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How Cyclical Is Bank Capital?

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Using annual data since 1834 and quarterly data since 1959, I find a negative correlation between output and current and lagged values of the bank capital ratio, but a positive correlation with leading values, although except for the period since 1996 the numbers are mostly small and usually insignificant. The most significant correlations tend to reflect movements in bank assets, rather than capital itself, and although the pattern of aggregate correlations matches those of large banks, small banks show a different pattern, with strongly procyclical capital ratios (counter-cyclical leverage).

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1 Introduction

The financial crisis has increased the focus on bank capital and its role linking financial conditions to booms and recessions. In fact, the capital-to-assets ratio, or, inversely, bank leverage, does not have a simple relationship with aggregate output, and depends sensitively on the time period, definition of capital, and bank size. At business cycle frequencies, in annual data since 1834 and quarterly data since 1959, the capital ratio shows signs of being countercyclical, in that output has a negative correlation with current and lagged bank capital ratios, but also positive correlation with leading values. Except for the period since 1996, however, the numbers are mostly small and statistically insignificant. The significant correlations tend to reflect movements in bank assets, rather than capital itself, and although aggregate correlations parallel those of large banks, small banks show a different, strongly pro-cyclical, pattern.

A longer data set encompasses a larger number of business cycles for comparison, and can pick up relations that may be robust across regulatory regimes. But comparing across different regimes can be difficult, as there are periods with and without a gold standard, with and without deposit insurance, and with and without a central bank. Because of these differences the paper begins with a short history of bank capital requirements in the US, before moving on to describe the data. It then measures cyclicality by examining the correlations between aggregate output–measured by RGDP–and leads and lags of several capital ratios, detrended both by the standard Hodrick-Prescott filter and a recent alternative championed by James Hamilton.

In general, the bank capital ratio turns out to be countercyclical, with a lag of about 4 quarters, though the exact results depend on the time period and the definition of capital, and very small banks often show a different pattern. Despite this being a rather reduced form, stylized fact sort of result, it has implications that challenge some conventional ideas in both theory and policy. First, and most broadly, it challenges the notion from the credit crunch literature that recessions are exacerbated, if not caused, by capital constrained banks reducing their lending. Bernanke and Lown (1991) is an early and influential paper investigating the issue, though they are somewhat skeptical about the macroeconomic effects of what they term a "capital crunch." Kashyap and Stein (2004) argue that losses in recessions erode bank capital, and contribute to reduced lending. Bliss and Kaufman (2003) likewise argue that credit crunches arise from bank capital ratios being higher in expansions and lower in recessions. At least superficially, this is hard to reconcile with the data.

There are also a variety of more recent models that take an explicit stand on the cyclicality of capital and find theoretically that the capital ratio should be pro-cyclical. Repullo and Suarez (2013) develop a discrete time infinite horizon economy with banks, and find that the capital ratio is higher in the good state than in the bad. Estrella (2004) examines the cyclical behavior of optimal bank capital, and finds a negative relationship between capital and losses, which indicates a positive relation between the state of the economy and capital. Estrella's model also takes a particularly careful look at the lead and lag structure of his variables, and that often is more in tune with the data. He and Krishnamurthy (2013), in modelling the dynamics of risk premia, find that the capital ratio of financial intermediaries falls during a crisis. To the extent that crises and recessions coincide, this suggests pro-cyclicality. Adrian and Shin (2014) produce a model with counter-cyclical capital (phrased as pro-cyclical leverage) but argue that any model with log utility, such as Brunnermeier and Sannikov (2016), will produce countercyclical leverage.

The broader literature on bank capital is extensive: Berger et al. (1995) provide a comprehensive review as of 1995, and Admati and Hellwig (2013) provide a detailed, readable, and opinionated view of recent controversies. The effect of bank capital on lending received more scrutiny with the advent of Basel I (Haubrich and Wachtel (1993), Berger and Udell (1994)), and more recent worries about regulatory-induced cyclicality are addressed in Gordy and Howells (2006), and

Goodhart et al. (2004), with post-crisis modelling efforts by Repullo and Suarez (2013), among others. Representative papers calibrating the optimal cyclical properties of capital regulations are Estrella (2004), Begenau (2013), Jokivuolle et al. (2014), and Davydiuk (2017). Flannery and Rangan (2008) and Rajan (2009), conversely, emphasize the market forces driving observed levels of bank capital.

Less work has been done on the empirical cyclical properties of bank capital: Ayuso et al. (2004) look at Spanish data from 1986-2000, and Bikker and Metzemakers (2007) look at 29 countries from 1990-2001. Bikker and Metzemakers find that a business cycle indicator does not have a significant impact on the bank capital ratio, but also point out that other cyclically sensitive factors, such as risk, may mask the effect. Brei and Gambacorta (2014) look at 14 advanced economies from 1995-2012 and find that the leverage ratio is more countercyclical than the risk-weighted capital ratio. Begenau's sophisticated model implies an acyclical capital ratio, and a binding capital requirement creates a strong corrleation between risky assets and bank equity. (Adrian and Shin, 2010, 2014) concentrate on broker-dealers but briefly look at how commercial bank leverage varies with bank assets. Amel-Zadeh et al. (forthcoming), looking at the impact of fair-value accounting, regress the change in leverage against bank assets. Some work related to Basel III has examined the relationship between bank capital and the credit cycle (Drehmann and Tsatsaronis (2014), Baron (2017)), but does not look at the business cycle, beyond noting the extensive differences between the two types of cycles. Some work has looked at the cyclical properties of non-financial corporate firms, comparing changes in debt and equity financing over the business cycle (Covas and den Haan (2011), Begenau and Salomao (2015)), with Rampini and Viswanathan (2017) emphasizing the dynamics that arise as bank and firm capital accumulations interact.

Some more recent papers are more closely related to the work in this paper. Laux and Rauter (2017), looking at whether fair-value accounting drives leverage, regress the change in individual bank leverage against the change in real GDP and bank characteristics over 1990-2013. Relative to them, I take a more aggregative approach, use a longer data set, and consider dynamic correlations. Nuño and Thomas (2017) develop and calibrate a DSGE model to explore the correlation between leverage and output in 1981-2014. I again use a longer data set, estimate a broader set of dynamic correlations, and take a deeper look at the impact of bank size and the distribution of capital ratios. Finally, directly comparing the results from the Hamilton approach with those from the H-P filter may contribute some practical experience with using different methods of separating trend from cycle.

2 The Definition and Regulation of Bank Capital

The regulations, and indeed the very concept of bank capital, have changed since the founding of the republic, and interpreting the historical results requires an appreciation of those changes. It requires an answer to several questions. What is bank capital? What are the regulations on bank capital, and how have they changed over time? The current concept of capital is an accounting one: a liability (or set of liabilities) that acts as a residual claimant, and thus can act as a "buffer" against losses. In the 18^{th} and 19^{th} centuries, capital more often meant the specie originally contributed by the bank's organizers (Hammond (1985) p. 134). Initially, capital requirements did not take the current form of a specified fraction of assets (perhaps adjusted for risk). Rather, the law required a minimum absolute level of capital. In the US, this often depended on a bank's location: section 7 of the National Banking Act (1864) prescribed \$50,000 for places with a population of 6,000 or less, \$100,000 for places with a population between 6,000 and 50,000, and \$200,000 for places with a population over 50,000. State regulations differed as to both capital levels and population, with Maryland at one time having seven categories and Nebraska eight (Grossman (2010), p. 236).

The early capital requirements also add some confusion to the idea of capital as a buffer stock, since equity at times had double, triple, or even unlimited liability (Grossman (2010), p.237). Furthermore, capital did not have to be fully subscribed before a bank opened: Section 14 of the National Banking Act required half of the capital to be paid-in before operations could commence. This created the distinction between authorized and paid-up capital. The remaining "uncalled" capital served as an additional buffer in case of losses. An individual might subscribe for, say, one thousand dollars of capital, pay in five hundred with specie, and remain liable for the additional five hundred if the bank had need of it. Double (or higher) liability became less common after the 1930s, with Arizona finally removing it in 1956 (Esty (1998)). An echo remains, however, in the Federal Reserve's "source of strength" doctrine, whereby companies that own or control a bank may be liable for more than their original capital investment (now codified in section 616(d) of the Dodd-Frank Act (Lee, 2012a,b)).

The earlier capital requirements showed more similarlity to their modern counterparts than readily meets the eye, however, in that their charters also restricted bank liabilities to a multiple of capital. While this was a restriction on liabilities, not assets (as capital ratios are phrased today), the logic of double-entry bookkeeping makes one a limit on the other. This identity was broken, however, because deposits were often exempted. One possible reason is that Hamilton and the other founders considered deposits and specie to be identical, a usage and assumption that did not last. Another possibility is that protecting note holders was considered more important, since they were often poor, and failure of the bank to pay would be a particular burden on them (Smith (1976), p. 343).[1] Exempting deposits effectively made the capital requirement a rule that specie backed note issue, and for that reason Hammond (1985) argues that these restrictions represent the origin of reserve requirements, not capital ratios. The restrictions soon explicitly required that banks hold a fraction of liabilities as specie.

What is often considered a major determinant of a firm's capital structure (Meyers (2001)), the corporate tax rate, did not play a major role in the early American economy. The corporate income tax was introduced on a permanent

[1] I thank Hugh Rockoff for pointing this out to me.

footing in 1909, with a temporary measure having been used in the Civil War (Slemrod and Bakija (2008)).

In the early years of the 20th century, capital ratios once again became more important. Most likely reacting to the experience of state bank supervisors, Comptroller of the Currency John Skelton Williams proposed making a capital to *deposit* ratio of one-tenth legislatively mandated (Hahn (1966)). So the notion of capital limiting liabilities was still around, and has some modern adherents such as Myerson (2014). In 1939 the FDIC defined capital adequacy as having a better than one-tenth capital to total assets ratio–New Deal legislation had listed adequate capital as a prime criterion for deposit insurance eligibility. Quantitative criteria were effectively suspended in 1942 by all three federal supervisors as well as the National Association of State Bank Supervisors, not wishing to restrain banks' purchase of Treasury securities for the war effort (Orgler and Wolkowitz (1976)). The question returned after the war, however, with the Comptroller looking at the ratio of capital to risk assets, that is, excluding cash and government bonds. By 1952 the Federal Reserve Bank of New York created an explicit formula for weighting different assets by their risk, and in 1956 the Board of Governors adopted a similar ABC (Analyzing Bank Capital) model. The trend was not monotonic, however, since in 1962 the Comptroller, at the urging of banks, de-emphasized formulas (Hahn (1966)) and even in the seventies maintained that they were only one part of a suite of tools for assessing bank health (Tarullo (2008)). Capital ratios were used as a supervisory instrument, but the legal authority to enforce capital limits was at best unclear. The Federal Reserve lost a court battle in 1959 when it tried to revoke Federal Reserve membership on the basis of capital problems (Orgler and Wolkowitz (1976)).

In the 1970s, oil shocks and stagflation created an uncertain macroeconomic environment. Large firms reduced their dependence on banks by accessing commercial paper and other products in the capital markets; savers moved into money market funds. Several high-profile failures, such as Herstatt and Franklin National, highlighted the problem. Banks' efforts to compete led to the erosion of the New Deal regulatory regime, which was based on restricting activities and investments. As the old regime crumbled, supervisors increasingly moved to capital regulation as a substitute for direct control. In 1981 the OCC and the Federal Reserve jointly issued formal capital ratios, of 5 percent capital to assets, while the FDIC separately issued a 5 percent guideline (Tarullo (2008)). In 1983 this was extended to the largest 17 banks in the US, and later that year, legislation explicitly required the agencies to set capital ratios.

Increasing concerns about the risk arising from low capital ratios at large international banks and worries about an uneven playing field in the international arena eventually led the Basel Committee for Bank Supervision (BCBS, formed in 1974 after Herstatt) to consider and eventually adopt international standards in 1988.

Capital requirements are currently in a state of flux, as provisions of the Dodd-Frank Act and Basel III are being implemented. For the most part, however, my data end before these changes take effect. For the latter part of the sample, capital requirements take the form of three ratios, and distinguish between different types of capital and different types of assets. The leverage ratio says that the ratio of Tier 1 capital to balance-sheet assets must be greater than or equal to 4 percent (3 percent if the bank or BHC has a 1 rating). The Tier 1 capital ratio says that the ratio of Tier 1 capital to risk-weighted assets must be at least 4 percent, and the total capital ratio says that the ratio of total capital to risk-weighted assets must be at least 8 percent. These are bare minimums: banks may exceed these ratios, but still be subject to some regulatory restrictions, specified by the prompt corrective action regime. In general, to face no restrictions, a bank must be well capitalized, having ratios of 5, 6, and 10 percent, or higher. Furthermore, if a bank is critically undercapitalized, with tangible equity below 2 percent, the regulator must put the bank into receivership or conservatorship.

Tier 1 capital (for this time period) includes common stockholders' equity, non-cumulative perpetual preferred stock, minority interest in consolidated subsidiaries, and some other items that the Dodd-Frank Act and Basel III will no longer include. Total capital adds in Tier 2 capital, which includes some amount of allowances for loan losses, cumulative perpetual preferred stock, long-term preferrred stock, and some subordinated debt. In addition, Tier 2 capital cannot exceed Tier 1 capital. At one point there was even Tier 3 capital, but it is no longer applicable, while a new measure, common equity Tier 1 (a subset of Tier 1 capital) is being phased in.

Balance-sheet assets for the leverage ratio are defined as quarterly averages under GAAP defintions, with a few adjustments for items such as goodwill, but with no weighting of assets by risk and no inclusion of off-balance-sheet items. Risk-weighted assets also adjust each item by a risk weight, if it is on balance sheet, or by a credit conversion factor, if it is off balance sheet. This is, of course, a rough simplification, and more details may be found in the Commercial Bank Examination Manual, section 3020.1, pages 1–60. The revised regulations can be found in the 275 pages of the Revised Capital Rules in the Federal Register and updates.

3 Data: Quarterly and Annual

Since notions of capital and its regulation have changed over time, we naturally end up with several different data sets. They all rely on book or regulatory capital, in part because that is how capital requirements are specified, but also because of data availability–most bank stocks have been rarely traded, making market values unavailable. The two most recent data sets are quarterly. The first is from 1959 Q4 to 2015 Q4, the constraint being the call report data (FFIEC Quarterly Reports of Income and Condition). The capital ratio is the ratio of total equity captial (RCFD3210) to total assets (RCFD2170) for banks with foreign and domestic offices, taken from the call reports. It corresponds most closely to what is now termed a leverage constraint. The original data for this series have some gaps: For the years 1963-1972, Q1 and Q3 are missing for all banks. I fill in the missing dates and insert the average of the previous and forward values. In addition, the reported asset numbers oscillate wildly in some quarters in 1973-1978. I replace each value of the series with the trailing average, the average of the current value and previous value. This smooths the value and the capital ratio can be computed from the new number. The interpolation and smoothing are done at the aggregate (as opposed to the bank) level. Interpolating and smoothing of course impacts the time-series properties of the data, though hopefully this disadvantage is offset by having a longer time series to examine for cyclical properties.

The second series is shorter, showing the ratio of Tier 1 capital (RCFD8274) to risk-weighted assets (RCFDA223, RCFAA223), from 1996 Q1 to 2015 Q4, the time period for which the risk weighted assets are available directly on the call reports. Figure 1 plots both quarterly series, with shaded areas indicating NBER recessions. The capital ratio is calculated by aggregating the capital for the industry and dividing by aggregate industry assets. This average reflects the concentration of assets and capital at large banks. Averaging across banks without adjusting for size, we would find a similar pattern, but with a higher average value. RGDP is gdph@usecon Real Gross Domestic Product (SAAR, Bil.Chn.2009 dollar) from the BEA, quarterly from 1959 Q4 to 2015 Q4.

Using annual data it is possible to construct a longer time series, from 1834 to 2015. The earlier data, 1834-1933, come from the Millennial Statistics of the United States (Carter et al. (2006)) and includes both state and national banks under the heading commercial banks, coming from Tables Cj251-264 "Commercial Banks - number and assets" and Cj265-272, "Commercial bank - liabilities." I use series Cj252 for total assets and Cj271 for capital accounts. At the very beginning of the period for which we have data, the Second Bank of the United States existed; though vetoed by Andrew Jackson in 1832, its charter did not expire until 1836. It is not included in the earliest data set, which restricts itself to state banks. That time period is also notable for fiscal policy, since in 1835 the federal government fully paid off all of its debt, and faced questions of what to do with the surplus. (Millennial Statistics also contains a series for state and national banks separately from 1843 to 1896 that is nearly identical to the longer series, and is very close to the series based on the earlier historical statistics volume used in Tarullo and U.S. Department of the Treasury (1991).) Starting in 1934 the data are from the FDIC Historical Statistics of Banking (Federal Deposit Insurance Corporation), "total assets" from Table CB09, and "total equity capital" from Table CB14, both balances at year end, both US and other areas. The output numbers are Real Gross Domestic Product, million 1996 dollars, 1834-2002 from the Millenial Statistics, series Ca9, and from the BEA since. Figure 2 plots the annual series along with shading for recessions, taken from the NBER since 1853, and from Sutch's annual dates (Table Cb1-4 in Millenial Statistics for 1834-1854). A year is counted as being in a recession if it is between the peak and the trough (inclusive).

The initial impression from these figures is that bank capital does not seem especially cyclical, particularly in the longer annual series, where trends dominate the picture. Table 1 reports simple back-of-the-envelope calculations comparing capital ratios during recessions and expansions. For the quarterly data, banks had similar capital ratios in expansions and contractions. The leverage ratio (equity to total assets, a standard but potentially confusing term since it is the inverse of leverage, which is the ratio of assets to capital) averaged 7.5 percent in expansions and 8.0 percent in contractions. The Tier 1 to RWA ratio averaged 11.1 percent in expansions and 9.9 percent in contractions. The annual series was mixed. The averages for the entire time period are countercyclical, averaging 22 percent in contractions and 16 percent in expansions. Three sub-periods, by contrast, have mildly pro-cyclical averages, though the post-Fed era shows a small amount of countercyclicality, 9.8 percent in contractions and 8.7 percent in expansions.

One comparison point for the cyclical differences is the Basel III countercyclical capital buffer (Basel Committee on Banking Supervision (2010)). National authorities have the discretion to require up to an additional 2.5 percent of Tier 1 equity to risk-weighted assets in times of potential stress. In terms of risk-weighted assets, at least, this is on the high side of the observed variation over the cycle.

Comparing averages is one way to see if bank capital ratios are higher in expansions or contractions, but for the recent periods, we have data on individual banks, and this lets us compare the distribution of capital ratios. Figure 3 uses a percentile comparison plot (or Q-Q plot) to compare the distribution of equity capital (1959:4 to 2015:4) and Tier 1 capital (1996:1 to 2015:4) ratios in expansions and recessions, with percentiles between 5 percent and 95 percent. Deviations from the 45° line indicate differences between the two distributions. In other words, it plots one distribution against another. Because the eye often has difficulty gauging vertical differences, the two lower panels show a Tukey mean-difference plot, which rotates the 45° line to the horizontal and expands the vertical axis. This makes it clear that the capital ratio in expansions is higher than in recessions across the entire distribution. This is consistent with the aggregate results for 1959–2015 that show a slightly higher mean in recessions, because no interpolation or smoothing was done at the individual bank level. The two results underscore the rather delicate nature of assessing cyclicality. A subtlety that an average would not pick up is that, except for the highest levels, banks with a higher capital ratio are more cyclical, since the difference between capital in expansions and recessions is larger. The less extreme difference at the low end makes intuitive sense, since banks with very low capital ratios are likely prevented by regulations from going lower.

4 Detrending to Find Business Cycles

Perhaps unfortunately, the definition of cyclicality is not uniform. For some purposes, a simple correlation with output or a regression coeffcient with a linear trend is sufficient, as in Brei and Gambacorta (2014), and Laux and Rauter (2017). For macroeconomic questions–and we think the role of bank capital in aggreagate output as inherently macroeconomic–it is often useful to make a distrinction between trend and cycle, and to consider cross-correlations dynamically, with several leads and lags. A standard approach for judging cyclicality goes back to the method laid out in Kydland and Prescott (1990), which removes a Hodrick-Prescott trend from the data and calculates the degree of co-movement, measured as cross-correlations at different lags, and phase shift, measured as the lag at which the maximum cross-correlation occurs. In fact, the Basel Committee, in its guidance to applying the countercyclical capital buffer (Basel Committee on Banking Supervision (2010)), uses the Hodrick-Prescott filter to determine the long-term trend in the credit-to-GDP ratio. [2]

Looking for cyclicality in bank capital, then, means applying this approach to the bank capital ratio and RGDP for the different series. Correlations close to 1 point to a pro-cyclical series, just as those close to -1 show a counter-cyclical series. How close a number must be to plus or minus 1 is a matter of judgment that undoubtedly depends on the specific circumstance. One set of guidance comes from Kydland and Prescott, who consider a cross-correlation of -0.20 as uncorrelated. Covas and den Haan (2011), looking at debt and equity issuance by non-financial firms, emphasize statistical significance at the 5 percent level, but their correlations are mostly well above 0.20, in the range of 0.5-0.92. (For statistical significance we use a bartlett window.) Jermann and Quadrini (2012) report correlations of equity payouts and debt repurchases of 0.45 and -0.70 (though they use a band-pass filter).

While the H-P filter (Hodrick and Prescott (1997)) has been (and remains) a standard tool in macroeconomics for assessing cyclical properties of time series, it has for some time been subject to criticism that it takes a rather procrustian approach to detrending, and can significantly alter the persistence, variablity and co-movements of series (King and Rebelo (1993)) along with creating spurious

[2] The BCBS guidance aims to adjust the gap over the credit cycle, as opposed to the business cycle; the two are not identical. One technical difference that emerges is that the BCBS recommends an H-P filter "tuning" or smoothing parameter of $\lambda = 400,000$ whereas the business cycle literature uses $\lambda = 1600$ for quarterly data. In this paper, I used 1600 for the quarterly data and follow Ravn and Uhlig (2002) and set $\lambda = 6.25$ for annual data.

cyclical behavior (Harvey and Jaeger (1993), Cogley and Nason (1995), Ashley and Verbrugge (2008)). Recently, there has been renewed interest in the properties of the H-P filter (de Jong and Sakarya (2016), Phillips and Jin (2015)), with Hamilton (2017) suggesting a simple alternative. Hamilton champions the approach (related to earlier work by den Haan (2000)) of treating the cyclical component as a forecast error from a linear projection. For business cycles, he suggests an OLS regression of the variable two years (eight quarters, 24 months) in the future against a constant and the current value and three lags. He thus shows that for

$$y_{t+h} = \beta_0 + \beta_1 y_t + \beta_2 y_{t-1} + \beta_3 y_{t-2} + \beta_4 y_{t-3} + v_{t+h} \tag{1}$$

the residuals

$$\hat{v}_{t+h} = y_{t+h} - \hat{\beta}_0 - \hat{\beta}_1 y_t - \hat{\beta}_2 y_{t-1} - \hat{\beta}_3 y_{t-2} - \hat{\beta}_4 y_{t-3} \tag{2}$$

in his words "offer a reasonable way to remove an unknown trend for a broad class of underlying processes."

The results for the quarterly equity to total assets ratio are plotted in Figure 4, which shows both the results of the H-P-filtered data and the Hamilton detrending. Tables 2 and 3 report the correlations and t-statistics. By these yardsticks, the (quarterly) capital ratio does not appear highly cyclical, either by the H-P or Hamilton method. Only a few correlations minimally exceed 0.20, and none are statistically different from zero.

The Tier 1 capital to risk-weighted assets ratio, charted in Figure 5 and reported in Tables 4 (for H-P) and 5 (for Hamilton), shows pronounced cyclicality, though of a rather complicated sort. Contemporaneous cross-correlations are small and statistically insiginificant, but longer lags show a different pattern. Real GDP is negatively correlated with past values of the bank captial ratios, as large as 0.75 at four quarters. The relationship turns positive with future ratios, again in the four-to-eight quarter ahead range.[3] Thus capital ratios appear contemporaneously acyclical, but to negatively lead the cycle.

Part of the difference stems from differing sample periods. When the equity to total assets ratio is computed over the same 1996-2015 period for which we have RWA data (Tables 6-7), it shows a similar pattern with negative correlation at lags and positive correlation at leads, although the numbers and statistical significance are smaller.

As seen in Figure 6 and Tables 8 and 9, the long annual data series show little cyclicality in the capital ratio, and what little there is shows a very different pattern from the quarterly data. In the quarterly data, the contemporaneous correlations were small; in the annual data they are the largest and most significant. Using the H-P-filtered data, only the contemporaneous correlation with the capital ratio is significant, and it is on the low side, -0.22. This suggests a simple counter-cyclical pattern: the capital ratio is low when real GDP is above trend. Using Hamilton detrending, there is also a negative correlation between current RGDP and next year's capital ratio. Perhaps of independent interest, the quarterly data show a similar pattern across the the H-P and Hamilton results, as RGDP varies negatively with lagged capital ratios and positively with leads: for the annual data, H-P data show a positive correlation at leads, whereas the Hamilton data shows a negative correlation.

Where cyclicality is found, a natural question is whether it arises primarily from the numerator or denominator, that is, from changes in capital, assets, or some combination thereof. The additional lines in Tables 2–9 address this. Tier 1 capital is generally non-cyclical–and while a few correlations reach the 0.2 to 0.3 range in the Hamilton approach, they are not statistically significant. Lagged risk-weighted assets have large and significant correlations under either detrending method. With these assets varying positively with RGDP, they undoubtedly contribute to the negative correlation between RGDP and the capital ratio. The

[3] The Estrella (2004) model predicts a similar pattern, but with the opposite sign.

ratio of risk-weighted assets to total assets, which might show how banks adjust their portfolios to reduce capital requirements, tend to be large and positive at lags (though significant only for the H-P data). This indicates that a high level of RGDP is associated with banks having a high proportion of risk-weighted assets, that is, a greater portion of the assets having a high risk weight. Equity and total assets show less cyclicality over the 1959-2015 period, but the positive relationship between RGDP and lagged assets is strong over the 1996-2015 period. Perhaps surprisingly, in the annual series the components show more cyclicality than the ratio itself. In several cases, a weak negative correlation of the capital ratio results from two positive correlations, with the assets showing more cyclicality than capital–perhaps indicating a reduced demand for loans in recessions.

5 Sorting by Size

It is a truism among banking researchers that banks of different sizes often perform very differently, which should not be surprising given that the size of banks in the US varies by a factor of over 10,000. The FDIC Statistics on Depository Institutions has an entire report for banks with less than \$100 million of assets, while the four largest banks hold assets worth over a trillion dollars. Regulation can have vastly different impacts on large and small banks. This section sorts banks by size and looks at the cyclical properties of their capital ratios.

As before, we look at both the equity to total assets ratio and the Tier 1 to risk-weighted assets ratio. Based on total assets, banks are placed in one of five size categories: less than \$100 million, between \$100 million and \$1 billion, between \$1 and \$10 billion, between \$10 and \$50 billion, and greater than \$50 billion (in part these are based on regulatory distinctions, since certain regulations come into force at \$10 and 50 billion). Several caveats are in order. First, the sort is on a quarter-by-quarter basis, so the same bank may be in several categories over the sample, as growth, mergers, acquisitions, and spin-offs take place. Second, the more detailed information from the call report also reduced the available time period, and the series thus runs only from 1996 Q1 to 2015 Q4, and thus encompasses only two recessions. Of course, other forms of disaggregation are possible, and in future work, it would be interesting to sort by region or primary business line.

As above, cyclicality is calculated by cross-correlations between the capital ratio and RGDP, each de-trended via a Hodrick-Prescott filter and the Hamilton procedure, but because the results were similar, I only report the results for the Hamilton procedure. Figure 7 plots the correlations and Tables 10 and 11 report the numbers. The results are fairly robust across the different capital measures. Most large banks show correlations that start negative at longer lags and gradually increase to positive at longer leads, though the statistical significance is small. This pattern is of course similar to the overall correlation, which reflects the dominance of the large banks in the aggregates. The smallest banks (<$100 million), however, show a markedly different pattern: a high positive contemporaneous correlation that decreases gently as leads and lags increase, becoming negative in the equity ratio case for larger leads. Covas and den Haan (2011) note a similar pattern for corporate firms, where large firms dominate the aggregate effect.

6 Conclusion

So how cyclical is the bank capital ratio? The short answer is that it exhibits signs of being countercyclical. A glance back at the charts or the tables shows that the contemporaneous correlation between detrended real GDP and the detrended capital ratio is uniformly negative, though the number is sometimes small and insignificant. The sign is robust across detrending methods and time periods. The Tier 1 risk-weighted assets ratio shows stronger countercyclicality, with output negatively correlated with lagged values of the ratio. There are mixed results coming from simple averages across expansions and contractions, and strong positive contemporaneous correlation arises for very small banks (under $100 million in assets). Since leverage is the inverse of the capital ratio, we find we have mixed evidence for the cyclicality of leverage–the evidence seems fairly strong for the period since 1996, but the relationship is less strong for other periods.

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Table 1 Average Capital Ratio by Contraction and Expansion

Equity to assets ratio, percent			
Annual Data		contraction	expansion
Full		22.2	16.3
	Pre-Fed	31.5	33.4
	Post-Fed	9.8	8.7
	Pre-FDIC	27.9	30.0
	Post-FDIC	7.9	8.1
Quarterly Data 1959-2015			
Equity/total asssets		8.0	7.5
Quarterly Data 1996-2015			
Tier 1/RWA		9.9	11.1
Equity/total asssets		9.6	10.0

Source: Carter et al. (2006), Federal Deposit Insurance Corporation, author's calculations

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Table 2 Cyclical Behavior of Capital Ratio, Deviation from HP Trend

cross-correlation of RGDP, 1959 Q4–2015 Q4

time	Caprat	Capital	Assets	RGDP
x_{t-8}	-0.181	-0.04	0.098	-0.292
	(1.441)	(0.329)	(0.087)	
x_{t-7}	-0.213	-0.01	**0.158**	-0.217
	(1.679)	(0.082)	(1.406)	
x_{t-6}	-0.221	0.03	0.208	-0.101
	(1.762)	(0.247)	(1.854)	
x_{t-5}	-0.209	0.07	**0.236**	0.045
	(1.667)	(0.577)	(2.104)	
x_{t-4}	-0.182	0.10	**0.238**	0.243
	(1.454)	(0.823)	(2.125)	
x_{t-3}	-0.183	0.07	0.221	0.453
	(1.451)	(0.577)	(1.967)	
x_{t-2}	-0.191	0.02	0.176	0.677
	(1.522)	(0.165)	(1.571)	
x_{t-1}	-0.150	-0.05	0.078	0.867
	(1.099)	(0.412)	(0.699)	
x_t	-0.083	-0.08	0.005	1.00
	(0.662)	(0.659)	(0.041)	
x_{t+1}	-0.023	-0.08	-0.037	0.867
	(0.181)	(0.659)	(0.333)	
x_{t+2}	0.040	-0.06	-0.061	0.677
	(0.319)	(0.494)	(0.540)	
x_{t+3}	0.106	-0.05	-0.109	0.453
	(0.842)	(0.412)	(0.972)	
x_{t+4}	0.153	-0.05	-0.152	0.243
	(1.220)	(0.412)	(1.353)	
x_{t+5}	0.151	-0.05	-0.155	0.045
	(1.202)	(0.412)	(1.380)	
x_{t+6}	0.148	-0.06	-0.167	-0.101
	(1.183)	(0.494)	(1.491)	
x_{t+7}	0.145	-0.02	-0.132	-0.217
	(1.156)	(0.165)	(1.173)	
x_{t+8}	0.179	0.02	-0.134	-0.292
	(1.427)	(0.165)	(1.197)	

Source: BEA, FFIEC, author's calculations

Significant at 5% or higher in bold.

Table 3 Cyclical Behavior of Capital Ratio, Hamilton Approach

cross-correlation of RGDP, 1959 Q4–2015 Q4

time	Caprat	Capital	Assets	RGDP
x_{t-8}	-0.144	-0.038	0.067	-0.123
	(0.907)	(0.247)	(0.425)	
x_{t-7}	-0.165	-0.017	0.106	0.006
	(1.040)	(0.109)	(0.674)	
x_{t-6}	-0.173	0.012	0.141	0.156
	(1.093)	(0.076)	(0.895)	
x_{t-5}	-0.167	0.036	0.159	0.313
	(1.055)	(0.230)	(1.011)	
x_{t-4}	-0.145	0.045	0.154	0.487
	(0.914)	(0.287)	(0.978)	
x_{t-3}	-0.126	0.040	0.139	0.642
	(0.799)	(0.256)	(0.882)	
x_{t-2}	-0.116	0.028	0.117	0.771
	(0.734)	(0.178)	(0.746)	
x_{t-1}	-0.072	-0.024	0.030	0.898
	(0.458)	(0.156)	(0.192)	
x_t	-0.027	-0.051	-0.027	1.00
	(0.171)	(0.326)	(0.172)	
x_{t+1}	0.023	-0.080	-0.095	0.898
	(0.143)	(0.513)	(0.601)	
x_{t+2}	0.064	-0.109	-0.159	0.771
	(0.402)	(0.730)	(1.013)	
x_{t+3}	0.107	-0.144	-0.230	0.642
	(0.674)	(0.923)	(1.462)	
x_{t+4}	0.131	-0.150	-0.265	0.487
	(0.830)	(0.966)	(1.685)	
x_{t+5}	0.159	-0.153	-0.300	0.313
	(1.004)	(0.981)	(1.905)	
x_{t+6}	0.197	-0.139	**-0.326**	0.156
	(1.242)	(0.892)	(2.072)	
x_{t+7}	0.211	-0.079	-0.290	0.006
	(1.334)	(0.507)	(1.845)	
x_{t+8}	0.237	-0.034	-0.284	-0.123
	(1.496)	(0.219)	(1.806)	

Source: BEA, FFIEC, author's calculations

Significant at 5% or higher in bold.

Table 4 Cyclical Behavior of Tier 1 Capital to RWA, Deviation from HP Trend

cross-correlation of RGDP, 1996 Q1–2015 Q4

time	Caprat	Capital(t1)	Assets(RWA)	Riskrat	RGDP
x_{t-8}	-0.416	0.126	0.463	0.401	-0.235
	(1.641)	(0.768)	(1.800)	(1.689)	
x_{t-7}	-0.491	0.208	**0.582**	**0.519**	-0.125
	(1.938)	(1.270)	(2.265)	(2.186)	
x_{t-6}	**-0.607**	0.177	**0.699**	**0.641**	0.004
	(2.396)	(1.083)	(2.718)	(2.702)	
x_{t-5}	**-0.700**	0.078	**0.767**	**0.686**	0.152
	(2.761)	(0.478)	(2.984)	(2.891)	
x_{t-4}	**-0.746**	-0.062	**0.773**	**0.689**	0.341
	(2.943)	(0.380)	(3.005)	(2.905)	
x_{t-3}	**0.725**	-0.085	**0.756**	**0.655**	0.525
	(2.862)	(0.519)	(2.941)	(2.802)	
x_{t-2}	**-0.690**	-0.187	**0.689**	**0.591**	0.720
	(2.721)	(1.144)	(2.681)	(2.489)	
x_{t-1}	**-0.589**	-0.220	**0.579**	**0.500**	0.881
	(2.234)	(1.344)	(2.253)	(2.106)	
x_t	-0.446	-0.217	0.430	0.459	1.00
	(1.760)	(1.323)	(1.670)	(1.936)	
x_{t+1}	-0.239	-0.128	0.241	0.379	0.881
	(0.943)	(0.780)	(0.936)	(1.599)	
x_{t+2}	-0.059	-0.038	0.078	0.265	0.720
	(0.232)	(0.231)	(0.304)	(1.117)	
x_{t+3}	0.114	0.052	-0.079	0.128	0.525
	(0.049)	(0.317)	(0.306)	(0.540)	
x_{t+4}	0.244	0.117	-0.200	-0.005	0.341
	(0.926)	(0.712)	(0.777)	(0.019)	
x_{t+5}	0.358	0.162	-0.313	-0.145	0.152
	(1.411)	(0.990)	(1.219)	(0.610)	
x_{t+6}	0.419	0.193	-0.374	-0.292	0.004
	(1.655)	(1.178)	(1.456)	(1.230)	
x_{t+7}	0.444	0.175	-0.413	-0.428	-0.125
	(1.752)	(1.067)	(1.606)	(1.804)	
x_{t+8}	0.436	0.128	-0.425	**-0.494**	-0.235
	(1.720)	(0.785)	(1.655)	(2.081)	

Source: BEA, FFIEC, author's calculations

Significant at 5% or higher in bold.

Table 5 Cyclical Behavior of Tier 1 Capital to RWA, Hamilton Approach

cross-correlation of RGDP, 1996 Q1–2015 Q4

time	Caprat	Capital(t1)	Assets(RWA)	Riskrat	RGDP
x_{t-8}	-0.167	-0.023	0.367	0.303	-0.165
	(0.604)	(0.091)	(1.309)	(1.132)	
x_{t-7}	-0.262	-0.029	0.495	0.363	-0.040
	(0.951)	(1.270)	(1.763)	(1.358)	
x_{t-6}	-0.387	-0.019	**0.632**	0.443	0.117
	(1.402)	(0.073)	(2.225)	(1.655)	
x_{t-5}	-0.523	-0.111	**0.731**	0.469	0.283
	(1.896)	(0.478)	(2.605)	(1.755)	
x_{t-4}	**-0.600**	-0.265	**0.741**	0.481	0.466
	(2.176)	(1.029)	(2.643)	(1.797)	
x_{t-3}	**0.640**	-0.328	**0.760**	0.478	0.626
	(2.318)	(1.272)	(2.706)	(1.786)	
x_{t-2}	**-0.648**	-0.388	**0.714**	0.428	0.7540
	(2.349)	(1.506)	(2.544)	(1.601)	
x_{t-1}	**-0.603**	-0.414	**0.650**	0.403	0.888
	(2.184)	(1.607)	(2.315)	(1.507)	
x_t	-0.479	-0.396	0.516	0.392	1.00
	(1.734)	(1.537)	(1.540)	(1.466)	
x_{t+1}	-0.320	-0.320	0.337	0.326	0.888
	(1.1603)	(1.244)	(1.200)	(1.219)	
x_{t+2}	-0.164	-0.220	0.182	0.195	0.7540
	(0.595)	(0.855)	(0.648)	(0.728)	
x_{t+3}	-0.010	-0.074	0.045	0.103	0.626
	(0.035)	(0.286)	(0.159)	(0.386)	
x_{t+4}	0.120	0.032	-0.075	0.016	0.466
	(0.436)	(0.123)	(0.266)	(0.0609)	
x_{t+5}	0.230	0.067	-0.206	-0.067	0.283
	(0.835)	(0.261)	(0.733)	(0.364)	
x_{t+6}	0.337	0.111	-0.275	-0.207	0.117
	(1.220)	(0.432)	(0.981)	(0.774)	
x_{t+7}	0.392	0.116	-0.310	-0.317	-0.040
	(1.422)	(0.449)	(1.105)	(1.186)	
x_{t+8}	0.407	0.089	-0.308	-0.425	-0.165
	(1.474)	(0344)	(1.098)	(1.586)	

Source: BEA, FFIEC, author's calculations
Significant at 5% or higher in bold.

Table 6 Cyclical Behavior of Equity Capital to Total Assets, Deviation from HP Trend

cross-correlation of RGDP, 1996 Q1–2015 Q4

time	Caprat	Capital	Assets(total)	RGDP
x_{t-8}	-0.316	-0.048	0.322	-0.235
	(1.435)	(0.253)	(1.427)	
x_{t-7}	-0.326	0.017	0.398	-0.125
	(1.481)	(0.088)	(1.761)	
x_{t-6}	-0.379	0.015	**0.464**	0.004
	(1.725)	(0.079)	(2.054)	
x_{t-5}	-0.401	0.048	**0.531**	0.152
	(1.823)	(0.252)	(2.348)	
x_{t-4}	-0.397	0.057	**0.542**	0.341
	(1.806)	(0.299)	(2.396)	
x_{t-3}	-0.350	0.085	**0.545**	0.525
	(1.594)	(0.589)	(2.413)	
x_{t-2}	-0.327	0.098	**0.516**	0.720
	(1.488)	(0.520)	(2.284)	
x_{t-1}	-0.213	0.150	0.436	0.881
	(0.970)	(0.791)	(1.927)	
x_t	-0.018	0.195	0.244	1.00
	(0.082)	(1.030)	(1.081)	
x_{t+1}	0.183	0.230	0.030	0.881
	(0.832)	(1.217)	(0.131)	
x_{t+2}	0.301	0.232	-0.116	0.720
	(1.370)	(1.226)	(0.511)	
x_{t+3}	0.378	0.217	-0.230	0.525
	(1.720)	(1.146)	(1.019)	
x_{t+4}	0.385	0.167	-0.296	0.341
	(1.752)	(0.885)	(1.309)	
x_{t+5}	0.410	0.161	-0.345	0.152
	(1.864)	(0.850)	(1.524)	
x_{t+6}	0.402	0.198	-0.304	0.004
	(1.830)	(1.045)	(1.347)	
x_{t+7}	0.352	0.209	-0.238	-0.125
	(1.603)	(1.105)	(1.051)	
x_{t+8}	0.313	0.203	-0.198	-0.235
	(1.425)	(1.073)	(0.874)	

Source: BEA, FFIEC, author's calculations
Significant at 5% or higher in bold.

Table 7 Cyclical Behavior of Equity Capital to Total Assets, Hamilton Approach

cross-correlation of RGDP, 1996 Q1–2015 Q4

time	Caprat	Capital	Assets(total)	RGDP
x_{t-8}	-0.436	-0.033	0.355	-0.168
	(1.574)	(0.116)	(1.262)	
x_{t-7}	-0.441	0.032	0.460	-0.045
	(1.593)	(0.112)	(1.636)	
x_{t-6}	-0.446	0.070	0.534	0.111
	(1.608)	(0.248)	(1.900)	
x_{t-5}	-0.448	0.095	**0.592**	0.279
	(1.823)	(0.338)	(2.104)	
x_{t-4}	-0.392	0.080	0.543	0.461
	(1.153)	(0.283)	(1.931)	
x_{t-3}	-0.319	0.075	0.494	0.625
	(1.153)	(0.266)	(1.756)	
x_{t-2}	-0.268	0.031	0.415	0.752
	(0.966)	(0.110)	(1.474)	
x_{t-1}	-0.173	0.027	0.306	0.887
	(0.626)	(0.097)	(1.088)	
x_t	-0.020	0.027	0.132	1.00
	(0.073)	(0.097)	(0.468)	
x_{t+1}	0.121	0.021	-0.029	0.887
	(0.436)	(0.075)	(0.104)	
x_{t+2}	0.224	0.029	-0.129	0.752
	(0.807)	(0.104)	(0.459)	
x_{t+3}	0.318	0.026	-0.235	0.625
	(1.147)	(0.093)	(0.837)	
x_{t+4}	0.363	0.022	-0.298	0.461
	(1.309)	(0.077)	(1.061)	
x_{t+5}	0.404	0.033	-0.348	0.279
	(1.459)	(0.117)	(1.239)	
x_{t+6}	0.456	0.097	-0.342	0.111
	(1.647)	(0.344)	(1.216)	
x_{t+7}	0.407	0.095	-0.300	-0.045
	(1.469)	(0.336)	(1.068)	
x_{t+8}	0.326	0.093	-0.235	-0.168
	(1.177)	(0.331)	(0.836)	

Source: BEA, FFIEC, author's calculations
Significant at 5% or higher in bold.

Table 8 Cyclical Behavior of Capital Ratio, Deviation from HP Trend, 1834–2015

	cross-correlation of RGDP			
time	Caprat	Capital	Assets	RGDP
x_{t-4}	0.135	0.007	**-0.197**	-0.262
	(1.551)	(0.077)	(2.063)	
x_{t-3}	0.029	0.118	-0.008	-0.353
	(0.338)	(1.248)	(0.082)	
x_{t-2}	0.000	**0.208**	0.167	-0.253
	(0.009)	(2.208)	(1.757)	
x_{t-1}	-0.110	**0.203**	**0.331**	0.200
	(1.266)	(2.153)	(3.474)	
x_t	**-0.220**	-0.023	**0.290**	1.00
	(2.535)	(0.245)	(3.040)	
x_{t+1}	-0.056	-0.181	-0.027	0.200
	(0.644)	(1.920)	(0.2833)	
x_{t+2}	0.078	**-0.205**	**-0.250**	-0.253
	(0.900)	(2.176)	(2.625)	
x_{t+3}	0.097	-0.160	**-0.283**	-0.353
	(1.115)	(1.696)	(2.975)	
x_{t+4}	0.107	-0.057	-0.188	-0.262
	(1.226)	(0.608)	(-1.970)	

Correlation of (HP filter of log)$RGNP_t$ with listed series denoted x_i
Source:Carter et al. (2006), Federal Deposit Insurance Corporation, author's calculations
Significant at 5% or higher in bold.

Table 9 Cyclical Behavior of Capital Ratio, Hamilton Approach, 1834–2015

	cross-correlation of RGDP			
time	Caprat	Capital	Assets	RGDP
x_{t-4}	0.163	0.118	-0.045	-0.099
	(1.703)	(1.290)	(0.485)	
x_{t-3}	0.051	**0.205**	0.115	-0.007
	(0.529)	(2.229)	(1.240)	
x_{t-2}	-0.016	**0.303**	**0.260**	-0.020
	(0.171)	(3.305)	(2.817)	
x_{t-1}	-0.161	**0.311**	**0.417**	0.488
	(1.682)	(3.385)	(4.512)	
x_t	**-0.298**	0.137	**0.421**	1.00
	(3.108)	(1.492)	(4.561)	
x_{t+1}	**-0.209**	-0.029	**0.192**	0.488
	(2.175)	(0.3190)	(2.073)	
x_{t+2}	-0.067	-0.098	-0.031	-0.020
	(0.697)	(1.072)	(0.338)	
x_{t+3}	-0.044	-0.170	-0.123	-0.007
	(0.456)	(1.850)	(1.331)	
x_{t+4}	0.001	**-0.195**	-0.168	-0.099
	(0.008)	(2.121)	(-1.814)	

Correlation of Hamilton residual(log)$RGNP_t$ with listed series denoted x_i
Source: Carter et al. (2006), Federal Deposit Insurance Corporation, author's calculations
Significant at 5% or higher in bold.

Table 10 Cyclical Behavior of Capital Tier1/RWA Ratio to Total Assets, Hamilton Approach

cross-correlation of RGDP, 1996 Q1–2015 Q4

time	<100m	100m-1B	1-10B	10-50B	50B<
x_{t-8}	-0.171	-0.369	-0.438	-0.342	-0.176
	(0.606)	(1.410)	(1.543)	(1.225)	(0.635)
x_{t-7}	-0.082	-0.418	- 0.511	-0.412	-0.274
	(0.289)	(1.599)	(1.799)	(1.478)	(0.986)
x_{t-6}	0.006	-0.454	-0.565	-0.455	-0.404
	(0.020)	(1.734)	(1.990)	(1.632)	(1.456)
x_{t-5}	0.121	-0.427	**-0.586**	-0.549	**-0.557**
	(0.427)	(1.632)	(2.064)	(1.970)	(2.007)
x_{t-4}	0.274	-0.361	-0.555	**-0.643**	**-0.646**
	(0.970)	(1.380)	(1.956)	(2.303)	(2.392)
x_{t-3}	0.446	-0.309	-0.477	**-0.665**	**-0.682**
	(1.578)	(1.183)	(1.681)	(2.383)	(2.456)
x_{t-2}	**0.595**	-0.227	-0.398	**-0.671**	**-0.690**
	(2.104)	(0.870)	(1.401)	(2.404)	(2.487)
x_{t-1}	**0.688**	-0.062	-0.263	-0.619	**-0.660**
	(2.435)	(0.235)	(0.926)	(2.220)	(2.379)
x_t	**0.742**	0.100	-0.150	-0.524	**-0.553**
	(2.626)	(0.383)	(0.527)	(1.880)	(1.994)
x_{t+1}	**0.754**	0.183	-0.027	-0.437	-0.394
	(2.666)	(0.700)	(0.095)	(1.565)	(1.421)
x_{t+2}	**0.705**	0.251	0.091	- 0.329	-0.222
	(2.494)	(0.960)	(0.322)	(1.179)	(0.799)
x_{t+3}	**0.596**	0.327	0.175	-0.174	-0.062
	(2.108)	(1.249)	(0.617)	(0.622)	(0.222)
x_{t+4}	0.487	0.380	0.242	-0.028	0.054
	(1.692)	(1.454)	(0.851)	(0.099)	(0.195)
x_{t+5}	0.335	0.416	0.289	0.066	0.148
	(1.184)	(1.592)	(1.107)	(0.237)	(0.535)
x_{t+6}	0.208	0.431	0.362	0.205	0.255
	(0.735)	(1.649)	(1.275)	(0.735)	(0.917)
x_{t+7}	0.124	0.407	0.368	0.325	0.312
	(0.438)	(1.557)	(1.296)	(1.164)	(1.124)
x_{t+8}	0.036	0.383	0.396	0.410	0.320
	(0.127)	(1.464)	(1.396)	(1.470)	(1.152)

Source: BEA, FFIEC, author's calculations

Significant at 5% or higher in bold.

Table 11 Cyclical Behavior of Equity Capital Ratio to Total Assets, Hamilton Approach

	cross-correlation of RGDP, 1996 Q1–2015 Q4				
time	<100m	100m-1B	1-10B	10-50B	50B<
x_{t-8}	0.310	-0.209	-0.287	-0.536	-0.342
	(1.079)	(0.7510)	(1.026)	(1.919)	(1.257)
x_{t-7}	0.372	-0.100	-0.242	-0.518	-0.356
	(1.296)	(0.360)	(0.864)	(1.854)	(1.309)
x_{t-6}	0.418	-0.012	-0.209	-0.466	-0.378
	(1.457)	(0.043)	(0.745)	(1.668)	(1.389)
x_{t-5}	0.491	0.109	-0.163	-0.453	-0.390
	(1.711)	(0.3912)	(0.581)	(1.621)	(1.435)
x_{t-4}	0.572	0.242	-0.074	-0.397	-0.356
	(1.994)	(0.871)	(0.263)	(1.419)	(1.311)
x_{t-3}	**0.615**	0.329	-0.023	-0.305	-0.290
	(2.142)	(1.184)	(0.080)	(1.090)	(1.068)
x_{t-2}	**0.644**	0.418	0.036	-0.221	-0.252
	(2.243)	(1.504)	(0.127)	(0.790)	(0.929)
x_{t-1}	**0.617**	0.476	0.132	-0.066	-0.191
	(2.145)	(1.712)	(0.470)	(0.236)	(0.704)
x_t	0.516	0.466	0.167	0.066	-0.045
	(1.797)	(1.674)	(0.597)	(0.237)	(0.167)
x_{t+1}	0.4104	0.472	0.222	0.151	0.083
	(1.429)	(1.696)	(0.792)	(0.542)	(0.305)
x_{t+2}	0.275	0.455	0.284	0.239	0.171
	(0.959)	(1.637)	(1.012)	(0.853)	(0.631)
x_{t+3}	**0.096**	0.398	0.320	0.319	0.256
	(0.334)	(1.432)	(1.141)	(1.141)	(0.941)
x_{t+4}	-0.086	0.324	0.319	0.345	0.289
	(0.300)	(1.164)	(1.138)	(1.233)	(1.063)
x_{t+5}	-0.216	0.294	0.352	0.344	0.312
	(0.754)	(1.057)	(1.257)	(1.232)	(1.148)
x_{t+6}	-0.317	0.262	0.376	0.366	0.344
	(1.105)	(0.940)	(1.342)	(1.310)	(1.265)
x_{t+7}	-0.376	0.224	0.339	0.340	0.286
	(1.309)	(0.840)	(1.209)	(1.217)	(1.051)
x_{t+8}	-0.397	0.225	0.360	0.330	0.170
	(1.383)	(0.809)	(1.286)	(1.181)	(0.627)

Source: BEA, FFIEC, author's calculations
Significant at 5% or higher in bold.

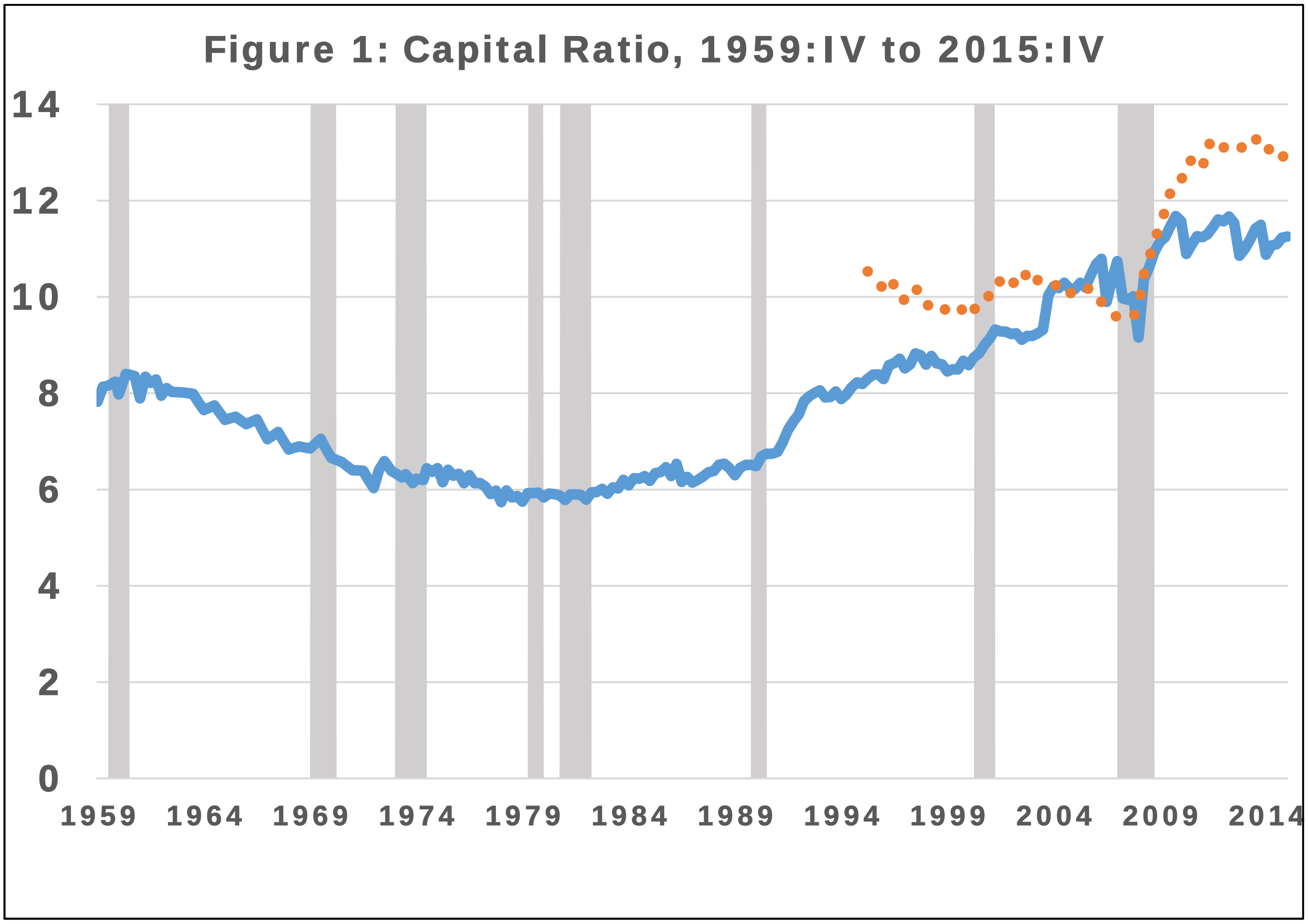


Figure 1: Capital Ratio, 1959:IV to 2015:IV
14
12
10
8
6
4
2
0
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014

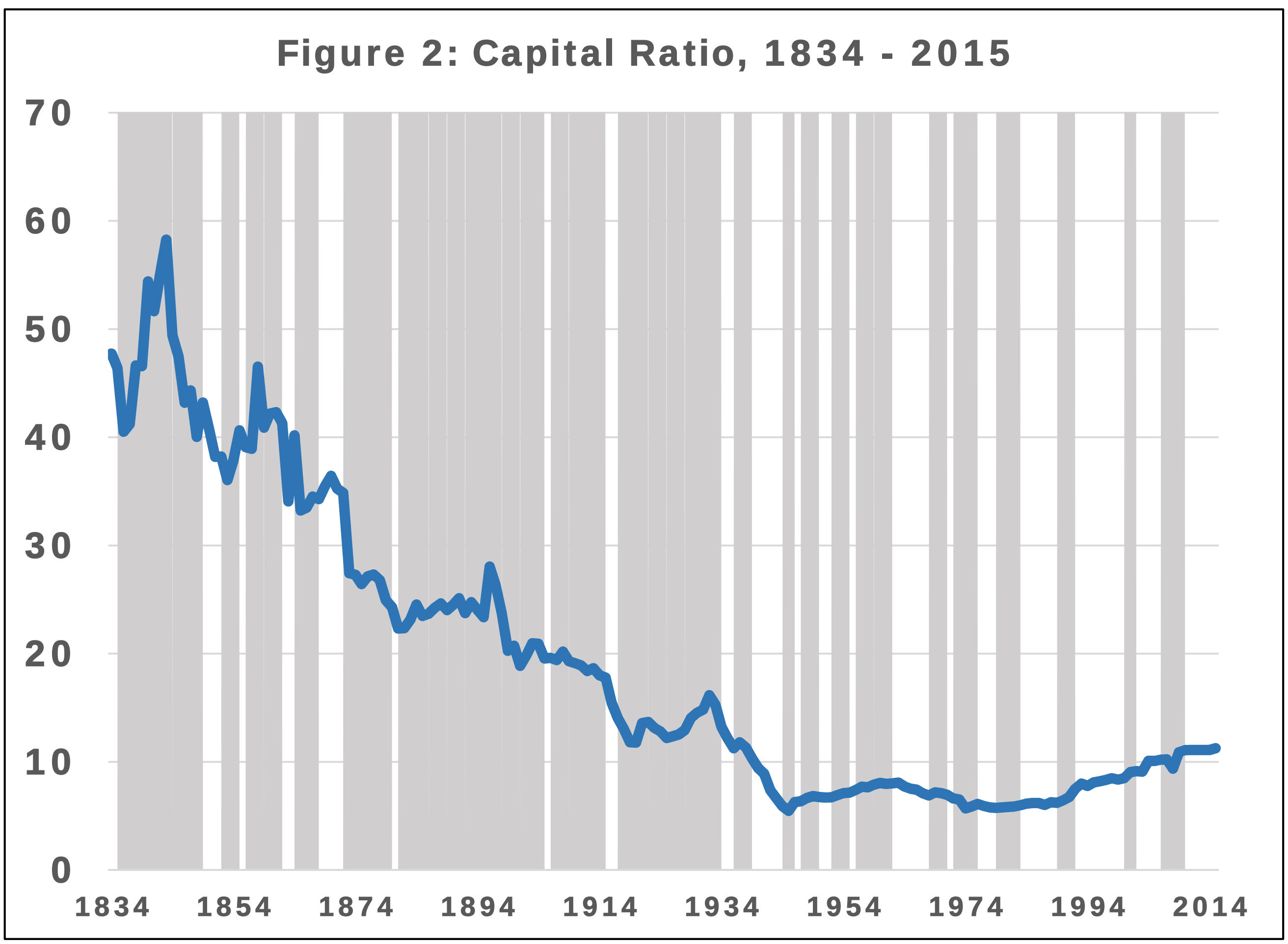
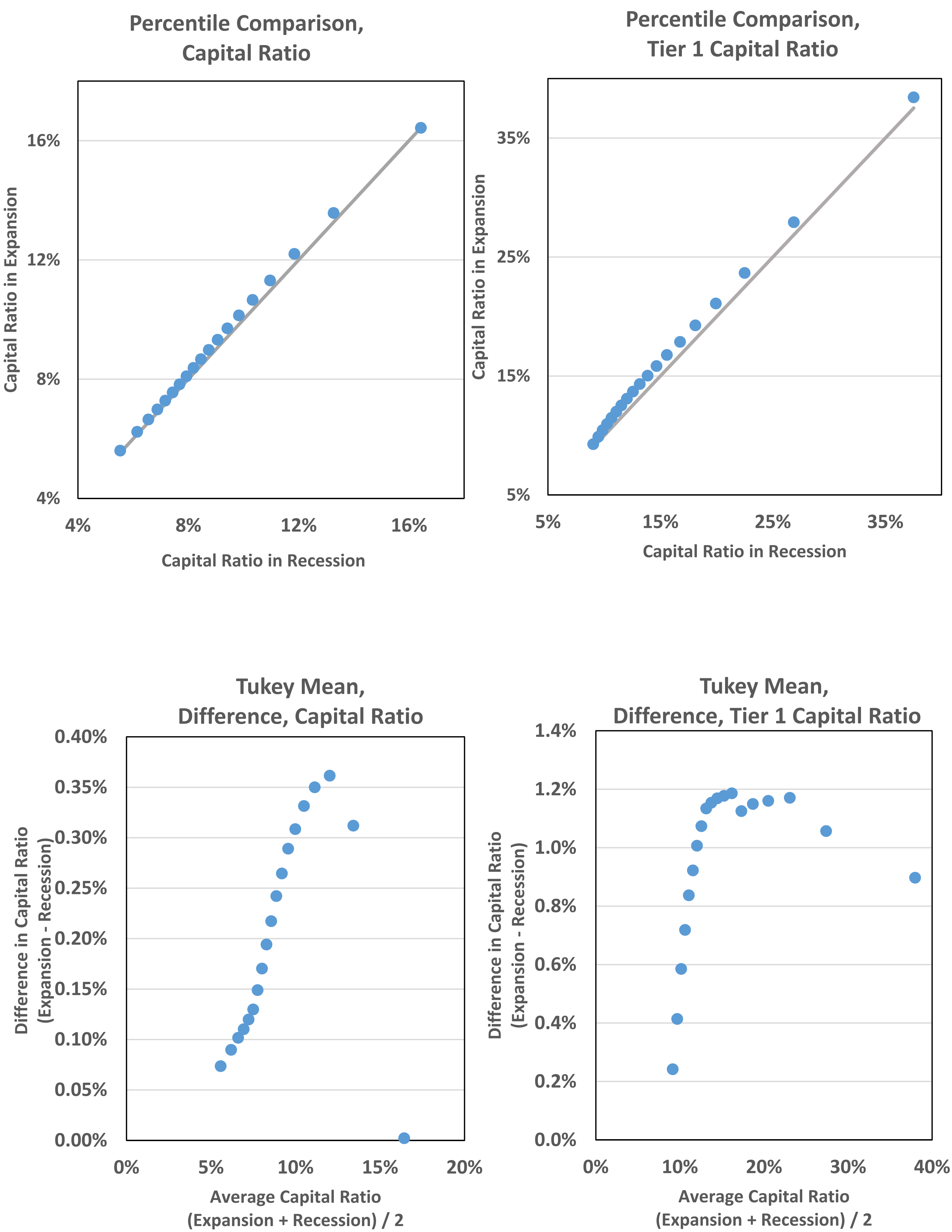


Figure 2: Capital Ratio, 1834 - 2015
70
60
50
40
30
20
10
0
1834
1854
1874
1894
1914
1934
1954
1974
1994
2014

Figure 3: Percentile Comparison



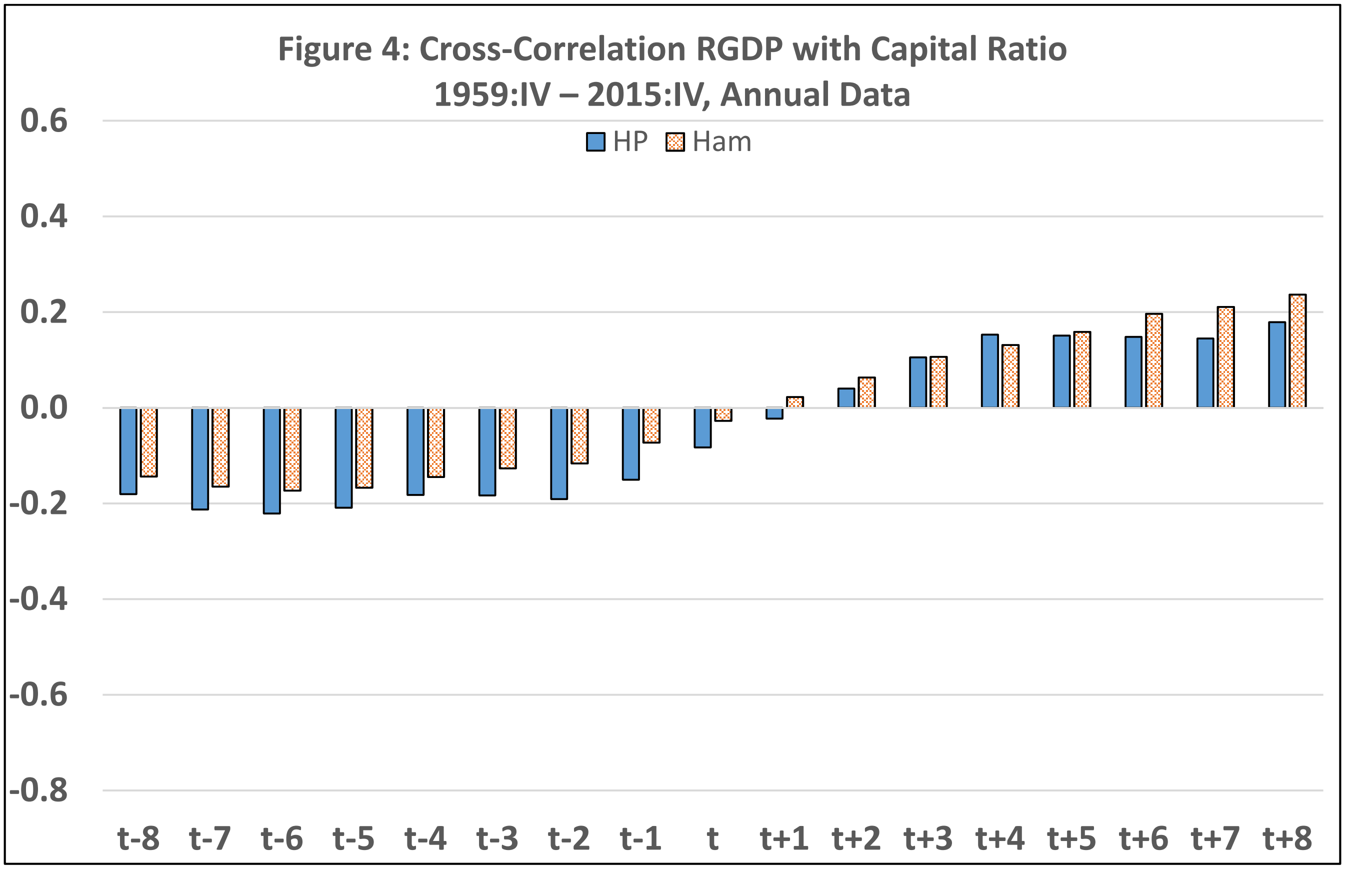


Figure 4: Cross-Correlation RGDP with Capital Ratio
1959:IV – 2015:IV, Annual Data
HP
Ham
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
t-8
t-7
t-6
t-5
t-4
t-3
t-2
t-1
t
t+1
t+2
t+3
t+4
t+5
t+6
t+7
t+8

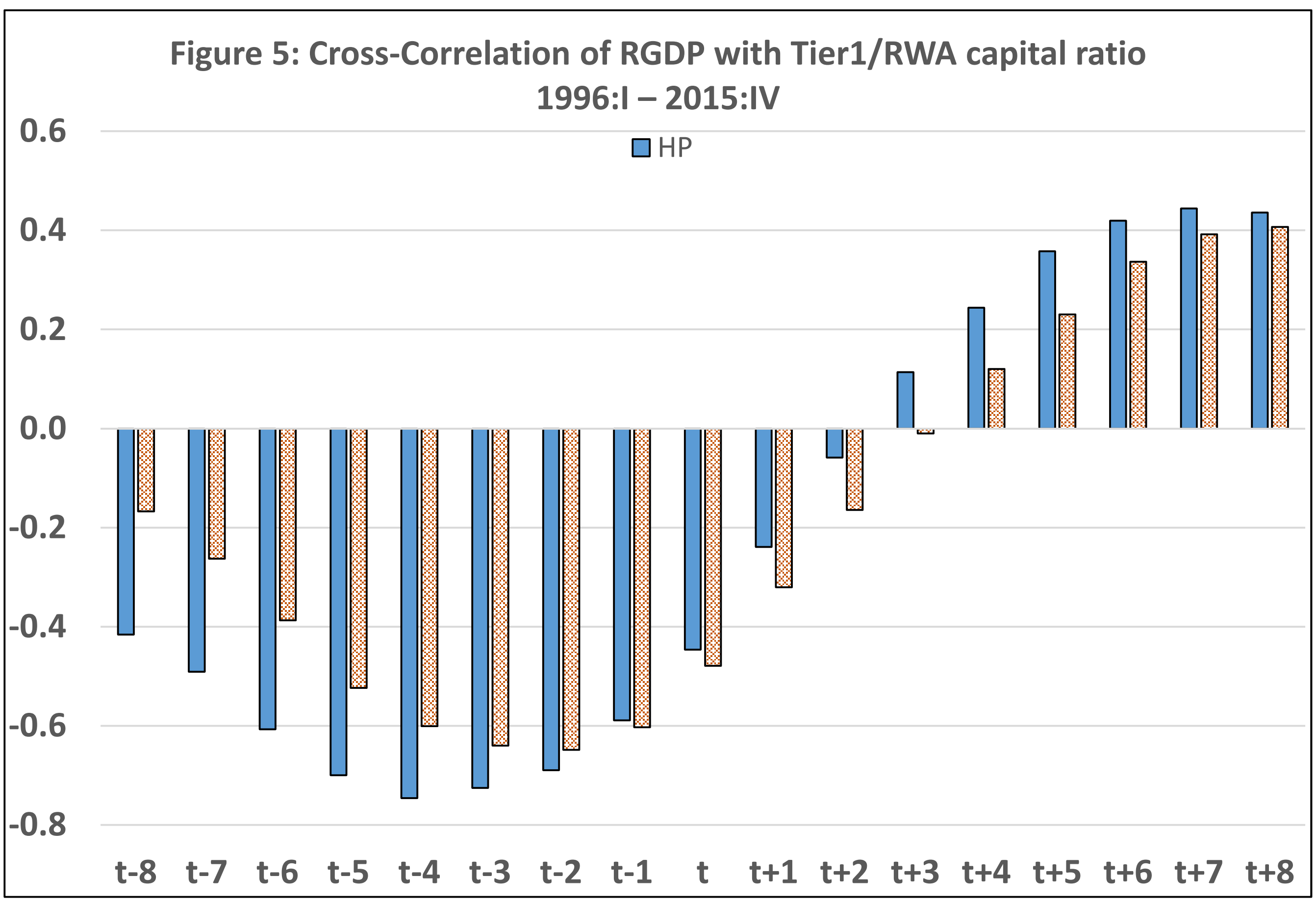


Figure 5: Cross-Correlation of RGDP with Tier1/RWA capital ratio
1996:I – 2015:IV
HP
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
t-8
t-7
t-6
t-5
t-4
t-3
t-2
t-1
t
t+1
t+2
t+3
t+4
t+5
t+6
t+7
t+8

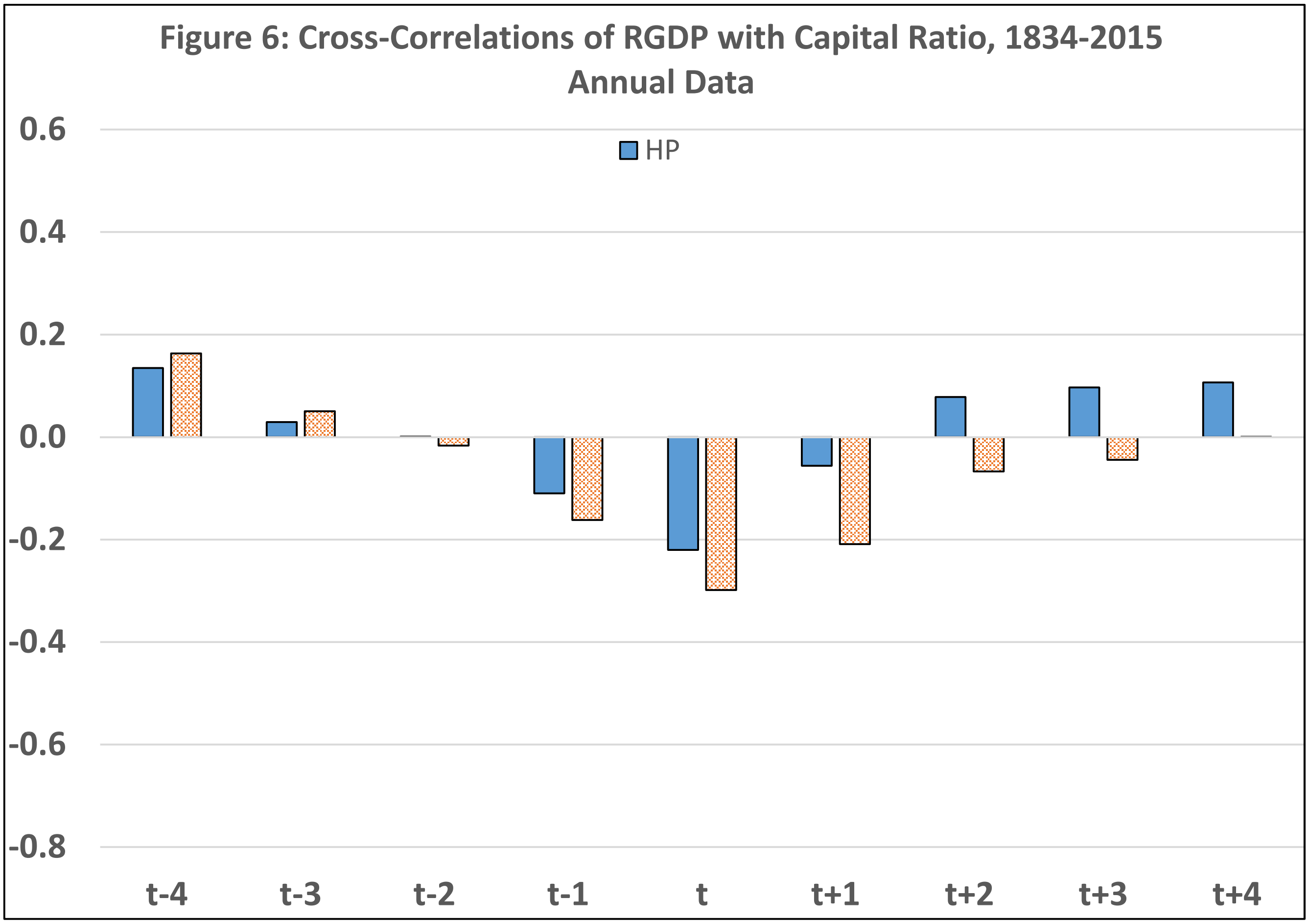


Figure 6: Cross-Correlations of RGDP with Capital Ratio, 1834-2015
Annual Data
HP
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
t-4
t-3
t-2
t-1
t
t+1
t+2
t+3
t+4

Figure 7: Cross-Correlations by Bank Size
1996:I - 2015:IV, Quarterly