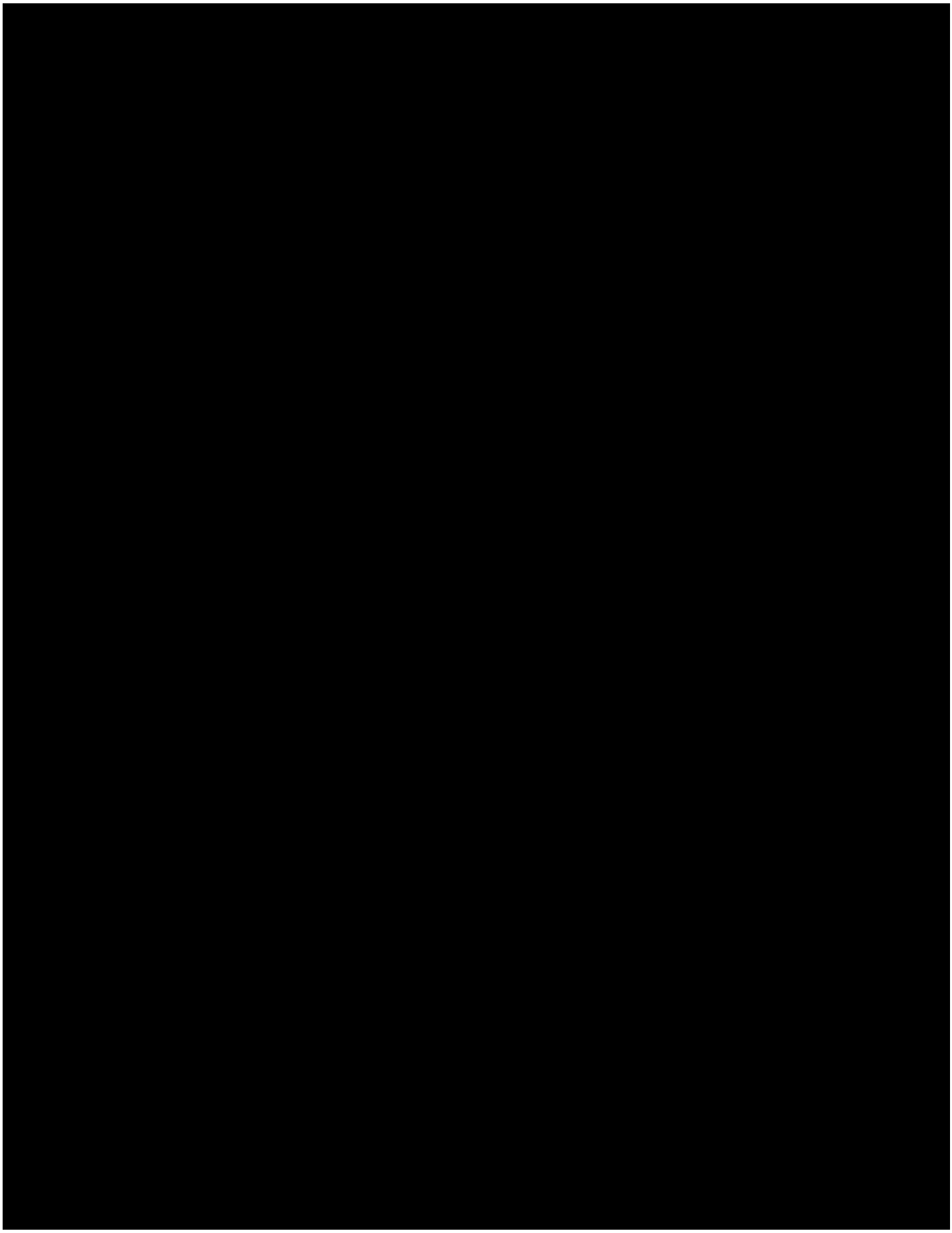

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Leverage—A Broader View

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Abstract

Traditional measures of leverage in the financial system tend to reflect bank balance sheet data. The paper argues that these traditional, bank-centric measures should be augmented by considering pledged collateral in the financial system since pledged collateral provides a measure of an important part of nonbank funding to banks. From a policy perspective, the paper suggests that a broader view on leverage will enhance our understanding of global systemic risk, and complement the theoretical work in this field by providing a link from micro-level leverage data to macro aggregates such as credit to the economy.

JEL Classification Numbers: G21; G28; F33;K22

Keywords: regulations; financial stability; leverage ratio; off-balance sheet; pledged collateral

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I. INTRODUCTION

Traditional metrics of leverage in the financial sector have important shortcomings. Leverage metrics commonly used in the literature are primarily based on bank balance sheet data (to be precise, "on-balance sheet" data), even though recent Basel rules propose to pick up several off-balance sheet transactions for their monitoring reports. Typical leverage metrics include the ratio of total assets to capital, or some variant such as ratio of risk-weighted assets to Tier 1 capital. Recently, the FSB's (Financial Stability Board) global shadow banking monitoring report has included balance sheet data of relevant nonbanks to enhance our understanding of the credit intermediation within the overall financial system. However, all such measures are similar in their construction, relying on the aggregation of balance sheet data only. These measures do not fully capture the bank-nonbank nexus, since the size of nonbank funding to banks is not readily available in standard bank databases constructed from on-balance sheet data only. We will argue that pledged collateral represents a useful measure of non-bank funding to banks, which is a driver of bank credit.

In this paper, we seek to demonstrate that the omission of off-balance sheet items in the standard measures implies a substantial underestimation of bank leverage. Adrian and Shin (2009, unpublished) suggest that leverage has two components: leverage from balance sheets of banks and leverage from the interconnectedness within the system (Annex 1). We focus on the latter component—leverage arising from the interconnectedness within the financial system—and show that it is large, rising, and not fully accounted for in bank balance sheets. We do so in a few ways. Firstly, our estimates, based on the theoretical framework described in Shin (2010), show that aggregate nonbank funding (i.e., wholesale and household deposits) to banks is on the rise among economies with large and inter-connected financial systems. We then dive deeper into one source of wholesale bank funding, by examining data we have collected on pledged collateral funding of the largest 15 global systemically important banks (G-SIBs). We find that such funding is large, and has been rising relative to the size of the banks' balance sheet assets. Finally, we estimate that fully accounting for pledged collateral transactions could increase bank leverage values by about a third at the G-SIB level; this aspect has not been covered in the recent literature on shadow banking issues, post-Lehman crisis. While accounting for pledged collateral does not allow us to fully measure the interconnectedness within the financial system, it nevertheless provides useful trends, and opens an avenue for research.

Given their size and importance, we believe that further efforts need to be made to adequately and systematically capture off-balance sheet items, especially pledged collateral transactions, in bank leverage metrics. Since many of these transactions are not accounted for in banks' balance sheets, it is not possible to compute precise leverage from a global financial stability perspective. For example, if Walmart wants to expand in Texas and needs funding from its relationship bank, Citi, the treasurer of Citi can choose to fund its client from deposits or wholesale funding (which are both on balance sheet), or from pledging collateral it has received off-balance sheet to another bank (e.g., Barclays). For the treasurer, deposits, or wholesale funding, or pledged collateral (after a few steps), are all fungible resources that can be mobilized to fund a client.

Balance sheet reporting at a national level can only focus on assets and liabilities of banks in their jurisdiction, and not on transactions that cannot be identified with any jurisdiction. Transactions that are cross-border in nature, such as a large share of pledged collateral agreements (or wealth management accounts, etc.) fall through the cracks. A more systematic collection of information on nonbank funding would help improve our understanding of global leverage and allow researchers and policy makers to observe the development of related risks in a much more accurate and timely manner. More generally, it would enrich the wide research sorrounding leverage.

The rest of the paper is structured as follows. Section II discusses some of the literature on bank leverage, and a few related studies on nonbank leverage. Section III examines why off-balance sheet data of banks are important to enhance our understanding of the overall leverage within the financial system. Section IV looks at the change in nonbank funding (i.e., household and wholesale) to banks over the past decade, and applies our "broader" leverage lens, including off-balance sheet funding. Finally, in the conclusion, we recommend augmenting the banking data-driven leverage to enhance our understanding of the overall financial leverage and credit to the economy at the macro level.

II. LITERATURE REVIEW

The literature has used a variety of measures to estimate leverage in the financial system. Data come from a variety of sources such as national statistics (for example, flow of funds), SNL Financial (a division of Standard & Poor's), the Bank for International Settlements (BIS) consolidated international banking statistics, and Fitch's Bankscope. These papers and databases share a common theme: either they only look at banks and rely on balance sheet information, or aggregate data that results in losing the overall picture of a bank at the holding company level.[2] Overall, nonbank linkages with banks are not fully captured in the flow-of-funds statistics, as banks' on-balance sheet data do not pick up sizable nonbank funding to banks that is reported off-balance-sheet. Almost two decades ago, Breuer (2000) suggested a need for appropriate capitalization of banks that accurately captures total exposure, on and off- balance sheet. However, recent regulations such as Basel III do not ask for a modified leverage metric that spans all off-balance sheet transactions (see Box 2).

At the macro level, Schularick and Taylor (2012) approximate leverage by credit-to-GDP (where credit is measured by total bank loans and adjusted by CPI), and suggest that "the entire bank balance sheet, the asset side, leverage, and composition, may have macroeconomic implications"—and that the entire balance sheet should encompass activities that remain off-balance sheet; similar arguments are made by Singh and Stella (2012). While Borio and Drehmann (2009) discusses the usefulness of credit-to-GDP gap as an early indicator of banking crisis, they also suggest that enhancing data on cross-border exposures beyond those captured by BIS international banking statistics would be better. Their work also recommends considering global measures of credit, rather than country-by-country ones.

[2] For example, flow-of-funds data show all elements of the holding company (bank, dealer, asset manager, etc.), but "tears up" holding company X's balance sheet and then aggregates all banks in one sheet, all dealers in another sheet, and so on. This aggregation leads to a loss of the overall picture of the holding company. Thus, the need to go back to financial reports to see the buildup of all business positions of the bank holding company.

Furthermore, they state, "one could improve on the measures of leverage. For example, the indicators do not consider leverage within the financial system itself, which appears to have been so prominent in the current episode." Lee et al (2017) construct vulnerability indices that include, among other constituents, leverage of banking and nonbanking sectors. The IMF's Global Financial Stability Reports (October 2014 and October 2017) also uses credit-to-GDP to shed light on emerging global risks.

To the extent credit-to-GDP is an important policy indicator, it is essential that we understand its drivers, such as bank-to-bank credit. As an analogy from the Venn diagram perspective, attempts are being made to understand the overall financial system in an additive sense where all sources are assumed to be mutually exclusive (i.e., adding on-balance sheets). We focus on large intersections of these sources as they are not mutually exclusive (i.e., focus on off-balance sheets where banks and nonbanks overlap).

Although nonbank funding has been recognized as large and increasing, their off-balance sheet funding to banks "falls through the cracks." Instead, the focus of recent work in this area (see Claessens and Ratnovski (2014), Adrian et al. (2013), Fischer (2015) among others), highlight funding from the perspective of nonbank "entities" or "activities." Aikman et al (2016) measure financial leverage as a ratio of total assets to equity of depository institutions, insurance companies, broker dealers, finance companies, real estate investment trusts (REITs), and financial holding companies. They note that "because of the growth of the derivatives market, leverage and short-term funding has become more difficult to measure." While they are unable to find such non-linear effects for leverage, they acknowledge data gaps that exist in their leverage measure. Fender and McGuire (2010) highlight the need to look at geographically disaggregated bank balance sheets—however, when data does not belong to a location, it is not captured in any balance sheet. Hahm et. al (2012) conclude that non-core bank liabilities may be a better measure than credit-to-GDP for predicting crisis; however, the former metric is balance-sheet driven only. Typically research in this field and related areas is limited to information from flow of funds data, where banking data comprises balance sheet data only. Thus, inclusion of these missing aspects would likely strengthen their results, as it would address the measurement error prevalent in these studies—see Box 3 on measurement error.

While Basel reporting and analysis presented in the Basel Quantitative Impact Study (QIS) use consistent methodologies, BIS databases (such as Consolidated Banking Statistics) do not include some important off-balance sheet items. Similarly, the IMF's Financial Soundness Indicators (FSI) measure of financial leverage (capital to total assets) only includes on-balance sheet measures to the best of our knowledge. FSI data also feed into the OECD's vulnerability indicators (Röhn and others 2015). Their leverage measure (Tier 1 capital to total unweighted assets) and their shadow banking measures both come from the FSI, which seem to rely primarily on balance sheet information, and do not factor large off-balance sheet transactions, such as those of pledged collateral, into their calculations. Nonbank leverage has been studied, but primarily from a hedge fund perspective (Ang and others 2011; McGuire and Tsatsaronis (2008). The United Kingdom's (U.K.'s) Financial Sector Authority also used to provide semi-annual leverage (or footprint) via the hedge fund industry in the U.K., but since its dissolution, such granular information has not been readily available—see Annex II and Singh (2011).

III. FINANCIAL SYSTEM LEVERAGE

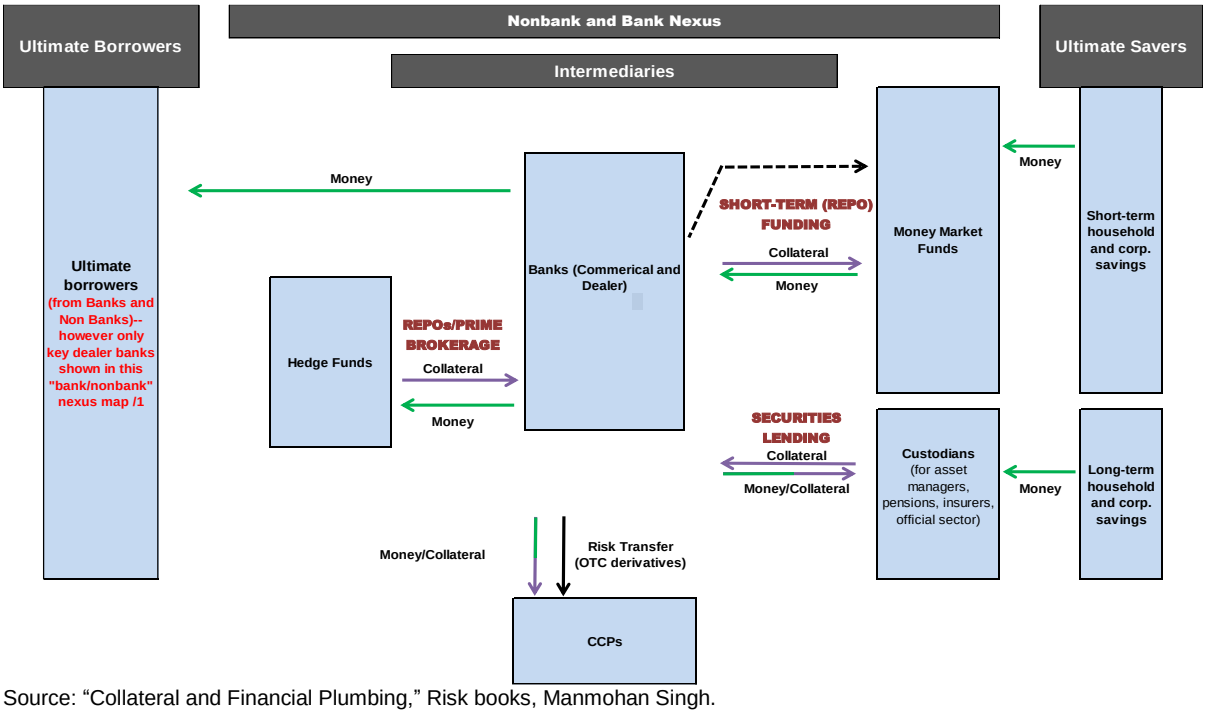
In this section, we discuss the role of leverage in the overall financial system and the importance of off-balance sheet data of banks. Box 1 discusses an analytical framework that explains the nonbank–bank nexus, illustrated in Figure 1. The diagram focuses on the pledged collateral market that underpins the understanding of nonbank leverage:

- Ultimate savers (rightmost column of Figure 1), which include short-term household and corporate savings and long-term investors through the asset-management complex (insurance, pension funds);

- Ultimate borrowers (leftmost column of Figure 1), which include corporations, households and government; and

- Dealer banks (center), which play a central role in intermediating collateral and money flows; these dealer banks (i.e., depository institutions active in this market) connect the nonbank space, and funnel collateral or money between various nonbanks such as money market funds, hedge funds, pension funds, insurers, and official sector accounts.[3]

Figure 1. Nonbank Funding to Banks



Source: "Collateral and Financial Plumbing," Risk books, Manmohan Singh.

[3] Dealer banks interact with nonbanks (e.g., hedge funds) via derivatives, securities lending, repo agreements or prime-brokerage activities. Commercial banks interact with nonbanks (e.g., households, corporates, etc.) primarily via loan syndication, deposits, etc. Ultimate borrowers are funded by both type of banks.

Box 1. Some Analytics on Nonbank/Bank Funding

Bank credit to ultimate borrowers is funded by either the equity of the banking system or the funding that nonbanks (i.e., households, pension funds and insurers) provide to the banking system. This is depicted in the equation below Shin (2010). The term on the left of the equation, y_i, denotes the total lending to ultimate borrowers. The term in the middle balloon denotes the total funding to the banking sector provided by nonbanks (or outside claimholders). And the term on the right denotes the total equity of the banking system.

$$\sum_{i=1}^{n} y_i = \sum_{i=1}^{n} e_i z_i (\lambda_i - 1) + \sum_{i=1}^{n} e_i$$

Total lending to ultimate borrowers | Total debt liabilities to non-banks | Total equity of intermediaries

yi is the total claims on ultimate borrower by $bank_i$

ei is the equity of $bank_i$

λ_i is the leverage of $bank_i$ (defined as asset over equity)

z_i is the fraction of nonbank funding $bank_i$ receives

The traditional view of a banking system is that total funding from nonbanks (the first term on right-hand side shown in red balloon) is relatively "sticky". In other words, it is often assumed that, nonbank funding to banks predominantly reflects households' deposits only (or M2, a metric that measures broad money) and the stock of household deposits is steady (in line with relatively slow-moving household wealth). Thus, according to earlier research, nonbank funding to banks does not vary much (e.g., Rixtel and Gasperini, 2013). Household deposits grow in line with household wealth and income—steadily. As such, rapid increases in the aggregate volume of credit supplied through the banking system must come via increased leverage (λ_i), which—due to the "stickiness" of the red balloon and the stable nature of M2—is assumed to come from increases in interbank claims. Thus, in this interpretation, the bank/nonbank nexus is largely an interbank phenomenon. Seminal work by Adrian and Shin (2009) suggest that M2 "is a good proxy for the total stock of liquid claims held by ultimate creditors against the financial intermediary sector as a whole," and later demonstrate that M2 has been slow-moving or stable over time, expanding "by a factor of 2.4 since 1994."

However, over the past decade researchers have realized the importance of funding that is not reflected in the national flow of funds data, but is captured in non-M2 data. We argue in this paper that there is a broader non-M2 component that is neither "sticky" nor dependent only on household assets. Furthermore, flow of funds (Annex III) and traditional databases do not pick up the key non-M2 funding components between nonbanks and banks, especially when such funding is off-balance sheet. Thus, the financial leverage metric needs to augment nonbank funding to banks which is often reflected in off-balance sheet data where transactions between hedge funds funding from banks (i.e., prime brokerage) and other sizable collateral flows from repo or derivatives or securities lending business do not come to balance sheet, due to netting that is permissible under regulations.

As illustrated in Figure 1 (drawn to mimic the equation in Box 1), there are many avenues where banks interact with nonbanks and receive significant funding from the asset-management complex. Thus, the credit creating capacity of banks is not limited by household deposits only. The bank/nonbank relationships are not fully captured in monetary aggregates such as M2—in contrast to the suggestion by Adrian and Shin (2009) described in Box 1 above. Even when household deposits are "sticky," when we introduce nonbank firms and intermediation through the shadow-banking system, both individual banks and the whole

banking system can quickly lever up. In the U.S., as noted, the gross volume of wholesale funding that was intermediated by banks may have been as high as US$25 trillion at end-2007 (Pozsar and Singh 2011). This was far greater than the banking system estimate of US$13 trillion at that time. In other words, it has now been recognized that nonbanks' funding to banks involves much more than just households and their deposits (Figure 1). Additionally, given the size of the nonbanking sector in comparison to the banking sector (especially in the U.S.), it is critical to factor in the nonbank share when calculating lending by the financial system to the economy. This points to the importance of the variable z (or, nonbank funding that a bank receives—see Box 1), which is either not fully captured, or ignored in current empirical research.

Unlike short-term household funds—which are primarily in M2 liabilities—short-term investments of asset managers are primarily in the form of non-M2 liabilities. In turn, the supply of privately guaranteed non-M2 liquid assets is, by and large, a function of the aggregate volume of short-term claims. Since the money holdings of asset managers are ultimately the claims of households, it follows that households ultimately fund banks through both M2 and non-M2 instruments (compare to Box 1 analytics with a focus on "z"). It is important to note, however, that, while households' direct holdings of M2 instruments reflect their own investment decisions, their indirect holdings of non-M2 instruments are not a reflection of their direct investment choices, but the portfolio choice and investment management techniques of their fiduciary asset managers. In addition, nonfinancial corporations like Microsoft, Amazon, Walmart, Apple also park cash with banks, or seek returns on their cash by investing with nonbanks (e.g., hedge funds).

$$\sum_{i=1}^{n} y_i = \sum_{i=1}^{n} e_i z_i (\lambda_i - 1) + \sum_{i=1}^{n} e_i$$

Z_i can be expressed as $Z_h + Z_w$,

where,

Z_h funding that $bank_i$ receives from households (i.e., core funding), and

Z_w funding that $bank_i$ receives from wholesale market

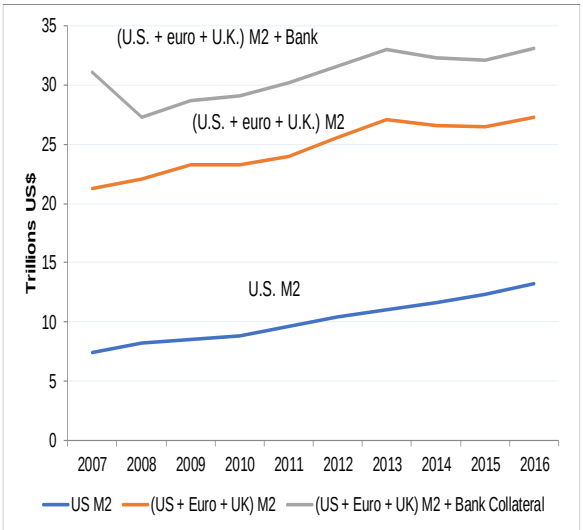
In order to understand wholesale funding, it is important to understand how the pledged collateral market works. For overall "lubrication" of its functioning, the financial system requires collateral or money for intraday debits and credits. The cross-border financial markets traditionally use "cash or cash equivalent" collateral (i.e., money or highly liquid fungible securities) in lieu of cash to settle accounts or margin calls. Financial collateral does not have to be highly rated AAA/AA—as long as the securities (which can be either debt or equity) are liquid, mark-to-market, and part of a legal cross-border master agreement, they can be used as "cash equivalent." In this way, collateral underpins a wide range of secured funding and hedging (primarily with OTC derivatives) transactions and is often preferred to cash settlement. Increasingly, collateral has regulatory value as well as being cash-equivalent. Such financial collateral has not yet been quantified by regulators and is not (yet) part of official sector statistics, but is a key component of financial plumbing (Box 2).

Collateral flows lie at the heart of any proper understanding of market liquidity, and hence of financial stability. Financial plumbing encompasses the biggest pipes that form the nexus between collateral and money. It can be seen as the interaction between nonbanks and banks in money markets and capital markets (the latter of which include securities lending, repos, derivatives, and prime brokerage). These activities are the nuts and bolts of financial plumbing.

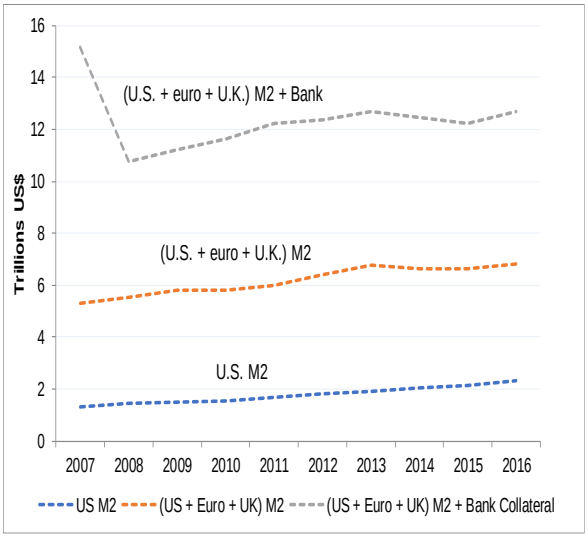
From a comparative statistics angle, Figure 2 illustrates that the pledged collateral used in financial transactions is probably at par with money, especially if all money does not flow towards market transactions. As a simple example, if annual savings are in the range of 20–25 percent of GDP in major advanced economies (that host financial centers like New York, London, Tokyo, Hong Kong etc.), then Figure 2b may be a better metric to consider as savings via various short-and long-term saving vehicles find a way to financial centers. The relevant portion of M2 that is savings is thus depicted in Figure 2b—savings comprise about 25 percent of M2 in advanced economies and only this fraction of money interfaces with pledged collateral.[4] Thus, our understanding of the pledged collateral market, relative to money, needs to be enhanced, or else we risk underestimating the sources of lubrication in the markets. A similar case could be made for wealth-management products (Adrian, 2017), since many of these transactions/products do not make it to the balance sheet. However, this paper restricts the analysis only to the pledged collateral market.

Figure 2. Relative Financial "Lubrication" from Pledged Collateral and Money

2a. Pledged Collateral and Unadjusted M2



2b. Adjusted for Savings Ratio

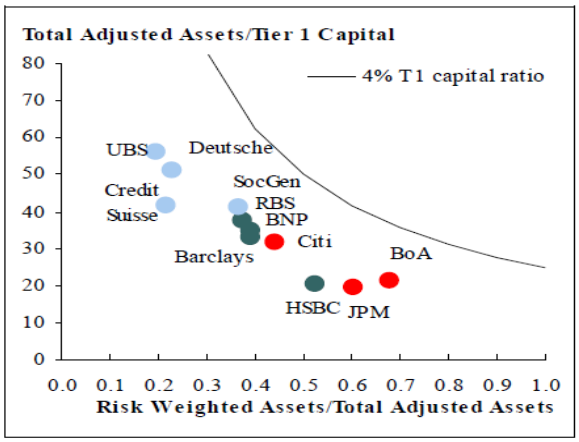


Source: IMF staff estimates.

[4] Savings to GDP ratio in U.S., United Kingdom (U.K.), Eurozone, and Japan have on average been 16.1 percent 14.5 percent, 23.3 percent, and 22.7 percent, respectively. Source: World Bank.

Box 2. International Accounting Standards and the Leverage Metric

Although the recent changes to Basel's framework make a good attempt to bring in financial data from G-SIBs to one platform, there is still room for improvement. The guidelines set in the reporting framework address two important challenges an international regulator would face to compare financial data coming in from different countries: (i) removing effects of accounting standard differences (GAAP vs. IFRS); and (ii) capturing transactions recorded off-balance sheet. While G-SIBs provide this information to Basel III monitors, they report to national authorities and so are bound by laws of the land in which they reside. Thus, bank characteristics and behavior such as composition of bank assets, balance sheet size, items on and overall size of off-balance sheet are all a function of the laws and regulations set by national authorities (e.g., standards set by SEC in the U.S. The chart below provides a 2007 snapshot of the structural differences that existed among U.S. and European banks.



Source: BIS.

The Basel QIS (Quantitative Impact Study) is a monitoring effort to support design of regulation "to assess the impact of the Basel III framework on banks", and banks' participation is voluntary. Currently, even though the latest QIS report suggests that nearly all banks are meeting leverage requirements of 3 percent, bank leverage measured as capital-asset ratio are different across countries. They are about 11.5 percent in the U.S., 6 percent in Germany, 5.5 percent in Japan and about 7 percent in U.K. and Switzerland. These differences reflect the different market structures and laws prevalent in each country. Furthermore, although QIS conforms to same data standards to make their calculations regarding important regulatory indicators (such as the 3 percent leverage ratio requirement), databases used in research pull data that is filed with national authorities, and that primarily (if not only) captures balance sheet information. Moreover, the Basel III leverage ratio framework lays out several general principles. One states that "banks must not take account of physical or financial collateral, guarantees or other credit risk mitigation techniques to reduce the [leverage ratio] exposure measure" (BIS, 2014). However, new accounting standards have forced banks to bring secured financing assets on-balance sheet, borrow vs. pledge (BVP) transactions are the one exception. BVP transactions involve an exchange of securities-for-securities and can still be held off-balance sheet, even under the new regulations. Any transaction that involves an exchange of cash must be held on-balance sheet. In a BVP transaction, a bank will exchange securities in exchange for other securities. Since cash does not change hands as part of a BVP transaction, it is allowed to be held off-balance sheet and therefore does not impact the leverage ratio of the banks (Horowitz and others 2013). If the bank has a large amount of BVP borrowings, there may be a sizable amount of funding that is sourced off-balance sheet.

Differences in netting policies under IFRS and GAAP make it difficult to compare off-balance sheet funding between the U.S. and European banks. Being cognizant of these realities leads to the observance of a problem in single-country and cross-country empirical work that use measures of leverage in their studies. These studies typically rely on balance sheet data obtained through data vendors (Datastream, Bloomberg, Fitch, etc.). These data will be bound by the prevalent accounting standards and laws governing the country in which the bank resides.

IV. A Broader View of Leverage

Bank credit generally tracks overall credit to the economy. However, the determinants of bank credit are not limited to bank's equity and leverage only, but are also influenced by the share of off-balance-sheet pledged collateral funding to banks. This suggests the need to augment the traditional bank leverage metric. This section finds that if we included off-balance sheet funding of G-SIBs from pledged collateral, wholesale funding has been higher in the post-Lehman-decade, relative to the size of the balance sheets.

One of the key objectives of the Basel framework is to set a binding minimum requirement for leverage on a consistent basis (together with an associated disclosure requirement) that would be implemented by each jurisdiction. Recent regulatory changes (e.g., Basel III) seem to suggest that the leverage ratio adequately captures both on- and off-balance sheet sources of bank leverage.[5] We find that at a national level, this is true. However, when transactions do not belong to any one balance sheet, they cannot be accounted for in national statistics such as flow-of-funds. For global financial stability reasons, these cannot be ignored since they are sizable, and provide a basis for interconnectedness among the G-SIBs. In the context of Figure 1 and the framework discussed earlier that extends Shin (2010) analytics on z, or the fraction of nonbank funding to banks, we can augment the leverage and equity terms to reconcile the drivers of credit to the economy (which include households, nonfinancial corporations, etc.).

Table 1 shows aggregated bank credit, capital, and leverage data that allow us to estimate z.[6] We find that while recent U.S. data show that bank leverage is sizably lower, bank capital is only marginally higher. However, bank credit to the economy has not changed much since 2008. We find that nonbank funding, from balance sheet data, has risen by about 50 percent since the crisis in the U.S. (see Table 1, last column). It should be noted that nonbank funding come from a variety of sources, some of which are less sticky than others. For example, household deposits are different (and stickier) than corporate working capital, or wholesale (including off balance sheet) funding—all of which are included in nonbank funding.

Intuitively, if regulations have made financial intermediation (relative to the pre-crisis period) costlier for banks, one may ask whether banks are seeking funding that can be sourced off-balance sheet. This is because expanding bank balance sheets requires additional equity which off-balance sheet funding does not. Figures 3a and 3b highlight the magnitude of off-balance sheet financing at the global banks active in the pledged collateral market (orange line). Total assets of banks as reported on their balance sheets are also shown. Discussions with some market participants suggest that up to half (with a wide variance) of the pledged collateral activity may not be on-balance sheet.

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[5] Basel III: Finalizing Post-Crisis Reforms," December, https://www.bis.org/bcbs/publ/d424.htm

[6] Assuming that nonbank funding (zi) for bank i is constant for any given time (but not over time), we can reach rough-indicative estimations of z. To reiterate, the estimates of z include funding from households (i.e., retail deposits) and wholesale market.

Table 1. Estimating Nonbank Funding to U.S. Banks (2008–16)

	Bank Capital (In trillions of U.S. dollars) **e**	Bank Credit (In trillions of U.S. dollars) **y**	Bank Leverage **λ**	Average Nonbank Funding to Banks (fraction) **z**
2008	1.6	8.4	9.2	0.52
2013	1.7	8.1	5.9	0.74
2016	2.0	9.7	5.6	0.86

Sources: FSI (IMF), OECD, and BIS.
Note: European banks leverage ratio are being harmonized under Basel's leverage rules. Thus Table 1 shows U.S. data as representative of the leverage trend under Basel.

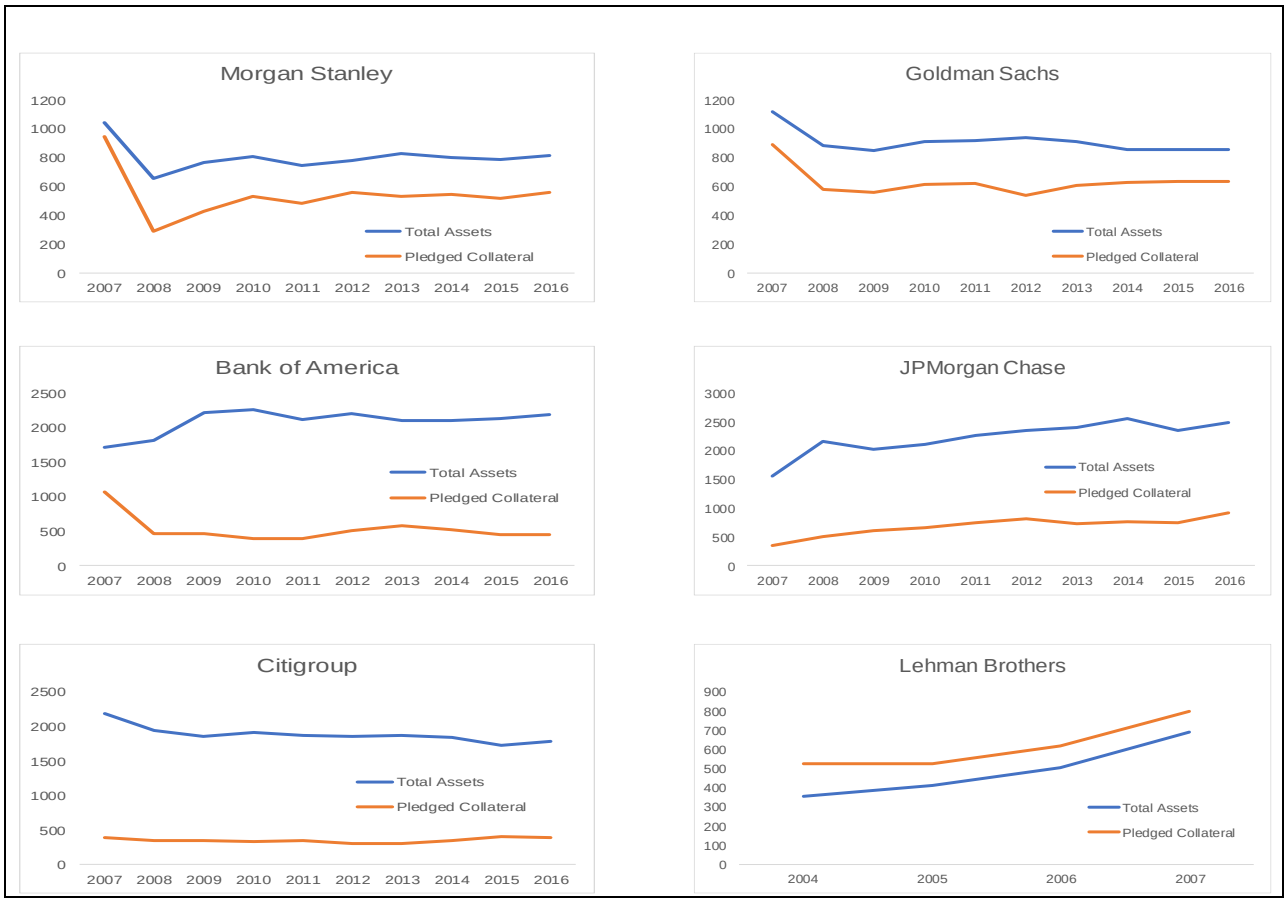
Specifically, we use the pledged collateral market to gain insights into z. Over the past 10 years, we have been compiling pledged collateral data from footnotes to annual reports, and verifying in some cases with investor relation offices of relevant G-SIBs; this information is not available in any database. Since this is a cross-border market, we focus on key jurisdictions—U.S., U.K., and Eurozone—where there is sizable interface between banks and nonbanks. For example, funding for a U.S. bank may be sourced from the U.K. and vice versa.

We restrict the sample of banks primarily to the U.S., the Eurozone, and the U.K. as the financial centers are located in these jurisdictions.[7] In fact, emerging market securities are not generally pledgeable oversees, and even Japan's JGBs are not used for cross-border pledging in size. This allows us to focus on only those economies that have interconnected pledged collateral markets. Pledged collateral is the largest off-balance sheet component for the 15 G-SIBs as shown in Figures 3a and 3b. In fact, pledged collateral was bigger than Lehman's balance sheet (2004–07), and a similar trend is emerging for Nomura.[8]

[7] Generally, the G-SIBs offices in Hong Kong and Singapore generally book any pledged collateral activity to their U.K. office.

[8] There are other G-SIBs, but they are not active in the global pledged collateral market.

Figure 3a. Panel of Global Banks Active in Off-Balance Sheet Collateral Financing
(In billions of U.S. dollars)



Sources: Banks' Annual Reports and hand-picked data from footnotes to the balance sheets. Aitken Advisors.

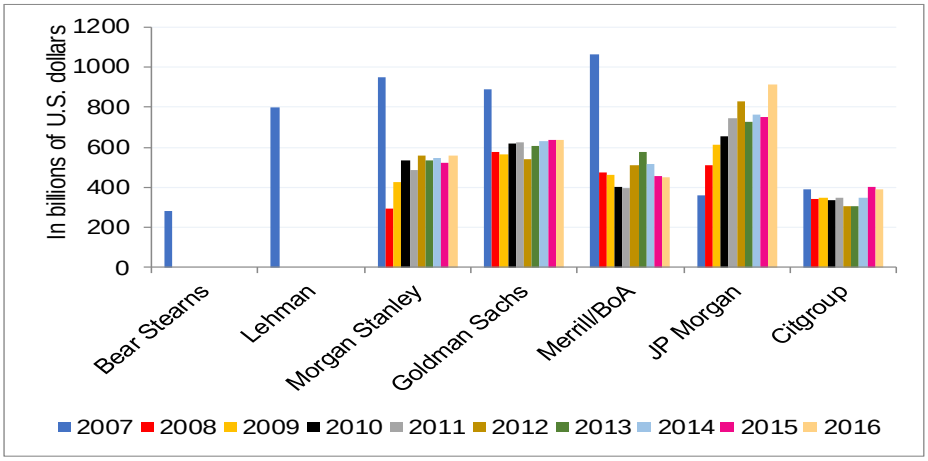
Figure 3b. Panel of Global Banks Active in Off-Balance Sheet Collateral Financing
(In billions of U.S. dollars)

Sources: Banks' Annual Reports and hand-picked data from footnotes to the balance sheets; Aitken Advisors.

All blue lines (representing balance sheet size) show a declining trend, aside from JPMorgan, Bank of America, and Nomura. These three are bigger, in part, due to their purchase of Bear

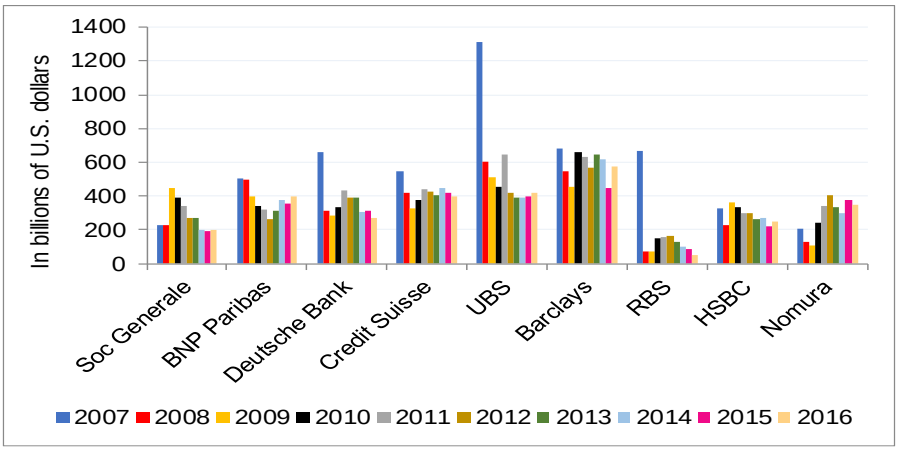
Stearns, Merrill Lynch, and certain business lines of Lehman respectively. In fact, the blue line for Barclays, despite picking pieces of Lehman, is now lower than what it was in 2007. Aside from the initial years after the Lehman crisis, off-balance sheet pledged collateral volumes have not declined. Thus, in relative terms, off-balance sheet funding (which, in part, z picks up) is higher now than in 2007. Specific examples are illustrated in Figures 4 and 5, which capture the pledged collateral received by the key dealer-banks that have a major footprint in the global market in reusing collateral. These figures also show that some are increasing their market share (JPMorgan and Barclays).

Figure 4. U.S. Banks Active in the Pledged Collateral Market



Sources: Annual Reports and hand-picked data from footnotes to the balance sheets; Aitken Advisors.

Figure 5. European Banks (plus Nomura) Active in the Pledged Collateral Market



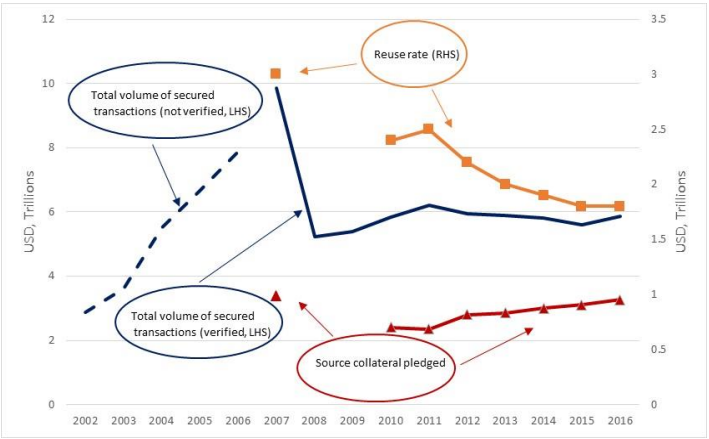
Sources: Annual Reports and hand-picked data from footnotes to the balance sheets; Aitken Advisors.

Has the proposed leverage regulation (i.e., ratio of total assets to capital, or some variant such as ratio of risk-weighted assets to Tier 1 capital) captured the sizable off-balance sheet transactions? Data are preliminary, as many banks are yet to fully embrace the new regulations, especially European banks. However, we see that banks continue to grow their

pledged collateral market share. Furthermore, data suggest that a sizable portion of the pledged collateral transactions do not make it on balance sheet as it is relatively more expensive than keeping if off-balance sheet (see Box 3).[9]

Box 3. Dealer Balance Sheet Constraints from Leverage Ratio

Even though pledged collateral has been rising relatively to the size of balance sheets. The volume in the pledged collateral market has remained the same at $6 trillion since 2009—this is shown via the blue line below. Although source pledged collateral that is available to be recycled is back to pre-crisis level (red line, in the figure), the dealer balance sheet constraints (primarily due to the leverage ratio) are binding. However, some banks are increasing their market share (e.g., JP Morgan and Barclays). This can be seen in the orange line (i.e., reuse rate or the average number of times pledged collateral is reused in the financial market), which is lower now, compared to pre-Lehman level. Pledged collateral needs on/off-balance sheet space to move within the financial system; it cannot flow in vacuum (Singh, 2017). It should be noted that QE-related increase in deposits with the banking system also contribute towards making the leverage ratio more binding.



Sources: Annual Reports and hand-picked data from footnotes to balance sheets; and author's estimates.

There is sizable dispersion in this data and discussions with bank analysts suggest that about 40 percent to 70 percent of off-balance sheet funding may not have appeared on-balance sheet pre-crisis. This means that traditional leverage metrics—even in their elevated pre-crisis state—were significantly underestimating brokers' true dependence on potentially volatile sources of financing. And even today's more stringent leverage metrics fail to reveal the full picture as highlighted in this paper.

For example, of Barclays' total pledged collateral in 2016—£466 billion (Table 2)—only £34 billion made it onto the balance sheet. Therefore, £432 billion, which are available to Barclays, does not make it on the balance sheet. This amount is sizeable. To provide context, Barclays total assets (as reported on the balance sheet) in 2016 were £1.2 trillion. By

[9] While new accounting standards have forced banks to bring secured financing assets on-balance sheet, borrow vs. pledge (BVP) transactions are the one exception. BVP transactions involve an exchange of securities-for-securities and can still be held off-balance sheet, even under the new regulations. Any transaction that involves an exchange of cash must be held on-balance sheet. In a BVP transaction, a bank will exchange securities in exchange for other securities. Since cash does not change hands as part of a BVP transaction, it is allowed to be held off-balance sheet and therefore does not impact the leverage ratio of the banks (Horowitz and others 2013). If the bank has a large amount of BVP borrowings, there may be a sizable amount of funding that is sourced off-balance sheet.

including pledged collateral transactions not included on the balance sheet, its true total assets in 2016 were 35 percent greater than its assets reported on the balance sheet. A fuller view of assets naturally has implications for leverage. Barclays' leverage (defined as assets/equity) rises from about 20.7 (based on balance sheet data alone) to 28.1, if their pledged collateral transactions are fully recorded. This rise occurs because pledged collateral transactions that do not make it to the balance sheet—£432 billion—do not have corresponding equity.

> *"In addition, £406 billion of the total £466 billion (see Table 2) securities accepted as collateral, and held off-balance sheet, were on-pledged, the significant majority of which related to matched-book activity where reverse repurchases are matched by repurchase agreements entered to facilitate client activity. The remainder relates primarily to settle …trading portfolio…"[£34 billion is in trading portfolio, page 192 of the 2016 Annual report]*.

Table 2. Pledged Collateral Received for Reuse
(In billions of British pounds

Off-Balance Sheet	Collateral Received	Collateral Received of which On-Pledged	Readily Available Assets
Fair value of securities accepted as collateral	466.2	405.5	59.7

Source: Barclays Annual Report 2016.

Leverage issues for financial stability stem largely primarily from the 20–30 GSIBs—and not from all banks—that have a global footprint in niche transactions such as peddling pledged collateral or wealth management products, that may not be on the balance sheet (IMF, 2014; Adrian, 2017). Furthermore, there is sizable dispersion between the extent of off-balance sheet use (that does not come to balance sheet) within these GSIBs, such as pre-crisis Lehman and UBS to present-day Barclays, JP Morgan and recently some Asian banks. Aggregation of this data removes the "left tail" that can be the key to early warning signals of financial stability (Shin, 2017). Therefore, studies that use aggregate measures of leverage are unable to precisely estimate the relationship leverage has on financial stability. Empirical issues are explored further in Box 4, which discusses the econometric consequences of an inaccurate measurement of leverage.

This paper elucidates that true leverage is systematically higher than what is captured in databases and used in empirical research. In econometric terms, leverage data imported from these databases are measured with error, which leads to bias in regression estimates, especially panel regression estimates. Thus, beta estimates from such regressions are biased toward zero. Moreover, t-statistics are also biased downward. Therefore, some of the smaller and/or insignificant effects of leverage that research finds could be an outcome of the measurement error in leverage. Box 4 describes measurement error in explanatory variables and its consequences on regression estimates.

Box 4. Econometric Implications of Using a Broader Leverage Metric

The presence of measurement error in explanatory variables may cause estimates of their regression coefficients to be biased towards zero. This bias will typically be more pronounced in panel regressions with fixed effects, and only under certain assumptions will the size of the bias in the two kinds of regressions (Ordinary Least Squares, and panel with fixed effects) be of the same size. In the context of leverage, the assumption that the expected value of the measurement error is zero may not be entirely accurate. As the paper tries to argue, *actual leverage* is much higher in advanced economies (due to unaccounted nonbank funding). So, the expected value of the measurement error is nonzero, since observed leverage in academic literature is either lower than the banks described in this paper that have sizeable transactions recorded off-balance sheet, or at the very most it would be equal to actual leverage (for those small banks that do not have an off-balance sheet). The attenuation in coefficient estimates resulting from measurement error still holds under this structure of the measurement error, since the attenuation is driven by the variance of the measurement error.

Therefore, current empirical research that uses leverage from existing databases suffers from measurement bias. Hence, studies that find significant (insignificant) estimates of the impact of leverage (on some dependent variable) might find their impacts to be much greater (significant and higher in magnitude) if they were to have a more complete measure of leverage. While it may be argued that accounting differences (GAAP vs. IFRS) can be differenced away by using panel fixed effects, measurement bias arises when leverage is measured using only on-balance sheet data, or even incomplete off-balance sheet information. Note that despite Basel's "uniformity" via the QIS—see Box 2—the database that researchers use will still incorporate data filed via GAAP or IFRS to the local regulators.

Given the size and multiplier effect of the collateral market (it has ranged from a high of 3 before the Lehman crisis to below 2 in recent years (Box 3), it is suspected that the variance of the measurement error would be comparable in magnitude to the recorded variance. Therefore, it is reasonable to suspect that estimated beta coefficients on leverage in the current library of research are much smaller than the "true" beta.

V. CONCLUSION

Policymakers and researchers interested in monitoring leverage and fully appreciating its impact on financial cycles and vulnerabilities would benefit from a deeper understanding of the links between banks with a global footprint, and their off-balance sheet funding from non-bank sources. As we show in this paper, nonbank funding (households and wholesale) is on the rise since the Lehman-crisis, and constitutes a major source of bank credit to the economy. Accurately accounting for this source of credit would provide a more complete picture of the financial system's leverage. Having a broader measure of leverage in the economy could enable policymakers to perceive financial cycles earlier and more accurately, allowing them to better apply policy options such as monetary and macroprudential policies in a timely fashion.

Information on off-balance sheet transactions is currently not used in empirical research, and is not readily available. Given the importance of leverage in macro-financial analysis, there is a need to develop databases that can fill the gap. A key step towards addressing this issue would be to properly account for pledged collateral transactions and other transactions such as wealth management accounts, or other areas that generally fall under the rubric of "shadow banking." The BIS's Quantitative Impact Study and related work bridge international accounting standards such as GAAP and IFRS, to conform to a standard

template for leverage. We suggest that such international fora also request information on the extent of pledged collateral (and other off-balance sheet transactions) that are not accounted for on the balance sheet. This information can augment the leverage data at a national level with an additional “cross-border leverage” metric.

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ANNEX I. LEVERAGING/DELEVERAGING COMPONENTS—BALANCE SHEET AND INTERCONNECTEDNESS

The purpose of this annex is to provide a mathematical framework developed by Hyun S. Shin (2009). In summary, this shows how the unwinding of systemic leverage (or deleveraging) can be separated into two components: balance-sheet shrinking (due to haircuts/shedding of assets) and reduced interconnectedness within the financial system (due to shorter collateral chains).

x_i = market value of bank i's total liabilities

y_i = market value of bank i's assets that can be pledged as collateral

e_i = market value of bank i's equity

a_i = market value of bank i's assets

π_{ji} = proportion of j's liabilities held by i, and j are nonbank j's funding to bank i

$d_i = 1 - \left(\frac{e_i}{a_i} \right)$ is the ratio of debt to total assets

Noting that the total assets of bank i are given by $a_i = y_i + \sum_j x_j \pi_{ji}$ and from a simple accounting identity, it follows that the total debt can be computed by multiplying the totals assets with the leverage ratio:

$$x_i = d_i \left(y_i + \sum_j x_j \pi_{ji} \right)$$

Let $x = [x_1 \cdots x_n]$, $y = [y_1 \cdots y_n]$, and $\Delta = diag[d_1 \cdots, d_n]$ and rewriting the previous equation in vector form:

$$x = y\Delta + x\Pi\Delta$$

Solving for x and using Taylor series expansion [1]

$$\begin{aligned} x &= y\Delta \left(I - \Pi\Delta \right)^{-1} \\ &= y\Delta \left(I + \Pi\Delta + \left(\Pi\Delta \right)^2 + \left(\Pi\Delta \right)^3 + \ldots \right) \end{aligned}$$

[1] Note that the sum of the elements of the rows of $\Pi\Delta$ is always strictly less than 1. This means that the infinite Taylor series converges and hence, $I - \Pi\Delta$ has a well-defined inverse.

The matrix $\Pi\Delta$ is given by

$$\Pi\Delta = \begin{bmatrix} 0 & d_2\pi_{12} & \cdots & d_n\pi_{1n} \\ d_1\pi_{21} & 0 & \cdots & d_n\pi_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_1\pi_{n1} & d_2\pi_{n2} & \cdots & 0 \end{bmatrix}$$

The interaction between institutions and the system is elegantly captured by the above matrix notation. While we often talk about systemic leverage and systemic risks, the above matrix notation captures a very subtle issue in that it makes a distinction between the impact of systemic leverage on an institution and impact of the institution on the remaining system. This distinction between the two concepts is essential to breaking down endogenous systemic leverage into two exogenous variables, which provide additional insight into the economics of building leverage through collateral. The sum of the elements of the *i-th* row of $\Pi\Delta$ represents the net impact of bank i's leverage of the remaining system. The sum of the elements of the *i-th* column represents the net impact of systemic leverage on bank i. Note that the powered matrices $(\Pi\Delta)^t$ indicate the collateral value of the asset in the *t-th* link of the repledging chain.

Using the matrix $\Pi\Delta$, the change in deleveraging can be decomposed into two effects: the price decline on balance-sheet assets and the decline in the interconnectedness factor, independent of the price decline of assets. Assume there is a parameter σ that captures measured risks, which affects both the price of marketable assets (y) and the haircuts (which determines the debt ratios and consequently Δ). Denote $\Delta(\sigma)$ as the diagonal debt ratio matrix, and $y(\sigma)$ as the market value of marketable securities as function(s) of σ. (note (y) is defined here as price of marketable assets on the balance sheet and off the balance sheet, i.e., pledged assets).

Define:

$$M(\sigma) \equiv \Delta(\sigma)\ (I - \Pi\Delta(\sigma))^{-1}$$

Suppose $\sigma < \sigma'$, then the decline in debt is given by:

$$x(\sigma) - x(\sigma') = y(\sigma)M(\sigma) - y(\sigma')M(\sigma')$$

Rewrite this as follows:

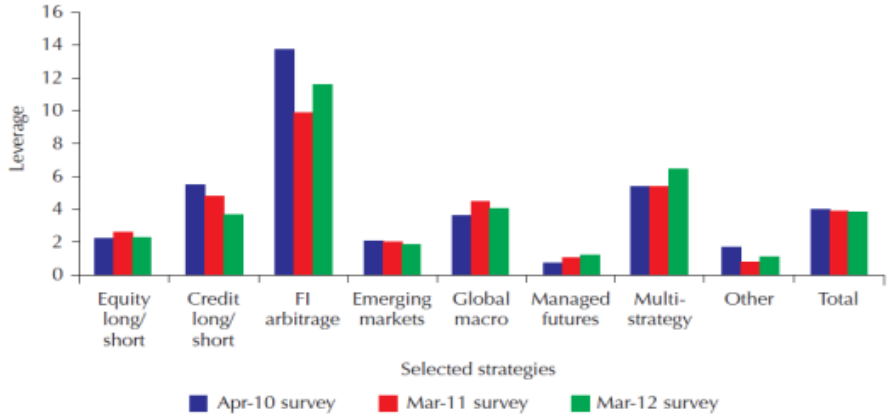
$$\begin{aligned} x(\sigma) - x(\sigma') &= y(\sigma)M(\sigma) - y(\sigma')M(\sigma) + y(\sigma')M(\sigma) - y(\sigma')M(\sigma') \\ &= \underbrace{(y(\sigma) - y(\sigma'))\ M(\sigma)}_{\text{Balance sheet shrinking (price decline)}} + \underbrace{y(\sigma')\ (M(\sigma) - M(\sigma'))}_{\text{Reduced interconnectedness (chain shortening)}} \end{aligned}$$

Th last equation identifies two parts (shown via a deleveraging scenario): the balance-sheet (i.e., on the balance sheet) and the interconnectedness (collateral chains). The first has been studied extensively. **The second term represents the leverage in the financial system and could be significantly larger than the on-balance sheet (first term).**

ANNEX II. HEDGE FUNDS LEVERAGE—SOME ESTIMATES

Hedge Funds (HF) largely finance their positions by either (i) pledging collateral to prime brokers (PB) to borrow money, or (ii) repurchase agreements (or repo) with a dealer bank where their collateral is funding the transaction. This box estimates the PB and repo financing by HF with the key banks active in collateral markets, as of 2007, 2013, and 2016. As background, HF leverage varies considerably according to the strategy they use—some of the fixed-income arbitrage strategies have a leverage of 10–15 while other strategies in equity, emerging markets, and futures are around 2 or even lower. Since HFs are primarily funded by large banks (see Figure 3 in this paper), they are an important lens to gauge the nonbank-bank nexus that is illustrated in Figure 1 of this paper.

Annex Figure 1. Representative Leverage in Some Hedge Fund Strategies



Source: FSA HFS

HFs generally **borrow from PBs** for equity long/short and event-driven strategies. Mark-to-market value of collateral has been defined in the paper to equate AUM times gross leverage in these strategies (approximates to net asset value (NAV of an HF). This is the sum of long-market-value (LMV) positions and the absolute value of short-market-value (SMV) positions. Figure below gives delta bias on the left axis. Delta bias captures the ratio of LMV/SMV. Arithmetically, delta bias = (total LMV/total SMV) minus 1. This ratio is a very useful indicator to gauge PB borrowing for HFs' equity long/short strategies. For example, as of end-2007, the delta bias was about 50 percent, which means LMV/SMV ratio of 150/100 or 3:2 (i.e., collateral to PB was 3/5 of total positions). Delta-bias figures were not produced as of end-2007, but market conditions were similar to end-2010 (e.g., AUM and gross leverage levels). We thus use similar delta bias figure for end-2007. With AUM at US$2 trillion, 36 percent share of relevant strategies being equity, with leverage of about 2, and adjusting for long/short ratio, the borrowing from PB was about US$4 trillion x 0.36 x 3/5, or about **US$850 billion** for end-2007. A similar calculation for end-2013, gives PB borrowing of a AUM ($2.6 trillion) times leverage (1.8) x 0.33 x long/short ratio of 3/5 again, or about **US$950 billion.**

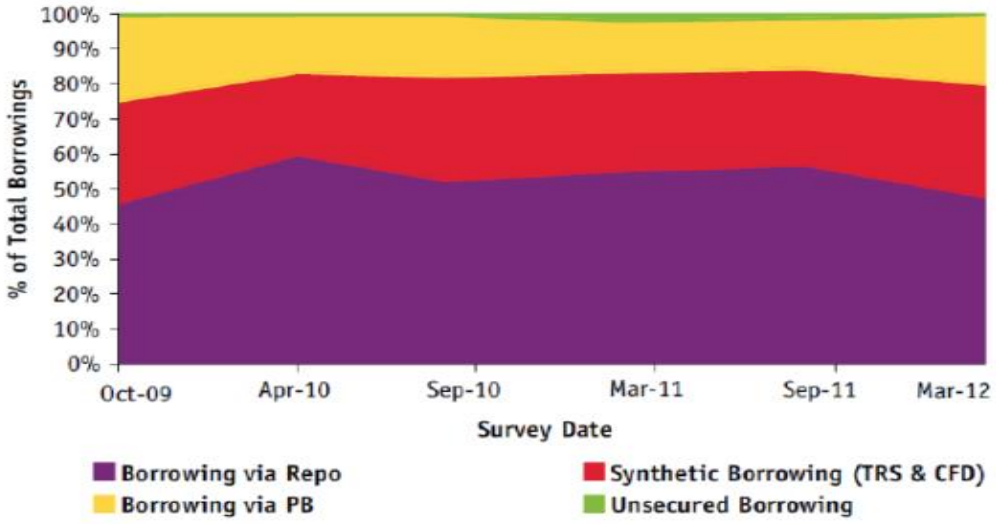
Annex Figure 2. HF Borrowings via Prime Brokerage

Source: Credit Suisse.

To estimate HF's *repo related borrowing* via collateral for 2007, we take the AUM of $2 trillion and the 27 percent share of strategies that would use repo (i.e., primarily non-equity related strategies). Aggregate leverage is higher in fixed income, global macro strategies that are funded via repo relative to equity type strategies. Using the aggregate leverage of 4 (per FSA hedge fund surveys, U.K.), this would imply that approximately $540 billion times four or, $2.2 trillion pledged collateral could have gone to the banks. However, about 60–70 percent of the strategies are hedged simultaneously so only one-third of US$2.2 trillion could reach the banks that can be re-pledged onwards—i.e., *$750 billion* pledged collateral that came to the banks could be re-used onwards as of end-2007. On the 60–70 percent threshold assumption—at the bottom of the rate cycle, there is more hedging so this threshold is higher when compared to top of the rate cycle. In other words, the threshold prior to Lehman's demise maybe closer to 60 percent and thus more pledged collateral available (i.e., less simultaneous hedging) to the dealers. Present times are close to the bottom of the rate cycle; so, threshold may now be over 70 percent (i.e., more simultaneous hedging) and thus, less pledged collateral for reuse passes to the dealers. Using similar arithmetic for end-2013, with aggregate leverage, including derivative use, lower at 3.5 (relative to end-2007) but AUM much higher at $2.6 trillion, and share of HF strategies using repo also higher (around 40 percent) relative to 2007, would put the estimate at *$900 billion* (adjusted downward due to the higher threshold for hedging due to the bottom rate cycle).

In summary, HF borrowing—from both PB and repo—release about half the pledged collateral received by the dealer banks. The extent of pledged collateral released from HFs in 2007 was about $1.7 trillion. In 2013, it was about $1.65 trillion but PB was gaining share over repo related borrowings. The latest figures (using the above methodology) for **2016 suggest $2 trillion** of pledged collateral released to the market, about two-third coming from PB, since repo takes more balance sheet space relative to PB.

Annex Figure 2. HF Borrowings via Repo Strategies



Source: FSA HFS

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ANNEX III. FLOW-OF-FUNDS DATA AND ITS LIMITATIONS

Banking sector and other financial data is captured in flow-of-funds (FoF) statistics such as those produced by the Fed. Yet aspects that cover the banking sector and its nexus with the nonbanks are not covered by the FoF statistics. This box attempts to highlight some of the salient aspects of the FoF statistics of the U.S. to show that, even in mature markets such as the U.S., there are "data gaps" in financial statistics that need to be complemented by a rigorous analysis of off-balance-sheet statistics, and linkages with other sectors that are outside the regulatory perimeter.

- Hedge funds' position and ownership of financial assets are buried in FoF data's "household" sector. By aggregating and netting across all banks, the FoF data loses relevant information. For example, security lending on Page L130 of the FoF data is shown "net" in line 20, and thus would not highlight large positive build-up in, say, Bank X and a negative build-up with, say, Bank Y. Thus, the FoF data has limitations for early-warning signals.

- The FoF accounts presently reflect only the flow of savings and investment of an economy. Derivatives data is also difficult to discern in the FoF data. Financial statements do not provide the under collateralization (or margin shortfall) of derivative positions. For some of the recent members of the "banking community", Goldman Sachs has most of its plain vanilla derivatives books in the bank part of the Goldman Sachs bank holding company, for example, while its equity and commodities derivatives are conducted out of the brokerage subsidiary. Most of the (notional) derivatives for Morgan Stanley were still being conducted outside the commercial bank. Derivatives unbundle risks associated with the securities that transmit the flow of savings and investments.

- FoF data shows all elements of the holding company (bank, dealer, asset manager, etc.) but "tears up" Holding Company X's balance sheet and then aggregates all banks in one sheet, all dealers in another sheet, etc. This aggregation leads to a loss of the overall picture of the holding company; hence the need to go back to the 10Q/10K (i.e., abbreviations in the U.S. for quarterly and annual financial reports, respectively) to see the build-up of all business positions of the bank holding company from its various components under one roof.

Overall, nonbank linkages with the banks are not fully captured in FoF statistics as "on" bank balance sheet data may not be complete.