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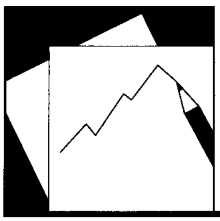

IMF Working Paper

Credit Matters: Empirical Evidence on U.S. Macro-Financial Linkages

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Credit Matters: Empirical Evidence on U.S. Macro-Financial Linkages

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Abstract

This paper develops a framework for analyzing macro-financial linkages in the United States. We estimate the effects of a negative shock to banks' capital/asset ratio on lending standards, which in turn affect consumer credit, mortgages, and corporate loans, and the corresponding components of private spending (consumption, residential investment and business investment). In addition, our empirical model allows for feedback from spending and income to bank capital adequacy and credit. Hence, we trace the full credit cycle. An exogenous fall in the bank capital/asset ratio by one percentage point reduces real GDP by some 1½ percent through its effects on credit availability, while an exogenous fall in demand of 1 percent of GDP is gradually magnified to around 2 percent through financial feedback effects.

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I. INTRODUCTION

For any analyst of the global economy, the million-dollar question is: how deep and protracted will the current U.S. economic downturn be? One of the main determinants will be how balance sheet deterioration for banks and other leveraged lenders affects credit and spending. A particular concern is the possibility of an adverse feedback loop from economic activity to the financial system, with second-round effects on the macroeconomy through reduced credit availability. U.S. policy-makers are aware of this potential feedback, as indicated for example by the minutes of the March 18, 2008, meeting of the Federal Open Market Committee of the Federal Reserve:

"Evidence that an adverse feedback loop was under way, in which a restriction in credit availability prompts a deterioration in the economic outlook that, in turn, spurs additional tightening in credit conditions, was discussed. Several participants noted that the problems of declining asset values, credit losses, and strained financial market conditions could be quite persistent, restraining credit availability and thus economic activity for a time and having the potential subsequently to delay and damp economic recovery."

This paper develops a practical framework for policy analysis of macro-financial linkages. The purpose is to complement the IMF staff's Financial Conditions Index, which uses vector autoregressions to examine the interaction of financial and macroeconomic conditions (Swiston, 2008). In contrast to the reduced-form approach used in that work, this paper examines the individual linkages using more structural methods. To our knowledge, this is the first paper to fully trace out these linkages for different components of private spending, although earlier papers have studied parts of the chain.

More specifically, we estimate the effects of a negative financial shock on consumption and investment through credit availability in the United States. We start the process by assuming an exogenous negative shock to the bank capital/asset ratio (CAR), for example from a rise in bank loan losses. In response, banks tighten their lending standards, which reduces credit availability. A credit tightening causes spending to fall, both directly through credit constraints and indirectly through the effects of an economic slowdown on balance sheets of banks, households, and firms. The linkages are described in more detail in Section II.

All else equal, we find that a one-percentage-point reduction in the CAR causes a fall in overall credit of some 2½ percent of GDP, and a reduction in the level of GDP by around 1½ percent. We can also use the model to see how demand shocks are amplified through macro-financial linkages. An exogenous one-percent decline in demand is gradually magnified and reduces GDP by around 2 percent.

It is interesting to compare our estimate of the effect of a financial shock with the findings of other recent studies. In general, while different assumptions regarding the initial shock makes direct comparisons difficult, our quantitative results are similar to other estimates. Lown and Morgan (2006) find that a 16 percent increase in the net fraction tightening in the Fed's senior loan officer's survey (similar to the impact from our CAR shock) causes GDP to decline by 1 percent, while Swiston and others (2008) find that a tightening in loan standards of 20 percentage points lowers GDP by around 1¼ percent in a paper that includes a wide

range of other financial variables. The Spring 2008 IMF *Global Financial Stability Report* uses a vector autoregression (VAR) model to investigate the effect of aggregate credit on growth. The variables included are real GDP growth, inflation, private borrowing and the prime loan rate. There is a significant effect of lower credit growth on GDP. Quantitatively, a reduction of credit growth from the U.S. post-war average of 9 percent to 4 percent ("credit squeeze") or 1 percent ("credit crunch") reduces year-on-year GDP growth by 0.8–1.4 percentage points. Finally, Greenlaw and others (2008) estimate (i) the losses by U.S. financial institutions due to their exposure to mortgage securities, (ii) the credit contraction from the resulting deleveraging and (iii) the effects on GDP growth. The authors find that a 3 percentage-point decrease in credit growth causes a decline in GDP growth of 1.3 percentage points over the coming year.

Thus there exists recent empirical evidence that financial shocks have real effects. But from a theoretical point of view, why should credit matter in the first place? After all, in a Modigliani-Miller world with perfect information and no credit constraints, real decisions are made independently of financial factors. Spending is determined by intertemporal optimization given preferences and technology. However, in the presence of financial frictions and information imperfections, the availability of financing is also an important consideration for consumption and investment decisions. There is an extensive theoretical literature which has shown that alternative ways to model imperfect information between borrowers and lenders (moral hazard, adverse selection or costly state verification) have similar implications for the importance of credit.[2] External financing is more expensive than internal financing, and credit rationing can occur. The effects are especially large when balance sheet positions are weak. In sum, according to theories of imperfect information, financial factors such as credit availability have real economic effects.

Much of the previous empirical literature on the effects of credit aims to distinguish between different transmission mechanisms, such as the balance sheet channel, the bank lending channel and the bank capital channel. Since these different channels have similar predictions for aggregate quantities, many empirical studies use micro-level data from banks and/or firms rather than aggregate data.[3]

In contrast, the focus of this paper is on calculating the quantitative importance of credit at a macroeconomic level. Therefore, we use aggregate data across different types of lending—consumer, mortgage, and corporate credit—to study the determinants and aggregate importance of credit availability, without necessarily distinguishing between specific transmission channels. Our approach to estimating the effect of credit on spending is similar in spirit to, but more comprehensive than, that of Bacchetta and Gerlach (1997) and Ludvigson (1998), who study the effects of predictable changes in credit on consumption. In turn, these papers are inspired by a Campbell and Mankiw (1990) paper on consumer

[2] For a survey, see Gertler (1988), and for a financial-accelerator model, see Bernanke, Gertler, and Gilchrist (1999).

[3] See e.g. Oliner and Rudebusch (1996) (balance sheet channel vs. bank lending channel) and van den Heuvel (2007a) (bank capital channel vs. bank lending channel).

liquidity constraints, which tests for effects of predictable changes in income on consumption.

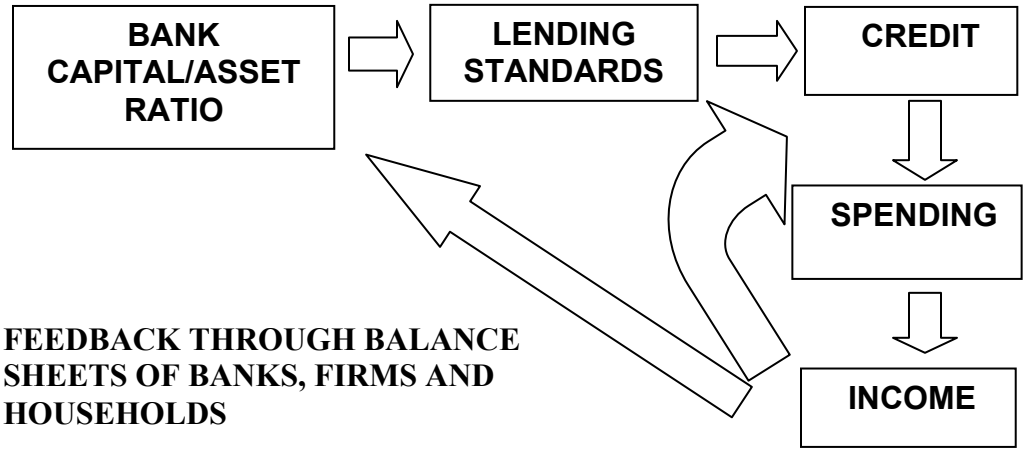
While the previous papers study only the effect of credit on consumption, we widen the types of spending analyzed to include consumption, residential investment, and business investment. In addition, our approach is more holistic, since we also study the links from bank capital adequacy through lending standards (survey measures of credit availability) to credit and spending, and allow for feedback effects from spending and income back to the credit market. Another related paper by Lown and Morgan (2006) uses vector autoregression (VAR) methodology to study the effect of lending standards on bank loans and output. Our paper uses less reduced-form methods, includes also non-bank loans, and studies separately all the main components of private spending, while Lown and Morgan only examine inventories and aggregate GDP.

The rest of this paper is organized as follows. Section II outlines our analytical framework for macro-financial linkages. The subsequent three sections present empirical estimates of the links in the chain from the bank capital-asset ratio to spending. We estimate the effects of capital adequacy on lending standards (Section III), lending standards on credit (Section IV) and credit on spending (Section V). Then we estimate how spending affects income (Section VI) and finally the feedback from income to banks' capital position (Section VII). In Section VIII we present the "bottom line", i.e. our quantitative estimates of how macro-financial linkages affect the propagation of financial and macroeconomic shocks. Section IX concludes.

II. A FRAMEWORK FOR ANALYZING MACRO-FINANCIAL LINKAGES

Figure 1 below presents a simple graphical framework for thinking about macro-financial linkages. Each link in the chain is described in more detail in the corresponding section of the paper, so what follows is just a brief outline of the structure of the paper and a summary of the links. We start with a negative exogenous shock to bank capital, which causes the Capital/Asset Ratio (CAR) to decline. Of course, the underlying motivation is subprime-related losses. Then we use our framework to trace out the macroeconomic effects, taking macro-financial feedback channels into account.

Figure 1. A Framework for Macro-Financial Linkages



The first link is from the CAR to lending standards. Capital requirements on banks are imposed by regulators and/or market discipline, so a negative shock constrains the capacity for lending. Thus banks are induced to tighten their lending standards in order to reduce the quantity of credit and restore the CAR. Lending standards are non-price loan terms, which reflect credit availability. We use the standard measure of lending standards used in the literature, which is based on answers from the quarterly Federal Reserve survey of bank loan officers.

A tightening of loan standards causes a decrease in the quantity of credit, as shown in the second link. We investigate separately the impact on consumer credit, mortgage credit and business credit. In the estimation, we also include other variables which affect credit, such as income and interest rates.

A key link in the chain goes from credit to spending. The credit data is from the Flow of Funds and the income data from the National Income and Product Accounts, so we integrate information from several different sources. When credit availability falls, there is a direct effect on spending due to credit constraints. For each of the credit categories, we estimate the effect of credit on the corresponding measure of spending (consumption, residential investment, and business fixed and inventory investment, respectively). A positive correlation between credit and spending does not necessarily reflect causality from credit to spending. Instead, it could be due to reverse causality from spending to credit. If households and firms choose to borrow in order to finance their spending, then the variables will move together even in the absence of credit constraints. To avoid an upward bias in the estimated effect of credit on spending due to reverse causality, we use instrumental variables with lagged variables as instruments.

Changes in spending cause changes in income through standard multiplier effects. For each of our different measures of income (personal disposable income, GDP and business profits), we estimate how income is affected when spending changes. We also allow for an impact of spending on home equity.

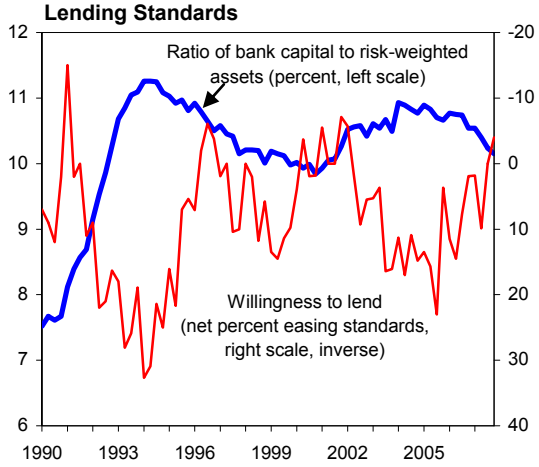
The final link is the feedback loop from income through balance sheets of banks, firms and households. The feedback takes place through two different channels. The first channel works through the effect of an economic slowdown on bank balance sheets. As spending and income fall, loan losses gradually increase and the CAR deteriorates further. In Figure 1, this channel is represented by the arrow from INCOME to BANK CAPITAL/ASSET RATIO. The second feedback channel is due to deterioration of incomes and balance sheets for households and firms, which has a further adverse financial-accelerator effect on credit availability. In Figure 1, this channel is represented by the arrow from INCOME to CREDIT. Taking these feedback mechanisms into account, the final effect of a CAR shock on aggregate economic activity is larger than the direct effect. Eventually, as bank credit declines the capital/asset ratio starts to improve. Bank deleveraging causes a decrease in the denominator of the capital/asset ratio, which increases the ratio.

III. The Effect of the Bank Capital /Asset Ratio on Lending Standards

The first link is from the bank Capital/Asset Ratio (CAR) to lending standards. While the interest rate is the price of a loan, standards reflect non-price terms associated with a loan, such as collateral requirements and loan limits.[4] It is useful to think of standards as measuring credit supply given borrower characteristics. As a proxy for bank lending standards, we use answers from the Federal Reserve's quarterly Senior Loan Officer Opinion Survey on Bank Lending Practices. Following the previous literature we define the tightness of lending standards as the percent of respondents reporting a tightening of standards minus the percent of respondents reporting an easing of standards.

Capital adequacy is the main determinant of banks' lending capacity. In Figure 2 we can see a clear negative relationship between changes in the CAR and standards. During periods when the capital/asset ratio is increasing, standards are typically negative, which means that there is a net easing of standards. It seems that the effect occurs with a lag. Conversely, when the CAR has been falling, as in the second half of the 1990's and in the recent past, there has been a subsequent net tightening of standards.

Figure 2. Bank Capital Adequacy and Lending Standards



Sources: Federal Deposit Insurance Corporation; and Haver Analytics.

A negative shock to the capital/asset ratio constrains the capacity for lending and forces banks to tighten lending standards in order to restore their capital adequacy. By reducing both assets (loans) and liabilities (short-term debt), banks can increase their capital/asset ratio. Another way for banks to increase the (risk-based) CAR is to substitute safe securities for riskier loans. Van den Heuvel (2007b) develops a model where a combination of (i) risk-based capital adequacy requirements and (ii) an imperfect market for bank equity causes a bank capital channel of monetary policy. More generally, the model implies that capital adequacy affects banks' willingness to lend.[5]

There is also empirical evidence that loan standards depend on bank balance sheets. In a recent paper using VAR methods and aggregate data, Lown and Morgan (2006) find that a negative shock to the CAR causes a tightening of standards. The peak effect occurs after 1–2 years after the initial shock. Other empirical studies use micro-level data and find evidence that differences in capital positions across banks causes differences in the response

[4] See Lown and Morgan (2006) for a discussion of the meaning and measurement of standards.

[5] The bank capital channel differs from the bank lending channel studied in earlier literature (see e.g. Bernanke and Blinder (1988)). Bernanke (2007) argues that the traditional bank lending channel is currently unlikely to be quantitatively important in the United States (because of financial deregulation), but that financial intermediaries are still important for the transmission of shocks, in particular through the bank capital channel.

to shocks. Kishan and Opiela (2000) and van den Heuvel (2007a) use U.S. bank-level panel data and find that the lending of less-capitalized banks reacts more strongly to monetary policy shocks. Peek and Rosengren (1995) study a cross-section of banks in New England during the 1990-1991 recession. They find evidence in favor of a "capital crunch"; in response to a negative capital shock, less-capitalized banks shrink their balance sheets to a larger extent than more-capitalized banks.

Other factors beyond capital adequacy may have an effect on loan standards. Gorton and He (forthcoming) develop a theoretical model where asymmetric information between competing banks cause lending standards to change over time. In empirical tests they find that relative bank performance affects subsequent credit card and C&I (Commercial and Industrial) lending. Another recent paper by Dell'Ariccia, Igan, and Laeven (2008) finds empirical evidence that increased competition and securitization caused an easing of lending standards in the US subprime mortgage market. Nevertheless, banks' balance sheet position is a key factor driving loan standards, which has also been shown in the literature. For example, Lown and Morgan (2006) find that loan standards are affected by the CAR, but not by GDP. Therefore we use a simple specification with the lagged change in the CAR as the only explanatory variable. However, in Section VII of the paper we introduce feedback from the aggregate economy to capital adequacy, which allows for an *indirect* effect of GDP on standards through capital adequacy.

We use an aggregate bank capital/asset ratio from the Federal Deposit Insurance Corporation. The definition of CAR is Tier 1 bank capital divided by risk-weighted assets. In the Federal Reserve survey of bank lending standards, loan officers are asked how their standards have changed over the past three months. There are separate questions for different types of loans (mortgages etc). For mortgage credit we use survey responses for residential mortgage loans, and for business credit we use the average of small-firm and large-firm responses for C&I (Commercial and Industrial) loans. The survey answers for consumer loans are reported as the net percent of respondents more willing to make loans. We change the sign of this variable so that an increase means that banks are less willing to make loans, i.e. a tightening of credit. Finally, the series are seasonally adjusted using the X12-ARIMA method.

For all three loan standards, we regress standards on the lagged four-quarter change in the bank capital/asset ratio. The Federal Reserve survey asks about changes in loan standards over the past three months, so the standards variable is already expressed in differences, which is why we use the change in the CAR. A lagged dependent variable is included to capture dynamic effects.

The specification used is:

$$\text{LOAN STANDARDS} = \alpha + \beta * \Delta(\text{BANK CAPITAL/ASSET RATIO})$$

$$+ \gamma * (\text{LAGGED LOAN STANDARDS}) + \varepsilon$$

Table 1: The Bank Capital/Asset Ratio and Loan Standards

	Consumer loan standards (t)	Mortgage loan standards (t)	Business loan standards (t)
CAR (t-1) - CAR (t-5)	-4.73 ***	-2.37 **	-3.99 ***
	(0.77)	(1.16)	(1.44)
Loan standards (t-1)	0.67 ***	0.80 ***	0.87 ***
	(0.06)	(0.10)	(0.07)
Adjusted R-squared	0.67	0.63	0.81

Source: IMF staff calculations.
Sample period: 1991q2 – 2007q3. Standard errors in parentheses (adjusted for heteroscedasticity and autocorrelation). ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

The parsimonious specification works well and the coefficient on capital adequacy is always negative and highly significant. Quantitatively, the estimates imply relatively similar short-run and long-run effects of a one-percentage-point reduction in the CAR across loan categories. In the short run, a percentage-point decrease in the capital ratio causes the balance of responses on loan standards to tighten by 2–5 percentage points. Taking into account the lagged dependent variable, the long-run effect is a tightening of our measure of standards by 10-30 percentage points.

In order to get a better sense for the size of a one-percentage-point CAR shock, it is useful to compare it with the standard deviation of CAR (0.72). Thus the assumed shock is somewhat larger than a typical change in CAR. Note also that we assume a permanent rather than a temporary shock.

The estimates confirm the expected negative relationship between the CAR and loan standards. In the next step, we investigate the effect of loan standards on credit.

IV. The effect of Lending Standards and Balance Sheets on Credit

There already exists some empirical evidence on the effect of lending standards on credit. The papers by Lown and Morgan (2006) and Lown, Morgan and Rohatgi (2000) find that a tightening of standards causes the quantity of bank credit to decline. However, while only bank lending is covered by the Federal Reserve loan officer survey, there are reasons to believe that the banks' responses contain some information about more general credit availability. The lending capacity of banks and other, non-bank credit providers (e.g. insurance companies, finance companies and pension funds) is likely to be positively correlated.

This hypothesis has received some support in the literature. Friedman (1991) discusses the generalized fall in credit during the credit crunch in 1990, and he advocates the supply interpretation: "the credit crunch of 1990 resulted from the impact on bank balance sheets of the credit excesses of the 1980s, and just as banks were not alone in participating in those excesses, they are not alone in suffering the consequences. The same problems that have

impaired some banks' capital have also shrunk the "surpluses" of insurance companies, have caused profitability problems for finance companies, and have led to the collapse of the junk-bond market." More recently, Bernanke (2007) argues that banks and non-banks are subject to similar forces in the sense that they all have to raise external funds in order to lend, and that their cost of external funds depends on balance-sheet variables such as net worth, liquidity and leverage.

Since non-bank lenders are likely to behave in a similar way as banks, we use broader measures of credit than only bank credit. More precisely, we use consumer credit, home mortgages, and nonfinancial corporation's credit market instruments.[6] For example, consumer credit is provided also by finance companies, and credit market instruments include commercial paper and corporate bonds. A specification with only bank credit works well (results are reported in Appendix I), but the quantitative impact of a change in loan standards on credit is underestimated. Since bank and non-bank credit move in the same direction following a change in loan standards, bank credit changes by less than total credit. Results for the impact of only bank credit on spending (not reported for the sake of brevity but available on request) find that this underestimation of the impact on credit also leads to a smaller effect on spending. Therefore, for macroeconomic analysis it is important to use a wider definition of credit.

In addition to loan standards, we include income and home equity as explanatory variables in order to allow for effects of borrower balance sheet conditions on credit provision. Loan standards reflect credit availability given borrower characteristics, while balance sheet variables have additional effects on credit availability because of changes in borrower characteristics.

We use Flow of Funds data on credit flows and balance sheet stocks for various sectors in the U.S. economy. Since the we measure have of loan standards is for the change over the last three months, the credit variables are defined using changes in the flow of credit. Income is defined as personal disposable income in the consumer credit equation, home equity for mortgage lending, and business profits in the business credit equation. To reduce potential heteroscedasticity problems and to facilitate the interpretation of coefficients, we divide changes in credit and income by lagged GDP and multiply by 100, so that changes are expressed as a percent of GDP. We use a long-term real interest rate for mortgage credit and a short-term rate for the other two sectors.[7] As in the previous section the loan standards variables are defined so that an increase means further tightening of credit conditions. As the changes in flow of funds variables appear to exhibit significant negative serial correlation, we include an MA(1) term in the error (for credit to firm's the estimated coefficient on the

[6] In the Flow of Funds, the variables "consumer credit" and "home mortgages" are taken from Table F.100 (lines 41 and 40, respectively), and the variable "credit market instruments" is taken from Table F.102 (line 39).

[7] The long-term rate is the 10-year Treasury note minus the 10-year ahead average expected inflation, and the short-term rate is the 3-month LIBOR minus the 1-year ahead expected inflation. The main source of inflation expectations is the Philadelphia Fed's Survey of Professional Forecasters (before 1991Q4 the sources are the Livingston Survey, also from the Philadelphia Fed, and the Blue Chip survey).

MA(1) error was unreasonably large, so we substituted an AR(1) error). Given that we use a specification in changes, it is not surprising that the R-squared's are relatively low.

The general specification is thus:

$$\Delta(\text{CREDIT})/GDP_{-1} = \alpha + \beta(L)*\Delta(\text{INCOME})/GDP_{-1} + \gamma(L)*(\text{LOAN STANDARDS})$$

$$+ \theta(L)*\Delta(\text{INTEREST RATE}) + \varepsilon + \tau\,\varepsilon_{-1}$$

Table 2: Loan Standards, Balance Sheet Variables, and Credit

	Change in credit at time (t)		
	Consumer	Mortgage	Business
Change in income 1/	0.19 **	0.23 ***	0.62
	(0.09)	(0.15)	(0.53)
Loan standards (t) 2/	-0.011 ***	-0.006	-0.013 **
	(0.003)	(0.007)	(0.006)
Change in interest rate (t-1)	-0.07	-0.71 ***	-0.04
	(0.07)	(0.25)	(0.21)
MA(1) term 3/	-0.57 ***	-0.59 ***	-0.39 ***
	(0.13)	(0.15)	(0.08)
Adjusted R-squared	0.31	0.29	0.18

Source: IMF staff calculations.
Sample period: 1990q4 – 2007q2/q3. See Table 1 for additional notes.
1/ At time (t-1) for consumer and mortgage credit, and time (t-2) for business credit.
2/ The first lead of standards is used in the mortgage credit regression.
3/ Business credit uses AR(1) term instead of MA(1) term.

The main result is that a tightening of loan standards causes the quantity of credit to decline. The effect is significant at the 1 percent level for consumer credit and at the 5 percent level for business credit. The estimated effect of standards on mortgage credit is somewhat smaller and not statistically significant. Mortgage loan standards did not tighten in the 2001 recession and there is little movement in the series during most of the sample period, which makes it difficult to find any significant effects.

For all three credit categories, the estimated effect of standards on credit is relatively similar. A one-percentage-point tightening of standards causes each separate measure of credit to fall by around 0.01 percent of GDP in the same quarter as the tightening is reported. However, a typical change in standards is much larger than one percentage point. The standard deviation of standards is in the range 9-18 depending on credit category. A larger tightening of 30 percentage points, which is similar to what we have seen in the recent past, would cause the flow of credit in each of the three categories to decline contemporaneously by around 0.25 percent of GDP, or around $35 billion in current dollar terms. For comparison, the flow

of consumer, mortgage and business credit in the last quarter of 2007 was around 85, 430 and 640 billion dollars, respectively.[8] The estimated direct effects are thus large in relative terms, especially for consumer loans. The coefficient on lagged income is positive for both consumer and business credit, but only significant (at the 5 percent level) for consumer credit. Home equity has a positive impact on mortgage credit (significant at the 1 percent level).

V. The Effect of Credit on Spending

One possible way to test for financial frictions/credit constraints is to investigate if income or cash flow has an effect on spending after controlling for fundamental determinants of spending according to benchmark theories without any frictions or constraints. Early examples of this approach are the papers by Campbell and Mankiw (1990) (for consumption) and Fazzari, Hubbard and Petersen (1988) (for investment). Campbell and Mankiw test the permanent-income hypothesis by estimating the effect of predictable changes in income on consumption. According to the permanent-income hypothesis, only unpredictable changes in income should affect consumption, so the theory predicts a coefficient of zero. In fact, the effect is found to be positive, indicating that at least some consumers are credit constrained.

Similarly, a seminal paper by Fazzari, Hubbard and Petersen (1988) tests the neoclassical theory of investment by including cash flow in a regression of investment on Tobin's Q. According to neoclassical theory, only fundamentals (in their approach, Tobins's Q) should matter for investment, and financial factors such as cash flow should be irrelevant. However, cash flow often has a positive and significant effect on investment, even when controlling for fundamentals. Hence for both consumption and investment there exists evidence that the availability of financing matters for spending. Recent evidence is provided by Dynan, Elmendorf and Sichel (2006) who investigate changes over time in the responsiveness of consumption and investment to income, interest rates and cash flow.

However, the purpose of this section is not to show that "credit matters" by demonstrating that income or cash flow affects spending. Instead, the aim is to estimate the quantitative effect of credit on spending, which is an important link in our chain of macro-financial linkages. For our purposes, a more useful empirical strategy is the one developed by Bacchetta and Gerlach (1997) and Ludvigson (1998). These authors study the effects of predictable changes in credit on consumption. The approach is closely related to and inspired by the Campbell and Mankiw (1990) paper which tests for effects of predictable changes in income on consumption. We apply the method to study the effects of credit on both consumption and investment.

The econometric method used is two-stage least squares. The following brief description of the Campbell-Mankiw model illustrates why OLS is not appropriate. A fraction of total income is earned by "rule-of-thumb" consumers who consume their current income rather than their permanent income. It follows that consumption can be written as

[8] All credit flows are expressed in annual terms.

$$\Delta C_t = \mu + \lambda * \Delta Y_t + (1-\lambda)\varepsilon_t \qquad (1)$$

where the parameter λ is the fraction of income earned by rule-of-thumb consumers and the shock ε_t is the innovation between time t-1 and t in agents' forecast of permanent income. The innovation is orthogonal to any variable known at time t-1. However, the change in income ΔY_t, and the permanent-income revision ε_t, are likely to be positively correlated. Such a correlation between the error term and an explanatory variable causes OLS estimates to be biased and inconsistent. The natural solution is to use instrumental-variable methods, using lagged variables (such as income and consumption) as instruments.[9]

More generally, in a regression of current spending on current income, there is an endogeneity problem, since spending affects income (reverse causality). For example, consumption and investment (spending) clearly affect GDP (income). There is a similar endogeneity issue in a regression of current spending on current credit. If spending is financed by credit, but without any credit constraints, then the variables will have a positive correlation even if the causality runs from spending to credit rather than from credit to spending. By using lagged variables as instruments for current income and credit, it is possible to solve the endogeneity issue.

Greenlaw et al (2008) also use an IV approach to study the effect of credit on spending. There are two main differences between their approach and ours. First, they study aggregate credit and aggregate GDP, while we use more disaggregated measures of credit and spending, which allows us get more accurate estimates. Second, in their first-stage regression of credit on lagged variables, they include variables associated with credit supply (e.g. loan standards) as instruments, but they exclude income. The idea is to identify movements in credit which are caused by credit supply. We use a broader set of instruments, including in particular lagged income, in the first-stage regression, and we also include income in the second-stage regression of spending on credit and other variables. The motivation is that if income has an effect on credit through its impact on the balance sheets of households and firms, it is important to include income both as an instrument and in the spending equation. Otherwise, the estimates do not capture financial-accelerator effects, which are likely to be important for macro-financial linkages.

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[9] There is a minor technical problem when estimating the model for consumption. If the Permanent Income Hypothesis holds in continuous time, then measured consumption is a (quarterly) time average of a random walk and follows an MA(1) process even under the null hypothesis that the PIH is true. Campbell and Mankiw solve the problem by lagging instruments at least twice. A disadvantage of this procedure is that it throws away the best instruments, i.e. variables lagged only once. We use an alternative method proposed by Carroll, Fuhrer and Wilcox (1994), who include an MA(1) error term, $v_t + \theta v_{t-1}$, in the estimation. Then variables dated t-1 are valid instruments, since they are uncorrelated with v_t.

Table 3: The Effect of Credit on Spending
(Two-stage least squares regressions)

	Change in spending at time (t)			
	Consumption	Residential investment	Business fixed investment	Inventory accumulation
Change in income (t) 1/	0.004	0.09 ***	...	0.68 ***
	(0.10)	(0.03)		(0.25)
Change in income (t-1) 1/	...	...	0.12 *	0.41 ***
			(0.06)	(0.10)
Q ratio (t-1)	...	...	0.10	...
			(0.05) **	
Change in credit (t) 2/	0.64 ***	...	0.12 ***	0.05 **
	(0.15)		(0.04)	(0.02)
Change in credit (t-1) 2/	0.26 **	0.02 ***	0.09 ***	...
	(0.11)	(0.01)	(0.02)	
Change in credit (t-2) 2/	...	...	0.08 ***	...
			(0.02)	
Change in credit (t-3) 2/	...	...	0.04 **	...
			(0.02)	
Change in credit (t-4) 2/	...	...	0.01	...
			(0.02)	
Change in spending (t-1)	...	0.72 ***	0.23 **	-0.31 ***
		(0.05)	(0.11)	(0.09)
MA(1) term	0.04	...	...	...
	(0.13)			
Adjusted R-squared	0.08	0.65	0.29	0.05

Source: IMF staff calculations.

Sample period: 1983q1 – 2007q3. See Table 1 for additional notes.

Instruments in consumption regression: lags one to four of change in personal disposable income, change in consumer credit, change in mortgage credit, change in interest rate, and change in consumption; current and lags one to four of loan standards; and lagged consumption-income ratio.

Instruments in residential investment regression: lags one to four of changes in GDP, mortgage credit, residential investment, and population of home-buying age; current and lags one to four of loan standards; and lagged Q ratio.

Instruments in business investment regression: lags one to four of change in profits, change in business credit, and change in business investment; current and lags one to four of loan standards; and lagged Q ratio.

Instruments in inventory accumulation regression: lags one to four of change in profits, change in business credit, and change in inventory accumulation; and current and lags one to four of loan standards.

1/ Income is defined as personal disposable income, GDP, and profits, respectively.
2/ Credit is defined as consumer, mortgage, and business credit, respectively.

Changes in spending are defined as quarterly changes divided by lagged GDP, i.e. in the same way as changes in income and credit are defined. To increase the number of observations, we start the sample in 1983. This choice restricts the availability of data on loan standards for some categories of credit. Following Greenlaw et al (2008) we use standards for consumer loans as a proxy instrument for general credit availability. The correlation between consumer and other loan standards is high (0.63 for business loans and 0.46 for mortgage loans). In the equation for business investment, we include a proxy for Tobin's Q ratio to control for fundamental determinants of investment. The Q ratio is defined as the market value of equities divided by net worth (for nonfarm nonfinancial corporate business). In table 3 we report our two-stage least squares regression results.

The general specification is:

$$\Delta(\text{SPENDING})/GDP_{-1} = \alpha + \beta(L)*\Delta(\text{INCOME})/GDP_{-1} + \gamma(L)*\Delta(\text{CREDIT})/GDP_{-1}$$
$$+ \theta(L)*\Delta(\text{SPENDING})/GDP_{-1} + \varphi(L)*(\text{OTHER FUNDAMENTALS}) + \varepsilon + \tau\,\varepsilon_{-1}$$

For all three components of spending (consumption, residential investment and business investment) we find a positive and significant effect of credit on spending. Most credit coefficients are significant at the 1% level. In quantitative terms, the effect of credit is particularly rapid and strong for consumption. An increase in consumer credit of 1 dollar causes spending to increase by 64 cents contemporaneously and an additional 26 cents—for a total of 90 cents—after one quarter. It is interesting to note that credit seems to be a more important direct determinant of spending than income (recall, however, that credit is itself a function of income). As a further check on the robustness of our specification, we estimate the equations using subcomponents of consumption, reported in Appendix II. As expected, the impact of consumer credit on spending is largest for durable goods and smallest for services (large parts of which are imputed, such as owner occupied housing) with aggregate effects similar to those from total consumption.

For business investment, the effects are smaller and more delayed, but they are still substantial. The effect of a one-dollar increase in business credit is to raise investment by 12 cents contemporaneously and almost 50 cents in the long run. The impact of mortgage credit on residential investment is quantitatively much smaller. After one quarter only 2 cents of a one-dollar increase in mortgage credit is reflected in higher residential investment, rising to around 10 cents in the longer run. Mortgage loans are generally made to finance purchases of old, existing houses or after the construction of new houses, so the absence of substantial effects of loans on housing investment is not surprising.

For each type of spending, we also estimate equations which allow for asymmetric effects of positive and negative changes in credit, but without finding any significant asymmetries. To the extent that credit constraints bite more in downturns that upturns, it appears to occur through the impact of banks on credit, not the impact of credit on spending.

VI. THE EFFECT OF SPENDING ON INCOME

When private spending changes, there are multiplier effects on income. A given increase in spending causes an equivalent increase in income, part of which further increases spending and so on. To estimate these multiplier effects, we run OLS regressions of income on components of spending and a lagged dependent variable. Similarly, increases in spending have positive effects on house prices and hence on home equity, so we also regress home equity on spending.

It should be noted that our empirical specifications are very simple. The purpose of this section is to provide rough estimates of the links from spending to income rather than to carry out an in-depth study of multiplier effects.[10] The results are reported in Table 4 below.

The general specification is:

$$\Delta(\text{INCOME})/GDP_{-1} = \alpha + \beta*\Delta(\text{SPENDING})/GDP_{-1} + \gamma(L)*\Delta(\text{INCOME})/GDP_{-1} + \varepsilon$$

Table 4: The Effect of Spending on Income

	Change in income at time (t)			
	Personal disposable income	GDP	Profits	Home equity
Change in consumption	0.44 *	0.97 ***	0.10	0.05
	(0.24)	(0.09)	(0.10)	(0.30)
Change in residential investment	0.36	0.65 ***	0.39 **	0.66
	(0.38)	(0.16)	(0.20)	(0.53)
Change in business fixed investment	0.81 ***	0.87 ***	0.005	-0.03
	(0.29)	(0.13)	(0.15)	(0.31)
Change in rate of inventory accumulation	0.40 **	0.91 ***	0.13 *	0.04
	(0.18)	(0.09)	(0.07)	(0.27)
Lagged dependent variable	-0.31 **	-0.09 *	-0.15	0.54 ***
	(0.13)	(0.05)	(0.11)	(0.08)
Adjusted R-squared	0.19	0.80	0.07	0.29

Source: IMF staff calculations.
Sample period: 1983q1 – 2007q3. See Table 1 for additional notes.

In almost all cases the estimated coefficients are positive, and in many cases they are highly significant. Since the variables are scaled by lagged GDP, the coefficients should be

[10] One potential concern is endogeneity problems. We tried other specifications with lagged explanatory variables or instrumental variables, but the estimated coefficients were often economically unreasonable (e.g. negatively signed).

interpreted in the same way as in the previous section. For example, in the regression of personal disposable income on spending, the coefficient 0.44 on consumption means that if consumption increases by 1 dollar, then personal disposable income increases by 44 cents.

VII. Feedback Loop through Balance Sheets of Banks, Firms and Households

In Sections III-VI we estimated the effects of a bank capital adequacy shock on spending and income through its impact on lending standards and credit. Now we allow for feedback from spending and income through the balance sheets of banks, firms and households. Taking these feedback channels into account, the final effect of a bank capital shock on aggregate economic activity is larger than the direct effect.

There are two distinct and mutually reinforcing feedback channels. The first channel is that as spending and income fall, loan losses increase and thus there are further negative effects on bank capital in addition to the initial negative bank capital shock. We model this feedback from the real economy to bank balance sheets by regressing the capital adequacy ratio on changes in lagged GDP growth. This specification is a simplification in the sense that GDP does not have any *direct* causal effect on CAR. There is only an *indirect* effect through increased loan losses. In Table 5 below we present estimates of the feedback from GDP growth to bank capital. A one-percent decrease in GDP growth is estimated to be associated with loan losses which decrease the capital ratio by around ½ percentage point.

The empirical specification is:

$$\text{BANK CAPITAL/ASSET RATIO} = \alpha + \beta(L)*\Delta(\text{GDP})/GDP_{-1} + \varepsilon$$

Table 5: Feedback Effects of GDP Growth on Bank Capital

	Bank Capital-Asset Ratio (t)
Change in GDP (t-1)	0.54 *
Adjusted R-squared	0.08

Source: IMF staff calculations.
Sample period: 1990q1 – 2007q3. See Table 1 for additional notes.

The second feedback channel is that a deterioration of incomes and balance sheets for households and firms has a further negative financial-accelerator effect on credit and spending. In the regressions in Section IV we allowed credit to be affected not only by loan standards, but also by lagged income and home equity. When calculating the feedback from a real economic slowdown to the credit market, we take the model's predicted decreases in income and home equity, and allow them to have further negative effects on credit. There is also a direct impact of lower incomes on spending, estimated in Section V. Hence there is no need for any further estimation in order to capture these feedback effects. It is sufficient to

allow the model's predicted fall in income to have second-round effects on credit and spending according to our previous estimates.

In addition to the two feedback channels from income to the CAR and credit, there is another mechanism which eventually reverses the adverse macro-financial cycle. All else equal, the gradual decline in bank credit improves the capital/asset ratio by shrinking the asset side of bank balance sheets (deleveraging), possibly supported by recapitalization. We attempted to estimate the empirical size of this effect directly, but with poor results possibly reflecting the impact of the cycle on risk-adjusted assets.

Instead, we impose a realistic impact of credit on the CAR, based on the regressions reported in Appendix 1 for the impact of tightening standards on bank's provision of consumer credit, mortgages, and corporate loans. The ratio of the coefficient on bank loans to overall loans allows us to calculate the reduction in bank assets implied by lower overall lending. For consumer loans, this is around one-half. Assuming that bank capital is $1100 billion and bank assets $11000 billion, which gives a realistic CAR of 10%, we can then calculate the impact of lower assets on the CAR. For example, a $200 billion reduction in overall consumer credit implies a $100 billion decline in the flow of bank credit; i.e. a reduction in assets to $10900. The new CAR would be 1100/10900 or around 10.1%. One caveat to this calculation is that the CAR is risk-adjusted, so the boost to bank capital may be overestimated. On the other hand, no allowance is made for active recapitalization through issuing additional equity. Overall, we regard our model as a reasonable estimate of the support to CAR from reductions in loans.

VIII. Bottom Line: Quantitative Importance of Macro-Financial Linkages

Having developed and estimated a model of macro-financial linkages, we can now study the model's implications for the quantitative effects of financial or macroeconomic shocks.

Our first experiment is to study the effects of a financial shock. Given a hypothetical one-percentage-point decrease in the bank capital/asset ratio, what is the effect on GDP, taking into account macro-financial feedback effects? We assume that the capital/asset ratio falls exogenously by one percentage point. Then we use our estimated links between the variables to investigate the dynamic response of the economy, allowing for macro-financial feedback. There is a gradual slowdown of economic activity as lending standards tighten over time. As a result, the CAR declines by more than the initial shock. The negative effect on GDP grows gradually over time, peaking at 1.4 percent of GDP three years after the initial CAR shock and two years after the maximum impact on bank lending standards. Figure 3 below presents the results within our graphical framework, Figures 4 and 5 present responses of the level and annualized growth rate of GDP and its components (the impact on growth peaks at ¾ percent just over a year after the initial CAR shock).

There are some interesting results when looking at the sub-components of spending. It is clear that changes in consumption and business fixed investment are the main factors behind the impact on GDP. Also, consumption responds more rapidly than business fixed investment. This is to be expected, given the longer planning horizons involved in investment decisions. The response of residential investment is very minor, which is not surprising given

the small estimated effects of mortgage credit, and the contribution of inventory investment is only somewhat larger.

Figure 3. The Effects of an Adverse Bank Capital Shock

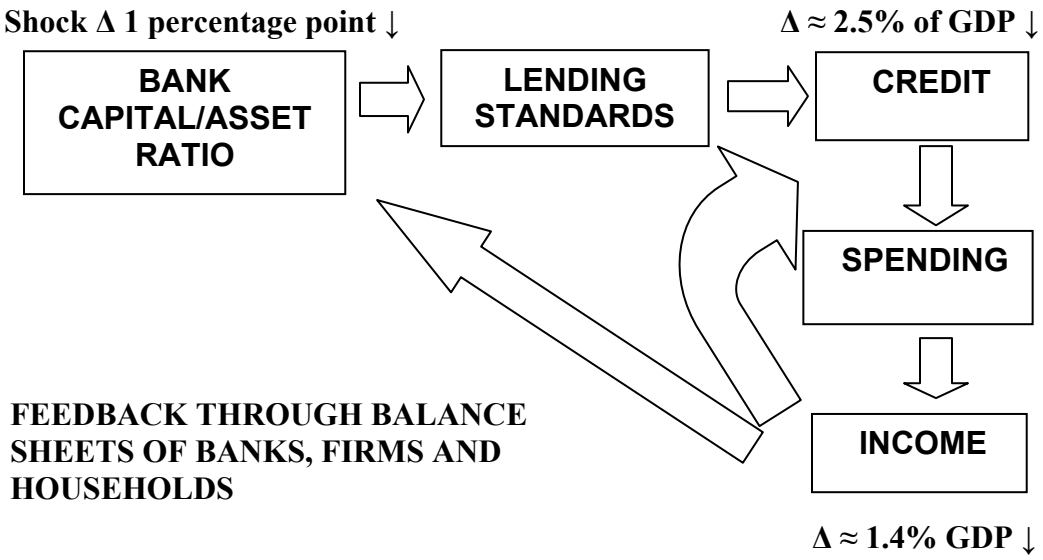


Figure 4. The Impact of an Adverse Capital Shock on the Level of GDP and its Components

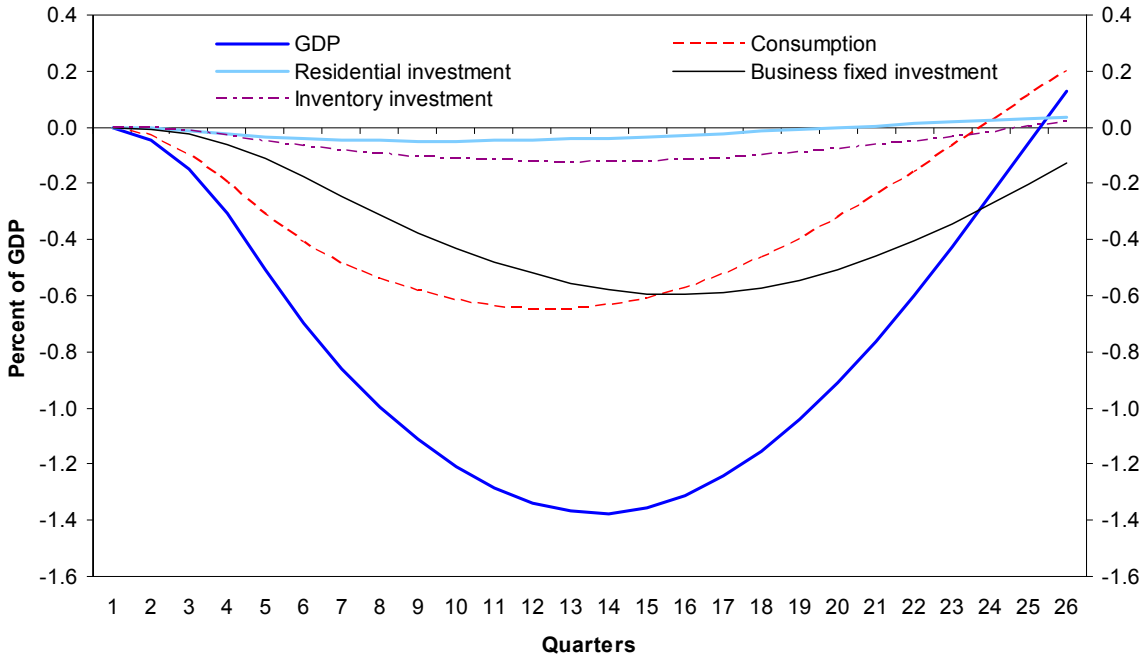
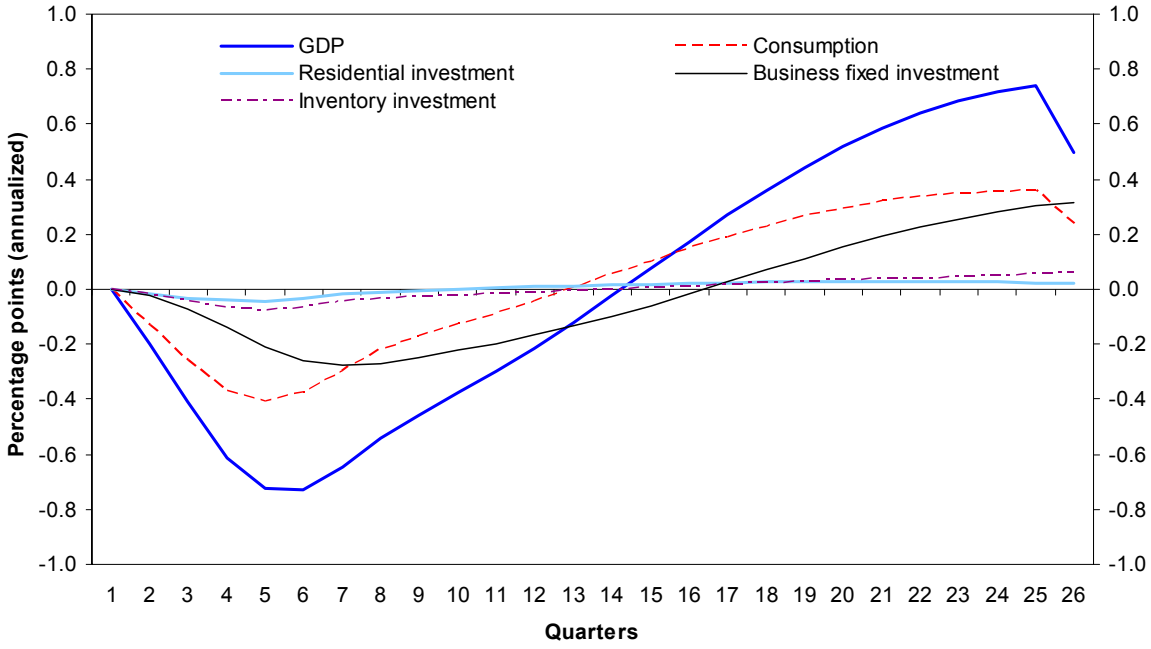


Figure 5. The Impact of an Adverse Capital Shock on GDP Growth and the Contribution of GDP Components



Another interesting experiment is to study the effects of a macroeconomic shock. We investigate how a real demand shock is propagated and amplified through the model's macro-financial linkages. The hypothetical negative demand shock is an exogenous decline in consumption and investment of 1 percent of GDP (in total). A weaker macroeconomic environment causes the CAR to decline, which causes a tightening of credit and makes GDP fall by more than the initial shock. Unsurprisingly, the response to a macroeconomic shock has similar time lags and dynamics for sub-components of spending as a financial shock. The additional impact on the level of GDP gradually grows to 1.2 percent after three years. Thus the initial demand shock is approximately doubled through macro-financial linkages. These results are summarized in Figures 6 and 7 below. Similar overall patterns are evident when (possibly more realistic) temporary shocks to spending are used.

Figure 6. The Effects of an Adverse Demand Shock

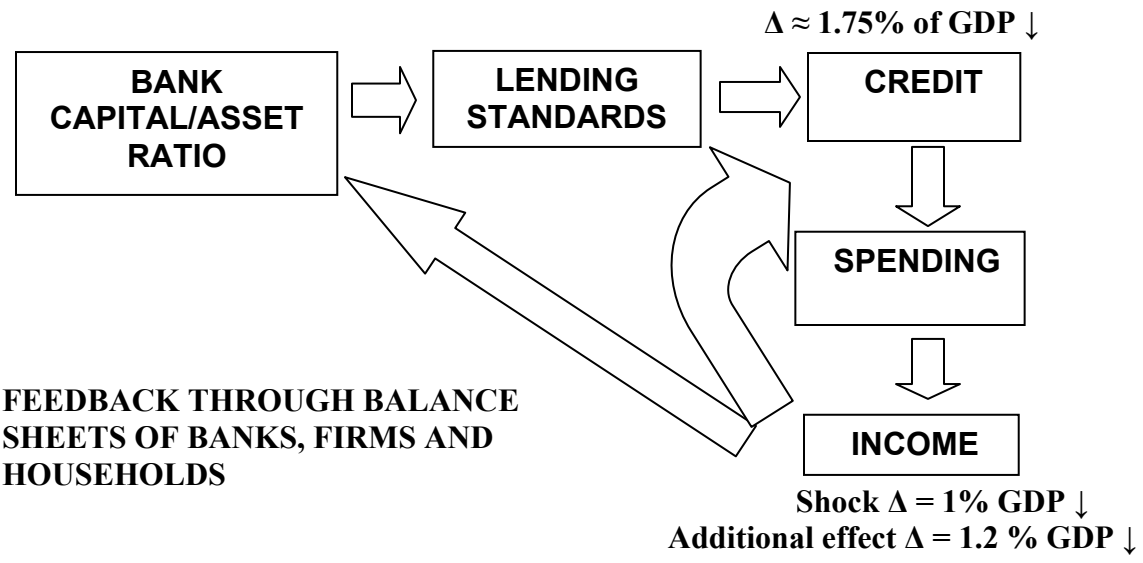
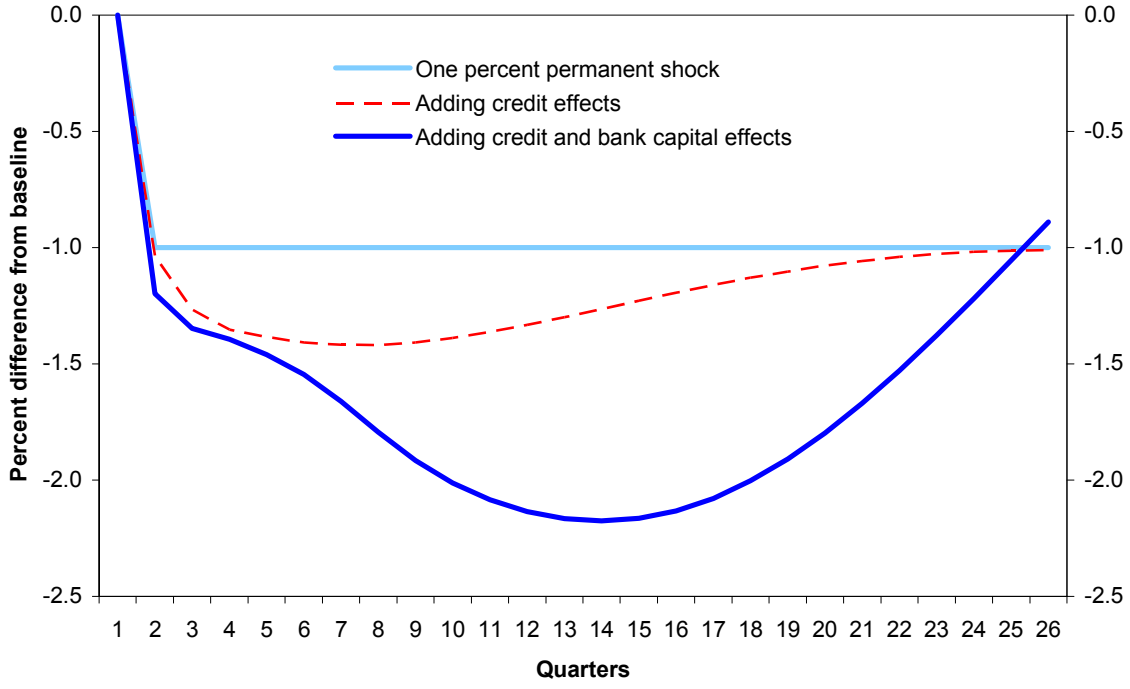


Figure 7. The Impact of an Adverse Demand Shock on the Level of GDP



We also investigate the effect of a demand shock in a restricted version of the model where the link from GDP to the CAR is cut off, so that the only macro-financial link is the traditional financial accelerator channel through credit constraints. The additional impact on

GDP is reduced to 0.5 percent, compared with 1.2 percent in the full model. This result implies that CAR effects and financial accelerator effects have approximately the same quantitative importance. A striking difference in the restricted model is that the peak effect on GDP occurs much sooner than in the full model (after 6 rather than 13 quarters). Thus the link from GDP to the CAR both deepens and lengthens the economy's response to shocks.

Naturally, all of these quantitative predictions of the estimated model have wide confidence intervals, due to potential model misspecification and uncertain parameter estimates and the simplifications necessary to obtain a tractable model. In particular, the following two caveats apply.

First, the model does not fully capture the likely dynamics of banks' adjustment to a deterioration of credit quality. Our empirical specifications in Section III assume that lending standard contractions occur only after capital losses are visible on bank balance sheets, which is a simplification, since banks are likely to tighten lending standards already in anticipation of capital losses.

Second, we do not directly model any monetary or fiscal policy response even to a substantial negative financial shock.

IX. CONCLUSIONS

This paper studies U.S. macro-financial linkages in a clear empirical framework which allows for feedback effects from the real economy to the credit market. The policy purpose is to investigate the likely effects of a negative shock to bank capital on the macroeconomy. Each separate link could be studied in more detail, using a larger number of explanatory variables and more sophisticated econometric techniques. Yet the main results are similar to what other studies have found using alternative (but not necessarily more sophisticated) methods. In particular, the estimated effect of an adverse credit market shock is similar to results using a Financial Conditions Index developed by the IMF staff.

The key findings are that (i) banks' balance sheet conditions have substantial effects on credit availability, (ii) credit conditions significantly affect real spending decisions of consumers and firms, and (iii) there are important feedback effects from the real economy to the credit market, which amplifies and prolongs the response to shocks.

By necessity the empirical estimates are based on historical patterns in the data. But the specific circumstances in each financial crisis are different, and it is possible that the current downturn may be more or less severe than implied by previous experience. For example, a significant increase in mortgage defaults due to widespread negative equity positions could potentially have larger effects than predicted by empirical models. On the other hand, banks appear to have recognized losses and recapitalized rapidly.

The topic of macro-financial linkages clearly needs to be studied further. One possible approach for future research would be to apply the methodology used in a paper by Hartelius, Kashiwase and Kodres (2008). They study the impact of changes in the sovereign credit

rating outlook on emerging market bond spreads. Similar methods could be used to study the impact of changes in the bank credit rating outlook on bank financing costs.

Future research could also investigate possible changes over time in the importance of macro-financial linkages. The increased credit securitization may have changed the links from banks' balance sheets to credit availability, as well as the sensitivity of private spending to changes in different components of credit.

APPENDIX I

CREDIT REGRESSIONS FOR BANK LENDING

Our measures of consumer, mortgage, and corporate sector credit include a significant share of financing from non-bank lenders. In this Appendix, we report the results for regressions using only bank credit. As expected, the impact of loan standards on bank credit is important but significantly smaller than overall credit. Hence, focusing only on bank loans would underestimate the shock to credit available to households and firms.

Table 6: Loan Standards, Balance Sheet Variables, and Bank Credit

	Change in credit from banks at time (t)		
	Consumer	Mortgage	Business
Change in income 1/	0.11 **	0.03	0.44 **
	(0.05)	(0.04)	(0.20)
Loan standards (t) 2/	-0.005 **	-0.004	-0.005 *
	(0.002)	(0.005)	(0.002)
Change in interest rate (t-1)	-0.08	0.03	-0.03
	(0.05)	(0.17)	(0.09)
MA(1) term 3/	-0.68 ***	-1.18 ***	-0.33 ***
	(0.09)	(0.27)	(0.09)
Adjusted R-squared	0.29	0.63	0.16

Source: IMF staff calculations.
Sample period: 1990q4 – 2007q2/q3. See Table 1 for additional notes.
1/ At time (t-1) for consumer and mortgage credit, and time (t-2) for business credit.
2/ The first lead of standards is used in the mortgage credit regression.
3/ Business credit uses AR(1) term instead of MA(1) term.

APPENDIX II

SPENDING REGRESSIONS FOR SUB-COMPONENTS OF CONSUMPTION

For the various sub-components of consumption, we find significant effects in most cases. As expected, the impact of consumer credit on the consumption of durable goods is large and significant. For non-durable goods the effect is smaller but still significant, and for services the impact is not significant. One reason for the insignificant impact on services could be that many services are not paid directly by the consumer, and are thus not subject to credit constraints. In particular, owner-occupied housing and health care paid for by insurance companies are two large components of services consumption.

Table 7: The Effect of Credit on Personal Consumption Expenditure
(Two-stage least squares regressions)

	Change in spending at time (t)		
	Durable goods	Nondurable goods	Services
Change in income (t)	-0.02	0.04	-0.06 *
	(0.06)	(0.03)	(0.04)
Change in credit (t)	0.32 ***	0.12 **	0.06
	(0.09)	(0.05)	(0.06)
Change in credit (t-1)	0.10 *	0.03	0.06
	(0.06)	(0.04)	(0.05)
MA(1) term	-0.19	-0.11	0.33 ***
	(0.12)	(0.14)	(0.09)
Adjusted R-squared	0.07	0.10	-0.02

Source: IMF staff calculations.

Sample period: 1983q1 – 2007q3. See Table 1 for additional notes.

Instruments in consumption regression: lags one to four of change in personal disposable income, change in consumer credit, change in mortgage credit, change in interest rate, and change in dependent variable; current and lags one to four of loan standards; and lagged consumption-income ratio.

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