Motivation

- The effect of changes in bank capital on the extension of bank credit has been one of the most critical financial-to-real linkage questions of the recent crisis.
  - Early in the crisis this question was central to calculating the effects of bank capital losses on bank lending (and activity).
  - Later, this question was key to calculating the effects on bank lending (and activity) of TARP-related capital injections.
- Theory only informs the *sign* of the effect of bank capital on lending, with many possible values for the *size*; specifically,
  - Zero, if banks can accommodate capital losses with no change in assets; or,
  - An amount equal to the leverage ratio, if banks manage assets to maintain a constant leverage ratio.
- The effect of bank capital on credit is ultimately an empirical question.
An active literature from the early-1990s developed models well suited to evaluating the effect of bank capital on loan growth. See, for example,

- Bernanke and Lown (1991);
- Hancock and Wilcox (1993, 1994); and,

This paper draws on this literature, as well as more recent approaches, to:

- Examine how bank capital affects bank lending; and,
- Study the impact of TARP capital injections on U.S. bank lending.

Our empirical analysis finds:

- Relatively modest effects of bank capital on lending; and,
- More notable roles for economic activity and bank’s perception of borrower riskiness.
Our results suggest considerably smaller effects of TARP injections on lending relative to U.S. Treasury estimates.

- Analysis for a panel of BHCs (who got $182 billion in TARP funds) suggests a $60 to $273 billion increase in loan volumes.
- Analysis at the aggregate level for commercial banks (whose top-holders got about $250 billion in TARP funds) suggests a $300 billion increase in loan volumes.

When discussing the likely effects on lending of capital injections and the anticipated capital raising of the stress tests, U.S. Treasury Secretary Geithner stated that:

- “A dollar of capital generates between eight and twelve dollars of lending capacity.” (See TG-95, April 21, 2009.)

The U.S. Treasury estimates would therefore suggest a $1.5 to $3 trillion boost to lending stemming from TARP injections.

Our results also provide an explanation for the notable slowing in loan growth over 2009 despite sizable capital injections.
An alternative – more prominent – view

- The constant leverage view has had a more significant influence on forecasters’ and policymakers’ perceptions as to the effect of bank capital on lending.
  - This view suggests that – because banks face difficulties raising equity – a $1 capital loss reduces loan volumes by a dollar amount equal to the the leverage ratio (i.e., about $8 to $12).
  - These effects of capital on lending are many times larger than our regression analysis finds.

- Hatzius (2007, 2008) relied on this assumption in considering the restraint on lending from bank capital losses.
- The U.S. Treasury *appears* to have relied on this assumption in estimating the effects of TARP injections on potential lending.
- The recent emphasis towards this view appears to be based on a scatterplot reported by Adrian and Shin (2007), which shows that commercial banks maintain constant leverage.
Commercial banks appear to manage their assets to maintain a constant leverage ratio.

How is this scatterplot reconciled with our regression results?
Reconciling our results

- What accounts for the difference between our results and the figure in Adrian and Shin (2007) is sample period.

- Adrian and Shin consider the sample 1963 to 2006.

- Our analysis starts in the early 1990s, reflecting the significant structural changes in banking stemming from:
  - The adoption of Basel I in the U.S. in the early 1990s; and,
  - The removal of Reg. Q and the episodes of disintermediation prior to the mid-1980s.

- There is *much* less evidence of commercial banks maintaining constant leverage ratios in later sample period.
Across the full sample period ...
Across different sample periods ...

- There is little evidence of banks maintaining constant leverage ratios in the post-1990 sample.
Building on the early 1990s literature we first take a panel approach to consider the effect of bank capital on lending.

Our panel models are styled on the cross-section models of Bernanke & Lown (1991) and Hancock & Wilcox (1993, 1994).

A concern with our panel-data analysis is survivor bias.

Another concern is that it does not capture the general equilibrium channels of the effects of bank capital on lending.

A vector auto regression model on aggregate data is one way to address such issues.

Here we use a variant of Lown & Morgan’s (2006) VAR model.

We then consider some policy questions; specifically,

- The impact of TARP capital injections on U.S. bank lending; and,
- The reasons for recent reductions in U.S. bank loan growth despite sizable capital injections.
Our panel regression approaches

- We model the loan growth of a panel of 154 large BHCs as functions of supply and demand factors (similar to Kashyap and Stein), with one of our supply factors being BHC capital:

\[
\frac{\% \Delta \text{loan}_{i,t}}{\% \Delta \text{gdp}_t} = \sum_{s=1}^{4} \alpha_s \cdot \% \Delta \text{loan}_{i,t-s} + \sum_{s=1}^{4} \gamma_s \cdot \% \Delta \text{gdp}_{t-s} + \sum_{s=1}^{4} \delta_s \cdot \text{inf}_{t-s}
\]

\[
+ \sum_{s=1}^{4} \beta_s \cdot \Delta \text{rff}_{t-s} + \sum_{s=1}^{4} \zeta_s \cdot \text{std}_{t-s} + \phi \cdot \text{liqu}_{i,t-1} + \chi \cdot \text{chg}_{i,t-1}
\]

\[
+ \psi \cdot \begin{cases} 
\text{capital surplus/shortfall (}\hat{Z}_{i,t}\text{), or} \\
\text{capital/ assets ratio (}\hat{k}_{i,t-1}\text{)} 
\end{cases} + \epsilon_{i,t}.
\]

- We consider two possible ways capital can affect loan growth:

1. Via the BHC’s capital surplus/shortfall from some target level, as calculated in an ancillary equation (Hancock & Wilcox); or

2. Via the BHC’s capital/assets ratio (Bernanke & Lown).
We first derive the target capital-to-assets ratio.

- The target capital-to-assets ratio, $k_{i,t}^*$, is modeled as a linear function $\theta \cdot X_{i,t-1}$ of:
  - Bank-specific variables (such as, bank size, earnings, and risk);
  - Institutional variables (such as, regulatory pressure); and
  - Aggregate variables (such as, stock-market volatility and the aggregate net charge-off rate).

- The actual capital-to-assets ratio, $k_{i,t}$, adjusts slowly to its target: $k_{i,t} = \alpha + (1 - \lambda) \cdot k_{i,t-1} + \lambda \cdot \theta \cdot X_{i,t-1} + \epsilon_{i,t}$.

- Each BHC’s estimated target capital-to-assets ratio is then: $\hat{k}_{i,t}^* = \hat{\theta} \cdot X_{i,t-1}$. 

Go to: Main estimation results from this step.
We then calculate target capital and the capital shortfall/surplus.

- Target capital, \( \hat{K}_{i,t} \), is derived based on actual assets, \( A_{i,t} \), and the estimated target capital-to-assets ratio, \( \hat{k}_{i,t}^* \).

- The capital surplus/shortfall, \( \hat{Z}_{i,t} \), is \((K_{i,t} - \hat{K}_{i,t}^*)/\hat{K}_{i,t}^*\).

The capital surplus/shortfall, \( \hat{Z}_{i,t} \), is then included in the first version of our loan-growth regression:

\[
\%\Delta \text{loan}_{i,t} = \sum_{s=1}^{4} \alpha_s \cdot \%\Delta \text{loan}_{i,t-s} + \sum_{s=1}^{4} \gamma_s \cdot \%\Delta \text{gdp}_{t-s} + \sum_{s=1}^{4} \delta_s \cdot \text{inf}_{t-s} \\
+ \sum_{s=1}^{4} \beta_s \cdot \Delta \text{rff}_{t-s} + \sum_{s=1}^{4} \zeta_s \cdot \text{std}_{t-s} + \phi \cdot \text{liqu}_{i,t-1} + \chi \cdot \text{chg}_{i,t-1} \\
+ \psi \cdot \hat{Z}_{i,t} + \epsilon_{i,t}.
\]
We find that a 1 p.p. shortfall in capital implies a 0.3 p.p. restraint in loan growth. This translates to:

- A $1 shortfall in actual capital from target resulting in a $1.86 reduction in loans over the following year.

This is a bit bigger than Hancock and Wilcox’s (1993, 1994) finding that a $1 shortfall in capital from a bank’s target results in a $1.50 reduction in loans over the following year.

This is notably smaller than (i.e., about one-quarter to one-sixth the size of) the $8 to $12 decrease that would obtain were banks to maintain a constant leverage ratio.

We find a more notable role for:

- Demand conditions (proxied by GDP growth); and,
- Borrower risk (proxied by net charge-offs).
Divergence between actual and target ratios are quite persistent.

Divergence conforms to conventional wisdom; *i.e.*, the build-up of large surpluses in the 1990s.

The capital surplus/shortfall approach is our preferred method for examining the effect of bank capital on lending.

However, it is vulnerable to our mis-specifying target capital.

We therefore also consider the capital/assets ratio approach.
The capital-to-assets ratio approach

This approach has only one step; the estimation of the loan-growth regression now with the bank capital ratio, $k_{i,t}$:

$$\%\Delta \text{loan}_{i,t} = \sum_{s=1}^{4} \alpha_s \cdot \%\Delta \text{loan}_{i,t-s} + \sum_{s=1}^{4} \gamma_s \cdot \%\Delta \text{gdp}_{t-s} + \sum_{s=1}^{4} \delta_s \cdot \text{inf}_{t-s}$$

$$+ \sum_{s=1}^{4} \beta_s \cdot \Delta \text{rff}_{t-s} + \sum_{s=1}^{4} \zeta_s \cdot \text{std}_{t-s} + \phi \cdot \text{liqu}_{i,t-1} + \chi \cdot \text{chg}_{i,t-1}$$

$$+ \psi \cdot k_{i,t-1} + \epsilon_{i,t}.$$ 

We consider several measures of the capital-to-assets ratio:

- The equity capital-to-assets ratio;
- The total risk-based capital ratio;
- The tier-one risk-based capital ratio; and,
- The tangible common equity ratio.
Key results from the capital-to-assets ratio approach (1)

- We find that a 1 p.p. decrease in the capital-to-assets ratio restrains annualized loan growth 0.7 p.p. to 1.2 p.p.

- Bernanke’s and Lown’s (1991) found that a 1 p.p. decrease in the equity capital-to-assets ratio restrains annualized loan growth 2 p.p.; our estimate of 0.7 p.p. is a good bit smaller.

  - Bernanke’s and Lown’s bank-level analysis was on New Jersey banks, which are much smaller than the BHCs in our sample.

  - Bernanke’s and Lown’s model only included the capital ratio in their bank-level regressions, which could be capturing the effects of other bank-specific variables.

- We do obtain a larger estimate of 1.5 p.p. when we perform a cross-section regression over the period 2007:Q3 to 2008:Q3.
Key results from the capital-to-assets ratio approach (2)

- Under the constant leverage assumption, the p.p. reduction in annualized bank lending growth implied by a 1 p.p. decrease in the capital-to-assets ratio is equal to the leverage ratio.
  - Both our results and those of Bernanke and Lown are notably smaller than the constant leverage assumption would imply.

- Our estimation results for other model variables are similar to those found for the surplus/shortfall equation; that is, more notable roles are found for:
  - Demand conditions (proxied by GDP growth); and,
  - Borrower risk (proxied by net charge-offs).

Go to: Estimation results.

Go to: Addressing endogeneity.
We estimate a vector auto regression – similar to Lown & Morgan – consisting (in the following order) of:

- Real GDP growth;
- GDP price inflation (excluding food and energy);
- The federal funds rate;
- The growth rate in *commercial bank and thrift* lending from the FoF accounts;
- The aggregate capital ratio of the *commercial bank* sector; and,
- C&I lending standards from the SLOOS.

We examine the response of loan growth to a capital ratio shock (for comparison with the panel results).

These shocks represent the component of changes in the capital ratio that are exogenous to other variables.
Response to a capital ratio shock (1)

Go to: Exploration of the output growth response.

Berropside & Edge  The effects of bank capital on lending
A 1 p.p. increase in the capital ratio ⇒ a 2-1/2 p.p. boost to lending in the first year following the impetus.

- This is four times larger than the effect found in the panel regressions.

A larger effect in the VAR is not that surprising.

- The VAR model is not susceptible to survivor bias.
- Small banks are present in the VAR model’s data.
- The VAR model has endogenous responses of several variables.

We can shut down the endogenous responses of standards and GDP growth (individually and together).
Without the standards and output responses a 1 p.p. increase in the capital ratio boosts loan growth 1-1/4 p.p.
Summary of regression results

- Our results indicate that capital-to-asset ratios affect lending much less than the constant leverage view would suggest.

- The constant leverage view suggests that the p.p. reduction in annualized lending growth implied by a 1 p.p. decrease in the capital-to-assets ratio is equal to the leverage ratio.
  - In our panel regressions: \( \text{A} \downarrow 1 \text{ p.p. in the K/A ratio} \Rightarrow \text{a} \downarrow 0.7 \text{ p.p. to 1.2 p.p. in loan growth.} \)
  - In our VAR model (with endogenous feedback): \( \text{A} \downarrow 1 \text{ p.p. in the K/A ratio} \Rightarrow \text{a} \downarrow 2-1/2 \text{ p.p. in loan growth.} \)
  - In our VAR model (without endogenous feedback): \( \text{A} \downarrow 1 \text{ p.p. in the K/A ratio} \Rightarrow \text{a} \downarrow 1-1/4 \text{ p.p. in loan growth.} \)

- The constant leverage view suggests that the dollar reduction in lending implied by a $1 shortfall of capital from target is equal to the leverage ratio.
  - Our panel regressions suggest that a $1 capital shortfall results in a $1.86 reduction in lending.
The BHCs in our panel received $182 billion in TARP funds. These TARP injections generated:

- A ↑14 p.p. in the capital surplus, thereby implying:
  - A ↑3.5 p.p. in annualized loan growth; and,
  - A ↑$273 billion in the volume of loans.

- A ↑1.4 p.p. in the equity capital-to-assets ratio, thereby implying:
  - A ↑1.0 p.p. in annualized loan growth; and,
  - A ↑$60 billion in the volume of loans.

- A ↑1.7 p.p. in the risk-based capital ratio, thereby implying:
  - A ↑1.4 p.p. in annualized loan growth; and,
  - A ↑$86 billion in the volume of loans.
In the VAR model the $250 billion in TARP funds injected into the banking system generated a ↑1.4 p.p. in the equity capital-to-assets ratio, thereby implying:

- A ↑3.7 p.p. annualized loan growth in the first year following the injection; and,

- An eventual ↑5 percent or ↑$300 billion in loan volumes.

The panel and VAR estimates are small relative to the $1.5 trillion to $3 trillion increase in lending capacity suggested by the Treasury.
The slowdown in BHC lending growth is:

- Mostly accounted for by reduced demand, increased bank risk and tighter lending standards.
- These factors offset the positive impact of K/A ratio.
The slowdown in commercial bank lending growth is:

- Mostly accounted for by demand, standards, and own-variable innovations;
- About one-fifth accounted for by K/A ratio innovations.
This paper applies a number of different methods to examine how bank capital influences the extension of bank credit.

- Our analysis based on panel data finds relatively modest effects of BHC capital on lending.
- Macroeconomic time series and aggregate commercial bank balance sheet data finds larger – but still modest – effects of capital ratio shocks on loan growth.

Our results are in contrast to the constant leverage view, which predicts changes in loan growth on the order six to fifteen times larger than our regression analysis finds.

Our empirical results find more important roles for other factors such as economic activity and banks’ perception of borrower riskiness.
Our results provide one explanation for the notable slowing in loan growth over 2009 despite sizable capital injections.

- Banks and BHCs give little consideration to their capital position when deciding whether to lend relative to loan demand and risk.

Our results could also mean that existing measures of bank capital do not capture the “true” capital position of banks.

- This interpretation calls into question whether existing risk-based regulatory capital measures are valid and suggests that such measures need to be improved.
Total assets and leverage growth, all sectors

Households

Non-financial, Non-farm Corporates

Commercial Banks

Security Brokers and Dealers

Go to: Total assets and leverage growth, commercial banks.
Results from the ancillary regression

We find that BHCs with:

- Greater size have higher capital ratios (***)
- Greater portfolio diversification across different loan types and securities have lower capital ratios (***)
- Higher individual (insig.) and aggregate net charge-off rates (***) have higher capital ratios
- Higher profits have higher capital ratios (insig.); and,
- Greater regulatory pressure have lower capital ratios (insig.).

In addition, higher stock market volatility (*** is associated with lower capital ratios (likely reflecting cyclical fluctuations).

Although some coefficient signs differ from what might be expected, the implied target capital paths seem plausible and conforms to conventional wisdom.
Determinants of BHC capital-to-asset ratio targets

Dependent variable: BHC capital-to-asset ratio

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged capital ratio</td>
<td>0.9108***</td>
<td>0.9189***</td>
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<tr>
<td>Size</td>
<td>0.0931***</td>
<td>0.0778***</td>
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<tr>
<td>ROA</td>
<td>0.0356</td>
<td>0.0373*</td>
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<tr>
<td>Aggregate Volatility</td>
<td>-0.0053***</td>
<td>-0.0035***</td>
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<tr>
<td>C&amp;I loan share</td>
<td>-0.0097***</td>
<td></td>
</tr>
<tr>
<td>Real Estate loan share</td>
<td>-0.0065***</td>
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</tr>
<tr>
<td>Consumer Loan share</td>
<td>0.0001</td>
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<tr>
<td>Securities share</td>
<td>-0.0059***</td>
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<tr>
<td>Regulatory Pressure</td>
<td>-0.0260</td>
<td>-0.0159</td>
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<td>Sector Chargeoff/Loan</td>
<td>0.1074**</td>
<td>0.0781**</td>
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<tr>
<td>Chargeoffs/Asset</td>
<td>0.0229</td>
<td>0.0094</td>
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<tr>
<td>$R^2$</td>
<td>0.852</td>
<td>0.870</td>
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<tr>
<td>$N$</td>
<td>8706</td>
<td>10512</td>
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### Impact of capital surplus on BHC loan growth

Dependent variable: BHC Total loan growth

<table>
<thead>
<tr>
<th></th>
<th>Total Loans</th>
<th>C&amp;I Loans</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Estimate</td>
</tr>
<tr>
<td>Loan Growth Lags (sum)</td>
<td>0.1598***</td>
<td>0.0731</td>
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<tr>
<td>Surplus capital</td>
<td>0.0523***</td>
<td>0.0602***</td>
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<tr>
<td>Securities/Asset</td>
<td>0.0668***</td>
<td>0.0559**</td>
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<tr>
<td>Net Chargeoffs/Asset</td>
<td>-1.6177***</td>
<td>-1.6410***</td>
</tr>
<tr>
<td>Lending Standards (sum)</td>
<td>-0.0181***</td>
<td>-0.0274***</td>
</tr>
<tr>
<td>GDP Growth Lags (sum)</td>
<td>0.8562**</td>
<td>2.1685***</td>
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<tr>
<td>Fed Funds Lags (sum)</td>
<td>-0.4534</td>
<td>-0.0059</td>
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<tr>
<td>Inflation Lags (sum)</td>
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<td>-1.7849</td>
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<tr>
<td>$R^2$</td>
<td>0.215</td>
<td>0.098</td>
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<tr>
<td>$N$</td>
<td>7793</td>
<td>7760</td>
</tr>
</tbody>
</table>

Go to: Key results from the surplus/shortfall approach.
Impact of capital-to-assets ratios on BHC loan growth

Dependent variable: BHC Total loan growth

<table>
<thead>
<tr>
<th></th>
<th>Equity to asset ratio</th>
<th>Risk-based Tier 1 ratio</th>
<th>TCE ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loan growth lags (sum)</td>
<td>0.1648***</td>
<td>0.1571***</td>
<td>0.1743***</td>
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<tr>
<td>Capital ratio</td>
<td>0.1405***</td>
<td>0.1674***</td>
<td>0.2521***</td>
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<tr>
<td>Securities/asset</td>
<td>0.0556***</td>
<td>0.0421***</td>
<td>0.0498***</td>
</tr>
<tr>
<td>Net Chargeoffs/asset</td>
<td>-1.6835***</td>
<td>-1.8346***</td>
<td>-1.6832***</td>
</tr>
<tr>
<td>Lend. standards (sum)</td>
<td>-0.0135**</td>
<td>-0.0130***</td>
<td>-0.0131***</td>
</tr>
<tr>
<td>GDP growth lags (sum)</td>
<td>0.8628***</td>
<td>1.0684***</td>
<td>0.8508***</td>
</tr>
<tr>
<td>Fed. funds lags (sum)</td>
<td>-0.1164</td>
<td>-0.5696*</td>
<td>-0.1792</td>
</tr>
<tr>
<td>Inflation lags (sum)</td>
<td>-1.1988***</td>
<td>-0.3482</td>
<td>-0.7072</td>
</tr>
<tr>
<td>Within $R^2$</td>
<td>0.186</td>
<td>0.197</td>
<td>0.190</td>
</tr>
<tr>
<td>$N$</td>
<td>8549</td>
<td>6658</td>
<td>8549</td>
</tr>
</tbody>
</table>
We interpret $\psi$ as reflecting the size of the increase in loan growth implied by a higher capital surplus or capital ratio.

Doing this requires us to rule out other reasons for a relationship between BHC capital and loan growth.

A positive correlation between BHC capital and loan growth may arise because both are correlated with economic activity.

Adding a direct measure of economic activity to the regression should absorb the predictive power of capital arising from this relationship.
A positive correlation between capital and loan growth may also arise because BHCs build up capital in anticipation of an expansion in lending.

If target capital is modeled correctly, the parameter $\psi$ in the surplus/shortfall regression should not be affected by this relationship (as both target and actual capital would change).

The parameter $\psi$ in the capital-to-assets ratio regressions is potentially affected by this alternate relationship.

However, the bias is in the upward direction and our goal is to examine whether the constant leverage assumption overstates the effect of capital on loan growth.

Adding the dividend-to-net-income ratio to the regression appears to absorb some of this effect and lowers $\psi$ slightly.
Exploration of the output growth response

Response of output growth

Response of bank, thrift, & ABS issuer loan growth

Response of standards

Response of the capital-assets ratio

Go to: Response to a capital ratio shock (1).

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