Edited by Markus Brunnermeier
and Arvind Krishnamurthy

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Risk Topography

A National Bureau of Economic Research Conference Report

Risk Topography
Systemic Risk and Macro Modeling

Edited by **Markus Brunnermeier and Arvind Krishnamurthy**

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8

Monitoring Leverage

John Geanakoplos and Lasse Heje Pedersen

8.1 Introduction

Systemic crises tend to erupt when highly leveraged financial institutions are forced to deleverage, sending the economy into recession; leverage is a central element of economic cycles and systemic risk. While traditionally the interest rate has been regarded as the single key feature of a loan, we argue that leverage is in fact a more important measure of systemic risk. We discuss how leverage can be monitored for assets, institutions, and individuals, and highlight the benefits of monitoring leverage. Our main conclusions are as follows:

- Monitoring leverage is "easy." Leverage at the asset level can be monitored by recording margin requirements, or, equivalently, loan-to-value ratios. This provides a model-free measure that can be directly observed, in contrast to other measures of systemic risk that require complex estimation.
- Monitoring leverage is monitoring systemic risk. Monitoring leverage provides information about how risk builds up during booms as

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leverage rises, and how crises start when leverage on new loans sharply declines.

- Monitoring leverage facilitates liquidity crisis management. Leverage data is a crucial input for crisis management and lending facilities, and for ascertaining the state of an indebted economy in the aftermath of a leverage crisis.
- Monitoring new versus old leverage is important. The leverage on new loans is a more timely measure of credit conditions and the beginning of a systemic crisis than the average leverage, but the average leverage signals the economy's vulnerability. The economy enters a crisis when leverage on new loans is low, and leverage on old loans is high, a deleveraging event that starts a liquidity spiral.

To understand the broad applications of these ideas, note that most loans are secured by some sort of collateral that can be confiscated by the lender in case of default. A house is a prime example of collateral. For example, a home owner may use a $100,000 house to collateralize borrowing $80,000. In this case, we say that the margin requirement (or down payment, or haircut) is 20 percent, the loan-to-value (LTV) ratio is 80 percent, and the leverage is 5 to 1. These ratios are all different ways of saying the same thing. These leverage numbers on individual loans and collateral are the building blocks out of which aggregate measures of asset leverage, institutional leverage, and household leverage can be most accurately and informatively constructed.

Before the crisis of 2007 to 2009, there had been absolutely no comprehensive monitoring of leverage aside from aggregate debt-equity ratios in a few markets. In particular, no effort had been made by the government to keep track of leverage ratios at the individual asset level. Though it would be a radical departure from past practice, our chapter discusses the potential benefits of collecting such data. Just as the Fed started collecting Treasury yields in the early twentieth century and other agencies started collecting macrodata for the national accounts, some government agency could begin to systematically collect leverage data at the level of individual loans backed by assets (such as houses and cars) and by securities (such as mortgages and mortgage derivatives in the repo market). Such leverage data would be very valuable input in monitoring and managing systemic risk.

For some agents, like designated financial entities, noncollateralized debt information could also be collected. All this individual loan data could then be aggregated up to give the leverage of financial institutions like banks, hedge funds, nonfinancial firms, the household sector in different geographical regions, and the government. Aggregated in different ways, the data could provide the average leverage on various assets and security types. The data could also be used to improve the flow of funds reports that the government currently releases.

We have a number of suggestions regarding data collection. We discuss how to collect leverage data for (a) real estate, (b) durable goods, (c) cash financial securities such as bonds, (d) exchange-traded derivatives such as futures, (e) over-the-counter derivatives such as interest-rate swaps and currency forwards, and (f) collateralized default swaps and other securities with asymmetric payoffs. To properly monitor leverage it is imperative to distinguish three numbers: leverage at origination on extant old loans, leverage offered on new loans, and current leverage on extant loans updated to reflect current collateral values and amortization of loan amounts. Current leverage on all existing loans is a barometer of vulnerability, while leverage on new loans is a barometer of current credit conditions. To see that, note that the current average loan-to-value ratio across all loans on assets of a particular kind (e.g., houses) signals how vulnerable the system is to shocks because this is the total debt that needs to be serviced relative to the aggregate equity (provided that the collateral value is measured at current market prices). For this purpose one should measure the aggregate loan-to-value ratio by taking the ratio of all outstanding loans on some asset class to the current value of all assets in that class, thus including in the composite number assets on which there is no borrowing. Similarly, the current average leverage of institutions and households measures the vulnerability in those sectors. These leverage numbers depend mostly on old loans and current asset values. The loan-to-value ratio on new loans has a small effect on the current leverage of all loans (since a flow only gradually affects the stock).

However, it is important to monitor the leverage on new loans since this reflects current credit conditions. As prices decline and lenders get more nervous and tighten credit, leverage on old loans will increase (because of dropping asset values) while leverage on new loans plummets (because of deteriorating credit conditions). Leverage on old loans and leverage on new loans thus often go in opposite directions. For example, Reinhart and Rogoff (2009) show that, on average, deleveraging begins two years after a crisis and lasts for many years. But they measure total debt/equity or debt/income, which is mostly leverage on old loans. If they had measured leverage on new loans, they would have found that new leverage falls just before the crisis; deleveraging is a key element of the crisis, not a lagged effect. Leverage on new loans reveals much more quickly the state of the economy. Of course leverage offered on new loans was not being monitored, so they could not have presented such data even if they had wanted to.

Leverage data on individual loans backed by individual collateral must also be properly aggregated and presented. Average (or median) leverage is one important statistic, but sometimes the distribution of leverage is also important. Obviously an economy is much more vulnerable if half the mortgage loans are at 100 percent LTV and half are at 0 percent LTV than if they are all at 50 percent LTV. Similarly, it is important to keep track of the distribution of leverage across buyers. For example, most home owners own one house. Many own two. Some own three or four or more, all bought by loans.

A sharp increase in the number of individuals with multiple loans on different houses would be an important signal of the rise of speculative buying.

An important advantage to collecting leverage data is that the investment community, as well as regulators, will find it extremely useful:

- An investor who learns that the other buyers are highly leveraged will understand that the market is more dangerous for him.
- Investors who leverage their way to profits will be exposed.
- Lending markets will be rendered more competitive.
- Regulators will be able to monitor the economic cycle and see early warning signals of rising systemic risk due to high levels of leverage.
- Central banks need leverage data to manage a liquidity crisis, including to set haircuts on the collateral they receive when they act as lenders of last resort.

The funding markets are opaque over-the-counter markets and, therefore, a governmental agency might need to use its authority if it were to collect this data. We discuss ways the data can be collected and published while imposing minimal revelation of proprietary information belonging to financial institutions; for example, by focusing on aggregated data from multiple institutions and delayed publication. Maintaining the enthusiastic support of the business community is crucial to this data collection program. The data must be kept secure, so that proprietary information is not leaked. And the collection process must be streamlined and coordinated so that financial firms do not feel they are spending half their time filling out questionnaires.

Further, we note that to ascertain an institution's true leverage, one must account for derivatives and off-balance sheet items in a meaningful way. Further, one must always include purchases made entirely by cash as "zero leverage loans," since such loans also provide information about leverage. Indeed, pure cash financing sometimes signals the extreme form of deleveraging where no credit is available for that collateral.

A solid theoretical foundation for the importance of leverage is emerging in the literature, though much more research is likely to follow as leverage data becomes available. Borrowing constraints can have significant effects on the real economy (Bernanke and Gertler 1989; Geanakoplos 1997; Holmstrom and Tirole 1997; Kiyotaki and Moore 1997), and bad news coupled with increased uncertainty can cause leverage and asset prices to plunge in a leverage cycle (Geanakoplos 2003, 2010a, b). Shocks to agent's funding conditions can also start liquidity spirals of deteriorating market liquidity, funding liquidity, and prices with spillover effects across markets (Fostel and Geanakoplos 2008; Brunnermeier and Pedersen 2009; and Pedersen 2009) and, just like the risk of a traditional bank run leads to multiple equilibria (Diamond and Dybvig 1983), so does the risk of a "collateral run" of increased margin requirements (Brunnermeier and Pedersen 2009). Leverage can rise to inefficient levels during booms (Lorenzoni 2008), while a clear piece of evidence that investors' leverage constraints become binding during crisis is that agents flee to assets that are more easily usable as collateral, causing, for example, violations in the law of one price (Fostel and Geanakoplos 2008; and Garleanu and Pedersen 2011). Theory and empirical evidence show that central banks' lending facilities alleviate leverage constraints during crisis (Ashcraft, Garleanu, and Pedersen 2010; Geanakoplos 2010b). Indeed, leverage/haircuts can be an important second monetary tool, complementing the traditional interest-rate tool (Ashcraft, Garleanu, and Pedersen 2010; Geanakoplos 2010a, b). Also, leverage effects can explain many features of emerging market economies, including issuance rationing (Fostel and Geanakoplos 2008). Investors' demand for leverage significantly affects the cross section of asset prices in equity, bond, and credit markets (Frazzini and Pedersen 2011) and creates a demand for securities designed to embed leverage (Frazzini and Pedersen 2012).

Margin requirements and down payments are not just abstract terms in our models. They are negotiated every day in a variety of markets. The data we discuss gathering exists. And it can be reported by two different and independent entities, the borrower and the lender. One just needs to collect it! It does not require model-based estimation (unlike many other systemic risk measures).

The chapter is organized as follows. Section 8.2 reviews the basic theory of leverage and macroeconomics, section 8.3 discusses how to monitor leverage in practice, and section 8.4 concludes.

8.2 Understanding Leverage and the Macroeconomy

8.2.1 Determinants of Leverage and Margin Requirements

Leverage tends to rise when there is substantial heterogeneity in outlook or risk tolerance in the population, when the volatility of the underlying asset prices is low, when liquidity is good so that seized assets can be quickly sold, when leverage can be hidden or disguised, when regulators relax their vigilance, when loans are guaranteed by third parties like the government, and when interest rates are low enough to induce investors to reach for yield.

Lower down payments allow new buyers to enter the market who previously could not raise enough cash to purchase (assuming a minimal indivisibility of the asset), and they allow existing buyers to buy more. When the asset supply is inelastic, because production is difficult or takes time, when short selling is difficult, and when there is substantial heterogeneity in the willingness of the population to pay for the assets, increases in leverage will lead to a change in the marginal buyer and therefore to an increase in the asset price.

Increased leverage makes asset owners more vulnerable, especially if the loans are short term, or subject to margin calls. Bad news for the asset lowers its price, and the highly leveraged owners might be forced to sell to meet margin calls just when they might desire to be even bigger buyers. Moreover, the losses from the asset declines fall disproportionately on the leveraged buyers, redistributing wealth away from those who value the assets the most to those who value them least. Often the bad news comes with increased volatility of economic fundamentals and the very vulnerability of the buyers creates more uncertainty. This leads lenders to demand more collateral, forcing deleveraging and more asset sales, and thus further price declines and a downward spiral.

In the crisis stage of the leverage cycle there tend to be many defaults, which are messy in and of themselves. Further, defaults often lead to chain reactions when borrowers are also lenders, and also to contagion when there are crossover investors between assets. Finally, the aftermath of the crisis can be marked by a long period when many agents are under water, or close to insolvent, and thus unable to borrow and unwilling to make productive investments.

Every stage of the leverage cycle can be monitored. We illustrate the subprime leverage buildup and crash in the housing market and the securities market in figures 8.1 and 8.2 (which are based on data from Ellington; see

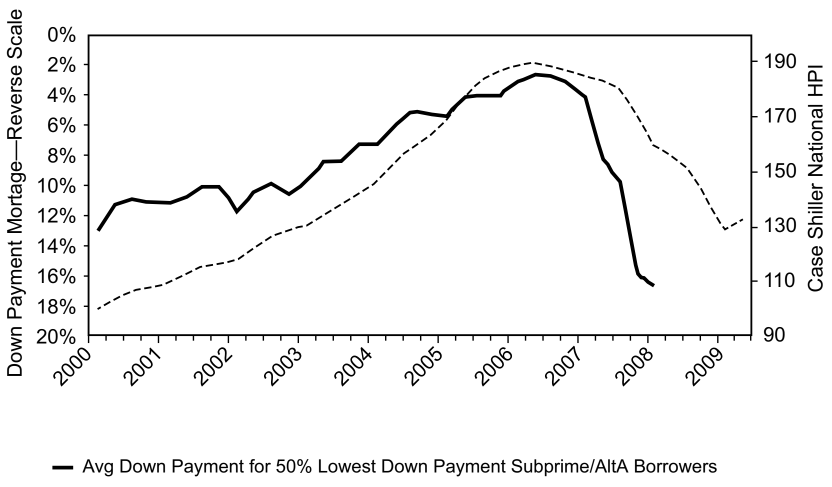

Fig. 8.1 Housing leverage cycle

Notes: Margins offered (down payments required) and housing prices. Observe that the down payment axis has been reversed, because lower down payment requirements are correlated with higher home prices. For every AltA or subprime loan originated from Q1 2000 to Q1 2008, down payment percentage was calculated as appraised value (or sale price if available) minus total mortgage debt, divided by appraised value. For each quarter, the down payment percentages were ranked from highest to lowest, and the average of the bottom half of the list is shown in the diagram. This number is an indicator of down payment required: clearly many home owners put down more than they had to, and that is why the top half is dropped from the average. A 13 percent down payment in Q1 2000 corresponds to leverage of about 7.7-to-1, and a 2.7 percent down payment in Q2 2006 corresponds to leverage of about 37-to-1. Subprime/AltA issuance stopped in Q1 2008.

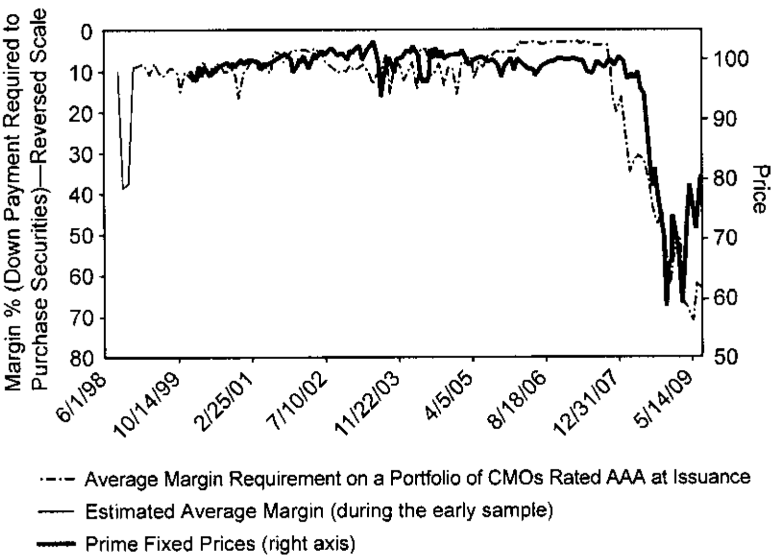

Fig. 8.2 Securities leverage cycle

Notes: Margins offered and AAA securities prices. The chart represents the average margin required by dealers on a hypothetical portfolio of bonds subject to adjustments noted. Observe that the "Margin %" axis has been reversed, since lower margins are correlated with higher prices. The portfolio evolved over time, and changes in average margin reflect changes in composition as well as changes in margins of particular securities. In the period following August 2008, a substantial part of the increase in margins is due to bonds that could no longer be used as collateral after being downgraded, or for other reasons, and hence count as 100 percent margin.

also Geanakoplos [2010]). Had the Federal Reserve or other regulatory bodies been aware of these numbers, they may have considered more policy options before the crisis, and been in a better position to act during and after the crisis. We next discuss how leverage builds up during good economic times, how crisis can be detected and managed, and how to handle the aftermath of a crisis.

8.2.2 The Buildup of Systemic Risk

Investor leverage is central to the vulnerability of the system. A ten times leveraged institution loses ten times as much of its capital when asset values fall as an unleveraged institution holding the same type of assets; indeed, this is the origin of the word leverage. Furthermore, a shock to prices might force a highly leveraged firm to sell to meet margin calls, locking in losses and further depressing the asset price, just when the firm thinks the assets are most undervalued, whereas an unleveraged firm could hold onto its position. When the leveraged institutions are playing a central intermediation function, the losses are far more dangerous than losses to dispersed unleveraged investors. As a case in point, the spillover effects during the recent global financial crisis were far more severe than those around the burst of the Internet bubble.

The upshot is that to monitor the vulnerability of the financial system and the growth of potential bubbles, one should keep track of the distribution of asset leverage, the distribution of investor leverage (especially in the high tail), the concentration of buyers, and the prices and volatility of the underlying assets. If the loans of the leveraged buyers are guaranteed by the government or some other agency, then monitoring is still more important, because the lenders will not be vigilant.

While asset pricing bubbles are notoriously difficult to identify in real time, it is useful to recognize that they are often fueled via leveraged investments by a limited group of optimistic agents (or agents believing they can sell to greater optimists). Thus data on the distribution of leverage and haircuts on new loans, juxtaposed with data on prices and volatility (especially downward volatility), would provide an indication of emerging credit bubbles. The evolution of margins across asset classes provides indications of risk-taking behavior in different market segments. Rising prices, rising leverage, the concentration of assets in the hands of fewer or different buyers, and the absence of episodes of asset price declines are together a signal suggestive of a bubble. If the prevailing haircut is not large enough to cover a price drop equal in size to a recent price run-up, then the market is heading into dangerously leveraged territory prone to bubbles. What can go up can come down, and bubbles often arise when lenders forget this.

The publication of aggregate data on leverage can thus help reveal systemic risk, but it has other benefits as well. Once market participants recognize that a recent rise in prices is more likely a leveraged-fueled bubble than a strengthening of fundamentals, they may take precautionary risk management measures, which in turn might change market dynamics. Further, public data on investor leverage will also reveal that some investors are making money primarily through leverage, and not through astute investments. Finally, leverage data might also make the lending markets less opaque and more competitive.

8.2.3 Crisis Detection

According to the leverage theory, large price declines and reductions in market liquidity are often accompanied by, or anticipated by, rising margin requirements for new loans. This is evident in both the housing leverage cycle and the securities leverage cycle as illustrated by the two graphs of home owner leverage and repo leverage previously shown. The crisis can thus sometimes be identified early if the data shows that margin requirements are suddenly increasing.

There are several reasons that rising margin requirements may signal a crisis: First, more uncertainty makes nervous lenders ask for more collateral, and these lenders may be aware of impending problems before prices collapse (partly because an increase in uncertainty does not directly reduce the expected payoff). Second, margin requirements may partly reflect the lenders' own funding conditions (and risk tolerance), so rising margins could be the beginning of a tightening credit environment. Third, increasing margin requirements may endogenously start a downward liquidity spiral, leading to forced sales, falling prices, and increasing liquidity risk. For detection purposes, it is crucial to have frequent margin requirement data on new loans at a granular level and to keep track of volatility.

8.2.4 Crisis Management

From at least the time of Irving Fisher in the early 1900s, it has been commonly supposed that the interest rate is the most important variable in the economy. When the economy slows, the public clamors for lower rates, and the Fed usually obliges. In this latest crisis, the Fed has been pumping out billions of dollars in bank loans and, in December 2008, the Fed lowered the fed funds rate to zero. But sometimes in crises, leverage and margin requirements are more important. Said simply, for many investors and individuals, it becomes a question of getting a loan, not the loan's interest rate. Hence, leverage/haircuts is a very important second monetary tool to manage liquidity crisis as well as limiting the risk buildup before the crisis.

A liquidity crisis can be managed by reversing the three main causes of the price collapse and the drop in market and funding liquidity:

1. Reducing the uncertainty that paralyzes lenders and investors. The growing uncertainty during the crisis is partly caused by doubts about who is solvent; if investor leverage for important financial entities were accurately reported, these doubts would be much reduced.
2. Injecting equity. Part of the collapse of asset prices stems from the loss of wealth of the most optimistic buyers. The government could counter this by injecting equity directly into these firms or into the market as a buyer; but it cannot know the scale of the necessary injections without knowing how much wealth was lost and how much these optimists were buying.
3. Stemming the rising margin requirements and deteriorating credit environment. During a crisis, required down payments (or margin requirements) drastically rise. A central bank can counter this by lending directly to investors on margins below what the market is offering (rather than at interest rates below what the market is offering) as exemplified by the lending facilities during the recent crisis. (For theory and evidence of the effect of this monetary tool, see Ashcraft, Garleanu, and Pedersen 2010, and for a discussion about how to manage such facilities see Geanakoplos 2010b.) This helpful method of crisis management can be facilitated far more easily and more prudently with a clear record of what margins had been and what they became. Indeed, central banks need to impose haircuts that are large enough to provide adequate protection to the central bank and low enough

to address the funding crisis. To find this reasonable level of haircuts, data on market haircut practices are essential.

8.2.5 Managing the Aftermath of a Crisis

After bad systemic crises, many investors and households find themselves underwater or close to it. Those agents will not take costly investments to increase value. A home owner who is well underwater will not spend $20,000 to increase the value of his house by $50,000 if he thinks he will lose the house in foreclosure at some point anyway. And even if he did want to undertake the investment, nobody would lend him the money to do it. If he is slightly underwater, but nonetheless endeavors to make his mortgage payments to avoid default, then he will not be able to move to take a job in a different state, unless he defaults after all.

To get a handle on how serious these kinds of problems are, for businesses as well as home owners, it is again essential to monitor current leverage at current market values. Here appraisals and home price indexes at the zip code level are helpful.

8.3 How to Monitor Leverage in Practice

8.3.1 Asset Leverage: Margin Requirements and Haircuts

A new data set on asset leverage across a wide spectrum of assets would be of tremendous usefulness, we believe. In particular, asset leverage could be measured in the main asset classes as follows:

1. For real estate, leverage can be monitored by collecting data on down payments or LTV ratios. Indeed, the down payment on a house is the flip side of leverage as it is the capital provided by the owner of the house.
2. Similarly, for cars and other durable goods, down payments data can be collected.
3. For cash financial securities such as bonds, leverage is measured as the margin requirement or haircut on a collateralized loan such as a repo contract.
4. For exchange-traded derivatives such as futures, the futures exchanges charge margin requirements and it would be helpful to consolidate this margin data for all the major exchanges and keep track of how they evolve over time.
5. For over-the-counter derivatives margin requirements are more difficult to collect, especially for exotic bespoke products, but it should be feasible to collect margin requirements for the large markets for standardized products such as interest-rate swaps and currency forwards.
6. For collateralized default swaps (CDS) one can again get haircut data. The party that writes the insurance is in effect in the position of an owner of the asset (losing value if it goes down), and so the CDS margin can be

recast in exactly the same terms as the leveraged purchase of the asset. When margin requirements are different for long and short positions, as they are in CDS, both these margins should be collected.

In addition to keeping the history of origination leverage for all the above-mentioned assets each time a loan is taken, leverage on outstanding loans must be regularly updated to reflect changes in the underlying collateral values and amortization of the loan amounts.

It is also important to keep track of which assets are being borrowed against and which are not. If certain securities are suddenly not accepted as collateral, no loans with these assets will be recorded. In this case, the margin requirement is effectively 100 percent and this is useful information about the credit environment. Only considering assets that are actively being used as collateral is a selection bias. In figure 8.3, we compute the average margin requirement in two ways (based on data from Ellington): one by giving the average leverage on a portfolio of loans backed by assets that could still be used for repo loans, and another average computed by including assets that could no longer be used to obtain repo loans. The difference is large.

To collect asset leverage data, it is useful to ask both lenders and borrowers to report the margin requirement as well as other terms like interest rate and maturity. Having both borrowers and lenders report the loan terms makes it easier to verify the accuracy of the data and makes it more difficult for market participants to misreport this data. Monitoring asset leverage also has the advantage in that it may be less subject to political pressure.

Once margins or LTVs are collected at the level of all individual collateralized loans, they must be aggregated. To get the average loan to value on

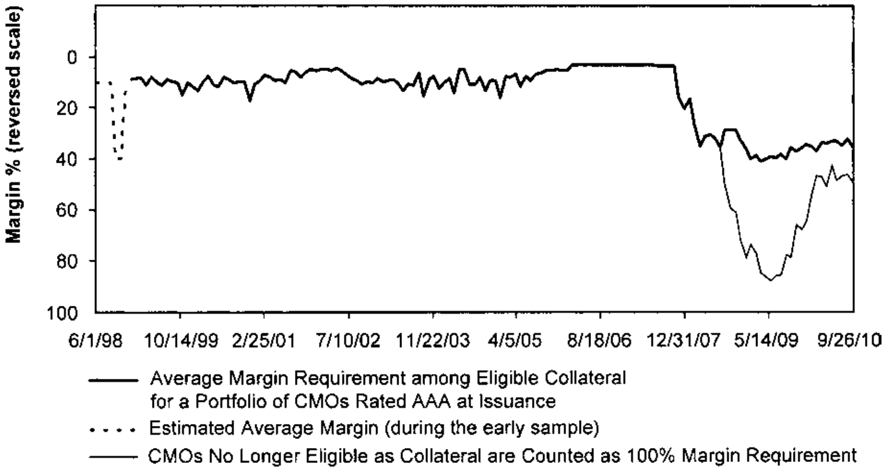

Fig. 8.3 Leverage (LTV) taking account of assets no longer allowed on repo

an asset, one can simply add up the total value of the asset in everybody's hands, and then divide that into the total size of all the loans using that asset as collateral. It will usually be more informative to get the distribution of LTV. For example, one might look only at the instances of the asset that were leveraged in the top decile, and then find the aggregate LTV ratio for that group. In the home owner leverage data presented in figure 8.1, homes were ranked according to how much their purchase was leveraged, and then the average LTV ratio was computed for the top half.

At present, both the Treasury and the Fed have initiated programs to collect leverage data. But to the best of our knowledge, these are proceeding via questionnaires sent to both lenders and borrowers including questions like, What is the average LTV ratio you have taken out on the mortgage securities you currently hold? While useful to be sure, this kind of question does not go nearly far enough, and in fact can mislead. The question does not get at loan-level information. It lumps loans of different kinds together. It makes it impossible to cross-check answers between borrower and lender on the same loan. It does not distinguish between repo margins negotiated three months ago (but still held today) from the repo margins being negotiated on new loans. It does not reveal the quantity of loans taken out, and is therefore of no help in computing the investor leverage of the institution, or in aggregating different margins across different lenders and borrowers. And, it falls prey to the selection bias by ignoring the possibility that the borrower drops loans when their margins get tighter and substitutes other higher-leveraged loans.

8.3.2 Leverage of Institutions and Individuals

It is also useful to continue and to improve the collection of data on the leverage of financial institutions and individuals. The advantage of borrower-level leverage data is that it is ultimately each borrower's ability to repay the loans that determine whether default occurs and financial crisis unfolds. For instance, even if a financial institution holds certain assets at a high LTV ratio, this may not create much risk if the firm simultaneously holds large cash reserves. In short, investor leverage needs to be kept as well as asset leverage.

However, it is worth noting that measuring the overall leverage of a complex financial institution can be difficult and is subject to accounting decisions and can be affected by moving things off the balance sheet, and so forth. Another issue is that overall borrower leverage does not distinguish the leverage of old loans from new loans and thus may not be a timely indicator of increase risk of a crisis.

8.3.3 Public Data

We believe that there could be many potential benefits of providing an extensive public data set of leverage. First, making leverage data public makes the agency that collects the data accountable and researchers and market participants can independently test if the data appears correct. Second, if each market participant can see that the overall leverage in the system is rising to unsustainable levels, then the market participant can start reducing his own leverage before the problem grows too large. Third, a greater transparency can possibly make funding markets more efficient. Fourth, firms that make large profits simply because they leverage more than others will be exposed, even in good times. Fifth, a public leverage data set will likely spur lots of new research that can further our understanding of how systemic risk arises and can be contained.

To achieve these benefits, it would be very useful to publish an easily accessible panel data set of margin requirement for each asset and time period. For instance, one data point would be that the median margin requirement for new loans with AAA corporate bond collateral made in June 2011 was X percent, where X is the number to be collected. The data set would have these margin requirement numbers for AAA corporate bonds for each month, as well as margin requirements for each of the other assets. In addition to the median (or average) margin requirements, it would be interesting to provide data on the dispersion of margin requirements (e.g., the interquartile range).

Similarly, it would be useful to provide aggregate data on the leverage of each borrower type, ranging from individuals, banks, and so on. For designated financial institutions, we believe it would be useful to publish firm-level leverage numbers.

Despite these advantages of public leverage data, certain market participants may have an interest in keeping funding markets opaque for several reasons. Leverage data may be proprietary, and the lender and borrower's interest could be respected when appropriate by keeping the public data anonymous by only making aggregate averages public, not loan-level data, and possibly by releasing the data with a time lag (though regulators should observe the data in real time). Also, an increased transparency may increase competition among lenders, but this is no reason not to release leverage data publicly.

There is much precedent for making economic data publicly available. Central banks have been collecting data on Treasury yields for a century and already monitor banks, and macrodata is being collected in the national accounts by the Bureau of Labor Statistics and others. Recently, the TRACE data introduced posttrade transparency for over-the-counter corporate bond trades, reducing transaction costs.

To understand how leverage evolves in a historical perspective, and to test the effects of leverage expansions and contractions, it would be helpful to have a data set of historical leverage at the asset level and at the borrower level. While this is surely not an easy task, perhaps it is possible with detective work in finding data sets and piecing them together.

8.4 Conclusion

Traditionally regulators, central banks, and researchers have focused on interest rates, not leverage. This is akin to controlling car safely by regulating gasoline prices without monitoring how fast people drive. Risk rises when everyone starts driving faster, and a crisis may start when someone gets scared and starts hitting the brakes on a crowded highway where speeding drivers keep little distance.

Systemic crises often arise when a highly leveraged financial system is hit by a shock that starts a downward spiral of deleveraging, forced selling, dropping prices, and economic contraction. While the global financial crisis of 2008 to 2009 is the most recent case in point, history contains a long list of prior examples such as the Great Depression and the S&L crisis. A central aspect in these crises is the extent to which leverage built up before the crisis, how leverage dropped during the crisis, and the central bank's ability to facilitate its role as lender of last resort. Monitoring leverage is therefore necessary to control how risk builds up, to detect early signs of crisis, and to manage an evolving crisis.

Leverage and margin requirements play a key role in models of financial frictions in finance economics, general equilibrium economics, macroeconomics, and monetary economics. To apply these models in mitigating systemic risk, leverage must be monitored. However, monitoring leverage does not rely on these models; leverage is a fundamental measure of systemic risk that is model free. Monitoring leverage is simply a matter of collecting the data. As the availability of leverage data grows, much new research will unquestionably follow.

References

Ashcraft, A., N. Garleanu, and L. H. Pedersen. 2010. "Two Monetary Tools: Interest Rates and Haircuts." In *NBER Macroeconomics Annual 2010*, vol. 25, edited by Daron Acemoglu and Michael Woodford, 143–80. Chicago: University of Chicago Press.

Bernanke, B., and M. Gertler. 1989. "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79 (1): 14–31.

Brunnermeier, M., and L. H. Pedersen. 2009. "Market Liquidity and Funding Liquidity." *Review of Financial Studies* 22:2201–38.

Diamond, D., and P. Dybvig. 1983. "Bank Runs, Deposit Insurance, and Liquidity." Journal of Political Economy 91 (3): 401–19.

Fostel, A., and J. Geanakoplos. 2008. "Leverage Cycles and the Anxious Economy." *American Economic Review* 98 (4): 1211–44.

Frazzini, A., and L. H. Pedersen. 2011. "Betting Against Beta." Working Paper, New York University.

———. 2012. "Embedded Leverage." Working Paper, New York University.

Garleanu, N., and L. H. Pedersen. 2011. "Margin-Based Asset Pricing and Deviations from the Law of One Price." *Review of Financial Studies* 24 (6): 1980–2022.

Geanakoplos, J. 1997. "Promises, Promises." In *The Economy as an Evolving Complex System II*, edited by W. B. Arthur, S. N. Durlauf, and D. A. Lane, 285–320. Reading, MA: Addison Wesley Longman.

———. 2003. "Liquidity, Default, and Crashes: Endogenous Contracts in General Equilibrium." In *Advances in Economics and Econometrics: Theory and Applications, Eighth World Congress 2000*, Vol. II, Econometric Society Monographs, 170–205. Cambridge: Cambridge University Press.

———. 2010a. "The Leverage Cycle." In *NBER Macroeconomics Annual 2009*, vol. 24, edited by D. Acemoglu, K. Rogoff, and M. Woodford, 1–65. Chicago: University of Chicago Press.

———. 2010b. "Solving the Present Crisis and Managing the Leverage Cycle." *Federal Reserve Bank of New York Economic Policy Review* August: 101–35.

Holmstrom, B., and J. Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics* 112 (1): 35–52.

Kiyotaki, N., and J. Moore. 1997. "Credit Cycles." *Journal of Political Economy* 105 (2): 211–48.

Lorenzoni, G. 2008. "Inefficient Credit Booms." *Review of Economic Studies* 75 (3): 809–33.

Pedersen, L. H. 2009. "When Everyone Runs for the Exit." *International Journal of Central Banking* 5: 177–99.

Reinhart, C., and K. Rogoff. 2009. *This Time is Different*. Princeton, NJ: Princeton University Press.

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