The effects of bank capital on lending: What do we know? And, what does it mean?*

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Abstract

The size of the effect of bank capital on the extension of bank credit has, from the financial-to-real linkage perspective, been one of the most critical questions of the financial crisis. This paper uses a number of different methods to gauge the size of this effect. We use panel-regression techniques—following Bernanke and Lown (1991) and Hancock and Wilcox (1993,1994)—to study the lending of large banks and find small effects of BHC capital-to-asset ratios on lending. We then consider the effects of capital ratios on lending using macroeconomic time-series and aggregate commercial bank balance-sheet data in a variant of Lown and Morgan's (2006) VAR model. Again, we find modest effects of bank capital ratio changes on lending. These results are in marked contrast to estimates obtained using scatter plots of aggregate commercial-bank assets and leverage growth, which have been quite influential over the recent crisis in shaping forecasters' and policymakers' views on the size of the effects of bank capital on loan growth. Our estimated models are then used to understand recent developments in bank lending and, in particular, to consider the role of TARP-capital injections in shaping these developments.

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The size of the effect of changes in bank capital on the extension of bank credit has, from the financial-to-real linkage perspective, been one of the most important questions of the current financial crisis. For example, very early in the crisis—when the question of whether a credit crunch would obtain was still an issue for debate—the size of the effect of bank capital on bank credit was central to any consideration of how losses in banks' subprime or other mortgage-related portfolios would impact lending and thereby economic activity. Likewise, about a year later, when the Troubled Asset Relief Program (TARP) became primarily one of injecting capital into banks via the Capital Purchase Program (CPP), the size of the effect of increases in bank capital on the extension of bank credit was again central to any consideration of how the CPP would likely bolster bank lending and economic activity.

Economic theory gives a very wide range of possible values for the size of the impact of a change in bank capital on bank assets and thereby its lending. Representing one extreme is the possibility that a decline in bank capital, which results from a capital loss, can be accommodated without any change in bank assets—and therefore any change in bank lending—likely because the bank is well capitalized both before and after the loss and because the capital loss can be offset by alternative sources of funding. Thus a \$1 reduction in capital results in no reduction in bank assets or bank lending. Another alternative is the possibility that banks very actively manage their assets in order to maintain a constant bank capital-to-assets ratio (henceforth bank-capital ratio) since they are very limited in their ability to raise equity to offset declines in capital. In this case, a bank's only option for maintaining a constant bank capital ratio is to reduce its asset levels, whereby the amount by which its asset levels must decrease is equal to the size of its capital loss scaled up by the inverse of the bank's capital ratio—that is, its leverage ratio. Since bank capital ratios are on the order of about 0.08 to (for convenience) 0.125, leverage ratios are on the order of 8 (= 1/0.125) to 12.5 (= 1/0.08). This means that a \$1 reduction in capital results in a \$8 to \$12.5 reduction in bank assets.[1] Clearly, therefore, the size, rather than just the sign, of the effect of changes in bank capital on bank credit is an empirical question.

Despite the importance in the current financial crisis of the size of the effect of bank capital on credit, few recent estimates for this effect exist. Indeed, rather than using parameter estimates obtained via regression analysis, several recent considerations of this issue appear to be largely informed by a striking scatter plot for aggregate commercial-bank asset and leverage growth reported in a paper (not actually about this question) by Adrian and Shin (2007).[2] This scatter

[1]Procyclical leverage, in which bank balance sheet size and leverage move together over the business cycle, represents another possibility. In this case the reduction in bank assets associated with a \$1 reduction in capital would generate a greater than \$8 to \$12.5 reduction in bank assets.

[2]To be clear, the focus of Adrian and Shin (2007) is not at all about the effects of bank capital ratios on loan growth. Rather, their paper presents the scatter plots reported in Figure 1 of this paper as part of a set of motivating facts before moving on to consider the foundations of procyclical leverage among securities brokers and dealers (shown

plot for commercial banks is shown in the lower left panel Figure 1 along with scatter plots for all of the other institutions that they consider; specifically, households, non-financial, non-farm corporates, and security brokers and dealers. The sample period used in Figure 1, 1963 to 2006, is the same as that employed by Adrian and Shin.[3] These charts give the strong impression—especially, when compared to other classes of institutions—that commercial banks actively manage their assets to maintain constant leverage. This implies that changes in bank capital have magnified effects—about equal to the size of the leverage ratio—on asset- and thereby lending-volumes.

The conclusion drawn from Adrian and Shin's scatter plots for commercial banks appear to have been quite influential over the crisis and associated recession in shaping forecasters' and policymakers' views on the size of the effect of bank capital changes on loan growth. For example, Hatzius (2007) in a mid-November Goldman Sachs U.S. Daily note, written fairly early in the crisis, used these commercial-bank scatter plots as the basis of his estimates of the impact on loan volumes of banks' losses in their subprime or other mortgage-related portfolios. Subsequently, in a Brookings paper on the same issue, Hatzius (2008)—while allowing for some offset in the effect of bank losses on loans via the ability of banks to raise capital—appealed to asset/leverage growth scatter plots to inform his revised estimates of the effect bank capital losses on loans. Finally and more recently, it appears—although it has not been explicitly stated—that such scatter-plot results have also had a strong influence on U.S. Department of Treasury estimates of the effect of bank capital injections made under the TARP on bank loan growth. For example, in testimony, when discussing the likely effects on lending of capital injections and anticipated capital raising at SCAP financial, U.S. Treasury Secretary, Timothy Geithner, stated that $1 invested in capital generates between $8 to $12 of lending capacity. Although not stated, these predicted magnitudes appear very consistent with a constant leverage view of lending.[4]

Focusing on scatter plots—like those reported in Figure 1—would represent a valid way to

in the lower right panel) through collateratized borrowing and value-at-risk lending practices.

[3]The series used to generate the reported cross plots in Figure 1 are as follows: In the top left panel, the growth rate of the household sector's total assets (series FL152000005.Q in the Flow of Funds Accounts) and the growth rate of the households sector's leverage ratio (measured as the ratio of total assets—series FL152000005.Q—divided by household equity, that is total assets—series FL152000005.Q—less total liabilities—series FL154190005.Q); in the top right panel, the growth rate of the non-financial, non-farm corporate sector's total assets (series FL102000005.Q) and the growth rate of non-financial, non-farm corporate sector's leverage ratio (total assets—series FL10200005.Q—divided by non-financial, non-farm corporate equity—series FL102000005.Q less series FL104190005.Q); in the bottom left panel, the growth rate of the commercial banking sector's total financial assets (series FL764090005.Q) and the growth rate of commercial banking sector's overall leverage ratio (total financial assets—series FL764090005.Q—divided by commercial bank equity—series FL764090005.Q less FL764190005.Q); and in the bottom right panel, growth rate of security brokers and dealers total financial assets (series FL664090005.Q) and the growth rate of security brokers and dealers overall leverage ratio (total financial assets—series FL664090005.Q—divided by brokers and dealers equity—series FL664090005.Q less series FL664190005.Q).

[4]See, Treasury Department Press Release (TG-95) "Treasury Secretary Timothy Geithner, Opening Remarks As Prepared for Delivery to the Congressional Oversight Panel," April 21, 2009 for the quoted lending capacity estimates.

consider the effect of changes in bank capital on assets (and lending) growth, were close to the entirety of the fluctuations in these variables stemmed from bank capital-ratio shocks. However, were bank capital-ratio shocks to represent a fairly modest source of fluctuations in these variables, scatter plots would be fairly uninformative. Scatter plots, moreover, provide no indication as to the relative contributions of the different types of shocks underlying the correlations they display. Regression analysis, by contrast, does allow us to pin down more precisely the effects of changes in bank capital on assets (and lending) growth and so this is the approach pursued in this paper.

The tendency of the recent literature to rely on scatter plots to consider the effects of bank capital on loan growth rather than regression analysis is somewhat ironic given the existence of a very active literature from the early 1990s that addressed precisely this question. In particular, in the early- to mid-1990s, when the U.S. economy was growing fairly sluggishly out of the 1990-91 recession, a highly debated area of research was on the question of whether newly introduced bank-capital regulations, associated with the adoption of Basel I, were inhibiting bank-lending activity and thereby acting as a headwind on the economic recovery. Although this debate did not yield a decisive answer on whether a bank-capital induced credit crunch was hindering the recovery, it did result in the development of empirical models that expressly addressed the question that again confronts forecasters and policymakers; specifically, the size of the effect of bank capital on bank lending. Hancock and Wilcox (1993, 1994), for example, in a pair of papers that documented support for a bank-capital induced credit crunch in the early 1990s (specifically over 1991), developed and estimated models that related changes in the loan growth of individual banks to measures of loan demand and bank shortfalls/surpluses in actual relative to (modeled) target level. Likewise, Berger and Udell (1994) specified an equation relating the growth rate of individual banks' various asset-side balance-sheet variables to differently defined capital ratios and argued against the presence of an early 1990s bank-capital headwind. Rather, they suggested that the decline in bank credit between 1990 and 1991 was the result of asset reallocations from loans and to securities, encouraged by the implementation of risk-based capital requirements associated with Basel I. Another paper from this era to argue against the restraining influence of bank capital on lending was that of Bernanke and Lown (1991) who using equations linking bank loan growth to bank capital ratios and employment (all at the state level) found bank capital ratios to be a less notable influence on bank loan growth than economic activity. That said their analysis was based on data ending in the first quarter of 1991, which is before when even the proponents of the credit-crunch view would argue it was occurring in its strongest form.[5]

[5]Peek and Rosengren (1995) is another notable paper in this literature, which, using data for New England, found, like Hancock and Wilcox (1993, 1994), support for the existence of a early 1990s capital-induced credit crunch. In contrast to the above-mentioned papers, however, Peek and Rosengren approached the question from the liabilities side of banks' balance sheets and as a result their modeling specification does not lend itself as directly as the other papers to studying the effect of bank capital on loan growth.

Clearly, the models developed in this early- to mid-1990s literature could be applied to more recent data so as to estimate the effects of bank capital on loan growth that now obtain and thereby address policy and economic-outlook questions of critical importance. To our knowledge, however—with the exception of Francis and Osborne (2009), who use the Hancock and Wilcox (1993, 1994) approach to study U.K. commercial banks—these models have not been applied to inform the current debate. The first part of this paper fills this gap by performing exactly this exercise, using large bank holding company (BHC) balance-sheet data and some macroeconomic variables as controls, which we discuss in section two. We consider variants of two of the models and approaches developed in the early 1990s literature; specifically, the model developed by Hancock and Wilcox (1993, 1994) and the model developed by Bernanke and Lown (1990). These are both presented in section three. In brief, these models, which use BHC level data in panel regressions, find relatively small effects of BHC capital on loan growth but find more important effects of aggregate demand and increased bank risk perception. The main difference between these two approaches—at least in terms of how they are implemented in this paper—is that whereas the Bernanke-Lown approach considers the effect of actual BHC capital-to-asset ratios on BHC loan growth, the Hancock-Wilcox approach considers the effect of shortfalls/surpluses in BHC capital (relative to target). Both approaches have merits, shortcomings, and potential vulnerabilities—which we will discuss in presenting the results of these models—but the fact that they both find such small effects of BHC capital on loan growth is striking, especially in light of how sharply this finding conflicts with the impression drawn from the scatter plots of Figure 1.

A potential concern that is present in both sets of panel results is that since they both only include banks that were in operation at the end of our sample period (specifically, 2008:Q3), they could entail a survivor bias that results in these estimates understating the effect of bank capital on loan growth. Pursuing a more aggregative approach (which we do in section four) is one way to address this issue. Specifically, we consider the effects of bank capital ratios on loan growth using macroeconomic time series and aggregate commercial bank balance-sheet data in a modified variant of one of the extended versions of Lown and Morgan's (2006) vector autoregression (VAR) model, which includes as one of its variables the bank capital ratio. This model allows us to investigate the dynamic and general equilibrium effects of an exogenous impulse in bank capital ratios on bank loan growth as well as the influence of bank capital ratios on fluctuations in bank loan volumes over the model's sample period and during specific episodes. Again, and even using this very different approach, we find relatively modest effects of bank capital-ratio changes on loan growth.

Interestingly, reconciling the regression results with the scatter plots of Adrian and Shin turns out to be very simple. While at first one might think that the explanation lies in the fact that the correlations shown in the scatter plots are underpinned by shocks other than capital-to-asset (or leverage) ratio shocks—a fact that a consideration of the other impulse response functions in the VAR model lends support to—ultimately the reason lies with differences in the sample periods used in the scatter plots of Adrian and Shin and the sample periods used in this paper's regression analysis. Due to the considerable structural change in the banking sector that occurred in the early 1990s associated with the adoption of the Basel Accord, empirical analyses of banking behavior aimed at generating estimates that can be used to inform current issues—particularly those that relate to bank capital—should not be conducted on data that dates back prior to the 1990s. Consequently, our regression analysis begins in the early 1990s. In contrast, Adrian and Shin's scatter plots—shown in Figure 1—span a much-longer period, starting in 1963.

The two left panels of Figure 2 consider scatter plots for commercial banks' asset and leverage growth over 1963:Q1 to 1989:Q4 (the top panel) and 1990:Q1 to 2008:Q3 (the bottom panel). As can be seen from these charts, the feature of the data that has lead to the view that commercial banks actively manage their assets to maintain constant leverage, is much more of an artifact of the early part of the sample and is considerably less evident in the latter (post-Basel) part, which is of greater relevance for considering current questions. Indeed in the latter part of the sample the scatter plot appears much more like a cloud of points with no obvious correlation. The two panels to the right of Figure 2 provide a different split of the sample; specifically, one that places a more equal number of observations (88 and 94 observations) in each chart. Again, the feature of the data reported by Adrian and Shin (2007) and emphasized by Hatzius (2007, 2008), is very evident in the first part of the sample and not at all evident in the second part. We would also note that there are reasons for wanting to consider splitting the data at 1985, although these owe more to data-quality issues rather than to structural developments in the U.S. economy. Specifically, call report data were less systematically collected and cleaned prior to 1985. Moreover, major changes were made to the reporting forms in early 1984 and this broke many of the existing time series, thereby making comparisons between the pre- and post-1985 periods difficult. Clearly, the scatter plots shown in the lower panels of Figure 2 make the discrepancy between the small effects of bank capital on loan growth found in the regression analysis much less surprising. Nonetheless, the fact that scatter plots provide a less clear relationship between asset and leverage growth heightens the need for alternatively derived (*e.g.* regression-based) estimates of the effects of bank capital changes on lending.

Our empirical results that suggest a modest impact of both capital shortfalls and changes in capital ratios on total loan growth, relative to the impact of other factors such as demand shocks or increased bank risk perception, have several interpretations. One is that in making lending decisions BHCs are not actively managing their assets on the basis of their capital position or the deviation of their actual capital from their desired level. We would note that this interpretation does not contradict the widely accepted view that adequate levels of bank capital are crucial to prevent institutional failure, given the risks in financial intermediation. If our results are correct, and other factors such as loan demand shocks or increased bank risk play a more important role in the explanation of BHC loan growth, they provide an explanation for the notable slowing of loan growth observed over the first three quarters of 2009: The impact of increases in the availability of loanable funds from various government provisions was more than offset by weak economic conditions that reduced loan demand, and by increased risks, as borrowers might still appear less creditworthy.

Given the widespread consensus that banks entered the most recent crisis with too little capital relative to the risks they were taking (even though by most measures they were previously viewed as well capitalized), another interpretation of our results is that existing measures of bank capital may be unable to capture the true capital positions that match the risks involved in the current state of the financial intermediation business. If this is the case then our results will naturally call into question the prevailing risk-based measures of the regulatory capital framework and will advocate for a strengthening of the risk coverage, particularly in terms of incorporating capital requirements for off-balance sheet operations, such as securitization activities and counterparty exposures.

The rest of the paper is organized as follows. We describe the data and sources used in our two approaches in Section 1. Section 2 contains the empirical results of the link between bank capital and bank loan growth at the institutional level. Section 3 discusses our results using aggregate data. Sections 4 and 5 then use the models developed in sections 2 and 3 to address some questions of practical policy interest. Specifically, in section 4 we use these models to estimate the likely impact that TARP capital injections had on bank loans and in section 5 we consider the factors underlying recent reductions in bank loan growth.[6] Finally, section 6 concludes.

1 Data

The paper employs a wide range of data sources as a result of its use of panel and time-series methods. We discuss these data sources in this section. In almost all cases, our regression analysis extends only out to 2008:Q3; though in our analysis of key policy issues we consider data to 2009:Q3.

1.1 Institution-level data

For our panel regression, which we conduct at the institution level, we use bank holding company (BHC) data rather than the loans of individual commercial banks within the BHC. This reflects the observation that many decisions for the activities of the BHC are taken for the institution as

[6]The models developed in this paper can also be used to consider the question of how proposals announced by the Basel Committee on Bank Supervision (BCBS) to raise banks' capital requirements and to limit bank leverage ratios could adversely impact economic activity and offset some of the benefits to the economy of greater financial and macroeconomic stability. We leave the application of our models to this question to future analysis.

a whole rather than on a subsidiary by subsidiary basis.[7] Institution-level data are taken from the Consolidated Financial Statements for Bank Holding Companies (FR-Y9C) over the period 1992:Q1 to 2009:Q3, with the exception of data series based on regulatory capital (which appear in some of our Bernanke-Lown type regressions), which begin only in 1996. Our sample consists of 165 large BHCs, all with total assets in excess of $3 billion as of 2008:Q3. These represent approximately 85 percent of the total assets in the banking sector.[8]

Table 1 reports the summary statistics for the variables used in the panel estimation. Although the sample is based on a panel of large BHCs, there is a large variation in the distribution of total assets. The median BHC in the sample has assets above $3 billion. However, the standard deviation of $145 billion is consistent with the fact that the four largest institutions in the sample have assets above $1 trillion, whereas total assets for the smallest ones are below $1 billion. Quarterly growth in total loans and C&I loans averages 3 percent across all BHCs and over time. The distribution of variables scaled by assets such as capital, securities and net charge-offs exhibit smaller variances. Both the mean and the median values for the equity-to-assets (leverage) ratio are about 8 percent, while the mean and median of total and tier one risk-based capital ratios (measured as total and tier one capital over risk-weighted assets) are 12-1/2 percent and 13-1/4 percent (for total) and 10-3/4 percent and 11-1/4 percent (for tier one). Finally, the Tangible Common Equity (TCE) ratio (measured as tangible common equity over tangible assets) for the mean and median BHC is about 7 percent.

The panels in the top two rows of Figure 3 depict the evolution of the average of different capital ratios over our sample. As is evident from the two panels in the top row of the figure, throughout most of the sample period, the average total and tier one risk-based capital ratio for large BHCs remained significantly above their well-capitalized regulatory minima.[9] Note, also the divergent movements across different capital-ratio measures. For example, while risk-based capital ratios have exhibited a downward trend since 2004, the capital-to-assets ratio—the middle left panel—remained until mid-2007 on an upward trend. This different behavior could partly reflect differences arising from the denominator of the capital-ratio measures which, in turn, could be associated with

[7]For evidence supporting this view see Ashcraft (2004), who documents the practice of BHCs providing assistance—sometimes in the form of capital injections—to distressed subsidiaries and Houston, James, and Marcus (1997), who report that BHC subsidiary loan growth is more sensitive to the cashflow and capital positions of the holding company than the position of the subsidiary.

[8]We exclude institutions with missing observations in total assets, loans, and capital, and also BHCs that remain in the sample for less than 30 quarters. In order to minimize the influence of extreme outliers, we remove observations with more than 50 percent growth in total assets over a single quarter and winsorize the remaining variables at the 1 percent and 99 percent levels. The final sample consists of about 11107 bank-quarter observations for 140 institutions out of the 165 BHCs.

[9]Among other criteria, a BHC is considered well-capitalized if it has a total risk-based capital ratio of at least 10 percent, and a tier-one risk-based capital ratio of at least 6 percent.

increasing risk-taking on the side of banks during the last 5 years. Excessive risk-taking behavior could have made risk-weighted assets increase faster than total assets.

As expected, the leverage ratio and the regulatory capital ratios all jump in 2008:Q4 after the implementation of the Treasury's capital injection program. (A vertical line is shown in the top four panels of Figure 3 at 2008:Q3, just before the capital injections.) However, because the Treasury injected capital through purchases of preferred stock with warrants rather than common equity, the TCE ratio—the middle-right panel—is not affected by TARP capital infusions and seems to have maintained the downward trend that it has displayed since 2003. Adverse market risk perceptions of the banking sector were more evident after the beginning of the financial crisis and this explains a deeper contraction in the average TCE ratio after the second half of 2007. This market-focused measure of capitalization reached its lowest value in 2009:Q1 due to adverse market expectations about the bank stress tests results in April 2009 (the average TCE ratio was below 6 percent, with some of the largest BHCs having ratios below 2 percent).

The lower two panels of Figure 3 plot the average four-quarter growth rate of total loans for the 165 BHCs in our sample as well as the growth rates of total and large commercial-bank loans. As seen from these panels, commercial bank and BHC loan growth slowed notably in the 2001 recession but recovered rapidly thereafter, with the average four-quarter growth rate prior to 2007 fluctuating between 10 to 15 percent. Total growth in bank loans exhibits a severe contraction starting in early 2008, with a further slowing in growth rates following the ongoing deterioration in credit conditions during 2008. Negative four-quarter growth rates were evident in the first part of 2009.

1.2 Aggregate data

Our panel regressions include a number of macroeconomic data series which we will discuss first before moving on to note those included in the VAR model; all macro data discussed in this section are reported in the panels of Figure 4. Our panel regression loan-growth equations include real GDP growth (the top-left panel), as measured by the NIPA, inflation (the top-right panel, solid line), as measured by the overall GDP deflator, the Federal funds rate (the middle-left panel), and (aggregate) net tightening of C&I lending standards (the bottom-right panel), as reported by the Federal Reserve Board's Senior Officer Opinion Survey (SLOOS). All other variables in our panel regressions are institution-level variables (discussed above).

A large fraction of the aggregate variables that are included in the paper's panel regressions are also included in the VAR model that we consider in section 3. Indeed our panel equation for loan growth has a broadly similar specification to our loan-growth equation in the VAR, albeit without the institution-specific variables that the former equation has. Our VAR model for example includes real GDP growth, which is measured as in the panel regression. Our VAR model also includes inflation, although here a slightly different measure—specifically, the GDP deflator excluding food and energy—is used (the top-right panel, dotted line). Our reason for using different inflation measures in our panel regression and VAR model is largely due to some very large swings in overall GDP prices (caused solely by energy prices) at the end of our sample. In our panel regressions, the difference between the two inflation measures has a minimal impact on our results since our estimation period stops at the third quarter of 2008, before we observe significant swings in the GDP deflator caused by changes in energy prices. In our VAR estimation, while these swings were not important for our impulse response functions, they were tending to influence (in an implausible way) the composition of estimated nonfinancial structural shocks being derived from our model over the 2008 to 2009 period, which was in turn affecting our conclusions regarding the influence of difference nonbanking shocks on economic developments.[10]

Like the panel regression, our VAR model also includes the Federal Funds rate and the net tightening in C&I lending standards from the SLOOS. Our measure of the aggregate capital-asset ratio (the bottom-left panel) is for commercial banks and is taken from the Call Reports. Finally, for loan growth (the middle-right panel) we use bank and thrift depository loan growth as reported by the Flow of Funds Accounts. Our principal motivation for using commercial bank and thrift loans in the VAR rather than just commercial bank loans—which may seem more sensible given that all other banking-sector variables pertain only to commercial banks—arises from some very sharp spikes in the latter series caused by purchases of large thrifts by commercial banks, such as Bank of America's purchase of Countrywide and JP Morgan's purchase of Washington Mutual. Using the aggregate bank and thrift data eliminates these swings and does not greatly alter the VAR's impulse response functions, although clearly it does allow a more plausible historical sequence of structural shocks estimated by the model.

2 Bank Capital and Loan Growth at the Institution Level

In this section we use BHC institution level data and panel regression techniques to study the effects of BHC capital on loan growth. Our principal approach to doing this is to model the loan growth of our panel of BHCs as functions of supply and demand factors, with one of our supply factors being BHC capital. Specifically, the loan growth regressions that we estimate are of the

[10]Specifically, when our model included the GDP deflator we were finding that the most important nonfinancial shock accounting for movements in bank and thrift loan growth over 2008 and 2009 was price shocks, which seemed somewhat counterintuitive. However, using the GDP deflator excluding food and energy eliminated this problem.

form

$$\Delta\%LOAN_{i,t} = \sum_{s=1}^{4} \alpha_s \cdot \Delta\%LOAN_{i,t-s} + \sum_{s=1}^{4} \gamma_s \cdot \Delta\%GDP_{t-s} + \sum_{s=1}^{4} \delta_s \cdot INF_{t-s}$$
$$+ \sum_{s=1}^{4} \beta_s \cdot \Delta RFF_{t-s} + \sum_{s=1}^{4} \zeta_s \cdot STD_{t-s} + \phi \cdot LIQU_{i,t-1} + \chi \cdot CHG_{i,t-1}$$
$$+ \psi \cdot \begin{cases} CAPITAL\ SURPLUS/SHORTFALL \quad or \\ CAPITAL\text{-}TO\text{-}ASSETS\ RATIO \end{cases} + \epsilon_{i,t}, \tag{1}$$

where $\Delta\%LOAN_{i,t}$ denotes the growth rate of BHC loans, $\Delta\%GDP_t$ represents real GDP growth, $\Delta\%INF_t$ is the inflation rate measured by the GDP deflator, ΔRFF_t is the change in the federal funds rate, and STD_t denotes lending standards. The bank-specific variable $LIQU_{i,t}$ denotes BHC liquidity and is measured by the ratio of securities to total assets while the bank-specific variable $CHG_{i,t}$ is the ratio of net charge-offs to total assets.

Because our loan-growth regression, equation (1), controls for the effects of other supply and demand variables, we can interpret the coefficient ψ on the equation's capital term as the effect of BHC capital conditions on loan growth. We consider two possible ways that capital can affect loan growth. In the first case—which corresponds to the approach of Hancock and Wilcox (1993, 1994)—it is the divergence between a BHC's actual and target capital, *i.e.* its capital surplus or shortfall, that is important for determining its loan growth. In the second case—which corresponds to the approach of Bernanke and Lown (1991)—it is a BHC's capital-to-assets ratio that influences its loan growth.

Clearly, while the BHC capital-to-assets ratio measures included in the Bernanke-Lown loan-growth regressions can be calculated from variables taken directly from the Consolidated Financial Statements for Bank Holding Companies (FR-Y9C), the capital measures used in the Hancock-Wilcox regressions first require the creation—for each BHC in our panel—of a timeseries of its desired/target capital level. From these timeseries, estimates of the percentage surplus/shortfall of actual capital relative to target can then be calculated. The precise method and results for this stage of the Hancock-Wilcox estimation procedure are discussed in subsection 2.1, after which, in subsection 2.2, the results from including these estimated capital surplus/shortfall measures in the loan growth equation are presented. Subsection 2.3 then presents the results of the Bernanke-Lown regressions using various capital-to-asset ratio measures. Subsection 2.4 discusses the endogeneity of our capital surplus/shortfall measures and capital-to-asset ratio measures, while subsection 2.5 documents the robustness analysis that we have performed. Note that in the regression results that follow the estimation period is 1992:Q1 to 2008:Q3; that is, we stop the analysis just about when the crisis intensified in late September 2008 and just before TARP capital injections began to occur. This approach allows us to use the magnitude of the TARP capital injections in 2008:Q4 as the measure of a shock to BHC's equity capital in forecasting their impact on bank loan growth over the next three quarters of 2009.

2.1 Estimation of BHC capital surplus/shortfall measures

We estimate individual bank-specific capital targets with a partial-adjustment model of actual capital holdings toward a desired, or long-run, target ratio as in Hancock and Wilcox (1993, 1994), and more recently in Flannery and Rangan (2008). The target capital ratio, $k^*_{i,t}$, is modeled as a linear function of a vector of control variable $X_{i,t}$, which include bank-specific characteristics as well as institutional and aggregate determinants; specifically, we have $k^*_{i,t} = \theta \cdot X_{i,t}$. Based on the rationale that costs of altering bank capital in practice prevent banks from taking their holdings of capital to their target levels immediately, the actual bank capital ratio $k_{i,t}$ is assumed to follow a partial-adjustment process of the form

$$k_{i,t} - k_{i,t-1} = \lambda \cdot (k^*_{i,t-1} - k_{i,t-1}) + \epsilon_{i,t}.$$

Substituting in our expression for $k^*_{i,t-1}$, re-arranging terms, and adding a constant yields our estimation equation of

$$k_{i,t} = \alpha + (1 - \lambda) \cdot k_{i,t-1} + \lambda \cdot \theta \cdot X_{i,t-1} + \epsilon_{i,t}. \tag{2}$$

The bank-specific variables in $X_{i,t}$ include the log of total assets, the return on assets, and the net charge-off rate; these are intended as proxies for size, earning, and risk, respectively. Size captures the fact that larger banks are likely to face lower risks (due, for example, to greater diversification) and better access to sources of funding (thereby requiring less capital). Earnings are included because dividend payments are often slow to adjust, resulting in an accumulation of retained earnings and bank capital. Risk captures the fact that markets require more capital to be held against riskier assets. In the benchmark specification of our capital ratio equation we also include the loan/security composition of bank assets, which reflects the differential risk exposures implied by different types of assets, and the composition of bank loans, which for similar reasons could also affect target capital ratios. These terms are dropped in the alternative specification of equation (2).[11] The institutional variable, called regulatory pressure, is a dummy variable that equals unity if the BHC's equity capital ratio is less than 1.5 percentage points above the minimum

[11] All composition variables, such as the security and loan composition variables, are calculated in terms of their share of bank assets.

of 5 percent.[12] We also include aggregate variables such as a measure for stock-market volatility and the aggregate net charge-off rate.

Note that the only measure of capital that we consider in deriving our surpluses/shortfalls estimates is equity capital and we derive this from a model of the equity capital-to-assets ratio. Consequently, we do not estimate models of the form described by equation (2) for the three other capital ratios—*i.e.* the total and tier one risk-based capital ratios and the tangible common equity-to-assets ratio—that we reported in Figure 3 and discussed in section 1.1. (The full set of capital ratios are examined when we consider the Bernanke-Lown version of equation 1.) We focus here on only the equity capital-to-assets ratio on the grounds that implicit in the Hancock-Wilcox loan-growth regression is the notion that the reason why BHC capital surpluses/shortfalls affect their loan growth is that BHCs alter the growth rate of their loan volumes—the dependent variable of equation (1)—so as to obtain a desired level of capital. If this is the case, however, it would then be most likely that such loan-volume adjustment would be made towards achieving a target ratio for a fairly broad measure of capital—like, total equity capital—rather than a more narrow measure—like, tangible common equity. With regard to why we do not consider total and tier-one risk-based capital surpluses/shortfalls, these are essentially regulatory concepts for which the relevant target is the threshold (of 6 percent and 10 percent respectively) that determines whether a BHC is well capitalized. Thus for these capital ratios it makes less intuitive sense to try to develop a model of their target. In addition, even if levels of these ratios were the target of BHCs it would be more likely that BHCs would adjust risk-based assets—that is, adjust loans along both the composition and volume dimension—which would then call into question why we would want to use such a surplus/shortfall measure to study the growth rates of aggregate loan volumes, the ultimate focus of our analysis.

Table 2 provides the estimation results for equation (2) under two different specifications of the $\theta \cdot X_{i,t-1}$ term. Other than the coefficients on bank size and aggregate stock-market volatility, most of the coefficients reported in Table 2 are close to what might be expected *a priori*. In both specifications there is a positive and significant coefficient on size, which suggests that larger BHCs have higher equity capital ratios. Our evidence seems to contradict previous findings that larger BHCs have lower capital ratios. We interpret our result of a positive effect of size on capital, as an indication of some economies of scale in holding capital existing at larger institutions.[13] We also

[12] We take 5 percent to be the approximate level below which regulators in the U.S. would have concerns about the capital adequacy of BHCs.

[13] Flannery and Rangan (2008) and Berger, De Young, Flannery, Lee and Oztekin (2008) find a negative relationship between capital ratios and size when they use market capital ratios and regulatory capital ratios respectively. For the BHCs in our sample we also observe that large BHCs operate indeed with lower market capital and regulatory capital ratios. However, the difference across different bank sizes is less evident when we use the equity capital ratios. Interestingly, results in Flannery and Rangan (2008) for a regression of the determinants of the book value equity ratio (defined as the ratio of common equity's book value to the book value of total assets, and therefore, close to our

find that larger shares of loans and securities (relative to assets) are associated with lower capital ratios, which we interpret as a signal that BHCs with more portfolio diversification (loans and investment securities) hold less capital. The negative coefficient on stock-market volatility appears to result from the counter-cyclical nature of volatility and the pro-cyclicality of bank capital. Both, individual and aggregate net charge-off rates are associated with higher capital ratios, though only the aggregate measure seems statistically significant. These two variables control for bank risks and suggest that BHCs hold additional capital during bad times, when the credit quality of loans deteriorate. Our dummy control for regulatory pressure has a negative coefficient but is statistically insignificant, which suggests that regulatory restrictions do not seem to affect equity capital ratios. Finally, BHCs with higher profits tend to hold more capital, but this result also appears to be statistically weak.

In addition to the typical determinants of the target capital ratio, the regression equation includes bank-specific fixed effects to control for possible omitted variables and to capture heterogeneous characteristics such as different risk preferences, governance structures, and managerial skills. The fixed effects explain a large fraction of the cross-sectional variation in target capital ratios without affecting the statistical significance of the other time-varying, firm-specific characteristics in the regression equation.[14] Interestingly, the coefficient on the lagged capital ratio implies a relatively quick adjustment. Our estimated average speed of adjustment of 36 percent per year is smaller than the 60 percent per year rate found by Flannery and Rangan (2008) but within the range of 28 percent and 41 percent reported by Berger, De Young, Flannery, Lee and Oztekin (2008).

As in Hancock and Wilcox (1993, 1994), the estimates of the coefficients in equation (1) are used to calculate a time-series for each BHC's target capital ratio, $k^*_{i,t}$. These estimated target capital *ratios* are then used to construct target capital *levels* $K^*_{i,t}$. Capital surpluses, denoted by $Z_{i,t}$, are calculated as deviations of actual capital relative to target; that is, $Z_{i,t} = (K_{i,t} - K^*_{i,t})/K^*_{i,t}$.

Figure 5 plots the average actual and average target capital ratios—that is, $\bar{k}_t$ and $\bar{k}^*_t$—over our estimation period, where we report the averages for our whole sample of BHCs. Differences between the average actual and average target capital ratio appear quite pronounced and quite persistent; nonetheless they do appear to conform with certain aspects of the conventional wisdom concerning movements in these series. In particular, in line with the findings of the literature on bank capital management, we find that BHCs operated with significant capital surpluses over

equity capital ratio definition) show an insignificant zero coefficient for a sample of the largest 100 BHCs between 1990 and 2001.

[14] Although the presence of fixed effects in dynamic panel data estimation can lead to biased OLS estimates, simulations by Judson and Owen (1999) suggest that the the bias is minor in panels with more than 30 observations. Given that our panel uses 59 periods of data and the minimum number of quarters for any BHC in our sample is 30, we make no correction for short-panel bias.

most of the late 1990s and early 2000s.[15] Furthermore, BHCs appeared to have operated with large shortfalls between 1993 and 1995, which may reflect widespread capital pressures after the implementation of the Basel I capital guidelines around 1992.[16]

Figure 6 plots the average actual and average target capital ratios over our estimation period for subgroups of BHCs based on bank size. Differences between actual and target capital seem also apparent among the largest and smallest BHCs in our sample. The largest four BHCs (those with total assets above $1 trillion at the end of the sample) seemed to have operated with capital closed to their target levels in the early 1990s (*e.g.* after the implementation of Basel I) and then accumulated large surpluses between 1995 and 2001. These plots suggest that most of the conventional wisdom of large capital surpluses in the late 1990s and early 2000s seems to be explained by the behavior of the largest BHCs. However, after 2002, the very large BHCs seem to be the most severely affected with capital shortfalls, which became more pronounced during the current financial turmoil. Unlike the largest institutions, smaller BHCs had relatively large capital shortfalls during the early 1990s, and gradually aligned their capital toward their targets during the late 1990s and early 2000s. The smallest 20 BHCs seemed to have conducted a quick capital adjustment during that period and started to be better capitalized and had large surpluses between 2003 and 2006. However, the smallest institutions started to reduce their capital ratios around mid 2004—mainly as a result of a rapid balance sheet expansion—and, as in the case of the largest BHCs, were operating substantially below target at the beginning and during the recent financial crisis. Consequently, the recent phenomena of large shortfalls in the aggregate data (Figure 5) seems largely to reflect developments at the smallest and very largest BHCs.

2.2 Estimation of the effect of capital surpluses/shortfalls on loan growth

To gauge the effects of capital surpluses/shortfalls on bank loans we include our estimates of bank capital surpluses—denoted by $Z_{i,t}$ above—in a regression model of bank loan growth. Our model is similar in spirit to the loan growth regression of Hancock and Wilcox (1993, 1994), who studied the link between bank capital surpluses/shortfalls and bank loan growth while controlling for macroeconomic conditions. It is specified, however, more closely to the regression set-up of Kashyap and Stein (1995, 2000), who modeled the growth rate of bank loans as a function of supply and demand factors. But whereas the set-up used by Kashyap and Stein focused on the differential impact of monetary policy on bank loans induced by different degrees of balance-sheet

[15] For example, Flannery and Rangan (2008), and Berger, De Young, Flannery, Lee and Oztekin (2008) document the build-up of capital cushions for large banks, substantially above the "well-capitalized" regulatory minima, during the 1990s and mid 2000s, a period of unusual profitability for the banking sector.

[16] Hancock and Wilcox (1994) find that by the end of 1991 more than 40 percent of banks had capital shortfalls relative to their bank-specific target.

strength, our specification focuses on the impact on loans of capital surpluses/shortfalls.

We model the growth rate of BHC loans ($\Delta\%LOAN_{i,t}$) as a function of its own lags, lags of economic growth ($\Delta\%GDP_t$), lags of the GDP price inflation rate ($\Delta\%INF_t$), and lags of the change in the federal funds rate (ΔRFF_t), and lags of lending standards (STD_t). In addition, we also include lagged BHC-specific characteristics such as a control for bank liquidity ($LIQU_{i,t}$), which is measured by the ratio of securities to total assets, and the ratio of net charge-offs to total assets ($CHG_{i,t}$). The last term is our estimates of bank capital surpluses/shortfalls ($Z_{i,t}$), which is the main variable of interest. Thus, the following panel regression equation is estimated

$$\begin{aligned}\Delta\%LOAN_{i,t} = &\sum_{s=1}^{4}\alpha_s\cdot\Delta\%LOAN_{i,t-s}+\sum_{s=1}^{4}\gamma_s\cdot\Delta\%GDP_{t-s}+\sum_{s=1}^{4}\delta_s\cdot INF_{t-s}\\ &+\sum_{s=1}^{4}\beta_s\cdot\Delta RFF_{t-s}+\sum_{s=1}^{4}\zeta_s\cdot STD_{t-s}+\psi\cdot LIQU_{i,t-1}+\chi\cdot CHG_{i,t-1}\\ &+\psi\cdot CAPITAL\ SURPLUS(Z_{i,t-1})+\epsilon_{i,t}. \qquad (3)\end{aligned}$$

The model is specified in growth rates to deal with non-stationary variables and uses four lags. To avoid potential endogeneity issues, only lags of the explanatory variables are used. We also include quarterly dummies to control for potential seasonality in the data. In this specification, GDP growth is included to control for changes in loan demand, lending standards are used to control for credit supply changes that arise from more conservative lending behavior, and the federal funds rate is included to control for monetary policy changes. Regarding controls for firm characteristics, the liquidity variable is intended to capture the extent to which BHCs use their stock of securities to adjust their loan growth, all other things equal (a point emphasized by Kashyap and Stein) while the fraction of charge-offs to total assets is a proxy for BHC risks, which should act as a drag on loan growth. Equation 3 is estimated with bank fixed effects in order to allow for potential omitted factors that vary across BHCs and are constant over time.

Table 3 presents the estimation results for equation (3).[17] The first pair of columns presents results when total bank loans are used as the dependent variable, while the second pair of columns presents results when C&I loans are used as the dependent variable. For both total bank loans and C&I loans there is a positive and significant coefficient on capital surpluses, indicating that the growth rate of both total and C&I bank loans is larger for banks with greater amounts of excess capital. The effects, however, are small. The long-run impact of a capital surplus/shortfall on both total and C&I BHC loan growth is roughly to increase/reduce annualized loan growth by

[17] Because an auxiliary equation is used to estimate the capital surplus variable, our estimation of equation (3) is subject to a generated regressor bias. We use a bootstrap procedure to obtain corrected standard errors and address this problem.

0.25 percentage point when capital exceeds/falls short of its target level by 1 percent.

Our estimate of the effects of a 1 percent surplus in actual capital from target on loan growth can—with some manipulation—be compared to the effects found by Hancock and Wilcox (1993, 1994), who looked at dollar amounts. Specifically, using a 10 percentage point average capital-to-assets ratio and a 60 percent average share of loans (as a fraction of bank assets), our model estimates imply that a \$1 capital surplus/shortfall results in a \$1.86 boost/reduction in loan volumes.[18] This is a touch higher than Hancock and Wilcox's estimates, which implied that a \$1 surplus/shortfall leads to a \$1.50 boost/reduction in loan volumes, but it is not considerably different. Our estimate is, however, very different—*i.e.*, about one-sixth to one-tenth the size—to the \$8 to \$12.50 boost/reduction in loans that the constant leverage ratio assumption would imply.

The results in Table 3 suggest a more important role for demand shocks and exogenous changes in net charge-offs in determining both total and C&I loan growth. Specifically, the results imply that a 1 percentage point reduction in GDP growth lowers the annualized growth rate of total loans by 4.1 percentage points and lowers the annualized growth rate of C&I loans by 9.4 percentage points. Furthermore, the potential effects of continued write-downs through further increases in net charge-offs imply a large and significant impact in both specifications. For example, a 1 percentage point increase in the net charge-off ratio depresses the annualized growth rate of both total and C&I BHC loans by about 7 percentage points. Although the coefficient on securities-to-assets ratio is significant, the effect of increased holdings of securities on the BHC loan growth is small. A 1 percentage point increase in the securities-to-assets ratio leads to about 0.3 percentage point increase in both total and C&I annualized loan growth. Finally, lending standards in both the total and C&I loan growth equations enter negatively (as expected) and is statistically significant, but has an economically small impact on loan growth. A 1 percentage point increase in the lending standards leads to about 0.1 percentage point decrease in both total and C&I annualized loan growth. This latter observation may be explained by the fact that the capital surplus measure and the increase in the charge-off ratio already capture potential effects associated with banks' diminished willingness to lend.

2.3 Estimation of the effect of bank capital ratios on loans growth

As we will discuss in section 2.4 (when we consider possible identification issues present in our panel regression analysis) one potential vulnerability of the implementation of the surplus/shortfall

[18]The calculation is performed as follows. The relationship between a percent capital surplus/shortfall and loan growth is $\frac{L_t - L_{t-1}}{L_{t-1}} = 0.25 \cdot \frac{K_t - K_t^*}{K_t^*}$. Assuming that the economy was initially in steady-state implies that $\frac{L_t - L_{t-1}^*}{L_{t-1}^*} = 0.25 \cdot \frac{K_t - K_t^*}{K_t^*}$, which re-arranging yields $(L_t - L_{t-1}^*) = 0.25 \cdot \frac{L^*}{A^*} \cdot \frac{A^*}{K^*} (K_t - K_t^*)$ (ignoring time subscripts on the steady-state variables). Since $\frac{L^*}{A^*} = 0.62$ and $\frac{A^*}{K^*} = 12$ in the data, this implies that $(L_t - L_{t-1}^*) = 1.86\, (K_t - K_t^*)$.

approach of Hancock and Wilcox (1993,1994) is that of mis-specifying the target capital-to-assets ratio equation. That is, if we model this variable poorly, our estimates of the effect of a capital surplus/shortfall on loans will also be poor, thereby biasing (likely downwards) the estimated surplus/shortfall impact coefficient, ψ. An alternative approach to investigating the link between bank capital and loans that does not face this vulnerability is to focus on the relationship between capital ratios and bank loan growth. For this purpose, we replace in equation (3), our measure of the capital surplus by the lagged value of different capital ratios as the main variable of interest. Specifically, we estimate:

$$\begin{aligned}\Delta\%LOAN_{i,t} = &\sum_{s=1}^{4}\alpha_s\cdot\Delta\%LOAN_{i,t-s}+\sum_{s=1}^{4}\gamma_s\cdot\Delta\%GDP_{t-s}+\sum_{s=1}^{4}\delta_s\cdot INF_{t-s}\\ &+\sum_{s=1}^{4}\beta_s\cdot\Delta RFF_{t-s}+\sum_{s=1}^{4}\zeta_s\cdot STD_{t-s}+\psi\cdot LIQU_{i,t-1}+\chi\cdot CHG_{i,t-1}\\ &+\psi\cdot \mathit{CAPITAL\text{-}TO\text{-}ASSETS\ RATIO}\,(K_{i,t-1}/A_{i,t-1})+\epsilon_{i,t}\end{aligned} \tag{4}$$

and consider several measures of the capital-to-assets ratio: the equity capital-to-assets ratio (book leverage ratio); the total risk-based capital ratio, the tier-one risk-based capital ratio, and the tangible common equity (TCE) ratio. We consider each capital ratio separately. The different capital ratios measure different dimensions of banks' balance-sheet positions and thereby reflect different forces that act to influence lending. For example, by using the equity capital ratio we examine the impact of capitalization decisions on loan growth, while using the two risk-based capital ratios in our regression reflects both the effect on loan growth of both capitalization and portfolio composition because the risk-based measures also include off-balance sheet assets. The TCE ratio is a more conservative measure of bank capital, intended to represent the first loss position in case of bank failure. We include this alternative measure of bank capital primarily because in the quarters after October 2008 it was the focus of market participants in evaluating the financial strength of banking institutions.

We would note that the specification of this equation is broadly similar to the loan growth equation estimated in our VAR model in section 3. The estimation results for the impact of shocks to capital ratios on BHC loan growth are reported in Table 4. As seen from the table, all variables enter with the expected sign and most are statistically significant. For example, there are positive and significant coefficients on the BHC capital ratios, which is consistent with the growth rate of bank loans being larger for banks with higher capital ratios. However, regardless of the capital ratio we use as our main explanatory variable, the effects of shocks to capital on the BHC loan growth are small. Depending on the capital ratio employed, our results in Table 4 suggest that a 1 percentage point increase in the capital ratio leads to an increase in annualized BHC loan growth of only between 0.7 and 1.2 percentage points.

The largest estimate of the effect of capital shocks on the BHC loan growth corresponds to the regression specification that uses the TCE ratio which, as mentioned above, received significant attention by market participants, especially during the weeks surrounding the bank stress tests in 2009. Our results suggest that even an increase in the most conservative measures of bank capitalization would have a very modest impact on BHC loan growth. In other words, in the event that, ceteris paribus, BHCs managed to raise additional capital by either issuing more common stock or converting preferred shares to common shares—as some proposals for regulatory reform have suggested—such increase in common equity would have a minor impact on the growth rate of bank loans.

Our estimate of the effect of a 1 percentage point increase in the equity capital ratio, which lies towards the lower end of the above range of estimates, can be compared with the effect obtained by Bernanke and Lown (1991), albeit for a very different sample of—specifically, New Jersey—banks. Bernanke and Lown's reported estimates are notably larger than ours: For their full sample of 111 New Jersey banks, they found that a 1 percentage point increase in the equity capital ratio resulted in a 2 percentage point increase in loan growth while for their sample of 90 small New Jersey banks, the corresponding increase in loan growth was a round 2-1/2 percentage points. Clearly, the size of the institutions considered is one reason for the difference between the size of our estimates and those of Bernanke and Lown and indeed Bernanke and Lown's analysis does indicate a smaller degree of sensitivity of bank loans to equity capital ratios for banks of larger sizes. The relative difference between the size of banks in our analysis and those of Bernanke and Lown are even more stark than the large-bank/small-bank distinction considered in their paper. Specifically, our analysis considers the largest 165 BHCs in the United States whereas Bernanke and Lown's analysis considers banks that only operate within the state of New Jersey. As a result even the smallest banks in our sample are larger than those considered large in Bernanke and Lown's set of banks. The small number of "large" banks in Bernanke and Lown's dataset prevents any regression analysis on this group alone. However, it would seem that estimates for large banks in the Bernanke-Lown analysis of the effects of equity capital on loan growth would be less than 2 percentage points, such that these estimates are modest multiples—rather than orders of magnitude—of the size of effect found in our analysis.[19] Of course, another reason for the smaller estimates in our analysis is the time period considered in our analysis and the fact that, as was noted in section 2.2, structural

[19] In principle, relative bank size should also induce similar differences between the estimates reported in section 2.2 and those found by Hancock and Wilcox (1993,1994). However, we do not observe such differences. One possible reason is that Hancock and Wilcox perform their analysis on the entire U.S. and exclude commercial banks with assets less than $300 million (just under one-half billion in current dollars). In addition, they "roll up" the commercial banks in their sample to the BHC top holder. As such it is likely that the banks in the Hancock and Wilcox study are on average larger than those used by Bernanke and Lown (1991).

changes in the banking sector that have taken place since Bernanke and Lown performed their analysis have likely also diminished the size of the effect of equity capital ratios on loan growth.

While the effects of the equity capital ratio on bank loan growth that we obtain in our analysis are somewhat smaller than the effects estimated by Bernanke and Lown (1991), they are notably smaller—*i.e.* on the order of one-tenth the size—of the loan-growth impact that would be implied by the constant leverage-ratio assumption. Specifically, the constant leverage-ratio assumption would imply that the percentage point increase in loan growth implied by a 1 percentage point increase in the equity capital ratio is equal to that of the capital ratio; *i.e.* 8 percentage points for a 8 percent equity capital ratio and 12 percentage points for a 12 percent equity capital ratio.

As was the case for our regression analysis on the effects of capital shortfalls on loan growth, the model's estimation results suggests that demand shocks and exogenous changes in net charge-offs play the most important role in determining total loan growth. The response of BHC loan growth to demand shocks, measured by GDP growth, implies that a 1 percentage point reduction in GDP growth leads to about 4 percentage points decline in annualized loan growth. Furthermore, the potential effects of continued write-downs through further increases in net charge-offs imply a large and significant impact in all capital ratio specifications considered. A 1 percentage point increase in the net charge-off ratio reduces the annualized growth rate of total BHC loans by about 8 percentage points. As before, the coefficient on the securities-to-assets ratio is significant but the effect of increased holdings of securities is small and leads only to 0.3 percentage point increase in BHC loan growth. Finally, the coefficient on lending standards is negative and significant but has also small impact on BHC loans. As in our previous estimation results of the equation that focuses on the impact of capital surplus/shortfall, this latter observation may be explained by the fact that the capital shock and the increase in the charge-off ratio already capture potential effects associated with banks' diminished willingness to lend.

2.4 Endogeneity of the capital measures

In the discussion of our estimation results in subsections 2.2 and 2.3 we interpreted our parameter ψ as reflecting the magnitude of the increase in loan growth implied by a higher capital surplus or a higher capital ratio. Doing this, however, requires that we rule out any other possible interpretations that may result in a relationship between a bank's loan growth and its capital surplus or capital ratio.

One possible, and widely recognized, reason why we might observe a positive relationship between a bank's loan growth and its capital surplus or ratio (whether lagged or not) is that in a strong/weak economy it is likely that capital ratios will be more elevated/depressed—because banks have strong/weak profits growth, which promotes/limits capital accumulation—at the same time that loan growth will be robust/lacklustre. Clearly, the inclusion of macroeconomic variables—in particular, economic growth—in the loan growth equation does limit the possibility of our ψ parameter reflecting this "third-factor" explanation for the positive relationship between loan growth and its capital surplus or ratio and indeed the fact that the coefficients on lags of real GDP growth are so large in our loan growth equations suggests that with this control we capture (reasonably successfully) movements in loan growth that arise from fluctuations in aggregate demand.

A positive relationship between a bank's loan growth and lagged measures of its capital levels could also arise if banks, when they anticipate an increase in loan volumes and thereby balance-sheet size, pre-emptively increase their capital levels so as to ensure that they will not in the future find themselves short of capital. This adjustment of bank capital levels to anticipated changes in loan volumes raises the possibility of an endogeneity issue in the Bernanke and Lown (1991) loan-growth equations. In the context of making statements as to the size of an increase in loan growth that would likely obtain from an increase in the capital ratio, this endogeneity issue does represent a limitation on the results obtained from the Bernanke-Lown approach. However, from the perspective of simply examining whether the constant leverage assumption exaggerates the magnitude of the response of loan growth to an increase in capital ratios, this endogeneity issue is not necessarily an overwhelming concern, because it simply generates an upward bias in our estimates of the parameter ψ. To confirm that the true effects of an increase in the capital ratio on loan growth would be even less than those suggested by our results reported in section 2.3, we considered an alternative specification that includes the BHC's ratio of cash dividends to net income. To the extent that BHCs change their dividend policy in anticipation of future lending opportunities (for example, banks may cut dividends when they expect further increases in loan growth), the dividend-to-net-income ratio would capture the endogenous variation in capital to expected changes in loan volumes. Our estimates (not reported) using this alternative specification of the Bernanke and Lown (1991) equation imply that, depending on the capital ratio employed, a 1 percentage point increase in the capital ratio leads to an increase in the annualized BHC growth rate of only 0.5 to 1 percentage points. This compares to a 0.7 to 1.2 percentage point increase in BHC loan growth when the benchmark Bernanke-Lown specification is used.

To the extent that when we follow the Hancock and Wilcox (1993,1994) approach we correctly model the target capital ($K^*_{i,t}$), this identification issue should be of limited concern. If the reason banks boost their capital is that they anticipate a future balance-sheet expansion, this should also be reflected in an increase in their target capital, which implies no net change in the capital surplus or shortfall. Consequently, the possibility that banks increase their capital in response to anticipated expansions in loans, does not generate a positive relationship between loan growth and surpluses/shortfalls of capital. Thus, the interpretation of ψ is preserved. That said, the possibility remains that our model of banks' target capital is incorrect and that—perhaps because we do not have a forward-looking component equation (2)—we have not completely purged our parameter ψ of this potential source of bias. Naturally, it would be possible to address this problem by introducing forward-looking behavior to equation (2), although this would then also entail the specification of some simple forecasting equations for the explanatory variables of equation (2), which in turn could also be mis-specified. Thus, we do not pursue this approach. Instead, we tolerate some possibility of an incorrectly modeled target capital inducing some modest amount of upward bias in the parameter ψ, in part because the mis-specification of the target capital ratio equation is always present (and always a vulnerability of this approach) and it is not clear that not including a forward-looking component to the equation is necessary the most important omission.

The preceding discussion highlights why we use both the Hancock and Wilcox (1993,1994) and Bernanke and Lown (1991) approaches in our analysis of the effect of bank capital on bank loan growth. Specifically, while we generally consider the Hancock and Wilcox approach is preferable from the perspective of being able to interpret the parameter ψ as the effect of an increase in capital—that induces an increase in the capital surplus—on loan growth, it is vulnerable to the mis-specification of its target capital equation, which can potentially distort down estimates of ψ. In contrast, while the Bernanke and Lown approach is not vulnerable to any mis-specification of a target capital variable, ψ, it is susceptible to some endogeneity issues, which could then limit the interpretation of the parameter ψ, but do not necessarily represent an overwhelming concern when determining the precise magnitude of the effects on bank loan growth implied by our estimates.

2.5 Robustness analysis

Because our estimates of the effect of capital shortfalls on loan growth appear small we conducted a number of robustness checks. Ultimately, we found that these do not alter our key conclusions.

First, we considered an alternative, atheoretic, approach to calculating the capital surplus/shortfall used in the Hancock-Wilcox regressions. Specifically, instead of estimating a model to calculate the banks' capital targets, we used a one-sided Hodrick-Prescott filter applied to each BHC's time-series of the capital ratio. The capital surpluses and shortfalls implied by the filter's estimates are smaller and smoother than their model-based counterparts, but are also less consistent with the conventional wisdom regarding when the banking system was operating with capital surpluses or shortfalls. Indeed, it is principally for this reason that we ultimately chose the model-based target measure as our primary specification. Nonetheless, we still considered how the alternative measure of the target capital level altered our estimates of the effects of capital shortfalls on loan growth and found that the estimates, which were significant, were larger—on the order of a 0.7 percentage point reduction in annualized loan growth when capital is 1 percent below its target level—but still small relative to values consistent with the constant leverage assumption.

We also included an additional four lags of both capital surplus/shortfall and capital ratios in our regression equations (3) and (4) respectively, to consider a less parsimonious specification aimed at capturing richer dynamics and potentially persistent effects of capital on loan growth. In both cases the coefficients of our variables of interest were almost unchanged so that we still obtained a modest impact of capital on BHC loan growth.

We also performed rolling-window panel regressions over the sample period to address the possibility of decreasing effects of shocks to bank capital on loan growth. In particular, we were concerned that estimating the equations over a fourteen-year period could dilute the effect of capital shortfalls or shocks to capital ratios on loan growth. We used fixed-size rolling windows of six, seven and eight years with quarterly data starting in 1992:Q1, for the regressions that use both capital surplus and different capital ratios as the main explanatory variables. In all cases, we found that the coefficients on our variables of interest were relatively stable, implying, therefore, a small impact on loans. For example, the coefficients fluctuated between 0.05 and 0.10 for the capital surplus/shortfall (*i.e.* Hancock-Wilcox) regressions, and between 0.10 and 0.55 for the equity-to-assets ratio (*i.e.* Bernanke-Lown) regressions. The largest coefficients that we estimated for both approaches correspond to the regressions that start between 1992 and 1995. We interpret this as being consistent with both the large rates of loan growth observed over the second half of the 1990s and the early 2000s and the period during which large BHCs were holding significant capital surpluses.

In light of the plots in Figure 6, which suggested differences in the magnitude of capital deviations from target across BHCs grouped by size, we also conducted our regression analysis of the impact of capital shortfalls and shocks to capital ratios for different BHC size: large (top 20), small (smallest 20) and medium-sized. Although, the difference in the magnitude of capital shortfalls or surpluses are notable across BHC of different size, there seemed to be no difference in their impact on BHC loan growth. We found that the coefficient on our capital surplus measure was slightly bigger for large BHCs (0.06 compared with 0.04 for smaller BHCs), but this difference was not statistically significant. We also excluded the largest 4 BHCs from our sample to deal with potential distortionary size effects these institutions may have on our estimation of both, the capital target and the impact of the surplus measure and the shocks to capital ratios on loan growth, and found qualitatively similar results to those reported in tables 2 through 4.

We also considered variants of the regressions described in equations (2) and (3) over a shorter sample period—specifically the most recent four years.[20] In this case we obtained a slightly larger

[20] In performing the regressions described in equations (2) and (3) we omitted the lagged dependent variables from the regressions since, given the short sample period, the presence of fixed effects would, as discussed earlier, otherwise lead to biased OLS estimates. Prior to using them, we verified that for the entire sample period, the regressions

coefficient on the capital surplus term in equation (3), although one that still rounded to imply a 0.1 percentage point reduction in quarterly loan growth when the capital shortfall is 1 percent.

Finally, we examined the possibility of nonlinear effects of capital on BHC loan growth by including in our loan-growth regressions quadratic and/or cubic terms of the different capital ratios and the surplus/shortfall measure. In all cases we found that none of these nonlinear terms were statistically significant. For the capital surplus/shortfall regressions we also considered differences in the impact of capital deviations on loan growth between BHCs operating with capital surpluses and those operating with shortfalls.[21] Here we found no statistically significant difference between surplus and shortfall coefficients.

3 Bank Capital and Loan Growth at the Aggregate Level

As noted earlier, because our panel estimation approach uses only BHCs that have existed over our entire sample period (or at least most of it), it suffers from a potential survivor bias, which may be lowering our estimates of the effects of bank capital on loans.[22] To address this concern, in this section we use aggregate data and a vector autoregression (VAR) model to study the effects of commercial-bank capital ratios on bank loan growth. In our panel regressions, we specified BHC loan-growth equations that, because we controlled for the effects of other supply and demand variables on loan growth, allowed us to interpret the coefficient ψ on the equations' capital terms as the effect of BHC capital conditions on loan growth. Here we take a different approach. Specifically, we rely on identifying structural innovations in bank capital ratios and then examining the dynamic impact of these structural innovations on bank loan growth (as well as other variables in our model). Because these innovations represent the component of changes in the capital ratio that are not due to developments in any other of the variables in the model, we can interpret the response of bank loan growth to a shock to the structural innovation in the bank-capital ratio as the effect of bank capital conditions on loan growth.

The identification of the structural innovations in bank-capital ratios is an important part of

without the lagged dependent variable, although with slightly lower goodness of fit, were still appropriate—for example, explanatory variables had slightly different coefficients but entered the regression with the expected sign and significance.

[21] We did this in two ways, with both yielding the same conclusion. The first way was to split our sample depending on the sign of the capital deviation and then re-estimate equation (3) for each group. The second way was to include a dummy variable that depends on whether a shortfall or surplus is present. This dummy variable then interacts with $Z_{i,t}$ in equation (3) and thus allows for different values of κ depending on whether $Z_{i,t}$ represents a surplus or shortfall.

[22] Note that such survivor bias was of limited concern for both Bernanke and Lown (1991) and Hancock and Wilcox (1993,1994) since both of these studies employed cross-sectional—rather than panel—data analysis over a single year; specifically, 1990 in the case of Bernanke and Lown and 1991 for Hancock and Wilcox.

our analysis and this is discussed in section 3.1. Section 3.2 then reports the dynamic impact of these structural innovations on bank loan growth and other variables in our model. An important dimension of the effect of structural innovations in bank-capital ratios on bank loan growth is the impact that arises through these innovations affecting other variables in the model—such as, real economic growth and bank lending standards—that in turn feedback to influence bank loans. These indirect channels should be borne in mind in considering how changes in bank capital affect loans and should also be accounted for in comparing the magnitudes of the effects found in the timeseries analysis from those obtained in the panel regressions. To allow this comparability we therefore conduct exercises to shut down these additional indirect effects. These results we also report in section 3.2. Finally note, that consistent with our panel regressions we use the estimation period 1990:Q3 to 2008:Q3; that is, we end the regression analysis just when the crisis intensified and just before TARP capital injections began to occur.

3.1 Estimation and identification of the VAR model

The vector autoregression model that we use is a slightly modified version of the extended VAR model with bank capital considered by Lown and Morgan (2006). Our VAR consists of six variables: real GDP growth and GDP price inflation (excluding food and energy), the Federal funds rate, the growth rate in commercial bank and thrift loan growth, the aggregate capital to assets ratio of the commercial bank sector, and the net fraction of loan officers at commercial banks reporting a tightening of credit standards for C&I loans. The first three variables in the VAR are standard components of a monetary-policy VAR, while the last three variables—commercial bank and thrift loan growth, the capital-asset ratio, and lending standards—are added to the model to allow us to study the interaction between banks and the macroeconomy.

The residuals obtained from each of the estimated OLS regressions are combinations of structural innovations to the model. Importantly, the structural innovations have economic interpretations, such as, exogenous shocks to monetary policy, technology, and the mark-up of prices over costs in the monetary-policy part of the model and exogenous shocks to bank lending standards (reflecting changes in cautiousness), bank capital ratios, and bank loan volumes (due to conditions in other credit markets) in the banking part of the model. However, although structural innovations underlie the residuals implied by the estimated regression they cannot, in the absence of any additional assumptions, be either observed or inferred. A wide variety of assumptions can be used to identify structural innovations from estimated equation residuals; for our VAR we make recursive assumptions (based on the ordering of variables described above) regarding the contemporaneous effects that different variables in the model can have on each other in order to identify the key structural shocks. We are primarily interested in separately identifying the three banking shocks in our model from the macroeconomic shocks, which for our purposes are sufficient to consider as a amalgamation of macroeconomic shocks.

Our identification method assumes that structural innovations to any of the model's banking variables do not affect contemporaneously the model's macro variables but that innovations to the model's macroeconomic variables do affect contemporaneously the model's banking variables. One interpretation for this assumption as it relates to economic activity and inflation is that households, firms, and all levels of government can arrange their spending, production, and price-determination plans for the *current* period in such a way that surprise developments in the credit sector will not prevent these plans (perhaps, more realistically, on the aggregate) from taking place. That said, such plans can be modified in response to surprise developments (captured by macroeconomic shocks) of direct relevance for spending, production, and price-determination, which moreover *will* affect variables in the banking sector. Likewise monetary policymakers do not alter their interest-rate setting decisions in response to within-quarter developments in the banking sector; although monetary policy surprises can have immediate effects on bank variables.

Within the banking part of the VAR model our identification method assumes that structural innovations to bank loan volumes can affect bank capital ratios and lending standards immediately but that innovations to these variables do not have contemporaneous effects on bank loans. The first part of this assumption suggests that contemporaneous structural innovations to bank loan-growth originate from (in addition to the real economy) the non-banking part of the credit sector. Thus, a reasonable interpretation of these innovations (particularly in the context of the current crisis) is that they reflect disruptions to segments of the financial system that in turn can impact (contemporaneously) bank loan-volumes.[23] The second part of the assumption—that capital ratios and lending standards do not affect lending contemporaneously—reflects the time that it takes to arrange a loan. This may at first appear to be at odds with our assumption that changes in the real economy can affect lending contemporaneously, however, in the case of real-economy developments we have in mind households and firms drawing down or repaying lines of credit on pre-arranged loans. Clearly, credit limits on loans that take the form of credit lines (such as HELOCs, credit cards, or C&I commitment loans) can be modified by banks in response to capital-ratio or standards innovations, but these changes are difficult to implement quickly.

Of course, our identification assumption that changes in lending standards have no impact on loan volumes contemporaneously raises the question of what it is then that tighter or looser lending

[23]Examples for this include commercial paper and bond markets. In the current crisis and its aftermath developments in there securities markets have impacted bank loan growth in important ways. For example, early in the crisis when CP markets were coming under strain, CP issuers drew down back-up lines of credit at banks and this had a sizable (positive) impact on bank loan growth. More recently, improving conditions in bond market appear to be having some (negative) effect bank loan growth as firms that can issue bonds substitute away from intermediated credit.

standards actually impact given that the question in the survey asks how the standards applied to approving applications for loans made in the survey's reference period differs from those applied in the preceding period. There are many ways, however, via which banks can tighten standards other than altering loan volumes contemporaneously. For example, banks can change the maturity of loans, the cost of credit lines, the spreads on loan rates, the covenants on the loan, and the loans' collateralization requirements and so our identifying assumption assumes banks make these changes only in the period in which standards are tightened.

Our identification method also assumes that standards innovations do not affect bank capital ratios contemporaneously, although bank capital ratios do affect standards. The first part of this assumption accords quite closely with the previous discussion that documented reasons why standards innovations did not affect loan volumes. The second part of the assumption reflects the fact that lending standards are in the current period the most easily altered variable in the VAR, albeit on the non-volume front.

Finally, note that we only separately identify loan-volume, capital, and lending-standards structural innovations, we do not identify the model's macroeconomic shocks separately. Thus in any results we show, we report the *combined* effects of the model's macroeconomics shocks.

3.2 The effects of an innovation to the equity capital ratio

Figure 7 shows the responses of key model variables—specifically, output growth, loan growth, the capital-assets ratio, and standards—to a one standard deviation structural innovation to the capital-to-assets ratio. This innovation induces an immediate 16 basis point increase in the variable, which then declines only very gradually back to steady state. Lending standards immediately loosen about 2 percentage points in response to the increase in capital ratios and loan growth is boosted for about two years with a maximum response of about 1/2 percent two quarters after the impact of the shock. The (insignificant) response of GDP growth is quite rapid and short-lived (about one year), peaking at 0.2 percent in the period following the shock. One possible reason for the smaller and shorter-lived response of output growth relative to loan growth is that some of the growth in loans may just represent the substitution across institutions as to where debt is being held. Indeed additional analysis—shown in Figure 8—which involves using the sum of bank and thrift loans *and* ABS issuers' holdings of mortgage and consumer credit in the VAR in place of just bank and thrift loans seems to support this view. Specifically, a shock to the equity capital ratio has no effect on this broader aggregate of loan volumes while having roughly similar effects on all other variables in the model. The fact that changes in capital ratios do appear to induce substitution between on- and off-balance-sheet credit is an interesting one, which we do not pursue here, since our specific interest in this paper is bank capital and loan growth. However, to the extent that ultimately we are ultimately interested in the effects of bank capital on real activity, this is certainly an issue to be pursued in future research.

Returning to the results presented in Figure 7, these suggest that a one percentage point increase in the capital ratio results in a 2-3/4 percent increase in loan growth about 2 quarters to a year after the initial shocks. This is almost four times the size of the response of loan growth to an equity capital shock in the panel regressions. A larger-sized estimate of the effect of a boost to the equity capital ratio in the VAR model relative to the panel regression is perhaps not surprising given that the VAR approach allows for the endogenous response of several variables—most notably standards and real GDP growth—which in turn have additional (positive) effects on loan growth. Given this, for the purposes of comparison, it is instructive to shut down these additional effects so as to see how the magnitude of the response of loan growth using the aggregate commercial-bank data compares to the results obtained using institution-level BHC data.[24]

Figure 9 reports the responses to a one standard deviation capital-to-assets ratio shock with various endogenous responses of different variables eliminated. In particular, the red line in Figure 9 shuts down the response of standards to the capital-to-assets ratio shock, the blue line shuts down the response of real GDP growth to the capital-to-assets ratio shocks, while the green line shuts down both the standards and real GDP growth responses. These results suggest that in the absence of endogenous responses from other variables, bank loan growth should increase approximately 1.2 percentage points in response to a one percentage point capital-assets ratio shock. This increase is about twice as large as the increase in loan growth implied by the panel regressions but is nonetheless considerably smaller than the estimates implied by the scatter-plot approach. Given the potential for survivor bias in the panel results it is not surprising—and indeed is somewhat expected—that the effect of capital ratio shocks should be larger in the VAR model. Of course, there is nothing to indicate how big we might expect this bias to be and thereby the relative magnitudes of the VAR and panel responses.

4 The Effects of Capital Injections on Loan Growth

We now use the models developed in sections 2 and 3 to estimate how TARP-related capital injections could be expected to affect bank loan growth.

[24] We shut down the different endogenous responses of standards and real GDP growth—both individually and together—following the approach laid out by Bernanke, Gertler, and Watson (1997). Specifically, in addition to subjecting the model to a one standard deviation capital-ratio shock we also apply a sequence of other shocks to the model so as to hold the variable or variables in question constant over the period of the impulse response simulations.

4.1 The effects of recent capital injections on BHC loan growth

The panel regression results from section 2 can be employed to provide estimates of the effect of the original TARP disbursement ($182 billion for our sample of large banks) on BHC loan volumes. The CPP capital infusions during 2008:Q4 raised the level of equity capital and thereby increased the surplus/decreased the shortfall about 14 percentage points (on average). Taken together with the estimation results of section 2.2, which indicate that a 1 percentage point increase in the capital surplus implies a 1/4 percent increase in annualized loan growth, this implies that the CPP injections to our sample of banks increased loan growth by 3-1/2 percent at an annual rate.

In ratio terms the CPP injections raised the equity-to-assets ratio about 1.4 percentage points (on average) and the risk-based capital ratio about 1.7 percentage points (on average). Taken together with the estimation results of section 2.3, which indicate that a 1 percentage point increase in the equity-to-assets ratio and the risk-based capital ratio generate a 0.7 to 0.8 percentage point increase in BHC loan growth respectively, this implies that the CPP injections boosted BHC loan growth between 1 and 1.4 percentage points.

In dollar volume terms, the results from the surplus/shortfall regressions imply that the $182 billion increase in capital that large BHCs in our sample received would result in a $273 billion increase in loans over the following year. The results from the capital-ratio regressions imply an increase in loan volumes of between $60 billion and $86 billion over the following year depending on the measure of capital considered. These volumes are significantly less than the boost in lending capacity based on the U.S. Treasury assumptions. Specifically, since the CPP considered that a dollar invested in capital would generate between eight to twelve dollars of lending capacity, this implies that a $182 billion capital injection should imply a $1-1/2 to $2-1/4 trillion increase in lending capacity.

4.2 The effects of recent capital injections on commercial bank loan growth

We can also use the VAR model impulse response functions presented in section 3 to estimate the magnitude of the impact of CPP injections on commercial bank loan volumes. As noted above CPP capital injections raised the equity-to-assets ratio 1.4 percentage points. Given the impulse response functions for a one standard deviation capital-to-assets ratio shock reported in Figure 7 this would suggest that the CPP capital injections would boost loan growth by 3.7 percentage points over the first year following the impetus. As discussed, this is almost four times larger than the effect implied from the capital-ratio panel regressions partly reflecting endogenous responses. If these endogenous responses are shut down (as they are in Figure 9) bank loan growth increases 1.8 percentage points following a 1.4 percentage point capital-assets ratio shock.

5 Understanding the Recent Decline in Loan Growth

Given that the models used in section two were all originally developed to study whether a credit crunch occurred in the early 1990s, we might ask what our models predict as to the effect of capital ratios on recent developments in loan growth. First, we use the panel estimation results to understand the factors underlying the recent decline in bank loan growth and to gauge whether the large decline in loans was mainly explained by supply or demand factors. Second, our VAR estimates can also be used to decompose the time-series of commercial bank loans into the various banking and nonfinancial shocks in the model.

5.1 Decomposition of BHC loan growth

We conduct out-of-sample forecasts of BHC loan growth using both our capital surplus/shortfall and capital-ratio panel regressions and decompose the quarterly growth rate of BHC loans into supply and demand factors such as capital, lending standards, bank risks and GDP growth. Figure 10 reports the results from the capital-ratio panel regressions.

As can be seen in Figure 10, our capital-ratio panel regression model performs relatively well in explaining the recent drop in the quarterly growth rate of BHC loans. The decomposition of the predicted growth rate confirms the importance of loan demand shocks and increased bank risks in accounting for most of the decline in BHC loan growth. Specifically, out of the 2.9 percentage point decline in the quarterly growth rate from 2008:Q4 to 2009:Q3—of which the model explains 2.2 percentage points—1.3 percentage points is accounted for by changes in GDP growth—the dark blue shaded area—and 1.1 percentage points are explained by exogenous changes in net charge-off rates—the green shaded area—which captures the deterioration in BHC loan quality. Interestingly, tighter lending standards—the purple area—significantly restrained BHC loan growth during the first half of 2009 (by about 1.3 percentage points), though this effect lessened in 2009:Q3 with BHCs appearing to be gradually reducing the rate at which they tightened. On net, lending standards account for only 0.2 percentage point of the 2008:Q4 to 2009:Q3 reduction in BHC loan growth.

Figure 10 also confirms a small impact of shocks to bank capital—the light blue area—on BHC loan growth. In particular, the changes in BHC capital ratios associated with both TARP related capital injections in 2008:Q4 and subsequent efforts to raise capital privately during the first half of 2009 had only a minor positive contribution on bank loan growth (only 0.1 percentage point) and were more than offset by adverse factors such as reduced loan demand, increased bank risks and somewhat tighter lending standards.

The results from the capital surplus/shortfall model (not shown) indicates that this model does not perform as well as the capital ratio model in terms of predicting the 2008:Q4 to 2009:Q3 decline in BHC loan growth. That is, the surplus/shortfall model explains only 1.3 percentage points of the 2.9 percentage point decline. That said, the conclusions obtained from the capital ratio—with respect to the importance of real GDP growth and net charge-off rates in explaining BHC loan growth relative to the role of bank capital—continue to hold.[25]

5.2 Decomposition of commercial bank loan growth

The VAR model's identification of the shocks underlying the fluctuations in all of the series of the model means that it is possible to decompose movements in model series over time into different sources of shocks. This is done in Figure 11. In all four panels of the chart we show the actual path of loan growth over the past three years—the solid black line—as well as the model's unconditional forecast—the dotted line. Then in each panel we show the path of loan growth that would be implied by the unconditional forecast and a specific sequence of innovations, where this varies by panel. This allows us to determine the relative importance of structural innovations to capital ratios in explaining the recent decline in loan growth. Here we find that structural innovations in capital ratios explain very little of the below-par pace of loan growth over the past year. Prior to the recent rebound in economic growth—following the sharp contractions in activity in 2008:Q4 and 2009:Q1—macro innovations appear to have accounted for much of the decline in loan growth, while standards innovations account for a notable portion too. Over the last two quarters of the simulation period own-variable innovations to loan growth account for the bulk of the decline.

To some extent the large recent contributions of own-variable loan growth innovations reflect the out-of-sample nature of our simulation exercise. The same exercise performed with a model estimated through to 2009:Q3—see Figure 12—attributes much less of the recent decline in loan growth to own-variable shocks and much more to standards and macro shocks. Note, however, that capital ratio shocks continue to explain just a small portion of the decline in loan growth.

6 Summing up

Motivated by the recent importance of the issue of how bank capital influences the extension of bank credit, this paper applies a number of different methods to address this issue. We first apply

[25]It is interesting to note that even though our parameter estimates for the effect of capital surplus/shortfall on BHC loan growth are similar to those in Hancock and Wilcox (1993, 1994), the size of deviations of capital from target are much smaller now than they were in the early 1990s. As a result, for a fairly similar contraction in bank loan growth in the 1990-91 and the 2007-09 recessions, we find a more important role in the recent episode for loan demand conditions—proxied by the GDP growth rate—than for shocks to bank capital. Clearly, this is not surprising given that the contraction in economic activity has been at least three times larger during the 2007-09 recession than during the 1990-91 recession. Therefore, despite similar parameter estimates, this difference leads us to conclude that the contribution of bank capital shortfalls on loan growth is smaller than the Hancock and Wilcox findings.

to more current data bank lending models that were developed by Bernanke and Lown (1991) and Hancock and Wilcox (1993,1994) in the early-to-mid 1990s to address precisely this question. This analysis finds relatively modest effects of BHC capital-to-asset ratios on BHC loans. We then consider the effects of capital ratios on lending using macroeconomic time series and aggregate commercial bank balance-sheet data in a modified variant of one of the extended versions of Lown and Morgan's (2006) vector autoregression (VAR) model, which includes as one of its variables the bank capital-to-assets ratio. Although we find larger effects of capital ratio shocks on loan growth in this model than in the panel regressions—likely due to possible survivor bias in the panel results, as well as the reflection of general equilibrium concerns and feedback effects in the VAR results—we still find fairly modest effects.

These results are in marked contrast to the constant leverage view, which has been quite influential over the crisis and associated recession in shaping forecasters' and policymakers' views on the size of the effect of bank capital ratio changes on loan growth. In particular, this view predicts substantially larger effects of bank capital-ratio changes on loan growth (on the order of six to ten times) than those found in either our panel or time-series estimation results. We attribute the difference between our results and the constant leverage view to the fact that the scatter plot of asset growth against leverage growth for commercial banks, which shows large deviations of the former and modest deviations of the latter and forms the basis of this view, is not very robust across time and in particular does not hold for the post-Basel sample period over which our analysis is conducted.

While our empirical results suggest relatively modest effects of both capital shortfalls and capital ratios on loan growth, we find more notable roles for other factors such as economic activity and increased bank risk perception. One interpretation of this result is that banks and BHCs give relatively little consideration to their capital position when deciding whether to grant loans and instead allow other factors such as loan demand and bank risk to guide their decision making. If this is the case this would provide one explanation for the slowing in loan growth over the first three quarters of 2009 despite the sizable capital injections that occurred in 2008:Q4 as part of the CPP. However, another interpretation of our results is that existing measures of bank capital do not capture the true capital position of banks that reflect the risks present in financial intermediation. Clearly, this interpretation calls into question the validity of existing risk-based regulatory capital measures and suggests a need for such measures to be improved.

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Table 1: **Summary Statistics for BHC-Level Panel Data**

This table presents summary statistics for the sample of 140 BHC from 1992 to 2008 used in the panel estimation. The data are taken from the Consolidated Financial Statements for BHCs (FR Y-9C). The sample excludes institutions with missing observations in total assets, loans and capital, and also BHCs that remain in the sample for less than 30 quarters. To minimize the influence of outliers, observations with more than 50 percent growth in total assets over a single quarter were also removed. The remaining variables were winsorized at the 1 percent and 99 percent levels.

Variable	N	Median	Mean	Std.Dev.
Total Assets ($ million)	11107	3595.30	27302.91	145408.60
Total Loan Quarterly growth	11107	2.15%	3.00%	5.03%
C&I Loan Quarterly growth	11107	2.09%	2.91%	8.82%
Equity/Assets	11107	8.17%	8.39%	2.16%
Tier 1 Capital ratio	7320	10.72%	11.38%	3.29%
Total Capital ratio	7320	12.54%	13.24%	2.20%
TCE ratio	9139	6.83%	7.02%	2.20%
Return on Assets	11107	0.1396	0.1296	0.8287
Securities/Assets	9460	0.2257	0.2424	0.1131
Net Chargeoffs/Assets	11099	0.1687	0.2963	0.4288

Table 2: **Determinants of BHC Capital Asset Targets**

This table presents the fixed-effect regression estimates of equation (2) for the determinants of BHC's target capital ratios. Bank-specific variables include $Size$, measured as the log of total assets, the return on assets ROA, the ratio of net charge-offs to total assets, the shares of C&I loans, Real Estate loans, Consumer loans, and Investment Securities in total assets. The regression also includes an institutional variable, called regulatory pressure, defined as a dummy variable that equals one if the BHC's equity capital ratio is less than 1.5 percentage points above the minimum of 5 percent. Aggregate variables include the stock-market volatility index provided by the Chicago Board Options Exchange (CBOE S&P 100 volatility index), and the ratio of net charge-offs to total loans for the commercial banking sector. Regressions include quarterly dummies to control for seasonal factors. Robust t-statistics are given in parenthesis. . *, **, and *** denotes significance at the 10%, 5%, and 1% respectively.

	Model 1		Model 2	
	Estimate	t-stat	Estimate	t-stat
Lagged capital ratio	0.9108***	(87.60)	0.9189***	(87.91)
Size	0.0931***	(4.12)	0.0778***	(5.09)
ROA	0.0356	(1.48)	0.0373*	(1.76)
Aggregate Volatility	-0.0053***	(-4.67)	-0.0035***	(-4.09)
C&I loan share	-0.0097***	(-2.95)		
Real Estate loan share	-0.0065***	(-3.20)		
Consumer Loan share	0.0001	(0.01)		
Securities share	-0.0059***	(-2.92)		
Regulatory Pressure	-0.0260	(-0.58)	-0.0159	(-0.43)
Sector Chargeoff/Loan	0.1074**	(2.45)	0.0781**	(2.58)
Chargeoffs/Asset	0.0229	(0.60)	0.0094	(0.75)
intercept	-0.1584	(-0.42)	-0.5334**	(-2.56)
R^2	0.852		0.870	
N	8706		10512	

Table 3: **Effect of Capital Surplus on BHC Lending growth**

This table reports the fixed-effect regression estimates from a regression of bank lending growth on a measure of BHC's capital surplus/shortfall and control variables. The dependent variable is the quarterly growth rate of total loans and C&I loans. Explanatory variables are as follows: four lags of loan growth, the measure of capital surplus, calculated as percent deviations of actual capital level relative to estimated capital targets, the ratio of investment securities to total assets, the ratio of net charge-offs to total assets, three lags of lending standards (fraction of banks reporting tightening lending in the Senior Loan officer Opinion Survey), four lags of quarterly GDP growth, four lags of the quarterly change in the Fed Funds rate, and four lags of the inflation rate (cumulative percent change of the Consumer Price Index during the previous three months). Regressions include quarterly dummies to control for seasonal factors. Because an auxiliary equation is used to estimate the capital surplus variable, standard errors are adjusted to correct for the generated regressor bias through bootstrap methods. χ^2-statistics are given in parenthesis. *, **, and *** denotes significance at the 10%, 5%, and 1% respectively.

	Total Loans		C&I Loans	
	Estimate	χ^2-stat	Estimate	χ^2-stat
Loan Growth Lags (sum)	0.1598***	(15.49)	0.0731	(1.34)
Surplus capital	0.0523***	(75.98)	0.0602***	(24.78)
Securities/Asset	0.0668***	(20.25)	0.0559**	(4.03)
Net Chargeoffs/Asset	-1.6177***	(25.02)	-1.6410***	(8.59)
Lending Standards (sum)	-0.0181***	(8.24)	-0.0274***	(6.47)
GDP Growth Lags (sum)	0.8562**	(5.52)	2.1685***	(7.65)
Fed Funds Lags (sum)	-0.4534	(1.83)	-0.0059	(0.00)
Inflation Lags (sum)	-0.1918	(0.07)	-1.7849	(2.19)
intercept	0.5080	(0.42)	1.5000	(0.99)
R^2	0.215		0.098	
N	7793		7760	

Table 4: **Effect of Capital shocks on BHC lending growth**

This table reports the fixed-effect regression estimates from a regression of bank lending growth on capital ratios and control variables. Columns 1-4 report estimation results for each of the different capital ratios. The dependent variable is the quarterly growth rate of total loans. Explanatory variables are as follows: four lags of total loan growth, the capital ratio as indicated in each column, the ratio of investment securities to total assets, the ratio of net charge-offs to total assets, three lags of lending standards (fraction of banks reporting tightening lending in the Senior Loan officer Opinion Survey), four lags of quarterly GDP growth, four lags of the quarterly change in the Fed Funds rate, and four lags of the inflation rate (cumulative percent change of the Consumer Price Index during the previous three months). Regressions include quarterly dummies to control for seasonal factors. Robust t and F-statistics are given in parenthesis. *, **, and *** denotes significance at the 10%, 5%, and 1% respectively.

	Equity-to-Asset Ratio (1)		Risk-based Capital Ratio (2)		Risk-based Tier 1 Ratio (3)		TCE Ratio (4)	
	Estimate	t/F-stat	Estimate	t/F-stat	Estimate	t/F-stat	Estimate	t/F-stat
Loan Growth Lags (sum)	0.1648***	(33.04)	0.1583***	(24.22)	0.1571***	(24.07)	0.1743***	(37.66)
Capital ratio	0.1450***	(3.23)	0.1572***	(4.69)	0.1674***	(4.98)	0.2521***	(5.75)
Securities/Asset	0.0556***	(5.64)	0.0431***	(2.76)	0.0421***	(2.66)	0.0498***	(4.84)
Net Chargeoffs/Asset	-1.6835***	(-6.75)	-1.8524***	(-6.92)	-1.8346***	(-6.86)	-1.6832***	(-6.65)
Lending Standards (sum)	-0.0135**	(10.46)	-0.0130***	(7.09)	-0.0130***	(7.09)	-0.0131***	(9.89)
GDP Growth Lags (sum)	0.8628***	(10.41)	1.0884***	(9.61)	1.0684***	(9.25)	0.8508***	(10.67)
Fed Funds Lags (sum)	-0.1164	(0.28)	-0.5391*	(2.88)	-0.5696*	(3.17)	-0.1792	(0.64)
Inflation Lags (sum)	-1.1988***	(6.65)	-0.4573	(0.44)	-0.3482	(0.26)	-0.7072	(2.31)
intercept	-0.1001	(-1.90)	-1.2893	(-1.64)	-1.1345	(-1.49)	-0.7761	(-1.28)
R^2	0.186		0.196		0.197		0.190	
N	8549		6658		6658		8549	

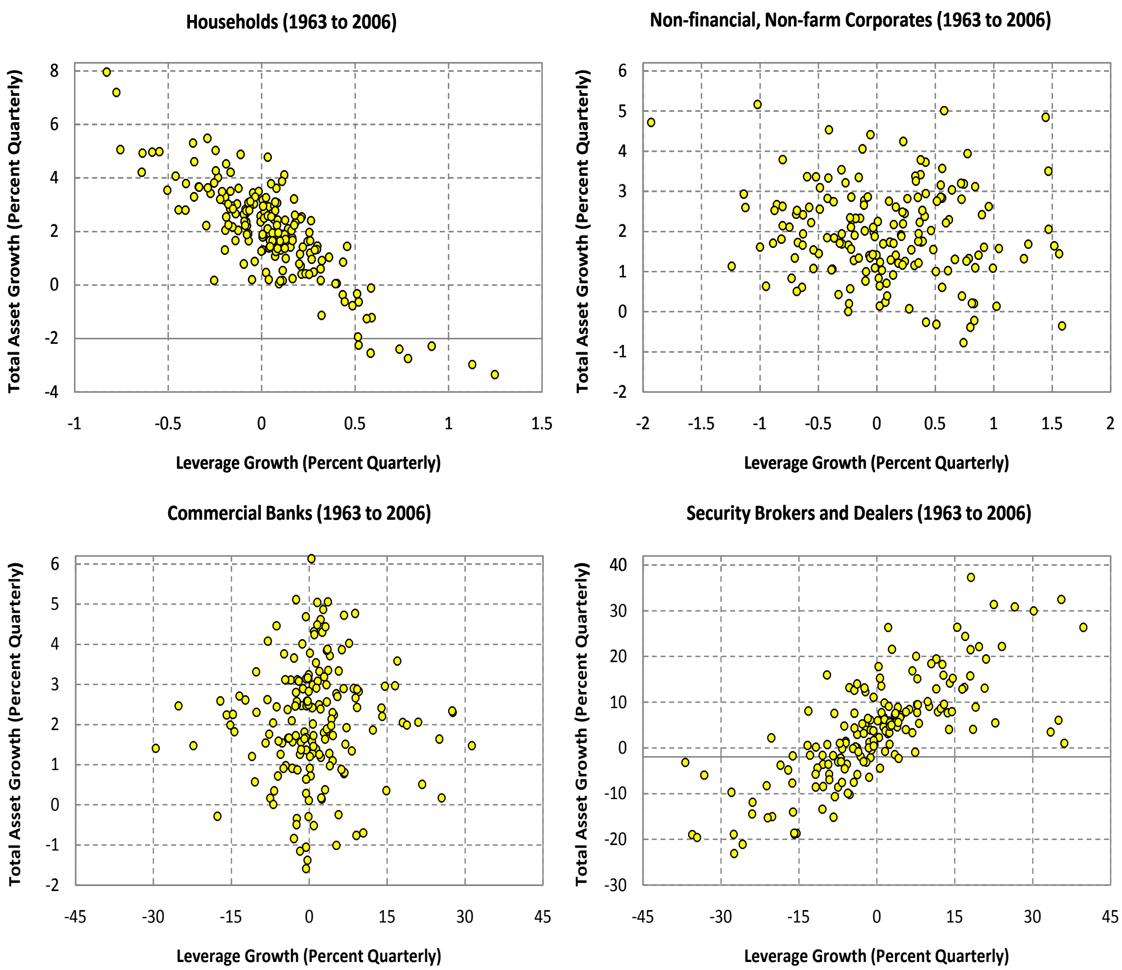

Figure 1: Assets and Leverage Growth of Various Institutions in the Flow of Funds Accounts

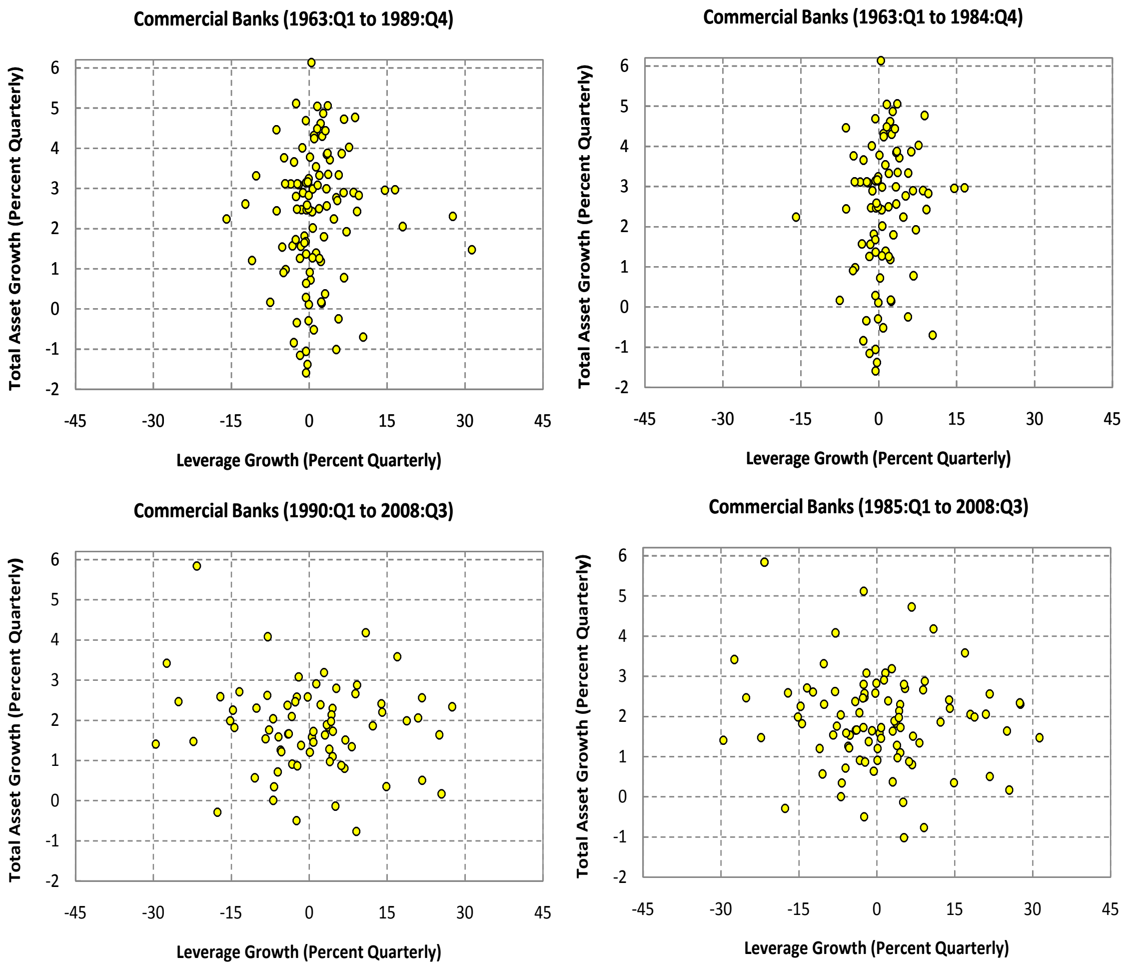

Figure 2: Assets and Leverage of Commercial Banks Across Different Sample Periods

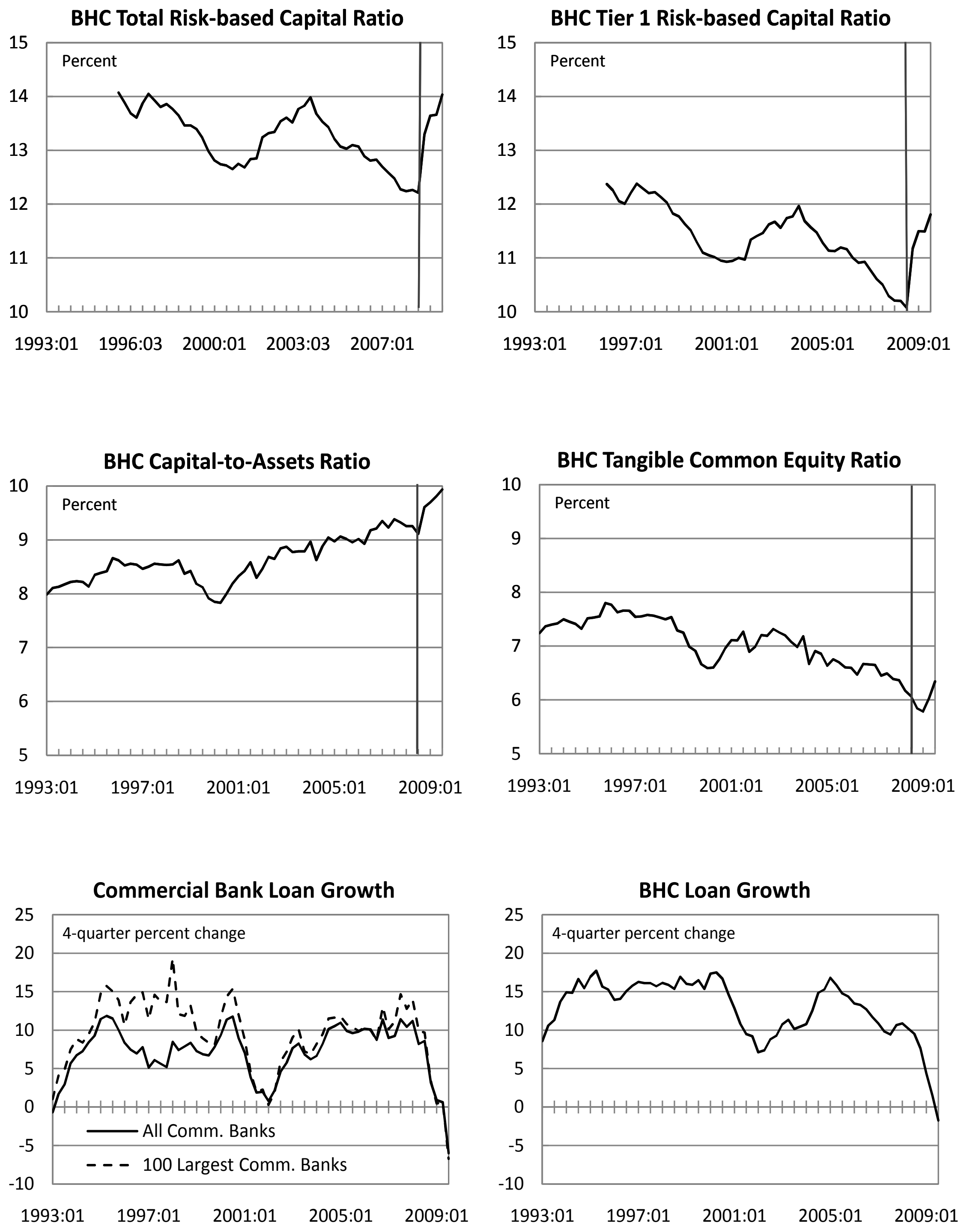

Figure 3: BHC Capital Ratios and Commercial-bank and BHC Loan Growth

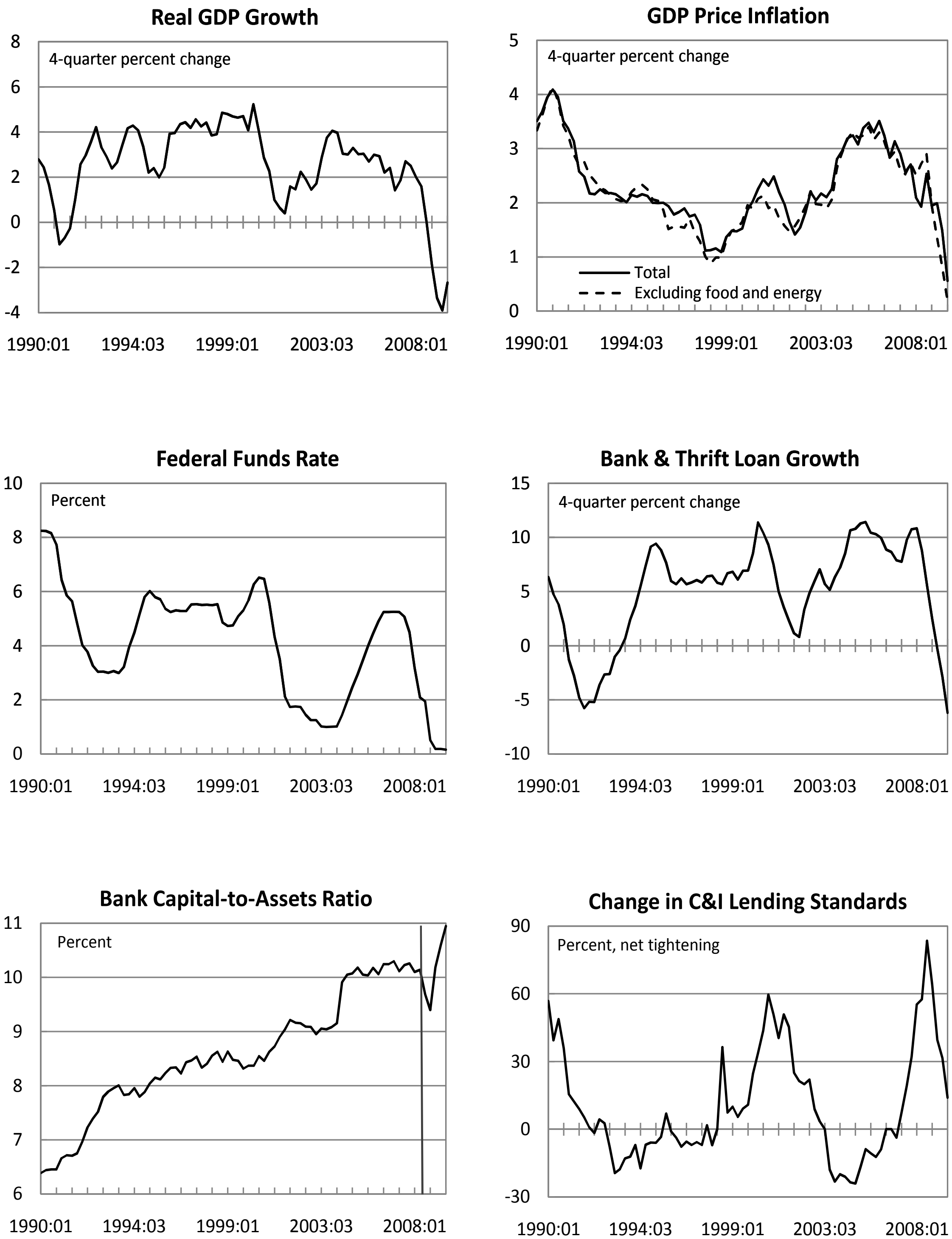

Figure 4: Aggregate Data Used in Panel and VAR models

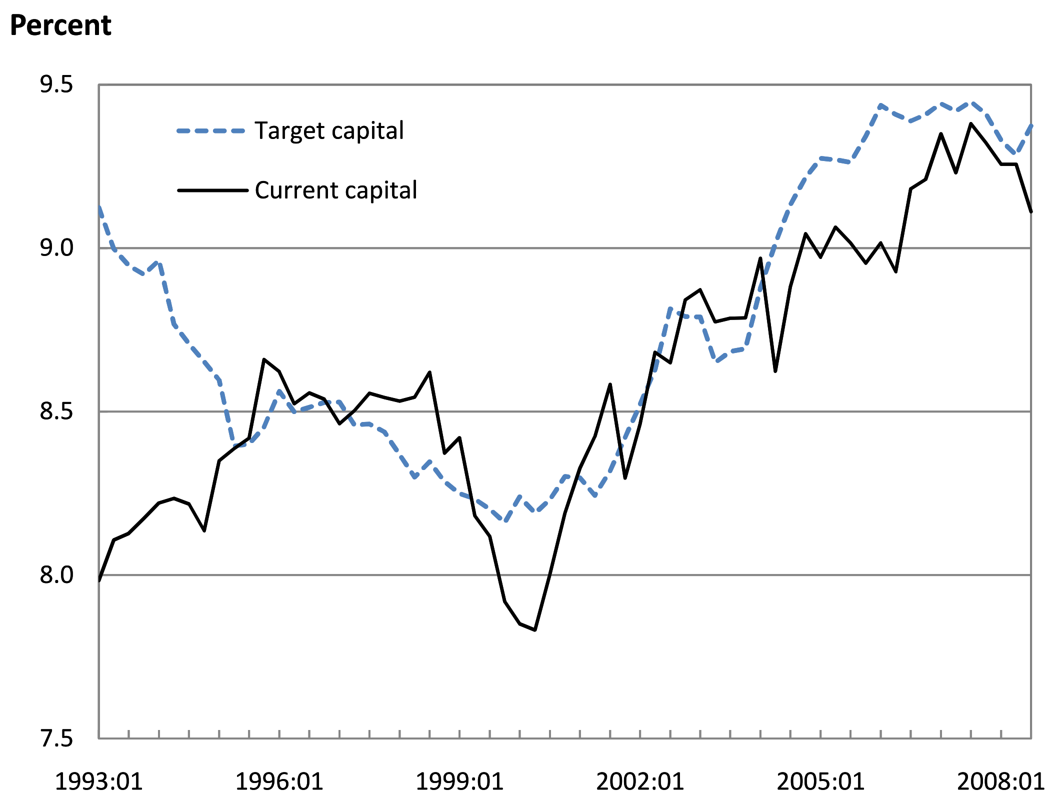

Figure 5: Average Actual and Target BHC Capital-to-asset Ratios

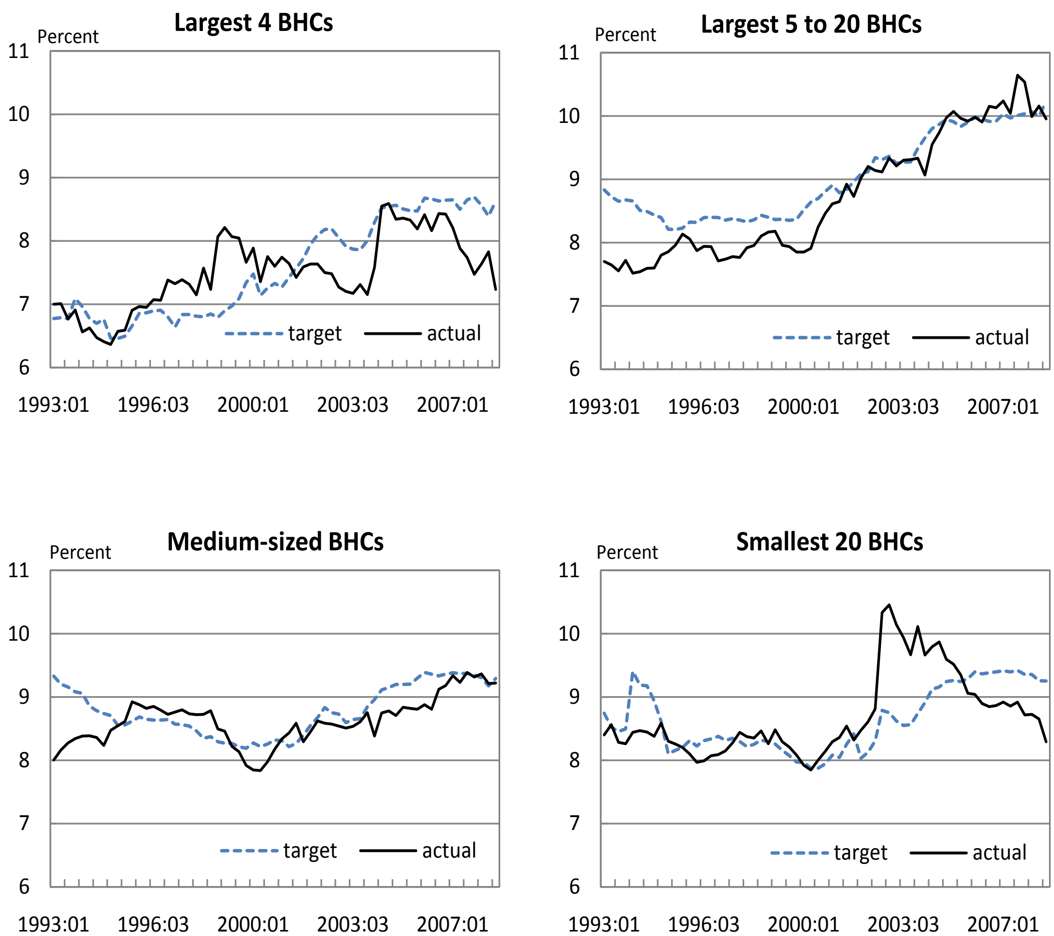

Figure 6: Average Actual and Target Capital-to-asset Ratios by BHC size

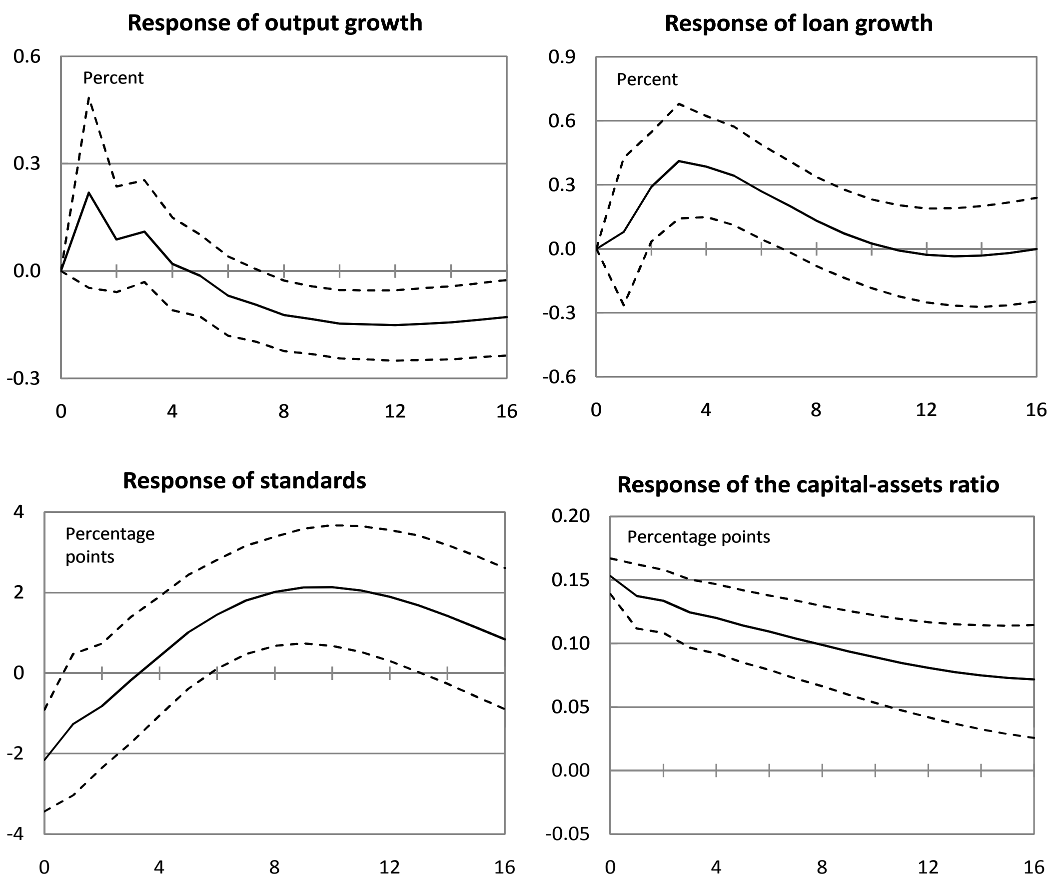

Figure 7: Response to a Capital-to-asset Ratio Shock

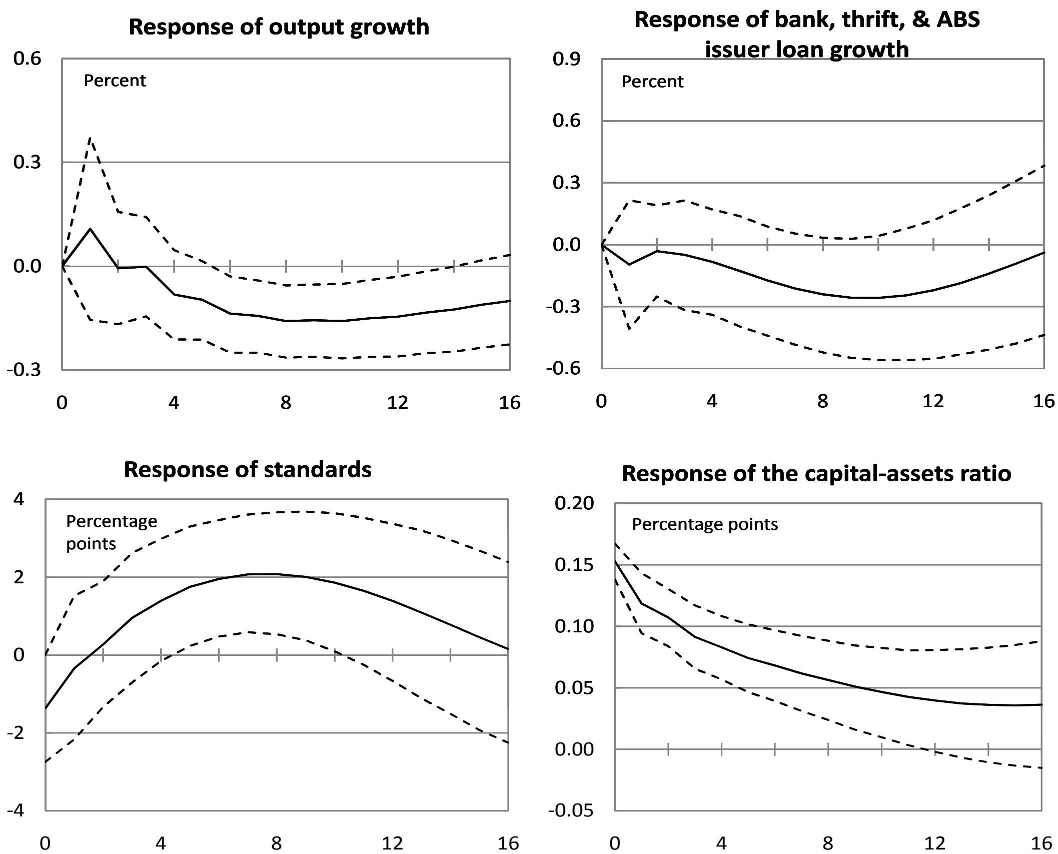

Figure 8: Response to a Capital-to-asset Ratio Shock (incl. credit extended by ABS issuers)

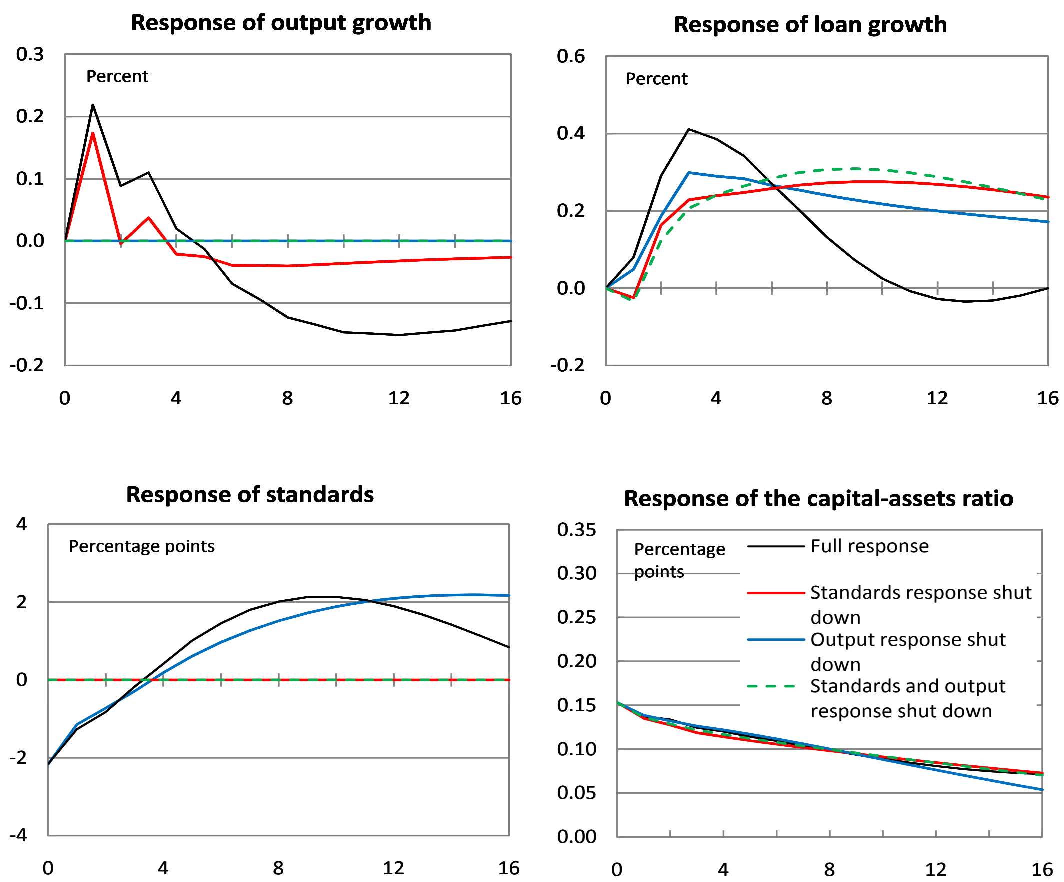

Figure 9: Response to a Capital-to-asset Ratio Shock (with endog. responses shut down)

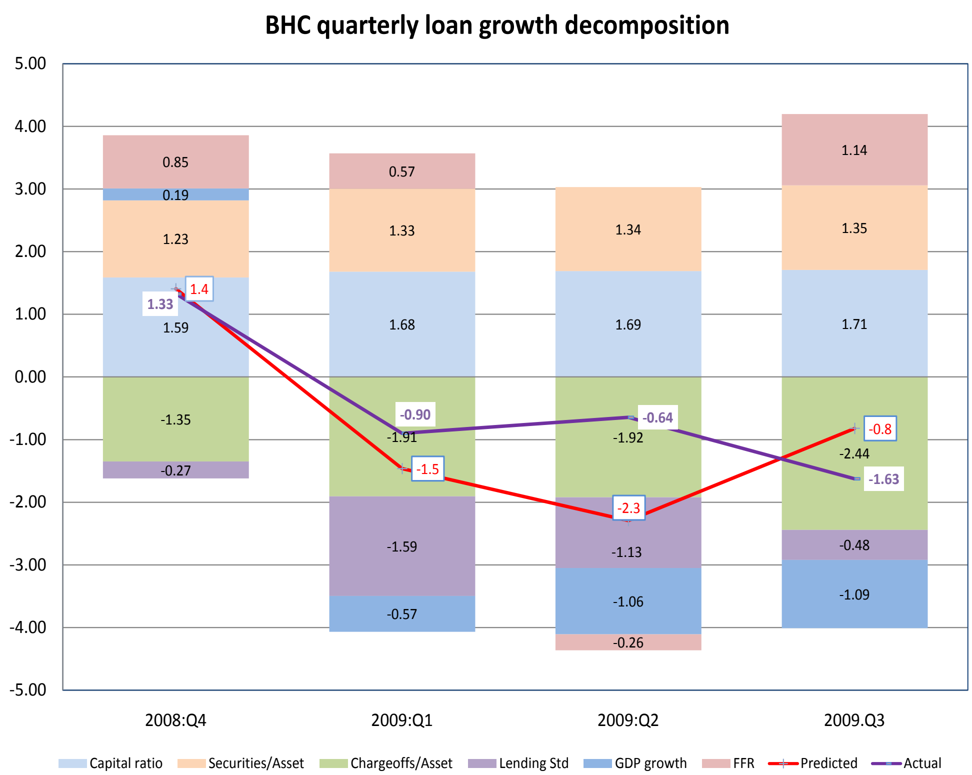

Figure 10: Decomposition of BHC Loan Growth

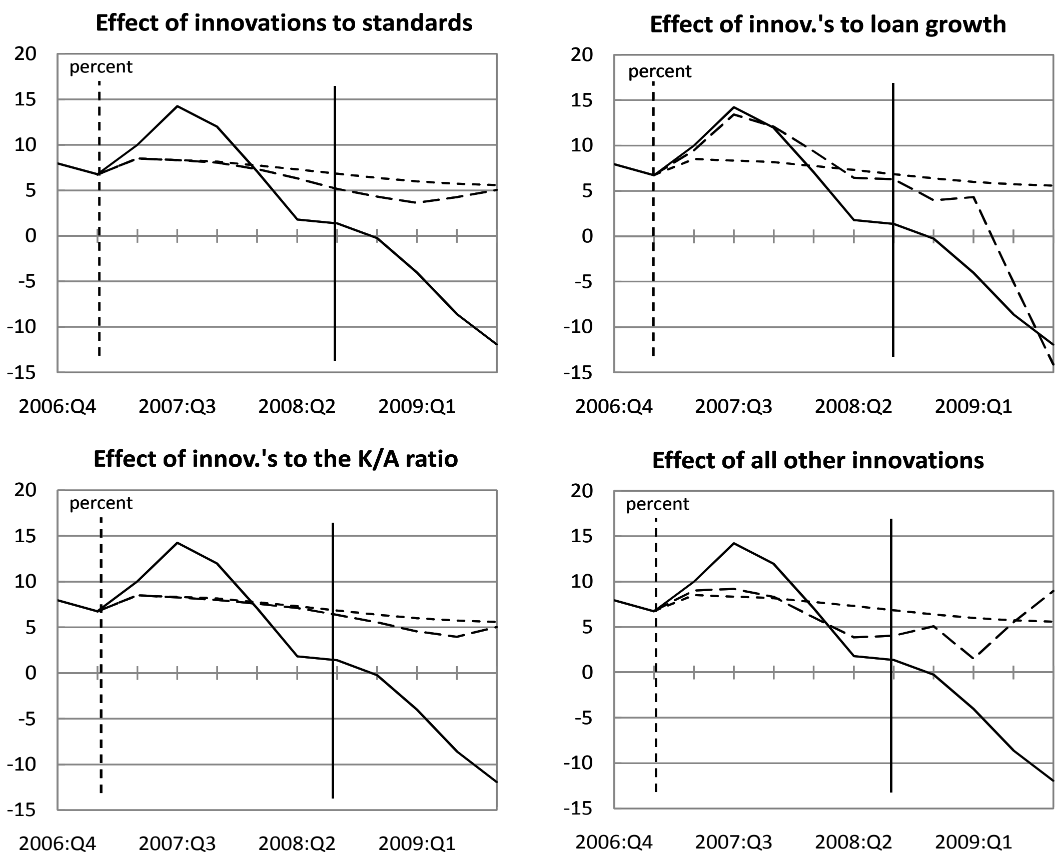

Figure 11: Decomposition of Loan Growth (model estimated through 2008:Q3)

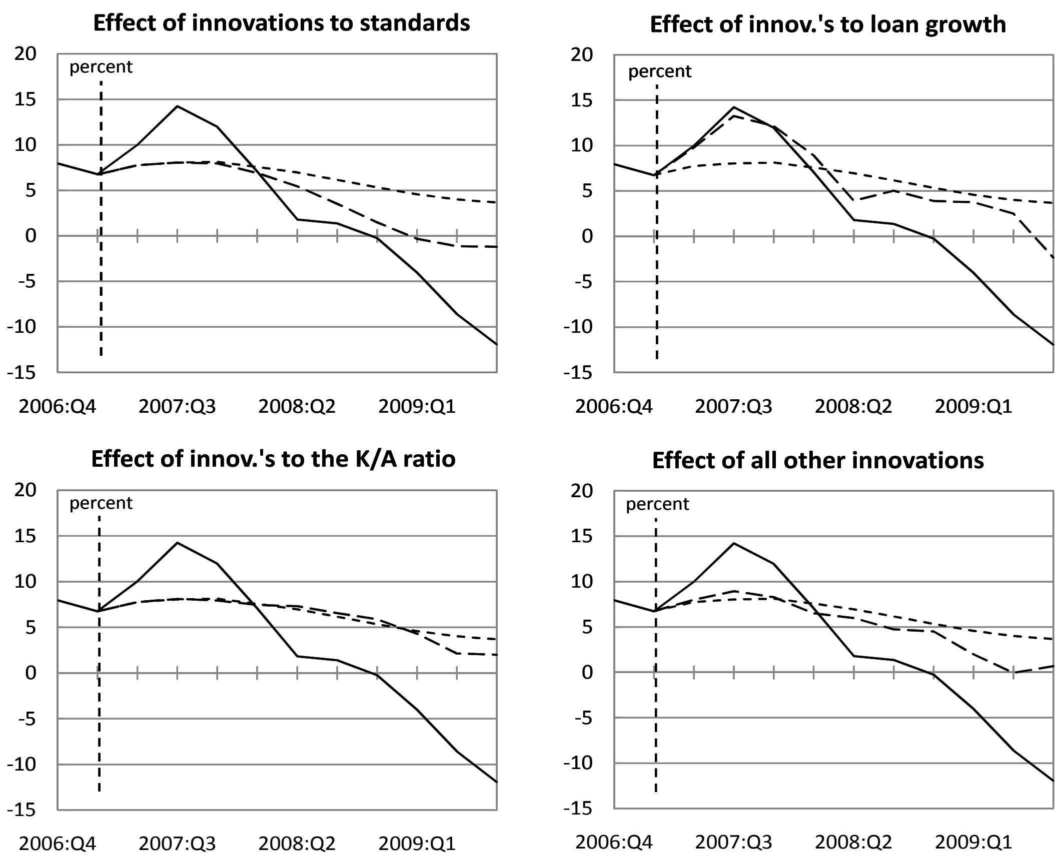

Figure 12: Decomposition of Loan Growth (model estimated through 2009:Q3)