Banks' Capital Buffer, Risk and Performance in the Canadian Banking System: Impact of Business Cycles and Regulatory Changes

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Banks' Capital Buffers, Risk and Performance in the Canadian Banking System: Impact of Business Cycles and Regulatory Changes

Abstract

Using quarterly financial statements and stock market data from 1982 to 2010 for the six largest Canadian chartered banks, this paper documents positive co-movement between Canadian banks' capital buffer and business cycles. The adoption of Basel Accords and the balance sheet leverage cap imposed by Canadian banking regulations did not change this cyclical behaviour of Canadian bank capital. We find Canadian banks to be well-capitalized and that they hold a larger capital buffer in expansion than in recession, which may explain how they weathered the recent subprime financial crisis so well. This evidence that Canadian banks ride the business and regulatory periods underscores the appropriateness of a both micro- and a macro-prudential "through-the-cycle" approach to capital adequacy as advocated in the proposed Basel III framework to strengthen the resilience of the banking sector.

Keywords: Capital Buffer, Risk, Performance, Basel Accords, Regulation, Business Cycles, Canadian Banks

JEL Codes: G21, G28

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I. Introduction

The 2007 subprime turmoil underscores the imperative for a sound micro- and macro-prudential framework for banking regulation and supervision to build up resilience against severe crises and to ensure the stability of the entire financial system.[1] During this crisis, Canada's banking system performed much better than other industrialized countries. Even as high-profile banks in Europe, the United States and elsewhere collapsed, were bailed out, or underwent imposed take-overs—Fortis, Citigroup, UBS and the Royal Bank of Scotland are a few examples—not one Canadian bank failed or was openly bailed out.

In this paper, we examine the relationship between bank capital buffers and business cycles in Canada's banking sector. We first examine the cyclicality of Canadian banks' capital buffer with respect to business cycles, where the buffer (excess capital) is the size of the capital cushion that exceeds the regulatory capital requirement of the Office of the Superintendent of Financial Institutions (OSFI). Cyclicality of bank capital is defined as the co-movement between business cycles and bank capital. Positive co-movement implies counter-cyclicality and negative co-movement denotes procyclicality.[2] Therefore, to have counter-cyclicality between bank capital buffers and the business cycle, capital has to be accumulated in booms and lower in troughs. Second, we analyze the impact of capital buffers on banks' risk and performance, controlling for business cycles as well as for capital regulatory environments, namely in the period preceding the Basel Accords, during Basel I, and during amendments to the Basel I and Basel II regimes. Our research questions are as follows: (1) Do Canadian banks' capital buffers run counter to business cycles? (2) Are Canadian banks' capital buffers sensitive to changes in capital regulations? (3) How sensitive are Canadian banks' risk to changes in their capital buffer? (4) How do induced changes in bank capital buffers affect the performance of Canadian banks?

Our work departs from the literature on capital buffers in several ways. First, it uses an extensive database of quarterly data over a relatively long period (1982 to 2010) to study Canada's banking sector. Second, unlike some previous research, our study period covers at

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[1] Micro actions pertain to management actions at the bank level. Macro actions refer to monetary and other policies at the country level or higher.
[2] See for instance, Illing and Paulin (2004).

least three regulatory environments. Third, we study the relationship between capital buffers, risk and performance simultaneously, developing a system of three simultaneous equations that link capital buffer, risk and performance within several business cycles and multiple regulatory changes. To our knowledge, this is the first paper to comprehensively address these issues relating to capital buffers in the Canadian context.

We find that Canadian banks are well-capitalized, exceed the minimum requirements for both the regulatory capital buffer (5.09%) and the leverage capital buffer (0.49%). These findings provide one possible explanation for how Canadian banks weathered the recent financial crisis better than banks in other countries.[3]

We also document positive co-movement between Canadian banks' capital buffer and business cycles (countercyclical effects): more capital is being accumulated during booms. In exploring the role played by the Basel regulations in this relationship, we find that this positive co-movement is still present after the 1996 amendment to the Basel I Accord adopted in 1998, although it is more pronounced over the 1988-1997 Basel I period.

We also find a negative but not statistically significant relationship between variations in banks' capital buffer and banks' risk exposure. This finding is similar to that of Lindquist (2004), who found support for the hypothesis that capital buffers may be considered as insurance against failure to meet capital requirements. Our results support the view that Basel and the leverage constraints imposed by Canadian regulators, principally the Office of the Superintendent of Financial Institutions (OSFI), have to some extent succeeded at better aligning Canadian banks' risk-taking with their capital base.

Finally, we find that the impact of capital buffer on the performance of Canadian banks depends on how performance is measured. When equity returns are used to measure performance, there is no effect. However, if returns on assets (ROA) or Tobin's Q are used as performance measures, capital buffers have a significant and positive impact on ROA and a negative impact on Tobin's Q.

We can then draw two main policy implications from the Canadian experience. First, rigorous and disciplined implementation of both risk-based and non-risk-based capital requirements may help mitigate the well-documented procyclicality associated with current Basel risk-based capital charges. Secondly, capital requirements should be higher during

[3] Other reasons include conservative mortgage practices, non-reliance on money market wholesale funding, and higher liquidity ratios (e.g., Northcott et al (2009), Ratnovski and Huang (2009)).

booming economic periods because this is when banks can accumulate more capital. Conversely, a reduction in capital requirements during recessionary periods would be welcome since this may provide more room for banks to operate.

The rest of this paper is structured as follows. In section II, we discuss our empirical framework. In section III, we describe the data and present the descriptive statistics. In section IV, we discuss and interpret the empirical results. In section V, we carry out robustness checks. We conclude in section VI.

II. Empirical framework

Shrieves and Dahl (1992), Jacques and Nigro (1997), Rime (2001) and others have used systems of two simultaneous equations to study the relationship between banks' risk and their capital. Kwan and Eisenbeis (1997) and Altunbas et al (2007), in contrast, formulated systems of three simultaneous equations to study banks' capital, risk and efficiency (derived from stochastic cost frontiers) endogenously. Note that while our specification follows the latter approach, we depart from it, first by focusing on capital buffers instead of capital ratios and second by superimposing the effect of business cycles under banking regulation changes. We use the following system of simultaneous equations:

$$\Delta BUF_{j,t} = f_1(SIZE_{j,t}, CREDIT_{j,t}, OUTGAP_t, \Delta RISK_{j,t}, \Delta PERF_{j,t}, BUFR_{j,t}, BUF_{j,t-1}, DREG_t, OUTGAP_t \times DREG_t), \quad (1)$$

$$\Delta RISK_{j,t} = f_2(VTSX_t, TERM_t, CV_{j,t}, OUTGAP_t, \Delta BUF_{j,t}, \Delta PERF_{j,t}, RISK_{j,t-1}, DREG_t, OUTGAP_t \times DREG_t, \Delta BUF_{j,t} \times DREG_t), \quad (2)$$

$$\Delta PERF_{j,t} = f_3(CR3_t, SIZE_{j,t}, TERM_t, OUTGAP_t, \Delta BUF_{j,t}, \Delta RISK_{j,t}, PERF_{j,t-1}, DREG_t, OUTGAP_t \times DREG_t, \Delta BUF_{j,t} \times DREG_t), \quad (3)$$

where the dependent variables are as follows:

$\Delta BUF_{j,t}$ The variation of the capital buffer of bank *j* at time *t*;

$\Delta RISK_{j,t}$ The variation of risk of bank *j* at time *t*;

$\Delta PERF_{j,t}$ The variation of performance of bank *j* at time *t*.

These variables and the other explanatory variables are defined below. But before describing the variables, we give a brief overview of the regulatory background in Canada.

2.1. Regulatory background

Canada's banking sector is regulated by the Bank Act and is enforced by Canada's Office of the Superintendent of Financial Institutions (OSFI). This law was passed in 1871 and was supposed to be reassessed and updated each decade (Calmès, 2004). The 1987 amendment to the Bank Act allowed banks to acquire investment dealers. In 1988, Basel regulations introduced credit risk-based capital requirements. Since then, Canadian banks have accounted for this risk when calculating their risk-weighted assets (RWA). In 1992, another amendment to the Bank Act allowed banks to buy trust companies. In addition, the Bank Act's review period was shortened from ten to five years (Calmès, 2004).

In 1997, following the 1996 amendment to the Basel I, the Bank Act required banks to account for market risk when computing their RWA. This amendment started to be enforced in 1998.[4] In 2004, Basel II introduced operational risk into the RWA calculation and proposed the internal ratings-based approach for credit risk. Canada enforced the Basel II requirements starting in November 2007.

2.2. Capital buffers, risk and performance measures

We use three capital ratio measures to compute the buffer. Our first and main measure of the capital ratio is the leveraged capital ratio (CAPL). It is the inverse of the balance sheet leverage ratio and is obtained as the ratio of shareholders' book equity over total assets, as in Flannery and Rangan (2008). The buffer with this capital ratio measure is denoted as BUFL and is measured by CAPL minus the inverse of the balance sheet leverage ratio cap fixed by Canadian banking regulations.

Our second capital ratio variable is CAP, which measures a bank's capital-to-risk-weighted assets (RWA) ratio. We use this second capital ratio to calculate the capital buffer as the difference between CAP and the minimum regulatory capital requirement and denote it as BUFR.

We also compute a third capital ratio, the economic capital ratio (CAPE), using the value at risk (VaR) based on the bank's asset distribution.[5] The economic capital buffer BUFE

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[4] An OSFI report states that "Beginning January 1st 1998, deposit-taking institutions with significant trading portfolios are required to maintain capital to cover market risks."

[5] We compute VaR using the asset distribution at the 99.97% confidence level, which supposes a credit rating of at least AA+ for each bank of the sample. We derive asset values from contingent claim analysis, as in Ronn and Verma (1986).

is obtained as the difference between the bank's actual capital ratio and its economic capital ratio.

BUFL is our main capital buffer measure because it is easy to compute and to interpret. BUFR and BUFE, however, are difficult to obtain due to the lack of complete and comprehensive information and data to compute the risk-weighted assets and VaR of Canadian banks; these measures are thus less precise than BUFL.

We use three risk measures: total equity risk (TRISK), market idiosyncratic risk (IRISK) and the implicit volatility of assets (ARISK). We calculate TRISK using the standard deviation of daily equity returns over the quarter. We calculate IRISK using a GARCH (1,1) in mean of conditional volatility on the residual from a multifactor market model over the last quarter of daily observations. This is similar to Song (1994), Flannery et al (1997) and Calmès and Théoret (2010), among others.[6] We add an additional factor for exchange rate risk to the market multifactor model used by Chen et al (2006) and Pathan (2009) as follows: $R_{j,t}= \beta_{0,t} + \beta_{m,j} R_{m,t}+ \beta_{I,j} U_{I,t}+ \beta_{x,j}U_{x,t} + \varepsilon_{j,t}$, where $R_{j,t}$ is the equity return of bank j at time t, $R_{m,t}$ is the market premium, $U_{I,t}$ represents the interest rate risk premium computed as the difference between the long-term Canadian government bond yield and the T-bill yield, $U_{x,t}$ is the exchange rate premium computed as one minus the exchange rate of the Canadian dollar to the US dollar (the US dollar is the most commonly used foreign currency in Canada) and $\varepsilon_{j,t}$ is the error term.

The risk measure ARISK is the implicit volatility of asset returns (σ_V) obtained using the approach of Ronn and Verma (1986). Total asset value (V) and its implicit volatility (σ_V) are obtained by solving a system of equations based on shareholders' equity defined as a call option: $K = V\ N(x) – \rho\ B\ N(x-\sigma_V\sqrt{T})$, with $x = [Ln\ (V / \rho\ B) + (\sigma_V^2T/2)]/ \sigma_V \sqrt{T}$ and $\sigma_K = \sigma_V\ V\ N(x)/K$, where V is the implicit total asset value (the first unknown), K is the market value of equity, B is the book value of the bank's total debt, σ_K is the standard deviation of the bank's equity returns, σ_V is the unobserved bank asset return volatility (the second unknown), ρ is a regulatory parameter, T is the maturity of the debt (we assume 1 year), N(.) is the standard cumulative normal distribution function, and Ln is the logarithmic operator. The parameter ρ equals 0.97 as in Ronn and Verma (1986) and Giammarino et al (1989) for American and

[6] We run several other conditional volatility specifications such as EGARCH and GJR. Evaluating the results with Akaike and Schwarz's criteria, we find GARCH-M to be best.

Canadian banks, respectively. Gueyie and Lai (2003) have also used this constant in their study of bank moral hazard and the introduction of deposit insurance in Canada.

As a measure of performance, we use the banks' mean daily stock market returns (RET) over the last calendar quarter. We also use alternative performance metrics: (i) the return on assets (ROA) obtained as the ratio of net income over total assets, and (ii) Tobin's Q (QTOB) computed as the market value of equity divided by its book value.

2.3. Explanatory variables

We use the following explanatory variables:[7]

- $SIZE_{j,t}$ represents the log of total assets of bank *j* at time *t* and controls for the size effect (Jacques and Nigro (1997) and Rime (2001), among others). We expect this variable to negatively impact the variation in the capital buffer and performance.

- $OUTGAP_t$ is a business cycle indicator. It is the cyclical component of real gross domestic product (GDP) obtained by applying the Hodrick-Prescott filter. We use the cyclical output gap instead of real GDP because it removes trends from time series variables.

- $GDPG_t$ is the quarterly growth rate of real GDP.

- $CR3_t$ is the income concentration ratio at time *t* computed as the ratio of the total net income of the three largest banks divided by the total net income of the sector. This variable is used to proxy industrial concentration and competition in the banking sector (e.g., Bikker and Haaf (2002), Beck et al (2006) and Alegria and Schaeck (2008)). We expect this variable to positively impact performance.

- $CV_{j,t}$ is the charter value used to control for banks' incentives for risk-taking (e.g., Jokipii (2009) and Keeley (1990)). It is calculated as follows:

  $CV = Ln((BVA + MVE – BVE) / BVE)$, where BVA is the book value of assets, MVE is the market value of equity, and BVE is the book value of equity.

- $VTSX_t$ is the volatility of the market index, a proxy for Canadian market risk. It has been calculated as the standard deviation of daily returns of the S&P/TSX Composite Index[8]

[7] To control for the active adjustment of capital buffers in response to banking regulations and business cycles, we added variables such as capital issuance, dividend policy parameters, reinvested earnings and external financing to the original model and found that results did not differ significantly from the results obtained from the basic model. Therefore, to keep the model simple, we dropped these additional variables.
[8] This index was the TSE 300 index before 2002.

over the last quarter. The index includes the six Canadian chartered banks in our sample, as well as many other firms. We expect a positive relationship between this market risk and our six banks' risk measures.

- $CREDIT_{j,t}$ is the ratio of total loans over total assets and is used to control for the impact of lending activities on a bank's capital buffer.

- $TERM_t$, the difference between the yield on long-term Canadian government bonds and the T-bill yield, captures shocks on the term structure of interest rates.

- $DREG_t$ are dummy variables to control for the stages of Basel regulations. $DREG_1$ takes a value of 1 over 1988-1997 and zero elsewhere to reflect Based I regulations before the amendment. $DREG_2$ controls for the 1997 amendment to the Bank Act and Basel II effects. The 1997 amendment to the Bank Act came at the end of that year and was enforced in 1998. $DREG_2$ takes a value of 1 from 1998 to 2010 and zero elsewhere.

- $OUTGAP_t \times DREG_t$ is the cross-product of $OUTGAP_t$ and the regulatory regime dummy $DREG_t$, and captures the interaction between business cycles and the regulatory regimes.

- $\Delta BUF_{j,t} \times DREG_t$ is the cross-product of $\Delta BUF_{j,t}$ and the regulatory regime dummy $DREG_t$, and captures the interaction between variations in capital buffers and the regulatory regimes.

- We also use bank dummies to control for bank-specific effects.

2.4. Econometric issues

In estimating our simultaneous equations, we use the two-step generalized method of moments (2SGMM) estimation technique in a panel data context to deal with potential endogeneity between variables. Since GMM is an instrumental variables method, we use the level and the first differences of the variables as instruments, and to tackle potential serial correlations, we use the first differences of the dependent variables as done by Blundell and Bond (1998). We also include lags of each dependent variable as instruments to account for the simultaneity of capital buffers, risk and performance adjustments.

Our focus on changes in bank capital buffers, risk and performance lead to the use of only first differences as dependent variables, thus reducing the likelihood of spurious regressions since first differences of variables are all stationary in this context. Furthermore, the two-step GMM with panel data is more efficient than two-stage least squares, which is also a limited information technique but does not account for heteroscedasticity.

Finally, the fixed effect panel estimation has been favored to the first difference estimation option which is the only available option for the 2-step GMM in the panel data context. There are two main reasons for this choice: (1) the system of endogenous equations that we have chosen is mixed, in that it considers both first differences and levels of variables, and (2) our database has a small number of banks, only six.[9]

III. Data and descriptive statistics

As of 31 December 2010, Canada's banking sector is comprised of 22 Canadian banks, 26 subsidiaries of foreign banks and 22 branches of foreign banks offering a full range of financial services. The entire sector managed approximately CAN $3100 billion worth of assets. Our sample is composed of the six largest Canadian chartered banks. The banks in our sample, ranked by asset size as of the last quarter of 2010, are as follows: the Royal Bank of Canada (RY), the Toronto-Dominion Bank (TD), the Bank of Nova Scotia (BNS), the Bank of Montreal (BMO), the Canadian Imperial Bank of Commerce (CM) and the National Bank of Canada (NA). These banks account for approximately 90% of the total assets of Canada's banking sector and 75% of the assets of deposit institutions.

For all bank-specific variables, we have used data from Bloomberg, supplemented by data collected manually from the banks' reports.[10] For Canadian economic variables, we obtained data from various publications and other sources at Statistics Canada and the Bank of Canada. Table 1 defines the variables and presents descriptive statistics (number of observations, means and standard deviations) of our sample of quarterly data from 1982 to 2010. Compared to other studies of Canadian banking, our number of observations is substantial.[11] We performed a synchronisation between market and accounting data as in Claessens et al (1998) and Easton and Gregory (2003).[12]

INSERT TABLE 1 HERE.

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[9] There is therefore no need to use a Haussmann test in our analysis.

[10] For the capital-to-RWA ratio before 1988, we used the ratio of capital to assets, as in Flannery and Rangan (2008).

[11] We used over 650 quarterly book observations. Shaffer (1993), who tested competition among Canadian banks, only used annual data between 1965 and 1989 (24 observations). Nathan and Neave (1989) used 39 observations, D'Souza and Lai (2004) used 125 quarterly observations and Gueyie and Lai (2003) used 115 annual observations. The best case is Allen and Liu (2007), who used 480 quarterly observations.

[12] In general, accounting data delay behind market data, but the lag is usually short. Since we are using quarterly data, we take one quarter as the lag.

From Table 1, we observe an average leverage capital buffer BUFL of 0.49%, a regulatory capital buffer BUFR of 5.09% and an economic capital buffer BUFE of 3.50% for the six banks. The average quarterly stock return (RET) is 3.99%. The quarterly average ROA is 0.20% and average Tobin's Q (QTOB) is 1.45. Quarterly total equity risk (TRISK) is 1.45% and idiosyncratic risk (IRISK) is 1.47%. Implicit asset volatility risk (ARISK) is 0.93%.

Table 2 presents the matrix of correlations between the variables. BUFL is negatively correlated to the three measures of banks risks but the correlation coefficients are very low, in absolute value not more than 6.92%. In fact, BUFL is negatively correlated with TRISK (-5.46%), with IRISK (-3.57%) and with ARISK (-6.92%). BUFL is negatively correlated to RET (-12.2%) and QTOB (-16.19%), but is positively correlated to ROA (3.34%), suggesting that the relationship between bank capital buffers and their performance may depend on the performance metric used.

Meanwhile, BUFL is positively related to BUFR (1.43%), but negatively correlated with BUFE (-6.30%). The correlation between BUFR and BUFE is 15.31%. These three measures of banks' capital buffer represent different capital requirement dynamics and one should be cautious in interpreting and generalizing results obtained with each measure. The correlations between the risk measures are positive: 64.12% between IRISK and TRISK, 10.81% between ARISK and TRISK, and 10.10% between ARISK and IRISK. RET is positively correlated with TRISK (5.36%) and IRISK (3.31%), and is negatively correlated with ARISK (-6.07%).

Finally, as seen in Table 2, there are no strong correlations between the variables forming our system of equations. The risk of multicolinearity in this study is thus very low.

INSERT TABLE 2 HERE.

IV. Empirical results

Let us look back at our four research questions: (1) Do Canadian banks' capital buffers run counter to business cycles? (2) Are Canadian banks' capital buffers sensitive to changes in capital regulation? (3) How sensitive is the risk held by Canadian banks to changes in their capital buffer? (4) How do induced changes in capital buffers affect the performance of Canadian banks?

To answer our research questions, as described previously, we constructed business cycles using the cyclical component of Canadian real GDP. Over the sample period of 1982-2010, we distinguish three regulatory regimes: (1) before 1988, when Canada's Office of the Superintendent of Financial Institutions (OSFI) adopted the Basel I Accords; (2) 1988 to 1997, when Basel I rules were enforced and the risk-weighted assets (RWA) approach based on credit risk was introduced. Canadian regulations mandated an 8% minimum capital-to-RWA ratio in 1988; this figure rose to 10% in 2000; and (3) 1998 to 2010, after OSFI adopted the 1996 amendment to the Basel I Accord, which introduced market risk as a distinct risk category, and when the spirit of the Basel II Accord shaped the 2000s.[13] These regulatory changes are captured by the dummy variables $DREG_1$ and $DREG_2$.

4.1. Do Canadian banks' capital buffers run counter to business cycles?

We use information about business cycles to create three data panels: (i) an unconditional panel that considers full business cycles without distinguishing troughs from peaks; (ii) an economic expansion panel, that only considers peak periods; and (iii) an economic recession panel, that only considers periods in the trough. For each panel, we calculate the capital ratios CAP, CAPL and CAPE for the six Canadian banks. We use these capital ratios to calculate the associated capital buffers BUFR, BUFL and BUFE.

Descriptive statistics for each economic phase, given in Table 3,[14] show that on average, CAP is higher than CAPE, which suggests that Canadian banks hold more capital than what is "economically" required, since economic capital can be viewed as the level of capital that banks have to hold to remain technically viable (Kretzschmar et al, 2010) in a fully disciplined market without government safety nets. Also, the average regulatory capital buffer BUFR is 5.09%, the leverage capital buffer BUFL is 0.49% and the economic capital buffer is 3.50%. These findings suggest that Canadian banks are well-capitalized. They also hold less capital in recessions according to all of the measures used. Canadian banks appear to build up their capital buffer during boom periods and consume them during troughs when they are most needed.

INSERT TABLE 3 HERE.

[13] Many regulatory in Canada resulted from bank problems in the 1990s. To prevent more bank failures, Canadian regulations were stricter than regulations elsewhere. For a history of Canada's banking system and changes in regulation, see Saunders et al (2006).

[14] To alleviate outliers' bias, when calculating aggregate BUFE, we exclude 5% of the right tail of the distribution and use the 95% of the data that remains to calculate the mean for the banks.

The graphs in Figure 1 plot capital buffers and the business cycles over the sample period. The graphs suggest a positive co-movement between capital buffers (BUFL and BUFR) and business cycles. In the case of BUFL, the relationship appears to change during the recent subprime crisis.

INSERT FIGURE 1 HERE.

We further our analysis with a multivariate analysis using the simultaneous equations (1-3). The results are presented in Table 4. Columns 1, 2 and 3 of the table present results without controlling for changes in regulatory frameworks. As mentioned above, changes in regulatory regimes are controlled with the dummy variable $DREG_1$ for OSFI's adoption of Basel I (columns 4, 5 and 6) and the dummy variable $DREG_2$ for the 1996 amendment of the Basel I Accord as well as adoption of Basel II (columns 7, 8 and 9). Columns 10, 11 and 12 include both dummies $DREG_1$ and $DREG_2$ and control for the two regulatory regimes. The results for each model show a positive and significant relationship between variations in capital buffers ($\Delta BUFL_t$) and the output gap ($OUTGAP_t$) over the sample period. We interpret this result as evidence that Canadian banks build up capital during boom periods and consume a portion of this buffer in the lean times, meeting the capital requirement. In fact, many critics have pointed out that the Basel capital regulations are procyclical by design, in that it requires banks to increase their capital ratio when they face greater risks. Unfortunately, this situation may force banks to lend less during recessions, leading to credit crunches and potentially aggravating a downturn. Our finding of positive co-movement between capital buffers and the business cycle, however, can be interpreted as evidence of countercyclical effects in the Canadian banking sector.

INSERT TABLE 4 HERE.

In the next section, we examine whether the countercyclical effect found above is sensitive to changes in the regulatory environment.

4.2. Are Canadian banks' capital buffers sensitive to changes in capital regulation?

Figure 2 shows business cycles and regulatory regimes over the study period.

INSERT FIGURE 2 HERE.

Figure 3 plots the banks' average capital-to-RWA ratio over time, along with the balance sheet leverage ratio, measured by total assets divided by shareholders' book equity. As shown in panel A of Figure 3, their average capital-to-RWA ratios increased over the study period after a secular decrease in banks' capital.[15] The increase is more pronounced in the periods leading up to regulatory change. Thus, we observe sudden increases, especially after the announcement of the Basel I Accords in 1987 and after the announcement of the amendment of Basel I in 1996. As for the impact of Basel II on Canadian banks, we observe that the increase in the capital ratio took place in 2008, four years after OSFI started progressive adoption of Basel II. This period corresponds with enforcement of the advanced credit risk approach in Canada. The graphs confirm our previous claim about the adequate level of capitalization of Canadian banks since the early 1980s, even after the minimum regulatory capital requirement rose to 10% in the beginning of the 2000s.

The explanations for these observed trends are as follows. First, no risk-adjusted capital ratio requirements existed prior to 1988 because Basel I guidelines were only introduced in that year. After Canadian regulators adopted the Basel I regulations and banks began to account for their credit risk in the denominator of their capital ratio, the ratio fell. However, with the 1996 amendment, Canadian regulators not only maintained the minimum regulatory capital requirement, but also reduced the leverage ratio limit. Indeed, Canada's banking authority capped the balance sheet leverage ratio at 30 from 1982 to 1991. Late in 1991, the authority decreased the limit to 20, where it remained until 2000, when it rose to 23 under certain conditions. This leverage ratio requirement has been shown to mitigate asymmetric information and agency problems (e.g., Blum (2008)), and some claim that it helped make Canada's banking sector more resilient to the recent credit turmoil (e.g., Bordeleau et al (2009) and Dickson (2009)). Also, after 2000, Canada increased the minimum regulatory capital-to-RWA ratio from 8% to 10%. These regulatory changes increased the level of capital in Canada's banking sector after 1998, since one would have expected the capital ratio to decrease or remain more or less the same after the introduction of market risk as a new risk category.

INSERT FIGURE 3 HERE.

To determine how sensitive Canadian banks' capital buffers are to regulatory changes, we analyse the impact of regulatory variables $DREG_1$ and $DREG_2$ on the change in bank capital buffers. As explained before, changes in regulatory regimes are controlled with dummy variables $DREG_1$ for OSFI's adoption of Basel I (see columns 4, 5 and 6 of Table 4

[15] Saunders and Wilson (1999) document a continual decrease of banks' capital from 1893 to 1982.

for the results) and $DREG_2$ for the 1996 amendment of the Basel I Accords and the adoption of Basel II (see columns 7, 8 and 9 of Table 4 for the results). In columns 10, 11 and 12 of Table 4, we include the dummies for both regulatory regimes in the regressions. We control for the combined effects of business cycles and regulatory environments by using the cross-products OUTGAP*$DREG_1$ and OUTGAP*$DREG_2$, respectively, for Basel I regulations and then the 1996 amendment of Basel I and the Basel II regulations.

The relationship between variations in BUFL and $DREG_1$*OUTGAP and $DREG_2$*OUTGAP are not significant. Hence, the magnitude of the positive co-movement between capital buffers and the business cycle is not affected by the two Basel regulatory regimes. This relationship between business cycles and capital buffers during the Basel Accord periods is very interesting, since many authors have criticized the Basel Accords as being procyclical by design, especially after the 1996 amendment and during the Basel II period. We instead find a countercyclical effect during Basel I as well as during the 1996 amendment and Basel II periods.

However, the regulatory dummy $DREG_1$ alone has a significant negative impact on the variations of BUFL, while the dummy $DREG_2$ has a positive significant impact on BUFL. Indeed, the balance sheet leverage ratio limit was decreased from 30 to 20 in 1991 and was increased to 23 in 2000. Also, after 2000, the capital–to-RWA ratio was increased from 8% to 10%. These capital regulatory changes probably helped boost the capital base of Canadian banks.

Having studied the behaviour of Canadian banks' capital buffers during different business cycles and changes in capital regulations, we now turn to the impact of changes in capital buffers on measures of Canadian banks' risk.

4.3. How sensitive are Canadian banks' risk to changes in their capital buffer?

Figure 4 depicts the pattern of Canadian banks' equity risk (TRISK), Canadian stock market risk (VTSX) and business cycles. We observe weak co-movement between VTSX and business cycles. The relationship between TRISK and business cycles is ambiguous.

INSERT FIGURE 4 HERE.

To address the sensitivity of banks' risk to changes in their capital buffer, once again we turn to our system of simultaneous equations. We use two additional risk measures: IRISK (the banks' market idiosyncratic risk) and ARISK (the implicit volatility of the banks' assets). The results are presented in Table 5, where columns 1-3 are for TRISK, columns 4-6 for IRISK and columns 7-9 are for the ARISK risk measure. We find that, over the entire sample period, changes in banks' capital buffer BUFL are not significantly related to variations in equity returns risk (TRISK) or idiosyncratic risk (IRISK), but are positively and significantly related to variations in ARISK. However, the effect is less pronounced during the 1996 amendment and Basel II periods. Thus, Canadian banks have better succeeded at aligning risk-taking and their capital base; this is consistent with the second pillar of Basel II on maintaining a permanent supervisory review process to adjust capital levels in response to risk exposures.

INSERT TABLE 5 HERE.

Analyzing the regulation dummies separately, we find that $DREG_1$ positively impacts TRISK and that $DREG_2$ negatively affects it (see Table 4). This may be seen as evidence of the success of the combination of risk-based capital requirements suggested by Basel Accords and the non risk-based capital constraints imposed by Canadian regulators, especially after the adoption of the 1996 amendment to Basel I and Basel II by OSFI.

The relationship between risk and OUTGAP is not significant for any of the risk measures. The co-movement between business cycles and measures of risk thus does not appear. Also, note that the positive co-movement between capital buffers and the business cycle is present for all risk measures used.

Since variations in both capital buffers and in banks' risk-adjusted return on capital and hence their performance, in the next section we analyze how changes in the capital buffer affect banks' performance.

4.4. How do induced changes in capital buffers affect the performance of Canadian banks?

Figure 5 depicts Canadian banks' performance measured by equity returns and business cycles. It appears that bank equity returns are negatively correlated to the business cycle, confirming the results of Table 2. This may be explained by a combination of several factors. First, the development of market derivatives and credit securitization in the late 1990s enabled banks to hedge the market risk component of their portfolio. Second, with the development of securitization, the introduction in 1998 of market risk as a distinct risk category pushed banks to reshuffle their asset portfolios towards assets with low market risk charges.

INSERT FIGURE 5 HERE.

To determine how capital buffer variations affect these banks' performance, we once again turn to our system of simultaneous equations. The results are presented in Table 6, where columns 1-3 are for equity returns (RET), columns 4-6 for return on assets (ROA) and columns 7-9 for Tobin's Q (QTOB) as performance measures.

For RET, the coefficient is not significant over the Basel regulatory periods. For QTOB, it is significantly negative, and for ROA, it is significantly positive. Thus, we observe that positive variations in capital buffers are not a significant factor explaining variations in banks' return on equity. With the other performance measures, we instead observe instead that a variation in bank capital buffers has a positive and significant impact on variations in ROA, while it has a significant and negative impact on QTOB.

INSERT TABLE 6 HERE.

The regulatory environment dummies $DREG_1$ and DREG2 have a positive and significant impact on banks' equity returns (RET), as well as return on assets (ROA). After controlling for other confounding effects, this implies that Basel I and Basel II have improved banks' performance. It can be interpreted as Canadian banks being well-capitalized and able to easily meet Basel capital requirements.

We also analyze the interactions between capital buffer and regulatory dummy variables in the same equations ($DREG_1$*ΔBUFL and $DREG_2$*ΔBUFL) to account for the effect of capital buffer on performance following the adoption of Basel I and Basel II. The results indicate that, for all of the performance measures, the behaviour of ΔBUFL*DREG is more or less the same under Basel I and Basel II. More precisely, it indicates that bank buffers have no impact on changes in return on equity of Canadian banks, while they negatively impact ROA and positively impact Tobin's Q. These results are intuitive. In fact, the combined negative impacts of the buffer and regulation significantly reduces the variation in return on assets, meaning that it reduces bank earnings. But the overall effect of the buffer on ROA remains positive. The non-significant results on equity returns suggests that market participants did not find this regulation to affect them. Finally, the result for Tobin's Q means that banks tend to reduce their level of investment when the capital buffer increases during the Basel regulatory periods.

V. Robustness Checks

In this section we verify the sensitivity of our results to different model specifications such as different capital buffer measures and the subprime crisis period which begins in 2007.

The positive co-movement between capital buffers and the business cycle observed in Table 4 holds for all measures of risk (see Table 5) and performance (Table 6) used.

5.1. Alternative capital buffer measures

We now turn to the sensitivity of the results to other capital buffer measures. The results are presented in Table 7. Columns 4-6 of Table 7 give the results for BUFR and columns 7-9 for BUFE. The effect of the business cycle on bank capital buffers is not significant for either BUFR or BUFE. This result highlights the importance of selecting a relevant measure of capital buffers. In fact, for example, to compute BUFR and BUFE, we need to obtain or compute risk-weighted assets (RWA). The conflicting results obtained from this metric can be explained by difficulties obtaining comprehensive data on risk-weighted assets.

INSERT TABLE 7 HERE.

5.2. Excluding the subprime period

The subprime crisis may introduce biases in our results because of the extreme volatility observed in the data during that period. In order to study the sensitivity of the results to the subprime crisis we perform our regressions excluding the subprime crisis period (2007-2010) to check if the crisis had a special effect on our results. The results available in columns 4-6 of Table 8 confirm that in period of economic booms, Canadian banks increased their capital buffer and absorbed it in difficult times. Furthermore, the regulatory regimes have not had specific effects on this co-movement between business cycles and capital buffers.

An increase in risk reduces the excess capital buffer held by banks; this differs from the results across the entire sample, where the impact is not significant. But changes in banks' capital buffers are still not significantly related to the change in their equity returns risk, as was the case for the entire sample. As for the performance measure RET, variations in capital buffers have no significant impact, as was the case for the entire sample.

INSERT TABLE 8 HERE.

VI. Conclusion

This paper examines the cyclical behaviour of Canadian banks' capital buffers (the difference between the banks' capital levels and minimum capital requirements) and analyzes its impact on the banks' risk and performance throughout business cycles and in response to Canadian regulatory changes during various Basel regimes. Our work departs from the literature on capital buffers in several respects. First, it stands out among studies of the Canadian banking sector in its use of a comprehensive dataset over a relatively long time frame (1982-2010). This sample period allows us to account for at least three business cycles and three major regulatory regimes: (1) the period before the Office of the Superintendent of Financial Institutions (OSFI) adopted Basel I guidelines, from 1982 to 1987; (2) 1988 to 1997, when OSFI adopted and enforced the Basel I Accord; and (3) 1998 to 2010, after OSFI adopted the 1996 amendment to the Basel I Accord, which introduced market risk as a distinct risk category, and the Basel II period. Second, our study is original in studying the cyclical behavior of bank capital buffers with respect to business cycles and regulatory changes—a question of paramount importance in the aftermath of the subprime credit crisis—on the resilient Canadian banking sector. Third, we study bank capital buffer, risk and performance simultaneously using a two-step generalized method of moments (2SGMM) framework. Comprehensively addressing the relationship between capital buffers, business cycles, risk, performance and regulatory changes in the Canadian context constitutes an important contribution to the literature.

We address the following research questions: (1) Do Canadian banks' capital buffers run counter to business cycles? (2) Are Canadian banks' capital buffers sensitive to changes in capital regulation? (3) How sensitive are Canadian banks risk to changes in their capital buffer? (4) How do induced changes in the capital buffer affect the performance of Canadian banks?

We find that Canadian banks are well capitalized, which helps explain why they weathered the recent financial crisis so well. We document that bank capital buffers exhibit a positive co-movement with business cycles. This result holds even when we control for changes in regulatory regimes. We also find no strong evidence that variations of banks' capital buffer impact banks' exposure to risks and return on equity. By and large, there is no strong relationship between capital buffers and risk. Hence, the motive to hold an excess capital buffer may be driven by market discipline.

We can then draw two main policy implications on the basis of Canadian experience. First, rigorous and strict implementation of both risk-based and non-risk-based capital requirements can help mitigate the well-documented procyclicality associated with current Basel risk-based capital charges. Second, increases in capital requirements should occur during periods of strong economic growth because it is during these periods that banks can accumulate more capital; conversely, during recessionary times, a reduction in capital requirements would be desirable since it may provide more flexibility for banks to weather downturns.

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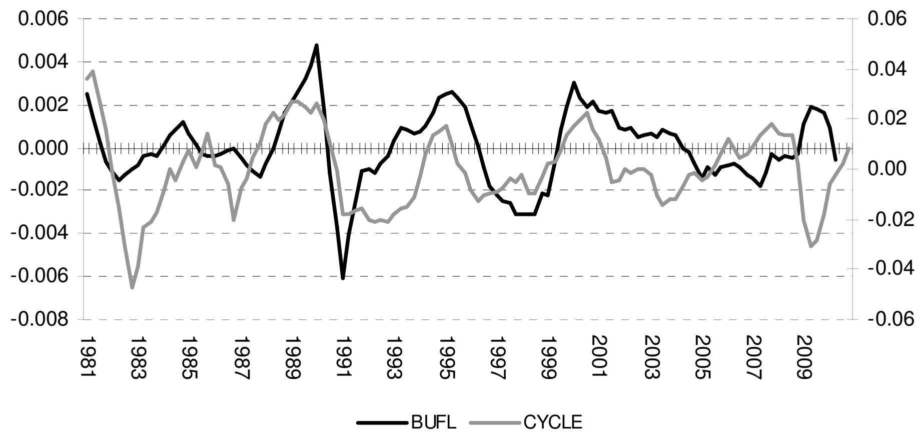
Figures 1a & 1b: Banks' capital buffer and business cycles in Canada

The right hand side axis gives values of business cycles measured by the cyclical component of real GDP. The left hand axis represents values of the cyclical part of capital buffers. To compute this last variable, we first adjust the seasonal components of capital buffer (by using the moving average over four quarters), then we use the Hodrick-Prescott (HP) filter to obtain cyclical components. The regulatory capital buffer (BUFR) is defined as the difference between banks' capital ratio and minimum regulatory capital ratio. The leverage-based capital buffer (BUFL) is equal to the difference between the shareholders' equity-to–assets ratio and the inverse of the regulatory ceiling on an unweighted leverage ratio.

A- BUFL and business cycles



B- BUFR and business cycles

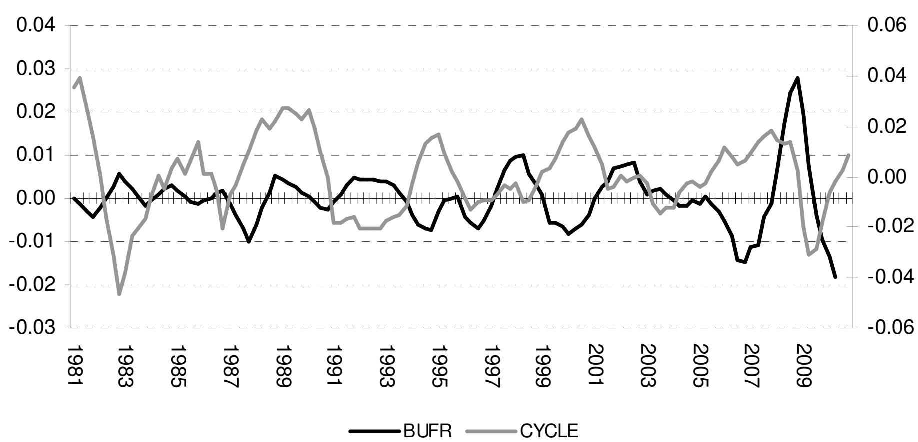


Figure 2: Business cycles and capital regulations

The gray areas designate major regulatory changes in the Canadian banking sector: (1) enforcement of Basel I in 1988, (2) implementation of the 1996 amendment of Basel I taking effect in 1998 and (3) the period in the spirit of Basel II starting in 2004. CYCLE is the cyclical component of real GDP.

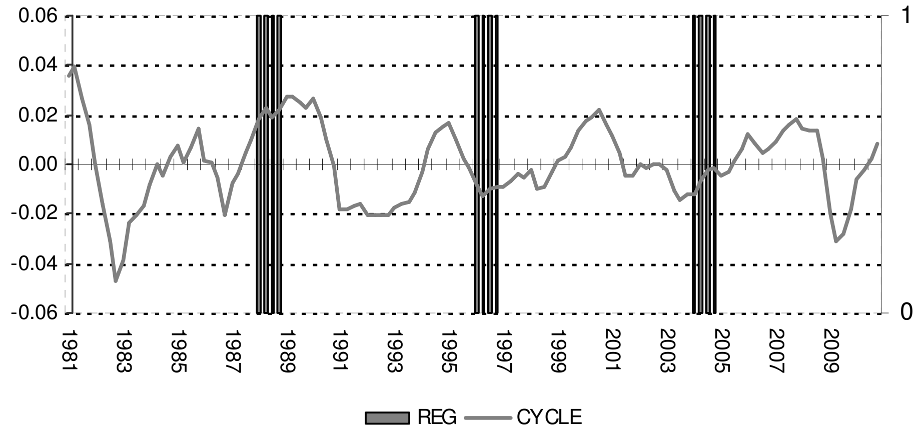
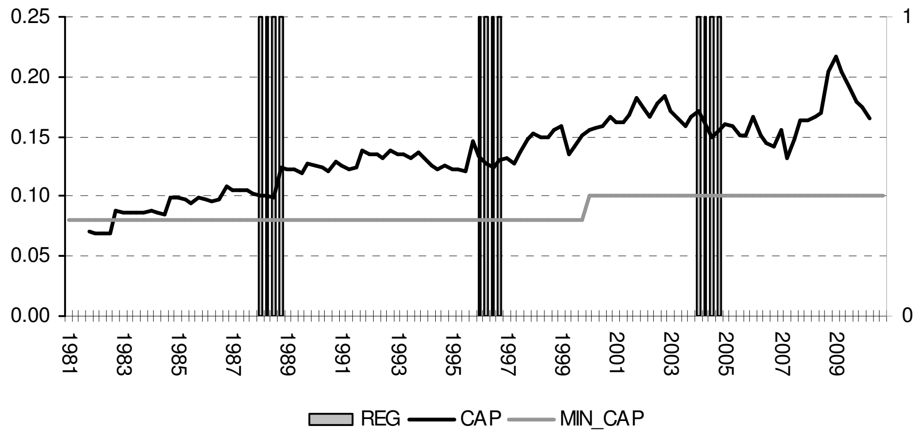


Figure 3: Trend of banks' capital and leverage ratio between 1982 and 2010

Before the enforcement of Basel I by the Office of the Superintendent of Financial Institutions (OSFI), in 1988, the bank's capital ratio was computed as the bank's capital-to-total assets ratio, and after 1988 it is computed as the capital-to-RWA ratio and has been taken from Canadian banks' official publications. Up to 1988, we consider a minimum capital ratio (MIN_CAP) of 8% as fixed by Basel I in 1987. In 2000, the minimum capital ratio was increased to 10% in Canada. The two graphs show the average ratios for the six big chartered banks. The gray areas designate major changes in capital regulation in the Canadian banking sector: (1) the enforcement of Basel I in 1988, (2) implementation of the 1996 amendment of Basel I that takes effect in 1998, and (3) the period in the spirit of Basel II starting in 2004. In the second graph (panel B), the scale on the right hand axis is for the capital ratio (CAP) measure and the left hand scale is for the balance sheet leverage ratio measure (LEV). For the maximum leverage ratio (MAX_LEV), the Canadian banking supervisory authority fixed a balance sheet leverage ratio cap of 30 from 1982 to 1991. Late in 1991, the limit was decreased to 20 and this was the ceiling until 2000, when it was increased to 23 under certain conditions.

A- Capital/RWA



B- Capital/RWA and asset/equity

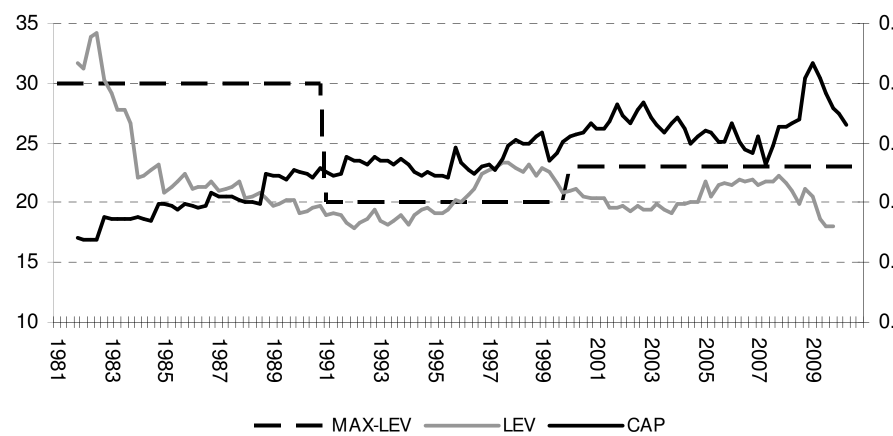


Figure 4: Canadian banks' risk, market risk and business cycles

The left hand axis gives values of the business cycles measured by the cyclical component of real GDP. The right hand axis represents the levels of average banks' equity risk (TRISK) and Canadian market equity risk (VTSX). To compute the last two variables, we first adjust their seasonal components using a moving four-quarter average, then we use the Hodrick-Prescott (HP) filter to obtain cyclical parts.

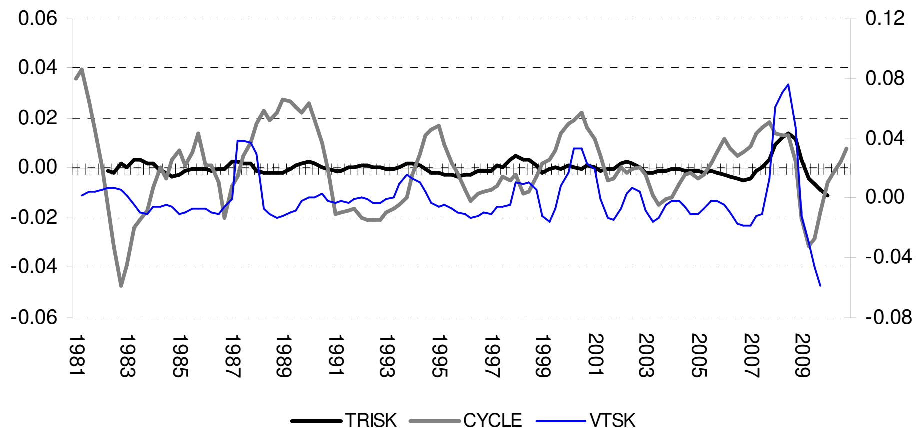


Figure 5: Banks' performance and business cycles

The left hand axis gives values of the business cycles, measured by the cyclical component of real GDP. The right hand side axis represents the levels of banks' average equity return (RET). To compute the last variable, we first adjust the seasonal components of RET using the moving four-quarter average, then we use the Hodrick Prescott (HP) filter to obtain cyclical components.

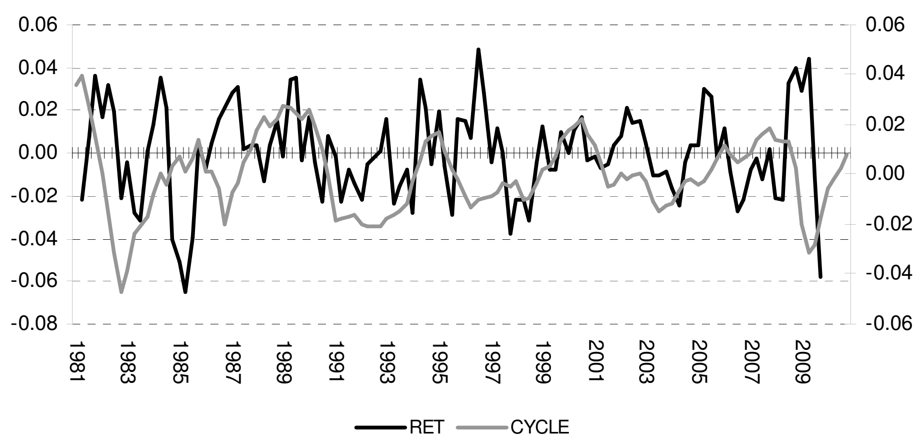


Table 1: Descriptive statistics of the variables (quarterly data from 1982 (Q1) to 2010 (Q2))

VARIABLES	DEFINITIONS	OBS	MEAN	STD. DEV	Min	Max
CAP	Book capital ratio = GAAP book capital / risk-weighted assets	609	0.139	0.043	0.055	0.258
CAPL	Inverse balance sheet leverage ratio = shareholders' equity / total assets	675	0.047	0.008	0.026	0.073
CAPE	Economic capital ratio = VaR economic capital / risk-weighted assets	625	0.097	1.153	0.001	28.829
BUFR	Regulatory capital buffer = CAP – minimum regulatory capital	632	0.051	0.036	-0.041	0.142
BUFL	Leverage capital buffer = CAPL – (1/leverage cap)	692	0.005	0.009	-0.014	0.034
BUFE	Economic capital buffer = CAP – CAPE	588	0.035	0.600	-7.156	0.211
ROA	Return on assets = net income / total assets	670	0.002	0.002	-0.007	0.013
RET	One quarter mean equity return based on daily observations	686	0.040	0.077	-0.584	0.272
QTOB	Tobin's Q = equity market value / equity book value	645	1.449	0.536	0.255	3.179
TRISK	Total equity risk = standard deviation of daily returns over the last quarter	672	0.015	0.006	0.007	0.040
IRISK	Idiosyncratic risk = conditional variance estimated by a GARCH-M (1,1) of errors in a multifactor model	654	0.015	0.008	0.006	0.087
ARISK	Implicit asset volatility computed using Ronn and Verma (1986) approach	629	0.009	0.018	0.000	0.269
VTSX	Volatility of S&P/TSX index based on daily observations of one quarter	684	0.068	0.033	0.035	0.204
CR3	Concentration ratio = total net income of 3 biggest banks / total net income of all banks	684	0.398	1.526	-14.923	2.691
TERM	Interest rate term premium = long term government bond yield minus T-bill yield	655	0.012	0.018	-0.044	0.052
GDPG	Quarterly growth rate of real gross domestic product (GDP)	714	0.006	0.008	-0.021	0.023
OUTGAP	Cyclical component of the logarithm of real GDP using HP filter	720	0.000	0.016	0.047	0.039
CV	Logarithm of charter value	644	21.402	3.521	13.103	36.941
CREDIT	Credit ratio = total loan / total asset	675	0.573	0.109	0.357	0.877
$DREG_1$	Dummy variable equals 1 over 1988-1997 and 0 otherwise	744	0.331	0.471	0.000	1.000
$DREG_2$	Dummy variable equals 1 over 1998-2010 and 0 otherwise	744	0.411	0.492	0.000	1.000

Table 2: Pairwise correlations between banks' specific variables

	CAP	CAPL	CAPE	BUFR	BUFL	BUFE	ROA	RET	QTOB	TRISK	IRISK	ARISK	VTSX	CR3	TERM	GDPG	OUTGAP	CV	CREDIT
CAP	1																		
CAPL	0.346	1																	
CAPE	-0.049	-0.020	1																
BUFR	0.916	0.325	-0.041	1															
BUFL	0.025	0.667	0.040	0.014	1														
BUFE	0.160	0.067	-0.497	0.153	-0.063	1													
ROA	0.015	-0.141	-0.007	0.031	0.033	-0.024	1												
RET	0.043	-0.045	0.003	0.069	-0.122	0.062	0.009	1											
QTOB	0.377	-0.006	-0.050	0.284	-0.162	0.140	0.044	0.025	1										
TRISK	0.22	0.017	-0.010	0.197	-0.055	0.015	-0.149	0.054	-0.133	1									
IRISK	0.192	0.023	0.010	0.143	-0.036	0.015	-0.131	0.033	-0.081	0.641	1								
ARISK	0.080	-0.026	0.056	0.067	-0.069	-0.041	-0.031	-0.061	0.162	0.108	0.101	1							
VTSX	0.391	0.063	-0.020	0.283	0.001	0.068	-0.063	0.067	0.183	0.687	0.488	0.146	1						
CR3	0.081	-0.034	0.000	0.050	0.013	0.008	0.043	0.025	0.179	0.025	0.015	0.045	0.135	1					
TERM	0.170	0.060	-0.024	0.165	-0.236	0.064	-0.086	0.024	0.044	0.102	0.098	0.124	0.148	0.020	1				
GDPG	-0.167	-0.108	0.056	-0.090	-0.151	-0.013	0.086	-0.033	0.029	-0.142	-0.166	0.003	-0.248	0.023	0.270	1			
OUTGAP	-0.001	0.093	0.037	-0.046	0.211	-0.018	-0.009	-0.076	0.087	-0.172	-0.038	-0.055	-0.070	0.196	-0.488	0.174	1		
CV	-0.138	-0.860	0.024	-0.157	-0.610	0.077	0.119	0.028	0.289	-0.007	0.040	0.071	0.136	0.063	0.038	0.092	-0.169	1	
CREDIT	-0.456	0.016	-0.037	-0.341	0.134	0.032	0.134	0.005	-0.568	-0.135	-0.140	-0.070	-0.451	-0.242	-0.060	0.058	-0.109	-0.222	1

Table 3: Aggregate capital buffer measures

Economic capital is calculated using Value at Risk (VaR) at the 99.97% confidence level. The regulatory capital buffer (BUFR) is defined as the difference between banks' capital ratio and minimum regulatory capital ratio. The leverage-based capital buffer (BUFL) is equal to the difference between the shareholders' equity-to-assets ratio and the inverse of regulatory ceiling on an unweighted leverage ratio. The economic capital buffer (BUFE) is defined as the difference between banks' capital ratio and their economic capital ratio.

Business cycles	Capital ratio (CAP)	Economic capital ratio (CAPE)	Inverse leverage ratio (CAPL)	Regulatory capital buffer (BUFR)	Economic capital buffer (BUFE)	Leverage-based capital buffer (BUFL)
Expansion	0.139	0.098	0.048	0.051	0.032	0.005
Recession	0.138	0.074	0.044	0.047	0.102	0.007
Non conditional	0.139	0.097	0.047	0.051	0.035	0.005

Table 4: Estimation results of the simultaneous equations of variations in regulatory capital buffer (BUFL), risk (TRISK) and performance (RET)

This table presents regression results of systems of simultaneous equations of changes in bank capital buffers, risk and performance. The estimations are performed using two-stage GMM regressions for panel data (2SGMM). Financial data are quarterly observations from statements covering 1982-2010. Market data was extracted from daily data and converted into quarterly units. In this table, we use total equity risk (TRISK) as the risk measure and equity returns (RET) to measure performance. The capital buffer (BUFL) is calculated as the difference between the shareholders' equity-to-assets ratio and the inverse of the regulatory ceiling on an unweighted leverage ratio. All other variables are defined in Table 1. The values in parentheses are robust standard deviations. Model 1 is shown in columns 1-3, model 2 in columns 4-6, model 3 in columns 7-9 and model 4 in columns 10-12. The 10%, 5% and 1% significance levels are respectively represented by *, ** and ***.

	Model 1			Model 2			Model 3			Model 4		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔTRISK	ΔRET
OUTGAP	0.0296***	-0.0075	0.334	0.0397***	0.0041	0.105	0.0270***	-0.0169	0.242	0.0345***	-0.0066	-0.308
	(0.005)	(0.010)	(0.210)	(0.007)	(0.017)	(0.237)	(0.006)	(0.011)	(0.270)	(0.012)	(0.031)	(0.524)
ΔBUFL		-0.078	-1.112		-0.0844	1.602		-0.510**	0.859		-0.399	14.45
		(0.140)	(2.468)		(0.226)	(3.099)		(0.200)	(5.441)		(0.709)	(13.630)
ΔTRISK	-0.0599		0.0504	-0.0817**		-0.137	-0.0594		-0.468	-0.0114		-0.25
	(0.050)		(1.389)	(0.040)		(1.385)	(0.048)		(1.459)	(0.051)		(1.411)
ΔRET	0.0053	0.0029		-0.0012	0.0025		0.0060*	0.0015		-0.0009	-0.0034	
	(0.004)	(0.005)		(0.003)	(0.005)		(0.004)	(0.005)		(0.003)	(0.005)	
$DREG_1$				-0.0014***	0.0008***	0.0100*				-0.0008***	0.0007	0.0258*
				(0.0001)	(0.0003)	(0.0056)				(0.0003)	(0.0007)	(0.0144)
$DREG_2$							0.0021***	-0.0012***	-0.0098	0.0012***	-0.0009	0.0212
							(0.0003)	(0.0002)	(0.0115)	(0.0004)	(0.0007)	(0.0183)
$DREG_1$*OUTGAP				0.0043	-0.0395**	0.165				0.0003	-0.0299	0.528
				(0.011)	(0.016)	(0.321)				(0.014)	(0.031)	(0.575)
$DREG_2$*OUTGAP							0.0103	0.0154	0.248	0.0038	-0.0202	0.673
							(0.012)	(0.015)	(0.314)	(0.016)	(0.033)	(0.573)

$\Delta BUFL*DREG_1$					0.267	-3.088					0.53	-15.81
					(0.240)	(3.677)					(0.704)	(13.850)
$\Delta BUFL*DREG_2$								0.591***	-3.835		0.673	-17.41
								(0.214)	(5.646)		(0.683)	(13.780)
SIZE	-0.0006***		0.0009	-0.0005***		0.0068*	-0.0018***		0.0078	-0.0013***		0.0027
	(0.0002)		(0.0032)	(0.0002)		(0.0037)	(0.0002)		(0.0091)	(0.0003)		(0.0084)
BUFR	0.0006			0.0040**			0.0013			0.0031*		
	(0.002)			(0.002)			(0.002)			(0.002)		
CREDIT	-0.0025***			0.0022**			-0.0003			0.0017*		
	(0.0009)			(0.0009)			(0.0009)			(0.0010)		
VTSX		0.0184***			0.0366***			0.0415***			0.0597***	
		(0.006)			(0.009)			(0.008)			(0.007)	
TERM		-0.0118	0.186		-0.0154**			-0.0094	0.175		-0.0128*	
		(0.007)	(0.160)		(0.007)			(0.007)	(0.168)		(0.007)	
CV		2.46E-05			6.56E-05			6.82e-05*			0.0001***	
		(0.00004)			(0.00005)			(0.00004)			(0.00004)	
CR3			-0.0002			2.77E-05			-1.23E-05			7.49E-05
			(0.0006)			(0.0006)			(0.0007)			(0.0006)
$BUFL_{t-1}$	-0.0390***			-0.0503***			-0.0567***			-0.0569***		
	(0.0091)			(0.0087)			(0.0099)			(0.0093)		
$TRISK_{t-1}$		-0.0311			-0.135*			-0.149***			-0.326***	
		(0.050)			(0.069)			(0.055)			(0.045)	
RET_{t-1}			-0.166***			-0.180***			-0.180***			-0.188***
			(0.054)			(0.054)			(0.056)			(0.052)
Observations	565	565	565	565	565	565	565	565	565	565	565	565
R-squared	0.045	0.064	0.087	0.201	0.139	0.087	0.105	0.113	0.086	0.211	0.143	0.092
Number of banks	6	6	6	6	6	6	6	6	6	6	6	6

Table 5: Estimation results with different risk measures

This table presents regression results of systems of simultaneous equations of changes in bank capital buffers, risk and performance. The estimations are performed using two-stage GMM (2SGMM). Financial data are quarterly observations from statement covering 1982-2010. Market data was extracted from daily data and converted into quarterly units. In this table, we use three risk measures: total equity risk (TRISK), idiosyncratic risk (IRISK) and implicit volatility of assets (ARISK); we use equity return (RET) to measure performance. The capital buffer (BUFL) is calculated as the difference between the shareholders' equity-to-assets ratio and the inverse of the regulatory ceiling on an unweighted leverage ratio. All other variables are defined in Table 1. Values in parentheses are robust standard deviations. Model 1 is shown in columns 1-3, model 2 in columns 4-6 and model 3 in columns 7-9. The 10%, 5% and 1% significance levels are respectively represented by *, ** and ***.

	Model 1			Model 2			Model 3		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔIRISK	ΔRET	ΔBUFL	ΔARISK	ΔRET
OUTGAP	0.0345***	-0.0066	-0.308	0.0344***	0.0748	-0.242	0.0077	0.0855	-0.19
	(0.012)	(0.031)	(0.524)	(0.011)	(0.095)	(0.539)	(0.016)	(0.115)	(0.685)
ΔBUFL		-0.399	14.45		0.184	13.77		4.724*	15.87
		(0.709)	(13.630)		(1.733)	(13.710)		(2.741)	(14.810)
ΔTRISK	-0.0114		-0.25						
	(0.051)		(1.411)						
ΔIRISK				-0.0097		-0.54			
				(0.011)		(0.386)			
ΔARISK							0.0044*		0.0533
							(0.002)		(0.134)
ΔRET	-0.0009	-0.0034		-0.0008	0.0009		-0.0102**	0.0155	
	(0.003)	(0.005)		(0.003)	(0.011)		(0.004)	(0.024)	
$DREG_1$	-0.0008***	0.0007	0.0258*	-0.0009***	-9.47E-05	0.0241*	-0.0006**	0.0059**	0.0275*
	(0.0003)	(0.0007)	(0.0144)	(0.0002)	(0.0019)	(0.0144)	(0.0003)	(0.0027)	(0.0153)
$DREG_2$	0.0012***	-0.0009	0.0212	0.0011***	-0.0035*	0.0187	0.0013***	0.0078***	0.0235
	(0.0004)	(0.0007)	(0.0183)	(0.0004)	(0.0020)	(0.0170)	(0.0004)	(0.0025)	(0.0177)
$DREG_1$*OUTGAP	0.0003	-0.0299	0.528	0.0014	-0.141	0.46	0.0237	-0.0866	0.411
	(0.014)	(0.031)	(0.575)	(0.012)	(0.095)	(0.589)	(0.017)	(0.105)	(0.712)

DREG$_2$*OUTGAP	0.0038	-0.0202	0.673	0.0035	-0.0309	0.667	0.0283	-0.0446	0.548
	(0.016)	(0.033)	(0.573)	(0.014)	(0.102)	(0.586)	(0.018)	(0.117)	(0.729)
ΔBUFL*DREG$_1$		0.53	-15.81		0.263	-14.99		-4.574	-17.22
		(0.704)	(13.850)		(1.718)	(13.950)		(2.868)	(15.000)
ΔBUFL*DREG$_2$		0.673	-17.41		0.117	-16.91		-4.700*	-18.9
		(0.683)	(13.780)		(1.673)	(13.830)		(2.778)	(14.930)
SIZE	-0.0013***		0.0027	-0.0012***		0.0035	-0.0014***		0.0022
	(0.0003)		(0.0084)	(0.0003)		(0.0074)	(0.0003)		(0.0076)
BUFR	0.0031*			0.0033*			0.0032		
	(0.0018)			(0.0018)			(0.0020)		
CREDIT	0.0017*			0.0019**			0.0012		
	(0.0010)			(0.0009)			(0.0010)		
VTSX		0.0597***			0.108***			-0.0111	
		(0.007)			(0.021)			(0.017)	
TERM		-0.0128*			-0.002			0.0328	
		(0.007)			(0.019)			(0.054)	
CV		0.0001***			0.0002*			0.0005***	
		(0.00004)			(0.0001)			(0.0001)	
CR3			7.49E-05			2.66E-05			7.26E-05
			(0.0006)			(0.0006)			(0.0006)
BUFL$_{t-1}$	-0.0569***			-0.0556***			-0.0500***		
	(0.0093)			(0.0091)			(0.0095)		
TRISK$_{t-1}$		-0.326***							
		(0.045)							
IRISK$_{t-1}$					-0.689***				
					(0.080)				
ARISK$_{t-1}$								-0.909***	
								(0.045)	
RET$_{t-1}$			-0.188***			-0.189***			-0.190***

			(0.052)			(0.051)			(0.053)
Observations	565	565	565	565	565	565	556	556	556
R-squared	0.211	0.143	0.092	0.216	0.355	0.083	0.109	0.544	0.085
Number of banks	6	6	6	6	6	6	6	6	6

Table 6: Estimation results with different performance measures

This table presents regression results of systems of simultaneous equations of changes in bank capital buffers, risk and performance. The estimations are performed using two-step GMM regressions (2SGMM). Financial data are quarterly observations from statements covering 1982-2010. Market data was extracted from daily data and converted into quarterly units. In this table, we use total equity risk (TRISK) to measure risk along with three measures of performance: equity return (RET), return on assets (ROA) and Tobin's Q (QTOB). The capital buffers (BUFL) are calculated as the difference between shareholders' equity-to-assets ratio and the inverse of the regulatory ceiling on an unweighted leverage ratio. All other variables are defined in Table 1. Values in parentheses are robust standard deviations. Model 1 is shown in columns 1-3, model 2 in columns 4-6 and model 3 in columns 7-9. The 10%, 5% and 1% significance levels are respectively represented by *, ** and ***.

	Model 1			Model 2			Model 3		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔTRISK	ΔROA	ΔBUFL	ΔTRISK	ΔQTOB
OUTGAP	0.0345***	-0.0066	-0.308	0.0344***	-0.0058	0.0042	0.0261**	-0.0034	0.701
	(0.0124)	(0.0308)	(0.524)	(0.0120)	(0.0312)	(0.0070)	(0.0127)	(0.0313)	(2.464)
ΔBUFL		-0.399	14.45		-0.514	0.748***		-0.333	-181.3***
		(0.709)	(13.63)		(0.711)	(0.261)		(0.733)	(65.25)
ΔTRISK	-0.0114		-0.250	-0.0134		0.0173	-0.0246		-41.65***
	(0.0514)		(1.411)	(0.0504)		(0.0292)	(0.0621)		(11.22)
ΔRET	-0.0009	-0.0034							
	(0.0031)	(0.0049)							
ΔROA				-0.177***	0.166				
				(0.0579)	(0.126)				
ΔQTOB							-0.0035***	0.0020	
							(0.0009)	(0.0019)	
$DREG_1$	-0.0008***	0.0007	0.0258*	-0.0008***	0.0006	0.0006***	-0.0003	0.0006	-0.194***
	(0.0003)	(0.0007)	(0.0144)	(0.0003)	(0.0007)	(0.0002)	(0.0003)	(0.0008)	(0.0638)
$DREG_2$	0.0012***	-0.0009	0.0212	0.0013***	-0.0010	0.0008***	0.0014***	-0.0011	-0.292***
	(0.0004)	(0.0007)	(0.0183)	(0.0004)	(0.0007)	(0.0003)	(0.0004)	(0.0008)	(0.0828)
$DREG_1$*OUTGAP	0.0003	-0.0299	0.528	0.0014	-0.0313	-0.0048	-0.0037	-0.0352	-0.403
	(0.0139)	(0.0306)	(0.575)	(0.0137)	(0.0309)	(0.0085)	(0.0142)	(0.0315)	(2.547)

DREG$_2$*OUTGAP	0.0038	-0.0202	0.673	0.0030	-0.0226	-0.0030	0.0009	-0.0230	-0.548
	(0.0156)	(0.0333)	(0.573)	(0.0154)	(0.0336)	(0.0085)	(0.0168)	(0.0330)	(2.792)
ΔBUFL*DREG1		0.530	-15.81		0.666	-0.738***		0.509	172.7***
		(0.704)	(13.85)		(0.708)	(0.268)		(0.725)	(66.34)
ΔBUFL*DREG2		0.673	-17.41		0.791	-0.715***		0.596	171.2***
		(0.683)	(13.78)		(0.686)	(0.261)		(0.702)	(64.13)
SIZE	-0.0013***		0.0027	-0.0013***		-7.24e-05	-0.0016***		0.177***
	(0.0003)		(0.0084)	(0.0003)		(0.0001)	(0.0003)		(0.0411)
BUFR	0.0031*			0.0031*			0.0041**		
	(0.0018)			(0.0018)			(0.0019)		
CREDIT	0.0017*			0.0017*			-2.64e-05		
	(0.0010)			(0.0010)			(0.0011)		
VTSX		0.0597***			0.0595***			0.0635***	
		(0.0067)			(0.0069)			(0.0066)	
TERM		-0.0128*			-0.0127*			-0.0154**	
		(0.0071)			(0.0071)			(0.0076)	
CV		0.0001***			0.0001***			0.0001***	
		(4.27e-05)			(4.29e-05)			(4.17e-05)	
CR3			7.49e-05			4.04e-05			-0.0038
			(0.0006)			(5.65e-05)			(0.0027)
BUFL$_{t-1}$	-0.0569***			-0.0588***			-0.0530***		
	(0.0093)			(0.0093)			(0.0098)		
TRISK$_{t-1}$		-0.326***			-0.326***			-0.327***	
		(0.0452)			(0.0459)			(0.0459)	
RET$_{t-1}$			-0.188***						
			(0.0515)						
ROA$_{t-1}$						-0.728***			
						(0.0744)			
QTOB$_{t-1}$									-0.138***

									(0.0327)
Observations	565	565	565	565	565	565	565	565	565
R-squared	0.211	0.143	0.092	0.197	0.149	0.328	0.030	0.097	-0.157
Number of banks	6	6	6	6	6	6	6	6	6

Table 7: Estimation results with different capital buffer measures

This table presents regression results of systems of simultaneous equations of changes in bank capital buffers, risk and performance. The estimations are performed using two-step GMM regressions (2SGMM). Financial data are quarterly observations from statements covering 1982-2010. Market measures were extracted from daily data and converted into quarterly units. In this table, we use total equity risk (TRISK) to measure risk, and equity return (RET) to measure performance. Capital buffers (BUFL) are calculated as the difference between the shareholders' equity-to-asset ratio and the inverse of the regulatory ceiling on an unweighted leverage ratio. The regulatory capital buffer (BUFR) is calculated as the difference between the book capital ratio (CAP) and the minimum regulatory capital requirement. Economic capital buffers BUFE are the difference between banks' actual capital ratio and their economic capital ratio (CAPE). All other variables are defined in Table 1. Values in parentheses are robust standard deviations. Model 1 in is shown in columns 1-3, model 2 in columns 4-6 and model 3 in columns 7-9. The 10%, 5% and 1% significance levels are respectively represented by *, ** and ***.

	Model 1			Model 2			Model 3		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	ΔBUFL	ΔTRISK	ΔRET	ΔBUFR	ΔTRISK	ΔRET	ΔBUFE	ΔTRISK	ΔRET
OUTGAP	0.0345***	-0.0066	-0.308	-0.0677	0.189	-3.03	-1.662	-0.0171	-0.87
	(0.012)	(0.031)	(0.524)	(0.066)	(0.271)	(3.148)	(5.777)	(0.047)	(0.856)
ΔBUFL		-0.399	14.45						
		(0.709)	(13.630)						
ΔBUFR					-11.00***	133.0***			
					(3.236)	(50.360)			
ΔBUFE								0.0004	-0.0239*
								(0.001)	(0.013)
ΔTRISK	-0.0114		-0.25	1.229***		15.34**	4.037		-0.887
	(0.051)		(1.411)	(0.365)		(7.148)	(8.125)		(1.453)
ΔRET	-0.0009	-0.0034		0.0067	-0.0533		0.986***	-0.0036	
	(0.003)	(0.005)		(0.0176)	(0.0496)		(0.2950)	(0.0046)	
$DREG_1$	-0.0008***	0.0007	0.0258*	0.0025*	-0.0127**	0.192***	0.0062	0.0008**	0.0128
	(0.0003)	(0.0007)	(0.0144)	(0.0013)	(0.0053)	(0.0713)	(0.0487)	(0.0004)	(0.0091)
$DREG_2$	0.0012***	-0.0009	0.0212	0.0060**	-0.0137***	0.199**	0.0172	-0.0009**	0.0005
	(0.0004)	(0.0007)	(0.0183)	(0.0024)	(0.0053)	(0.0794)	(0.0632)	(0.0004)	(0.0159)
$DREG_1$*OUTGAP	0.0003	-0.0299	0.528	0.0311	-0.185	2.867	1.423	-0.0194	0.956

	(0.014)	(0.031)	(0.575)	(0.067)	(0.263)	(3.163)	(5.810)	(0.047)	(0.871)
$DREG_2$*OUTGAP	0.0038	-0.0202	0.673	-0.176**	-0.161	3.041	1.185	0.0004	1.035
	(0.016)	(0.033)	(0.573)	(0.080)	(0.263)	(3.160)	(5.821)	(0.049)	(0.884)
ΔBUFL*$DREG_1$		0.53	-15.81						
		(0.704)	(13.850)						
ΔBUFL*$DREG_2$		0.673	-17.41						
		(0.683)	(13.780)						
ΔBUFR*$DREG_1$					10.96***	-133.9***			
					(3.225)	(50.420)			
ΔBUFR*$DREG_2$					11.05***	-134.0***			
					(3.237)	(50.530)			
ΔBUFE*$DREG_1$								0.0033	0.866***
								(0.006)	(0.172)
ΔBUFE*$DREG_2$								0.0169**	0.621***
								(0.007)	(0.190)
SIZE	-0.0013***		0.0027	-0.0017		-0.0219	-0.0109		0.0062
	(0.0003)		(0.0084)	(0.0016)		(0.0206)	(0.0343)		(0.0083)
BUFR	0.0031*								
	(0.002)								
BUFL				0.0699*			0.0239		
				(0.041)			(1.110)		
CREDIT	0.0017*			-0.0042			-0.0334		
	(0.0010)			(0.004)			(0.129)		
VTSX		0.0597***			0.0521**			0.0653***	
		(0.007)			(0.022)			(0.007)	
TERM		-0.0128*			0.0145			-0.0101	
		(0.007)			(0.028)			(0.008)	
CV		0.0001***			-0.0002			0.0001***	
		(0.00004)			(0.00020)			(0.00004)	
CR3			7.49E-05			0.0021**			0.00041
			(0.0006)			(0.0010)			(0.0006)

$BUFL_{t-1}$	-0.0569***								
	(0.0093)								
$BUFR_{t-1}$				-0.0422***					
				(0.013)					
$BUFE_{t-1}$							-0.155		
							(0.196)		
$TRISK_{t-1}$		-0.326***			-0.386***			-0.349***	
		(0.045)			(0.149)			(0.048)	
RET_{t-1}			-0.188***			-0.338***			-0.228***
			(0.052)			(0.086)			(0.055)
Observations	565	565	565	564	564	564	556	556	556
R-squared	0.211	0.143	0.092	-0.109	-11.971	-4.495	0.114	0.124	0.146
Number of banks	6	6	6	6	6	6	6	6	6

Table 8: Estimation results excluding the subprime crisis period (2007-2010)

This table presents regression results of systems of simultaneous equations of changes in bank capital buffers, risk and performance. The estimations are performed using two-step GMM regressions (2SGMM). Financial data are quarterly observations from statements covering 1982-2010. Market data was extracted from daily data and converted into quarterly units. In this table, we use total equity risk (TRISK) to measure risk and equity returns (RET) to measure performance. Capital buffers (BUFL) are calculated as the difference between shareholders' equity-to-assets ratios and the inverse of the regulatory ceiling on an unweighted leverage ratio. All other variables are defined in Table 1. Values in parentheses are robust standard deviations. Model 1 (columns 1-3) includes the whole sample period 1982-2010. Model 2 (columns 4-6) only covers 1982-2006. The 10%, 5% and 1% significance levels are respectively represented by *, ** and ***.

	Model 1 (Period 1982-2010)			Model 2 (Period 1982-2006)		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ΔBUFL	ΔTRISK	ΔRET	ΔBUFL	ΔTRISK	ΔRET
OUTGAP	0.0345***	-0.0066	-0.308	0.0304***	0.0078	-0.215
	(0.012)	(0.031)	(0.524)	(0.011)	(0.032)	(0.527)
ΔBUFL		-0.399	14.45		-0.115	18.75
		(0.709)	(13.630)		(0.687)	(13.250)
ΔTRISK	-0.0114		-0.25	-0.0995*		0.954
	(0.051)		(1.411)	(0.053)		(1.814)
ΔRET	-0.0009	-0.0034		-0.0032	-0.0073	
	(0.003)	(0.005)		(0.0033)	(0.0051)	
$DREG_1$	-0.0008***	0.0007	0.0258*	-0.0009***	0.0006	0.0254*
	(0.0003)	(0.0007)	(0.0144)	(0.0003)	(0.0007)	(0.0141)
$DREG_2$	0.0012***	-0.0009	0.0212	0.0010**	-0.0002	0.0173
	(0.0004)	(0.0007)	(0.0183)	(0.0004)	(0.0007)	(0.0185)
$DREG_1$*OUTGAP	0.0003	-0.0299	0.528	0.0036	-0.0319	0.485
	(0.014)	(0.031)	(0.575)	(0.013)	(0.031)	(0.580)
$DREG_2$*OUTGAP	0.0038	-0.0202	0.673	0.0228	-0.0185	1.008*
	(0.016)	(0.033)	(0.573)	(0.014)	(0.035)	(0.596)
ΔBUFL*$DREG_1$		0.53	-15.81		0.227	-20.32
		(0.704)	(13.850)		(0.683)	(13.510)
ΔBUFL*$DREG_2$		0.673	-17.41		0.363	-22.70*
		(0.683)	(13.780)		(0.667)	(13.510)
SIZE	-0.0013***		0.0027	-0.0010***		0.0068
	(0.0003)		(0.0084)	(0.0003)		(0.0091)
BUFR	0.0031*			0.0013		
	(0.002)			(0.002)		
BUFL						
CREDIT	0.0017*			0.0020**		
	(0.0010)			(0.001)		
VTSX		0.0597***			0.0188**	
		(0.007)			(0.008)	
TERM		-0.0128*			-0.0163**	

		(0.007)			(0.007)	
CV		0.0001***			0.0001***	
		(0.00004)			(0.00004)	
CR3			7.49E-05			2.09E-05
			(0.0006)			(0.0006)
$BUFL_{t-1}$	-0.0569***			-0.0517***		
	(0.0093)			(0.009)		
$TRISK_{t-1}$		-0.326***			-0.186***	
		(0.045)			(0.053)	
RET_{t-1}			-0.188***			-0.199***
			(0.052)			(0.055)
Observations	565	565	565	510	510	510
R-squared	0.211	0.143	0.092	0.249	0.08	0.088
Number of banks	6	6	6	6	6	6