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Does Prolonged Monetary Policy Easing Increase Financial Vulnerability?

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Abstract

Using firm-level data for approximately 1,000 bank and nonbank financial institutions in 22 countries over the past 15 years we study the impact of prolonged monetary policy easing on risk-taking behavior. We find that the leverage ratio, as well as other measures of firm-level vulnerability, increases for banks and nonbanks as domestic monetary policy easing persists. Cross-border effects are also notable. We find effects of roughly similar magnitude on foreign financial sector firms when the U.S. eases policy. Results appear robust to a variety of specifications, and to be non-linear, with risk-taking behavior rising most quickly at the onset of monetary policy easing.

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Keywords: Banks, nonbank financial institutions, prolonged monetary policy easing, financial vulnerability, financial stability, risk-taking behavior, spillovers.

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I. Introduction

Stabilizing the economic and financial system in the face of the global crisis has required extraordinary central bank actions. One way to characterize monetary policy since 2007 is as a sequence of accommodative actions, first based on interest rates alone and then on balance sheet measures. Most observers agree that these actions succeeded in reducing the severity of the real economic downturn, preventing a deep recession from turning into a protracted depression in most parts of the world. But as the period of policy easing was prolonged from quarters to years in the large advanced economies, concerns arose about its impact on financial stability, and on cross-border spillovers.

This leads us to ask two related questions: First, does prolonged monetary policy easing increase the vulnerability of the domestic financial system? And, second, does prolonged monetary policy easing in the United States (U.S.) have an impact on vulnerabilities of financial systems elsewhere in the world?

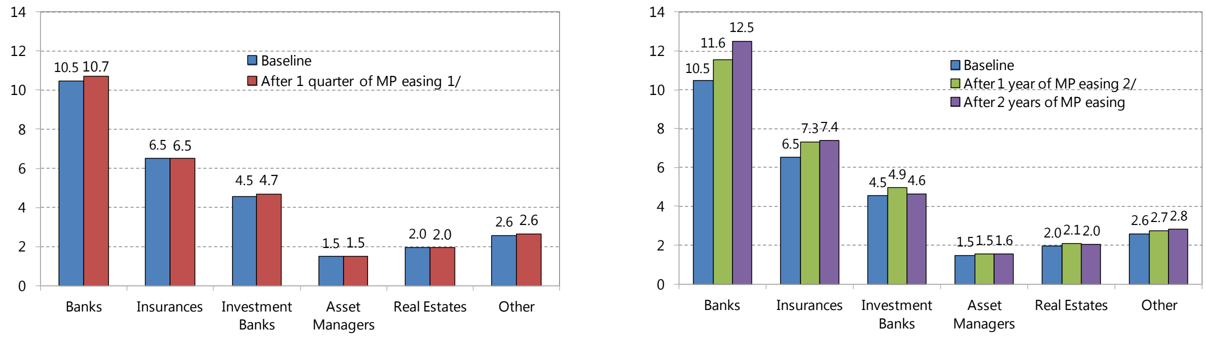
A simple plot of the data suggests a positive answer to both questions. We examine a comprehensive firm-level data set composed of 994 publicly listed financial institutions in 22 countries over the period from 1998 Q1 to 2014 Q4. Beginning in the upper left of Figure 1, we plot financial institution leverage on average over the entire data set (the blue bar) as well as leverage following a single quarter of policy easing in the institution's home country (the red bar). The impact is minimal. Moving to the top-right, we plot the average leverage after one- and two-years of prolonged policy easing (the green and purple bars, respectively). The difference is notable; prolonged—as opposed to one-time—easing makes quite a difference. For banks, the leverage benchmark is 10.5. But after two consecutive years of policy easing, the level has risen to 12.5. Insurance companies also show a notable increase in leverage following an extended period of monetary easing—after two years, the median firm's leverage increases from 6.5 to 7.4.

The bottom panel of Figure 1 reports the results of this same calculation based on U.S. policy easing. That is, we drop the American institutions from the sample and examine the impact of prolonged Federal Reserve monetary accommodation on financial firms in the remaining 21 countries of our sample. These results are striking, as the impact appears even larger than the own-country policy impact.

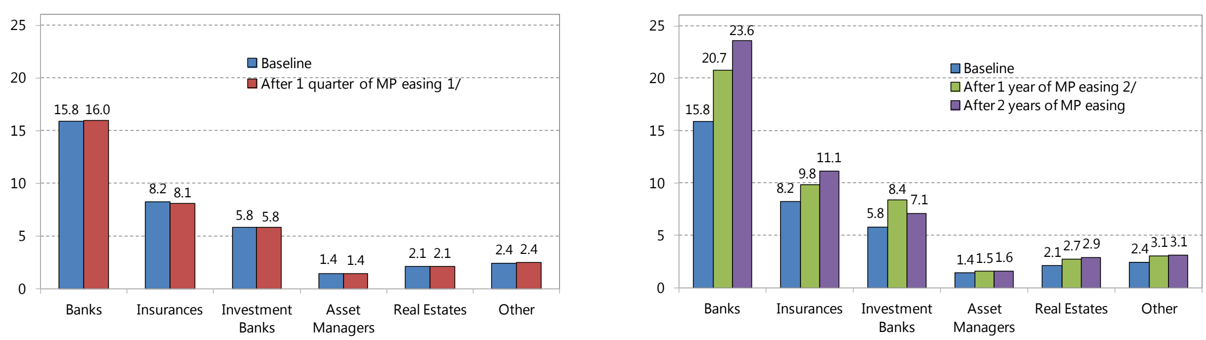
In the remainder of the paper we examine this link more carefully and confirm the impression from Figure 1. Bank and nonbank leverage, as well as other measures of financial firms' vulnerability, increase the longer the period of monetary policy easing both in an institution's home country and in the U.S. We show that these effects are statistically and economically significant not just for banks, but for nonbank financial institutions, including insurance companies, investment banks, and asset managers.

Figure 1. Change in the Asset-to-Equity Ratio

Panel A. Following extended monetary policy easing in the own economy
(Full sample)



Panel B. Following extended monetary policy easing in the U.S.
(Non-U.S. sample)



Sources: Bloomberg, Datastream, Haver, Worldscope, and authors' calculations.

Note: The asset-to-equity ratios before and after monetary policy easing periods are calculated using the median percent changes and median levels in each industry. We first take firm-level medians, and then industry-level medians of the firm-level medians. Panel A is based on data for a total of 994 publicly listed financial firms 19 advanced economies plus Brazil, Mexico, and South Africa from 1998Q1 to 2014Q4. Panel B is based on the sub-sample of the financial firms outside the U.S.

1/ The duration measure in the left panels is the number of consecutive quarters of a decline in the eight-quarter moving average of overnight rate.
2/ The duration measure in the right panels is the number of consecutive quarters of a decline in the eight-quarter moving average of two-year yields.

Our results provide further quantification of the channels linking monetary policy to financial stability. First, the fact that prolonged policy accommodation results in an increase in leverage across the financial system is consistent with the presence of a risk-taking channel from monetary policy transmission through both banks and nonbanks.[2] Our results for banks add to the now extensive literature showing the impact of monetary policy easing on bank

[2] For a description of the risk-taking channel of monetary policy transmission, see Borio and Zhu (2012).

(continued…)

lending standards and bank solvency.[3] More noteworthy and new are our findings for nonbank financial institutions, and the finding that the relationship between persistent monetary policy easing and vulnerability of banks and nonbanks appears to be non-linear, with risk-taking behavior rising most quickly at the onset of policy easing.

Second, our analysis shows that risk-taking by banks and nonbanks responds in the same direction to monetary policy; this contrasts with other papers that show credit extension by banks and nonbanks responds in opposite directions to changes in monetary policy.[4] Our results are consistent with the suggestion that insurance companies and other nonbanks target nominal returns and may thus take on higher risks when interest rates decrease, and that lower funding costs reduce agency problems, prompting banks to shift into riskier assets.[5]

Third, our analysis offers building blocks for a richer study of how monetary policy affects financial stability. Further research would have to establish the link between leverage and the probability or severity of crises (as Schularick and Taylor (2012) do for credit growth). With that, a cost-benefit analysis similar to that in Svensson (2015) or IMF (2015) could help central banks decide whether higher interest rates are warranted to support financial stability, at the expense of lost output and lower inflation.

The estimates of the spillover of U.S. monetary policy easing on the rest of the world are truly novel. Prolonged easing in the U.S. increases the vulnerability of financial sector firms abroad by approximately as much as domestic easing. Our results therefore inform the debate on monetary policy independence in small open economies, as recently examined in Rey (2014) and Obstfeld (2015). We suspect that prolonged interest rate reductions in the United States have an impact on financial firms elsewhere for two reasons. First, U.S. accommodative monetary policy results in capital outflows from the U.S.—a phenomenon some observers have labeled "global liquidity."[6] Second, since such a large fraction of global trade and finance is denominated in U.S. dollars, when the Federal Reserve acts to ease financial conditions domestically, it reduces funding costs globally. Our results add to evidence that, possibly as a consequence of the increase in financial globalization, U.S. policy spillovers have increased over the past quarter century.[7]

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[3] See Maddaloni and Peydro (2011), Dell'Ariccia et al. (2013), and Jimenez et al. (2014) for results on the impact of monetary policy on lending standards; and Gambacorta (2009) and Altumbas et al. (2010) for studies on bank solvency.

[4] See Den Haan and Sterk (2010), Nelson et al. (2015), and Herman et al. (2015) for the evidence on credit extension by banks and nonbanks that is based on U.S. flow of funds data.

[5] See, for example, the arguments in Rajan (2005), Feroli et al. (2014) and Morris and Shin (2014) on the search for yield; and Agur and Demertzis (2013), Dell'Ariccia et al. (2014), and Valencia (2014) on how lower funding costs can reduce agency problems, increasing leverage and the riskiness of bank assets.

[6] Bruno and Shin (2015) and Rey (2015) show that U.S. monetary policy easing increases the leverage of international banks.

[7] For an examination of the change in the strength of policy spillovers see Chen, Mancini-Griffoli and Sahay (2014).

The remainder of this paper is organized in five sections. Section II presents our measures of monetary policy easing and financial institution vulnerability. The following two sections present our results, first for own-country policy and then for U.S. policy. In Section V, we examine the robustness of our results and consider some extensions. And the final section concludes.

II. MEASURES OF PROLONGED MONETARY POLICY EASING AND FINANCIAL INSTITUTION VULNERABILITY

To examine the impact of prolonged monetary easing on financial institution vulnerability we need quantitative measures. For the former, our empirical analysis is based on interest rates; and for the latter on a measure of firm leverage. In this section we describe how we compute each of these. Appendix I provides details on the data definitions and sources.

Measures of prolonged monetary policy easing

We define the "duration" of monetary policy easing as the number of consecutive quarters of interest rate cuts based on four measures: (1) the nominal short-term rate; (2) the real short-term rate; (3) the nominal two-year sovereign yields; and (4) the nominal 10-year sovereign yields. Each measure is taken as an 8 quarter moving average in order to remove high-frequency movements in interest rates. A cut in interest rates from one quarter to the next is defined as a drop in the moving average calculated up to the current quarter, relative to the moving average for one quarter ago.[8] That is, for each of the above-mentioned interest rates i_t, we compute the duration D_t as follows:

$$D_t \coloneqq \begin{cases} D_{t-1} + 1 & \text{if } MA_t < MA_{t-1} \\ 0 & otherwise, \end{cases} \quad (1)$$

where $MA_t \coloneqq \frac{1}{8}\sum_{\tau=1}^{8} i_{t-\tau+1}$. We explicitly focus on market rates that can be readily observed, as opposed to deviations from Taylor rules, the natural interest rate, or other benchmarks, which are based on unobservable variables and require strong assumptions.[9]

Our preferred indicator of duration is based on the two-year sovereign bond yields. While the short-term interest rate is one of the most widely used indicators of monetary policy, it becomes less informative once it reaches the zero lower bound. During recent episodes of

[8] Another measure is also possible, found by adding the extent—as opposed to counting the instances—of consecutive drops in interest rates. We return to this continuous measure in the robustness section, where we find that results do not vary.

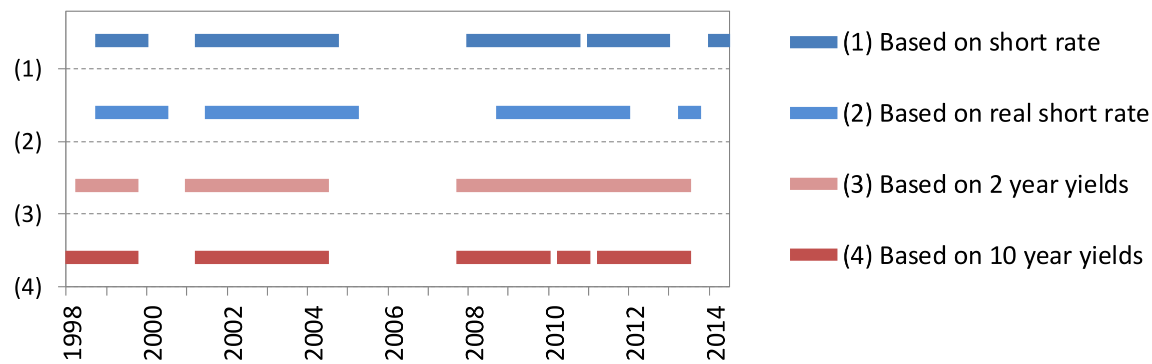
[9] For the survey and the debates over various specifications of the Taylor type interest rate rules, see Taylor (1993, 1999), Orphanides (2001), Carare and Tchaidze (2005), Rudebusch (2005), Christiano et al. (2010), and Nikolsko-Rzhevskyy and Papell (2013). On the natural interest rate, see Laubach and Williams (2003) and Wu (2005).

(continued…)

unconventional monetary policy (UMP) based either on quantitative easing or forward guidance, the longer-term sovereign rate becomes a better measure of the stance of policy.[10] However, ten-year bond yields are less sensitive to monetary policy impulses, especially prior to the global financial crisis. Two-year interest rates thus offer a balanced indicator of monetary policy.[11]

Figure 2 illustrates the periods of U.S. monetary policy easing as determined by each of our four measures. We use quarterly data from 1998 to 2014. We note that the measures are quite similar in their timing. They all show easing cycles in the late 1990s, associated with the Asian Crisis, the collapse of Long-Term Capital Management and the default of Russia; early 2000s, related to the bursting of the dot-com bubble; and 2007–09 during the global financial crises. The same process is used to generate similar series for each of the other 21 countries in our sample.

Figure 2. Periods of Persistent Monetary Policy Easing for the U.S.



Sources: Bloomberg, Datastream, Haver, and authors' calculations.

Note: Based on data for the United States from 1998Q1–2014Q4. Highlighted quarters indicate the periods of consecutive quarters of monetary policy easing based on each of the four variable definitions (our "duration" measure).

Summary statistics for the duration of monetary policy easing in all 22 countries[12] in our sample are reported in Table 1. For example, based on our preferred indicator, the two-year yield measure (labeled "Y2 yields"), we find that the median duration of an easing period is

[10] For a discussion of how UMP acts through long-term rates, see, for example, Gagnon et al. (2011), Wright (2012), Swanson and Williams (2014), and Chen, Mancini-Griffoli and Sahay (2014).

[11] For other studies using two-year yields as the indicator of monetary policy, see Gilchrist et al. (2014) and Gertler and Karadi (2015), for example.

[12] The sample countries consist of 19 advanced economies (Austria, Australia, Belgium, Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Republic of Korea, Spain, Sweden, Switzerland, the United Kingdom, and the U.S.) and three emerging market economies (Brazil, Mexico, and South Africa).

six quarters. In a few cases, duration can be extremely long, but such instances are rare, considering that the duration at the 75th percentile is less than four years for all measures.

Table 1. Summary Statistics of the Duration Measures of Monetary Policy Easing

Number of consecutive quarters with …	25th Percentile	50th Percentile	75th Percentile	Max	Number of observations
Declines in the moving average of					
Short rate	3	6	10	37	857
Real short rate	2	5	9	26	695
Y2 yields	3	6	10	25	843
Y10 yields	4	8	14	33	892

Sources: Bloomberg, Datastream, Haver, and authors' calculations.

Note: Based on country-level panel data from 1998Q1-2014Q4. Data covers 22 countries (19 advanced economies plus Brazil, Mexico, and South Africa).

Since three of our measures are based on nominal interest rates, there is a risk that our duration measures will be driven by declines in inflation, and thus not represent periods of accommodative policy. While many advanced economies have experienced considerable decreases in the inflation rates since the 1980s, these disinflation trends mostly ended in the early 1990s.[13] In addition, the series built with consecutive cuts in nominal rates are very similar to those based on cuts in real rates (Figure 2). Our measures should thus faithfully capture monetary policy accommodation.

Measures of financial institution vulnerability

Turning to the information on financial institutions, we develop various measures of vulnerability, though focus in the main text on leverage. The robusntess section offers two alternative measures: one tracking the risk-return profile of firms (based on risk-adjusted return on equity), and the second their solvency (based on the z-score). Results are qualitatively unchanged when these alternative measures are used. Leverage plays a key role in the amplification of shocks, and is the basis for various measures of systemic risk.[14] For financial firms, leverage is a simple indicator of the fraction of a firm's assets that are financed by its non-equity liabilities, and hence by external funding. Higher leverage, which

[13] See Pehnelt (2007).

[14] The classic references on the relationship of debt to the amplification mechanism are Bernanke and Gertler (1995) and Kiyotaki and Moore (1997). For discussion of the relationship between leverage, systemic risk and financial crisis, see Adrian and Shin (2009, 2010), Acharya et al. (2012), Gourinchas and Obstfeld (2012), and Schularick and Taylor (2012).

(continued…)

can stem from greater risk taking, indicates a greater financial obligation, implying greater vulnerability to an adverse shock.[15]

Levels of leverage, defined as assets-to-equity, differ across financial industries. Table 2 reports summary statistics from our data set of nearly 1,000 publicly listed financial firms in 22 countries from 1998 Q1 to 2014 Q4. We divide the data into six industry groups using the Global Industry Classification Standard provided by MSCI and Standard & Poor's. These are banks, insurance companies, invesment banks, asset managers, real estate firms, and others. The median leverage ratio ranges from 1.5 for asset managers to 10.5 for banks.[16]

Table 2. Leverage Ratio by Financial Industry

	25th percentile	50th percentile	75th percentile	Number of Firms
Banks	6.5	10.5	19.7	245
Insurance companies	3.2	6.5	12.6	122
Investment banks	3.2	4.5	12.2	47
Asset managers	1.2	1.5	2.1	124
Real estates	1.6	2.0	2.6	370
Other financials	1.5	2.6	5.2	86

Sources: Datastream, Worldscope, and authors' calculations.

Note: Computations are based on an unbalanced panel data for a total of 994 publicly listed financial firms in 22 countries (19 advanced economies plus Brazil, Mexico, and South Africa) from 1998Q1-2014Q4. To avoid over-representation from firms with more observations, industry percentiles (reported in the first three columns) are calculated from firm-level medians.

III. The Impact of Own-Country Policy Easing

We now turn to a comprehensive empirical examination of the impact of prolonged monetary policy easing on leverage. The unconditional positive correlation between leverage and persistent declines in interest rates shown in Figure 1 could result from a variety of factors. We aim to control for these factors with a combination of macroeconomic and firm-specific variables in our regression analysis. Specifically, we estimate the following regression, for each of the six industry categories:

$$\ln(\mathrm{Y_{ikt}}) = \alpha_0 + \alpha_1 \mathrm{D_{kt}} + \boldsymbol{\beta}\mathbf{X_{kt-1}} + \mathrm{c_{ki}} + \varepsilon_{\mathrm{ikt}} \qquad (2)$$

for firm *i* in country *k* at time *t*. The model relates financial firms' leverage ($\mathrm{Y_{ikt}}$) to the duration of own-country monetary policy easing ($\mathrm{D_{kt}}$) measured as the number of consecutive quarters of declines in country *i*'s interest rates. The regression allows us to control for other (lagged) macroeconomic variables ($\mathbf{X_{kt-1}}$) potentially affecting leverage.

[15] Dell'Aricia et al. (2014) show that higher bank leverage implies greater risk-taking in a limited-liability framework.

[16] These calculations are not weighted by asset size.

(continued…)

We include real GDP growth to capture changes in income and confidence, growth of the stock price index to control for the cost of equity financing, and the automatic valuation effect on leverage from stock prices,[17] a volatility index to control for the degree of uncertainty in financial markets, and a sovereign bond rating to control for actual or perceived sovereign risk. To control for structural differences among the six industries and 22 countries, such as differences in business models, domestic regulations, and accounting practices we include a set of fixed effects (c_{ki}).

Table 3 presents the results from equation (2) for each industry estimated based on firms' own-country monetary policy easing. In each case—for each industry and duration measure—we report the estimated impact of an increase in the duration of policy easing by one quarter. We focus again on the measure of duration which we believe most accurately captures monetary policy accommodation over the entire sample—consecutive drops in the moving average of the two-year rate (the third row of Table 3). We see that an additional quarter of monetary policy easing raises bank balance-sheet leverage by 0.19, insurance company leverage and investment bank leverage by 0.08, and asset manager leverage by 0.01. The estimates are significantly different from zero at the 1 percent level in the first three industries, and at the 10 percent level in the fourth. To put these numbers into perspective, recall from Table 2 that the median leverage for banks in our sample is 10.5, so an additional quarter of policy easing increases leverage by roughly 2 percent.

[17] Adrian and Shin (2010) point out that, if other things are kept unchanged, leverage would decline when stock prices go up.

Table 3. Marginal Impacts of the Duration of Domestic Monetary Easing on Leverage

Number of consecutive quarters with declines in the moving average of:	Bank	Insurance	Investment Bank	Asset Manager	Real Estate	Other
Short rate	0.15*	0.08***	0.06**	0.01***	0.02**	0.02
Real short rate	0.08	0.09***	-0.01	0.01	0.01*	0.01
Y2 yields	0.19***	0.08***	0.08***	0.01*	0.00	0.02
Y10 yields	0.10*	0.04**	0.06***	0.00	0.00	0.00
Median (A/E)	10.5	6.5	4.5	1.5	2.0	2.6

Sources: Bloomberg, Datastream, Haver, WEO, Worldscope, and authors' estimates.

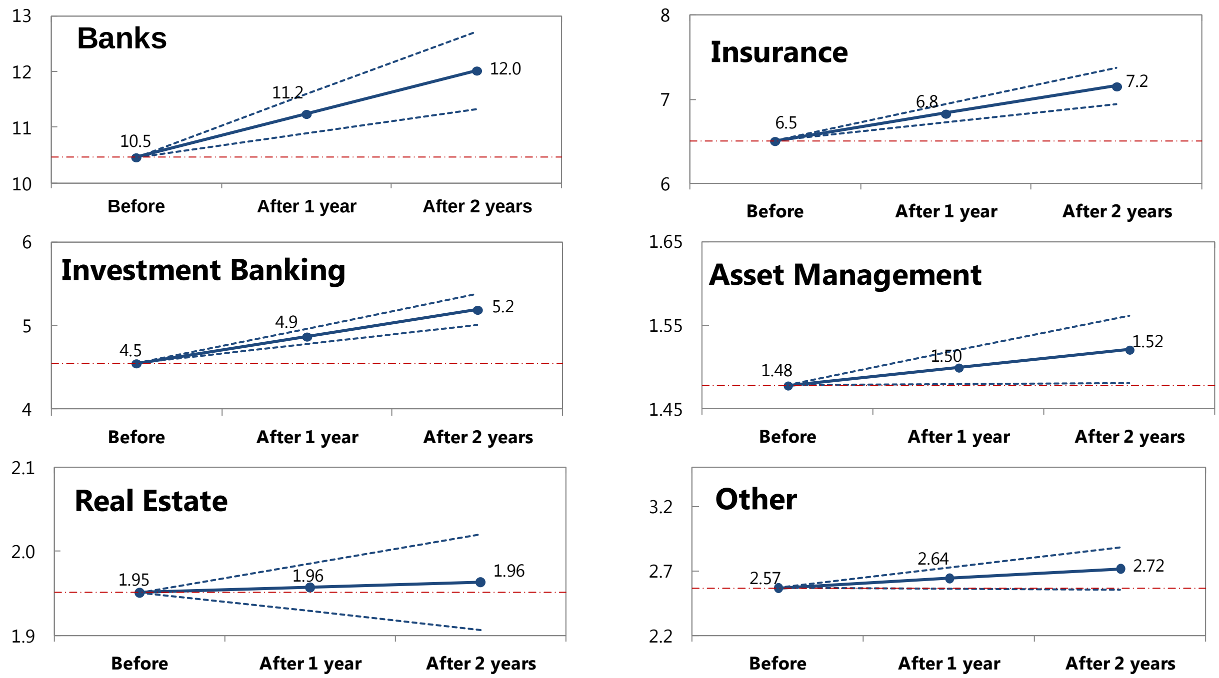
Note: Table shows the estimated marginal impact of the duration of monetary policy easing on the asset-to-equity leverage ratio of additional one quarter of MP easing ($\partial Y/\partial D = \alpha_1 \cdot Y^{med}$). The duration is the number of the consecutive quarters with a decline in the moving average of the specified interest rate. Estimation is conducted by industry, using unbalanced panel data of about 1,000 firms in 22 countries from 1998Q1 to 2014Q4. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which are robust to heteroscedasticity and cross-sectional as well as temporal dependence. Stars indicate significance at 1 percent (***), 5 percent (**), and 10 percent (*).

Figure 3 illustrates the same results, using the two-year rate indicator, graphically. Here, for each indicator and each industry group, we plot the estimated impact on each industry of additional quarters of domestic monetary policy easing. For banks, for instance, we see that two years of persistent easing raises leverage, on average, from 10.5 to 12.0—nearly the same amount as in the unconditional relationships illustrated in Figure 1.

Drawing macro implications from the increase in leverage requires caution. On the one hand, the increase in leverage provides evidence for how conventional stabilization policy is intended to work. That is, monetary policy easing is designed to boost real economic activity by getting people to take risks that they were previously unwilling to take. On the other hand, however, higher financial firm leverage could increase the probability of a financial crisis.[18]

[18] For example, Gourinchas and Obstfeld (2012) and Schularick and Taylor (2012) find that credit growth is a predictor of financial crisis.

Figure 3. Estimated Effect of the Duration of Domestic Monetary Policy Easing on Leverage



Sources: Bloomberg, Datastream, WEO, Worldscope, and authors' estimates.

Note: The asset-to-equity leverage ratios before and after monetary policy easing are calculated with the estimated coefficients and median levels in each industry. The duration is the number of the consecutive quarters with a decline in the moving average of two-year bond yields. Estimation is conducted by industry, using unbalanced panel data of about 1,000 firms in 22 countries from 1998Q1 to 2014Q4. Blue dashed lines indicate 90 percent confidence intervals. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which are robust to heteroscedasticity and cross-sectional as well as temporal dependence.

IV. The Impact of U.S. Policy Easing

We now examine the impact of prolonged U.S. monetary easing on financial firms elsewhere in the world. As mentioned earlier, this analysis is motivated by a growing literature suggesting that policy accommodation in large advanced economies affects capital flows, asset prices, credit growth and financial system leverage in other countries. [19]

To study the spillover impact of U.S. policy, we do two things: we remove U.S. firms from our sample and add the duration of U.S. policy easing to equation (2). That is, we estimate:

$$\ln(Y_{ikt}) = \alpha_0 + \alpha_1 D_{kt} + \alpha^{US} D_t^{US} + \boldsymbol{\beta X_{kt-1}} + c_{ki} + \varepsilon_{ikt} \qquad (3)$$

where *k* includes all countries in our sample except for the U.S., and all variables are as defined in Section III.

[19] For example, see Neely (2010), Chen et al. (2014), Bruno and Shin (2015), Morais et al. (2015), and Rey (2015).

Results suggest that prolonged periods of monetary policy easing in the U.S. do increase the leverage of banks and nonbanks in foreign countries. This is despite controlling for each country's domestic monetary policy. Results are reported in Table 4 and illustrated in Figure 4. In the case of our preferred measure of duration based on two-year rates, effects of U.S. monetary policy easing are either equal to those of domestic monetary policy easing (for investment banks and asset managers), greater (for banks), or substantially greater (for remaining financial firms). Moreover, effects of domestic policy duration remain mostly unchanged relative to the earlier set of regressions not explicitly controlling for U.S. policy. This implies that U.S. policy effects can add to the direct effects of domestic monetary policy. When business cycles are correlated, domestic and U.S. monetary policies will work together to amplify the swings in financial sector vulnerability.

We consider that the off-shore impact of U.S. policy is likely a consequence of two related factors. First, consecutive cuts in U.S. interest rates lead to capital outflows that alleviate funding constraints and potentially increase asset prices thereby improving collateral valuations. Both allow greater leverage. In addition, there are substantial U.S. dollar assets and liabilities outside the U.S. As a result, when dollar interest rates change, it affects balance sheets of financial firms worldwide.[20] Thus all the arguments for why U.S. firms adjust behavior following domestic interest rate cuts carry over to firms elsewhere in the world.

[20] For example, Bruno and Shin (2015) document foreign currency assets and liabilities of banks outside the U.S. and point out the prominent role played by the U.S. dollar.

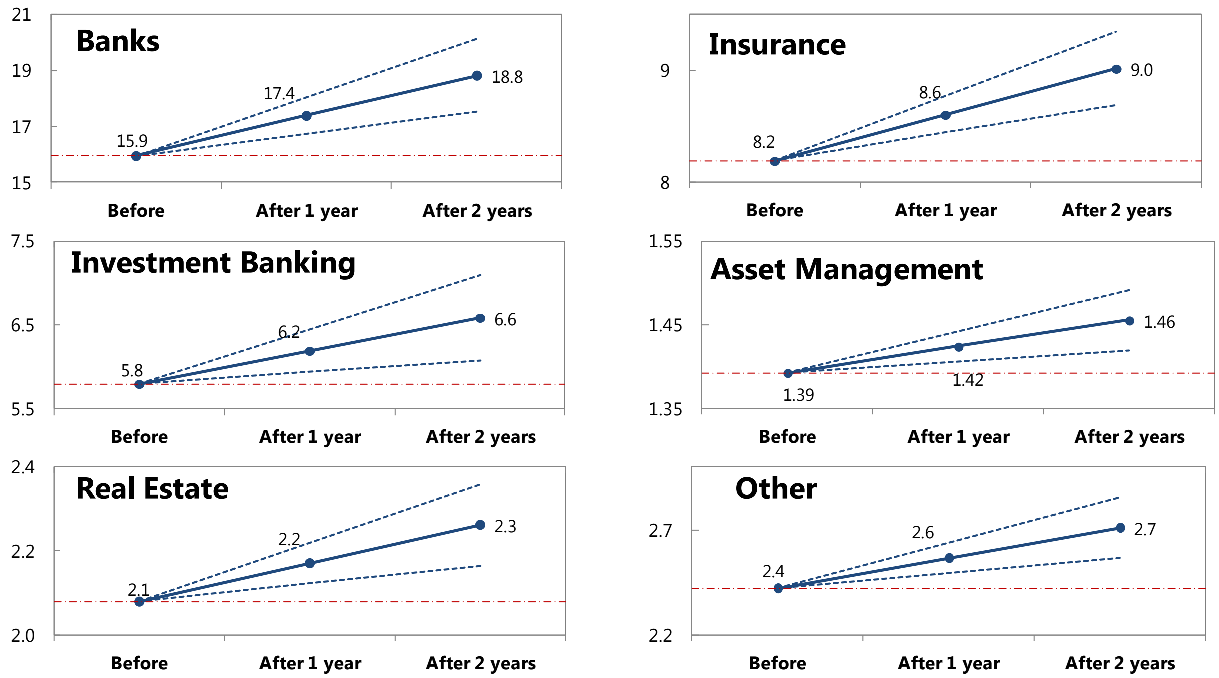
Table 4. Marginal Impacts of the Duration of U.S. and Domestic Monetary Easing

	Bank	Insurance	Investment Bank	Asset Manager	Real Estate	Other
Short rate						
U.S. duration	0.18	0.13***	0.01	0.01**	0.02*	0.04**
Domestic duration	0.27***	0.04	0.08**	0.01***	0.02***	0.01
Real short rate						
U.S. duration	0.28	0.10**	0.06	0.01	0.02**	0.04**
Domestic duration	0.01	0.09***	-0.09	0.00	0.01	0.00
Y2 yields						
U.S. duration	0.36***	0.10***	0.10**	0.01***	0.02***	0.04***
Domestic duration	0.22***	0.05**	0.11***	0.01**	0.00	0.00
Y10 yields						
U.S. duration	0.02	0.08**	-0.03	0.00	0.01	0.01
Domestic duration	0.25***	0.05**	0.10***	0.01***	0.01	0.00
Median (A/E)	15.9	8.2	5.8	1.4	2.1	2.4

Sources: Bloomberg, Datastream, Haver, WEO, Worldscope, and authors' estimates.

Note: Table shows the estimated marginal impacts of the durations of domestic and US monetary policy easing on the asset-to-equity leverage ratio ($\partial Y/\partial D = \alpha \cdot Y^{med}$, where $\alpha = \alpha_1$ or α^{US} in equation (3)). The duration is the number of the consecutive quarters with a decline in the moving average of the specified interest rate. Estimation is conducted by industry, using non-U.S. sample of our panel data from 1998Q1 to 2014Q4. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which is robust to heteroscedasticity and cross-sectional as well as temporal dependence.

Figure 4. Estimated Effect of the Duration of U.S. Monetary Policy Easing on Leverage
(Non-U.S. sample)



Sources: Bloomberg, Datastream, WEO, Worldscope, and authors' estimates.

Note: The asset-to-equity leverage ratios before and after monetary policy easing are calculated with the estimated coefficients and median levels in each industry. The duration is the number of the consecutive quarters with a decline in the moving average of two-year U.S. bond yields. Estimation is conducted by industry, using non-US sample of our panel data from 1998Q1 to 2014Q4. Blue dashed lines indicate 90 percent confidence intervals. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which is robust to heteroscedasticity and cross-sectional as well as temporal dependence.

V. Robustness and Extensions

Results are robust to various alternative specifications.

Policy tightening, macroprudential instruments, and endogeneity

First, we ask whether the effect of prolonged monetary policy easing on leverage is symmetric. In other words, are periods of consecutive hikes—defined symmetrically—associated with lower leverage? Indeed, in the second line of each panel in Table 5 (labeled "Y2 yield increases"), we report coefficient estimates that are approximately of the same size, but with the opposite sign.

Second, the extent to which financial institutions respond to monetary policy easing might depend on the regulatory environment in which they operate. To examine this, we introduce Cerutti et al.'s (2015) macroprudential policy index (MPI) into our baseline regression. Constructed using 12 potential macroprudential instruments, the MPI takes values from 0 to 12 depending on the number of instruments in use. The results of this exercise, reported in the "Macroprudential policies" line of Table 5 show virtually no change from the baseline.

Finally, we address the possibility of endogeneity. If monetary policy is eased (tightened) when aggregate leverage decreases (increases), a potential endogeneity bias would underestimate the effect of duration. However, on the basis of generalized method of moments (GMM) estimation, following Arellano-Bover (1995) and Blundell-Bond (1998),[21] we find that results are nearly unchanged relative to the baseline (see the lines labelled "Potential endogeneity" in Table 5).

[21] In the system GMM estimation, we use lagged differences of the duration measure as instruments for the equation in levels, and the second lags of the duration measure as instruments for the equation in first differences.

Table 5. Robustness

	Bank	Insurance	Investment bank	Asset manager	Real estate	Other
	Marginal impact of domestic duration (full sample)					
Number of consecutive quarters with …						
Y2 yield declines (Baseline)	0.19***	0.08***	0.08***	0.01*	0.00	0.02
Y2 yield increases (i.e., tightening)	-0.27***	-0.14***	-0.09**	-0.01**	-0.03***	-0.05***
When controlling for …						
Macroprudential policies[1/]	0.22***	0.09***	0.07***	0.01***	0.00	0.03***
Potential endogeneity[2/]	0.27***	0.10***	0.07**	0.01**	0.01***	0.05***
Median (A/E), full sample	10.5	6.5	4.5	1.5	2.0	2.6
	Marginal impact of U.S. duration (non-U.S. sample					
Number of consecutive quarters with …						
Y2 yield declines (Baseline)	0.36***	0.10***	0.10**	0.01***	0.02***	0.04***
Y2 yield increases (i.e., tightening)	-0.55***	-0.15***	-0.14**	-0.01***	-0.05***	-0.06***
When controlling for …						
Macroprudential policies[1/]	0.39***	0.12***	0.04***	0.01**	0.06***	0.03**
Potential endogeneity[2/]	0.37***	0.11***	0.10***	0.01*	0.02***	0.03***
Median (A/E), non-U.S. sample	15.9	8.2	5.8	1.4	2.1	2.4

Sources: Bloomberg, Datastream, Haver, WEO, Worldscope, Cerutti et al. (2015), and authors' estimates.

Note: Tables show the estimated marginal impacts of the durations of domestic and U.S. monetary policy easing (or tightening) on the asset-to-equity ratio ($\partial \mathrm{Y}/\partial \mathrm{D} = \alpha \cdot \mathrm{Y}^{\mathrm{med}}$, where $\alpha = \alpha_1$ or the domestic duration results and $\alpha = \alpha^{\mathrm{US}}$ for the US duration results). Standard errors are calculated by Driscoll and Kraay (1998) standard errors for all cases except for the system GMM estimation. When the system GMM estimation is performed to address the potential endogeneity issue, standard errors are calculated by cluster-robust standard errors. Stars indicate significance at 1 percent (***), 5 percent (**), and 10 percent (*).

1/ This row shows the marginal impacts of additional one quarter with declines in the moving average of two-year bond yields when macroprudential policies are controlled for. Note that estimation is conducted using data from 2000Q1 to 2013Q4. This observation period is shorter than that for the baseline model estimation because the index of macroprudential policies is only available for 2000-2013.

2/ The marginal impacts of additional one quarter with declines in the two-year bond yields are estimated using the system GMM estimation, following Arellano-Bover (1995) and Blundell-Bond (1998).

Alternative measures of financial institution vulnerability and nonlinear effects

We next turn to the examination of alternative measures of financial firm vulnerability, and nonlinear effects of duration. We first examine other measures than leverage[22], such as the risk-adjusted return on equity (ROE) and the z-score. The first of these, a measure of the risk-return profile of a firm, is computed as the ROE divided by its standard deviation over the previous two years.[23] The second, the z-score, is a measure of solvency of a firm defined as the average return on assets (ROA) plus the average ratio of equity to assets, divided by the standard deviation of ROA over the past two years.[24] Lower risk-adjusted ROE and z-scores are consistent with more vulnerable financial firms.

Second, we consider a non-linear model in which the duration of monetary policy easing can affect financial firm vulnerability exponentially. In other words, an additional quarter of policy easing may affect leverage differently depending on the duration of prior policy easing.

Results showing combinations of alternative measures of vulnerability and model specification for domestic and U.S. monetary policy easing are presented in Tables 6 and 7, respectively. When testing the effects of U.S. policy, we continue to control for domestic monetary easing.

Looking at these tables, we see that the results are broadly consistent across different measures of financial firm vulnerability. That is, regardless of whether we use leverage, the risk-adjusted ROE, or the z-score, the longer monetary policy is accommodative either at home or in the U.S., the more vulnerable the firm. As the duration of easing increases, leverage goes up, and both the risk-adjusted ROE and z-score go down. Furthermore, as for leverage, the impact is the largest for banks, insurance companies, and investment banks.

The results in Tables 6 and 7 also show that the relationship between the duration of policy easing and measures of vulnerability is non-linear, especially for the risk-adjusted ROE and z-score. Specifically, the marginal impact of an additional quarter of policy easing is greater at the onset of the accommodation period than it is later on. This pattern suggests that the biggest impact of monetary policy on risk-taking occurs quickly. Also, the fact that the nonlinearity is very modest for leverage, but larger for the two alternative measures, suggests that the impact on risk-shifting activities may occur more quickly than the changes in the capital structure of financial institutions.

Finally, we note that all the results for alternative measures of financial vulnerability, and for nonlinearity, are similar for domestic and U.S. monetary policy easing. That is, the results in

[22] See Kalemli-Ozcan et al. (2012) and Feroli et al. (2014).

[23] The risk-adjusted ROE is sometimes referred to as the “Sharpe ratio” because it controls for risk in the same way as the classical Sharpe ratio does (i.e., the one proposed by Sharpe [1966]). For example, see Stiroh (2004), Demirguc-Kunt and Huizinga (2010), Bergers et al. (2013), and Gaganis et al. (2015).

[24] For the studies using the z-score, see for example Stiroh (2004), Bergers et al. (2013), and IMF (2013).

Tables 6 and 7 are alike. This reinforces the earlier interpretation that U.S. monetary policy easing may affect foreign financial firms' leverage (or risk-taking behavior more generally) directly through the cost of dollar funding, in addition to the cost of domestic currency funding.

Table 6. Alternative Measures of Financial Institution Vulnerability and Nonlinearities: Own-Country Duration

	Bank	Insurance	Investment Bank	Asset Manager	Real Estate	Other
	Marginal impact on the asset-to-equity ratio					
Linear model (Baseline)	0.19***	0.08***	0.08***	0.01*	0.00	0.02
Nonlinear model[1/]						
0 quarter	0.16	0.11**	0.12**	0.01***	0.05***	0.10***
4 quarters	0.17	0.09***	0.10***	0.01***	0.03***	0.07***
8 quarters	0.19***	0.08***	0.09***	0.01**	0.01	0.03**
Median (A/E)	10.5	6.5	4.5	1.5	2.0	2.6
	Marginal impact on the risk-adjusted ROE					
Linear model	-0.13***	-0.08**	-0.07***	-0.05*	-0.03*	0.02
Nonlinear model[1/]						
0 quarter	-0.71***	-0.36***	-0.41***	-0.38***	-0.15	-0.35***
4 quarters	-0.46***	-0.24***	-0.27***	-0.24***	-0.10*	-0.19***
8 quarters	-0.21***	-0.12***	-0.13***	-0.09***	-0.05**	-0.04
Median (Risk-adjusted ROE)	6.2	3.9	2.4	2.5	3.2	4.8
	Marginal impact on the Z-score					
Linear model	-2.8***	-0.7**	-0.1	-0.3	-0.2	0.0
Nonlinear model[1/]						
0 quarter	-7.7**	-3.2***	-2.4***	-4.1***	-2.4***	-3.3***
4 quarters	-5.6***	-2.1***	-1.5***	-2.5***	-1.4***	-1.9***
8 quarters	-3.5***	-1.0***	-0.6***	-0.8***	-0.5***	-0.5***
Median (Z-score)	86.0	40.4	30.7	29.3	45.7	32.5

Sources: Bloomberg, Datastream, Haver, WEO, Worldscope, and authors' estimates.

Note: Table show the estimated marginal impact of the duration of monetary policy easing on the asset-to-equity ratio, and the risk-adjusted ROE, and the Z-score. It is calculated as $\partial Y/\partial D = \alpha \cdot Y^{med}$ for linear models and $\partial Y/\partial D = (\alpha_1 + 2\alpha_2 \cdot D) \cdot Y^{med}$ for nonlinear models. The duration is the consecutive quarters with a drop in the moving average of two-year bond yields. Estimation is conducted by industry, using unbalanced panel data of about 1,000 firms in 22 countries from 1998Q1 to 2014Q4. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which is robust to heteroscedasticity and cross-sectional as well as temporal dependence. Stars indicate significance at 1 percent (***), 5 percent (**), and 10 percent (*).

1/ For nonlinear models, the marginal impact of additional one quarter of monetary policy easing depends on the current duration. The table shows the marginal impact for the specified current duration.

Table 7. Alternative Measures of Financial Institution Vulnerability and Nonlinearities: U.S. Duration

	Bank	Insurance	Investment Bank	Asset Manager	Real Estate	Other
	Marginal impact on the asset-to-equity ratio					
Linear model (Baseline)	0.36***	0.10***	0.10**	0.01***	0.02***	0.04***
Nonlinear model[1/]						
0 quarter	0.40	0.12**	0.01	0.02*	0.08***	0.11***
4 quarters	0.38*	0.11***	0.05	0.01**	0.05***	0.08***
8 quarters	0.37***	0.11***	0.08*	0.01***	0.03***	0.05***
Median (A/E)	15.9	8.2	5.8	1.4	2.1	2.4
	Marginal impact on the risk-adjusted ROE					
Linear model	-0.11**	-0.04	-0.09***	-0.03*	-0.08***	-0.08***
Nonlinear model[1/]						
0 quarter	-0.62***	-0.49***	-0.35***	-0.25***	-0.41***	-0.44***
4 quarters	-0.41***	-0.31***	-0.25***	-0.16***	-0.28***	-0.29***
8 quarters	-0.21***	-0.13***	-0.15***	-0.07***	-0.14***	-0.15***
Median (Risk-adjusted ROE)	4.3	3.7	2.2	2.0	2.8	2.6
	Marginal impact on the Z-score					
Linear model	-0.08	-0.81***	0.18	-0.28	-0.88***	-0.53**
Nonlinear model[1/]						
0 quarter	-1.39***	-4.09***	-2.79*	-3.59***	-3.84***	-3.90***
4 quarters	-0.84**	-2.77***	-1.65*	-2.25***	-2.65***	-2.57***
8 quarters	-0.30*	-1.45***	-0.51	-0.92***	-1.46***	-1.24***
Median (Z-score)	29.3	37.7	24.8	22.1	26.7	24.4

Sources: Bloomberg, Datastream, Haver, WEO, Worldscope, and authors' estimates.

Note: Table show the estimated marginal impact of the duration of monetary policy easing on the asset-to-equity ratio, and the risk-adjusted ROE, and the Z-score. It is as $\partial Y/\partial D = \alpha^{US} \cdot Y^{med}$ for linear models and $\partial Y/\partial D = (\alpha_1^{US} + 2\,\alpha_2^{US} \cdot D) \cdot Y^{med}$ for nonlinear models. The duration is the consecutive quarters with a decline in the moving average of two-year bond yields. Estimation is conducted by industry, using non-U.S. sample. Standard errors are calculated by Driscoll and Kraay (1998) standard errors, which is robust to heteroscedasticity and cross-sectional as well as temporal dependence. Stars indicate significance at 1 percent (***), 5 percent (**), and 10 percent (*).

1/ For nonlinear models, the marginal impact of additional one quarter of monetary policy easing depends on the current duration. The table shows the marginal impact for the specified current duration.

VI. Conclusions

While decisive and persistent monetary policy accommodation was necessary to support aggregate demand in advanced economies during and after the financial crisis, there is lingering concern about the side effects of low interest rates and central bank balance sheet expansion on risk-taking behavior in the financial sector. In this paper, we investigate the extent to which financial vulnerabilities build up at the firm level during extended periods of monetary policy easing at home and in the U.S.

Based on a data for roughly 1,000 bank and nonbank financial institutions—including insurance companies, investment banks and asset managers—in 22 countries over the past 15 years, we find significant evidence of increased risk-taking behavior. Domestic banks and nonbanks alike increase their leverage ratios in response to persistent monetary policy accommodation at home. In addition, prolonged Federal Reserve policy easing leads banks and nonbanks outside the U.S. to take on more risks, with an effect similar to equivalent domestic monetary policies.

These results are robust to alternative measures of financial vulnerability, controls, and specifications. Importantly, the relationship between persistent monetary policy easing and financial firm vulnerability appears to be non-linear, with risk-taking behavior rising most quickly at the onset of policy easing.

Our findings ideally will spur research in two directions. First, further work is needed to develop benchmarks for risk-taking behavior. While we document an increase in risks taken by financial institutions, we are unable to take a position on whether such increases in risk are worrisome or excessive. Some degree of change in risk-taking is an inherent part of the monetary policy transmission mechanisms. To some extent, if prudential policies and regulations inhibit financial institutions from taking more risk in response to monetary policy easing, the expansionary effect of monetary policy on the real economy may be diminished.

Second, our results should inform the ongoing debate on using monetary policy tightening for financial stability purposes (see IMF, 2015, for instance). Costs of doing so would arise from lower employment and output in the short to medium run, feeding back to higher defaults and funding costs, thus reducing financial stability. But benefits need further exploration. The emphasis so far has been on the link between policy rates and credit growth, and in turn between credit growth and financial stability (Svensson, 2015). However, this paper suggests that the link could also go through the leverage of financial sector firms.

But even without further work, our results have several policy implications. Countries should closely monitor financial sector risks during periods of monetary policy accommodation at home, and in the U.S. They should develop solid prudential and regulatory frameworks, so as to preserve room for monetary policy to manoeuver to achieve its inflation and output objectives. Such frameworks should apply to both banks and nonbanks.

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APPENDIX I. DATA AND DEFINITIONS OF VARIABLES

This appendix descibes our data set, discusses why it is suitable for our study, and lists data sources.

Panel data set on finanical firms

The analysis is conducted using a panel data set of publicly listed financial firms in 22 countries from 1998 Q1 to 2014 Q4. It covers the whole financial sector based on Global Industry Classification Standard, which are further classified into six industries: banks, insurance companies, investment banks, asset managers, and other financials. Our sample countries consist of 19 advanced economies (Austria, Australia, Belgium, Canada, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Republic of Korea, Spain, Sweden, Switzerland, the United Kingdom, and the U.S.) and three emerging market economies (Brazil, Mexico, and South Africa).

Our firm-level financial data come from the Worldscope (Thomson Reuters), which harmonizes definitions for cross-country analysis. It is important to use such harmonized data because accounting presentations and terminologies differ across countries. Firm-level data are merged with country-level macroeconomic indicators. The firm-country unbalanced panel data set covers a total of 1,039 listed financial firms available in the Worldscope. In our sample, there are 38,883 firm-quarter observations based on 994 firms whose indicators of financial vulnerabilities are available. Appendix Tables 1 and 2 summarize data sources and definitions for each variable.

The novelty of our firm-level panel data set is that it covers both the banking and the nonbank financial sector. Including all financial industries allows us to conduct a comprehensive analysis to examine potentially different effects of monetary policy on different industries. In addition, the data set provides ample variations across firms and countries, which enable us to identify the effect of the duration of monetary policy easing on vulnerability of financial institutions.

Appendix Table 1. Definitions and Sources

Variable	Description	Source
Firm-level variables		
Leverage ratio	The "market" asset-to-equity ratio calculated as the sum of total liabilities and market capitalization divided by market capitalization.	Computed
Risk-adjusted return on equity	The returns on equity divided by its standard deviation over the past 8 quarters (t-7 to t).	Computed
Total liability	All short and long term obligations expected to be satisfied by the company (Field 03351).	Worldscope
Market capitalization	The share price multiplied by the number of ordinary shares in issue (Field MV).	Datastream
Returns on equity	Net income divided by total equity (Field 08301).	Worldscope
Country-level macroeconomic variables		
Real GDP growth	The year-on-year percent change of the real GDP.	WEO
Growth of stock price index	The year-on-year percent change of the natural log of the main stock indicator. The main stock indicator in each country is listed in Table 9.	Datastream
Volatility index	Estimated time-varying volatility of the main stock indicator using a GARCH(1,1). The main stock indicator in each country is listed in Table 9.	Datastream
Sovereign bond rating	Moody's Local Currency Long-Term Debt Rating. The values from 1 to 22 are assigned to the rating category so that a higher value indicates a better rating (e.g., 22 indicates "AAA").	Bloomberg
Three-month yields	The three-month government bond yields. For countries where three-month government bonds are not available, three-month interbank rate is used.	Bloomberg, Datastream, Haver
Inflation	The year-on-year percent change of the Consumer Price Index (CPI).	Haver
Output gap	The output gap estimates provided by Oxford economics.	Datastream
Macroprudential policy index	The number of macroprudential measures used out of the total of 12 macroprudential measures.	Cerutti et al. (2015)

Source: Authors.

Appendix Table 2. Main Stock Indicators

Country	Main Stock Indicator	Field	Source
Austria	ATX—Austrian Traded Index	ATXINDX	Datastream
Australia	Standard and Poor's / Australian Stock Exchange 300	ASX300I	Datastream
Belgium	Belgium 20	BGBEL20	Datastream
Brazil	Brazil Bovespa	BRBOVES	Datastream
Canada	Standard and Poor's / Toronto Stock Exchange 60 Index	TTOSP60	Datastream
Switzerland	Swiss Market (SMI)	SWISSMI	Datastream
Germany	DAX 30	DAXINDX	Datastream
Spain	IBEX 35	IBEX35I	Datastream
Finland	OMX Helsinki 25 (OMXH25)	HEX25IN	Datastream
France	France CAC 40	FRCAC40	Datastream
United Kingdom	FTSE 100	FTSE100	Datastream
Greece	FTSE / Athex Large Capital	FTASE20	Datastream
Ireland	Iseq 20	ISECP20	Datastream
Italy	FTSE MIB Index	FTSEMIB	Datastream
Japan	TOPIX	TOKYOSE	Datastream
Korea, Republic of	Korea Stock Exchange Composite (KOSPI)	KORCOMP	Datastream
Mexico	Mexico IPC (Bolsa)	MXIPC35	Datastream
Netherlands	AEX Index (AEX)	AMSTEOE	Datastream
Portugal	PSI-20	POPSI20	Datastream
Sweden	OMX Stockholm 30 (OMXS30)	SWEDOMX	Datastream
U.S.	Standard and Poor's 500 Composite	S&PCOMP	Datastream
South Africa	FTSE / JSE Top 40	JSEAL40	Datastream

Source: Authors.

Measures of monetary policy stance

In measuring the duration of monetary policy easing and tightening, we consider the number of consecutive quarters with a decline in the eight quarter moving average of interest rates, as discussed in Section 2.1 (see Appendix Table 3 for definitions and sources of interest rates). By considering the moving average, we avoid falsely associated easing with temporary fluctuations in the interest rates. Results are robust to the use of the moving averages over the past one year and the past three years.

Appendix Table 3. Indicators of Monetary Policy

Variable	Description	Source
Interest rates		
Nominal short rate	The overnight interbank interest rate.	Haver
Real short rate	The ex-post real short rate, defined as the difference between the nominal short rate and the realized CPI inflation rate.	Computed
Two-year yields	The two-year government bond yields.	Bloomberg, Datastream
10-year yields	The 10-year government bond yields.	Bloomberg, Datastream

Source: Authors.