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How Cyclical Is Bank Capital?

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The alleged pro-cyclicality of bank capital (high in good times, low in bad) has received some blame for the recent financial crisis. Others blame the countercyclicality of capital regulations: too low in high times and too high in bad. To address this problem, Basel III has introduced countercyclical capital buffers for large banks. But just how cyclical is bank capital? We look at the question from several vantage points, using both detailed recent data on risk-weighted assets and several sources of annual data going back to 1834. To help understand the historical data, we provide a short summary of capital concepts and regulation from early America to the present.

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1. Introduction

The financial crisis has initiated a great deal of work on both the level and quality of bank capital. A major concern has been how capital impacts bank lending, and whether market forces or capital requirements make lending procyclical. One response has been to make the regulations themselves countercyclical, and indeed the Basel Committee on Bank Supervision allows national regulators to impose a counter-cyclical capital buffer of up to an additional 2.5 percent Tier 1 capital for the country's banks. Perhaps surprisingly, however, research on the actual extent of capital cyclicality has been relatively scarce.

This paper provides a start at that analysis, focusing on the US experience, both recent and historical. Taking a longer view provides 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 uses a variety of statistical techniques, including Hodrick-Prescott filtering and spectral methods, to assess the business cycle properties of bank capital.

The literature on bank capital is extensive: Berger, Herring and Szego 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 Bliss and Kaufman (2002), Kashyap and Stein (2004), Gordy and Howells (2006), and Goodhart, Hofman and Segoviano (2004), with post-crisis modelling efforts by Repullo and

Suarez (2012), among others. Representative papers calibrating the optimal cyclical properties of capital regulations are Estrella (2004), Begenau (2013), and Okivuolle, Kiema and Vesal (2014). 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 actual cyclical properties of bank capital: Auso, Perez, and Saurina (2003) look at Spanish data from 1986-2000, and Bikker and Metzemakers (2007) look at 29 countries from 1990-2001. Adrian and Shin (2010) concentrate on broker-dealers but briefly look at how commercial bank leverage varies with bank assets. Some work related to Basel III has examined the relationship between bank capital and the credit cycle (Drehman and Tsataroinis 2014, Baron 2014), but does not look at the business cycle, beyond noting the extensive differences between the two types of cycles.

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 any valid interpretation of 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 residual claimant, and thus can act as a "buffer" against losses. In the eighteenth and nineteenth 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 U.S., this often depended on a bank's headquarters: 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 both as to 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, as it 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. That is, an individual might subscribe for, say, one thousand dollars of capital, pay in five hundred of that 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). Echoes remain, however, in that the Dodd-Frank Act requires that "the bank holding company or savings and loan holding company to serve as a source of financial strength for any subsidiary of the bank holding company or savings and loan holding company that is a depository institution." (DFA, sec. 616 (d)).

There is a sense, however, in which the earlier capital requirements showed more similarlity to their modern counterparts than readily meets the eye. That is because 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 a limit on liabilities a limit on assets. This identity was broken, however, because deposits were often exempted. One possibility is that Hamilton and the other founders considered deposits and specie to be identical, a usage and assumption that did not last.

Another possible reason is that protection for note holders was felt to be more important, as they were often of the poorer class, and failure of the bank to pay would be a particular burden on them (Rockoff, Smith, p.343 1776). Exempting deposits meant that the capital requirement was effectively a requirement 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 were soon explicitly imposed as a requirement of specie as a fraction of liabilities.

It is interesting to note that what is often considered a major determinant of a firm's capital structure (Myers, 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 footing in 1909, with a temporary measure having been used in the Civil War (Slemrod, 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 adquacy 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, as in 1962 the Comptroller, on the urging of banks, de-emphasized formulas (Hahn, 1966) and indeed even in the seventies maintained 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).

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, highlighed 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 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 recquired 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, our data end before these changes take effect. For the latter part of our 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 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 (as of this writing) includes common stockholders' equity, non-cumulative perpetual preferred stock, minority interest in consolidated subsidiaries, and some other items that DFA and Basel III will not 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.

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 (2013).

3. Data: Quarterly and Annual

As notions of capital and its regulation have changed over time, we naturally end up with several different sorts of data sets. The two most recent are quarterly. The first is from 1959 Q4 to 2013 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 (RCON3210) to total assets (RCON2170) for consolidated domestic banks, taken from the call reports. It corresponds most closely to what is now termed a leverage constraint. RGDP is gdph@usecon Real Gross Domestic Product (SAAR, Bil.Chn.2009 dollar) from the BEA, quarterly from 1959 Q4 To 2013 Q4. Figure 1 plots this series, with shaded areas indicating NBER recessions. The second series is shorter, showing the ratio of Tier 1 capital (RCON8274) to risk weighted assets (RCONA223), from 1996 Q1 to 2013 Q4, the time period for which the RWA are available directly on the call reports. Figure 2 plots this series, again with recession shading. Both figures are calculated by aggregating the capital for the industry and dividing by aggregate industry assets. This way of taking the average recognizes the concentration of assets and capital at large banks. Averaging the capital ratio across banks without adjusting for size, we would find a similar pattern, but with a higher average value.

For annual data, longer series exist, and I rely on two separate data sources. The first set comes from the Millennial Statistics of the United States. This provides a consistent series from 1834 to 1980, including 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 it was vetoed by Andrew Jackson in 1832, the charter did not expire until 1836. This is not included in the earliest data set we use, which restricts itself to state banks. That time period is also notable for fiscal policy, as 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 2008, and U.S Department of Treasury, 1991.)

The second series comes from Smith and Hengren, Journal of Political Economy, 1947. It runs from 1875 to 1946, and is based on annual reports of the Comptroller's Office. From 1897 on it is nearly identical to the series from Millennial Statistics. Smith and Hengren also report a series for total assets less 'safe' assets, which they count as cash and government bonds. Figure 3 plots all three series along with shading for NBER recessions. Note that the NBER has not demarcated recessions prior to 1854, so there is no shading for the early years on this chart.

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 tend to have somewhat higher capital ratios in expansions, lending some credence to pro-cyclicality. The leverage ratio (equity to total assets), averaged 8.8 percent in expansions and 8.2 percent in contractions. The Tier 1 to RWA ratio averaged 15.4 percent in expansions and 14.1 percent in contractions, again showing some evidence of pro-cyclicality. The annual series were more mixed. For the Millennial commercial bank data (when cycles are defined), the averages for the entire time period are counter-cyclical, averaging 19 percent in recessions and 17 percent in expansions. Each sub-period, by contrast, has pro-cyclical averages, though in the post-FDIC era the difference is small, 8.0 percent in contractions versus 8.2 percent otherwise. The ratio in the Smith and Hengren data is again counter-cyclical, with contractions averaging 21.49 percent as opposed to 17.92 percent for expansions.

One comparison point for the cyclical differences is the proposed Basel III counter-cyclical capital buffer (BCBS 2010). National authorities have the discretion to require up to an additional 2.5 percent Tier 1 equity to risk weighted assets in times of potential stress. In terms of risk weighted assets, at least, this is in line with the natural variation over the cycle.

Just looking at averages potentially misses other ways the distribution of capital may differ between expansions and contractions. For the more recent period we have data on individual banks, and this lets us compare the distribution of capital ratios in expansions and contractions. Figure 4 compares the two distributions using a percentile comparison plot (or Q-Q plot) for bank capital ratios, using percentiles between 5 percent and 95 percent. (The plot also indicates the range of capital ratios in the data.) Deviations from the 45° line indicate differences between the two distributions. Because the eye often has difficulty gauging vertical differences, two panels of the figure use a Tukey Sum-Difference plot, which rotates the 45° line to the horizontal and expands the vertical axis. This makes it clear that expansions have higher capital ratios at all percentiles, but the difference is less extreme at both high and low capital ratios. At least at the low end this inuitively makes sense, as banks with very low capital ratios are likely constrained by regulations from going lower.

4. Hodrick-Prescott Filters

One of the standard methods in macroeconomics for judging cyclicality looks at correlations between series, having first extracted a Hodrick-Prescott trend. The method laid out in Kydland and Prescott, 1990 checks for cyclicality by removing a Hodrick-Prescott trend from the data and then comparing amplitude (percent deviations from trend), 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 counter-cyclical capital buffer (BCBS 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. Start first with the quarterly series. Table 2 reports the results for the equity-to-assets ratio (1959 Q4 to 2013 Q4) and Table 3 reports the Tier 1 to risk weighted assets ratio (1996 Q1 to 2013 Q4). Correlations close to 1.0 point to a pro-cyclical series, just as those close to -1.0 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

[2] The BCBS guidance aims at adjusting 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 $\lambda = 400,000$ where as the business cycle literature uses $\lambda = 1600$ for quarterly data. In this paper, we use 1600 for the quarterly data and follow Uhlig and Ravn (2002) and set $\lambda = 6.25$ for annual data.

(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).

By these yardsticks, the (quarterly) capital ratios measured either as equity to total assets (Table 2) or Tier 1 to RWA (Table 3) show 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 positively correlated with past values of the bank captial ratios, as large as 0.29 for the equity to total assets ratio at eight quarters. The relationship turns negative for correlation with future ratios, again in the four to eight quarter ahead range. Thus capital ratios appear contemporaneously acyclical, to positively lead the cycle but negatively lag the cycle.

For the annual data, Table 4 reports the Millennial (1834-1980) results, and Table 5 reports the results for the data from Smith & Hengren (1875-1946). The contemporaneous correlation is negative and is the only significant correlation. This suggests a simple counter-cyclical pattern: the capital ratio is low when real GDP is above trend. This appears most strongly in the Smith and Hengren data, where the correlation is highly significant and quite large (in absolute value). Size and significance drop off for the capital ratio using 'risky' assets (excluding cash and government bonds), and in the longer series, from 1834–1980, the contemporary correlation, although negative, is smaller and barely significant at the 5 percent level.

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 3, 4, and 5 address this (Shifts in coverage make such a breakdown unreliable for the equity ratio.) Tier 1 capital appears non-cyclical: the correlations are small (none exceeding 0.2) and uniformly insignificant. Risk-weighted assets show some cyclicality, with correlations between RGDP and future RWA large, significant and positive. The ratio of risk-weighted assets to total assets, which might show how banks adjust their portfolios to reduce capital requirements, shows no evidence of cyclical behavior. Perhaps surprisingly, in the annual series the components show more cyclicality than the ratio itself. In several cases, (particularly one period ahead) a weak negative correlation of the capital ratio results from two positive correlations, with the assets showing more cyclicality than capital.

5. Spectral Techniques

Another standard way of documenting cyclical properties uses spectral analysis, which breaks the series up into components of different frequencies. There are a variety of tools available in the frequency domain, but King and Watson (1996) find two particularly helpful for assessing business cycle properties. The first is the power spectrum. The height of the power spectrum represents that frequency's contribution to the total variance of the series. Typically, much of the power (variance) is accounted for by low frequencies when the series is considered in levels, but taking differences often emphasizes more power in business cycle and other medium-range frequencies. The second tool, coherence, looks at the co-movement of two series, and roughly measures correlation at different frequencies. Two series may have very different seasonal components, but still move together during business cycles (or vice versa).

The natural questions that arise, then, are whether bank capital exhibits cyclical properties in the frequency domain, either by a peak at the appropriate frequency or by showing high coherence between capital and real GDP. The extent to which capital exhibits the typical spectral shape will also provide information about its time series properties.

In calculating the spectral measures, we use the growth rate of RGDP, whereas for the HP approach we used the level of RGDP. King and Watson use the conventional definition of a business cycle as having a frequency between six and thirty-two quarters, or frequencies between $1/32 = 0.03$ and $1/6 = 0.16$ cycles per quarter. In annual terms that is between one-and-a-half and eight years, or $2/3 = 0.67$ and $1/8 = 0.125$ cycles per year. The following figures plot the angular frequency, and so those numbers should be multiplied by π, yielding business cycle ranges of 0.09 to 0.5 for quarterly data and 0.375 to 1 for annual data.

Figure 4 plots the spectral density for the quarterly series of equity capital to total assets (1959-2013), with shading for the business cycle frequencies. It shows only a small degree of cyclicality: there is a small local peak but the total power in cyclical frequencies is only 9 percent, or put another way, only 9 percent of the variance in the time series is accounted for by business cycle frequencies. The spectral density for Tier 1 capital to risk weighted assets, (1996-2013) plotted in Figure 5, shows more evidence of cyclicality: while a local peak is not evident, a full 60 percent of the power lies in the business cycle frequencies. The spectral density for the capital ratio 1834-1980 is shown in Figure 6, which shows no evidence of cyclicality, with only 2.4 percent of the power at business cycle frequencies, and no discernable peak in the relevant range. Figure 7, which looks at the 1875-1946 Smith and Hengren data, shows somewhat more evidence of cyclicality, with a small but noticeable local peak and 18 percent power at business cycle frequencies. All four series, both quarterly and annual, show what Granger has called the "typical spectral shape" for an economic time series, with much of the power concentrated at low frequencies.

The next set of charts (Figures 8-11) plot the coherence, which can be thought of as the correlation at a given frequency, in this case between (the growth rate of) real GDP and the capital ratio. As in previous cases we have considered, the Tier 1 risk weighted assets ratio shows the greatest cyclicality. The series shows high coherence, particularly at longer business cycle fequencies, where it exceeds 0.8 at points and averages over 0.6. Though the longer equity to assets ratio is above 0.6 at some frequencies, its average in the business cycle range is a much lower 0.37. The annual data shows less coherence between capital and real GDP, with the average coherence at business cycle frequencies for the the Millennial data (1834-1980) at 0.34, and the data from Smith and Hengren showing coherence at 0.24.

6. 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 over a trillion dollars of assets. When the question touches on regulation, it is particularly important to make distinctions based on bank size, as the effect on institutions can be vastly different. To this end this section sorts banks by size and looks at the cyclical properties of their capital ratios.

More specifically, the capital ratio is defined by the ratio of total equity capital (RCON 3210) divided by total assets (RCON 2170). Based on total assets, banks are placed in one of four size categories: less than 100 million, between 100 million and 1 billion, between 1 and 10 billion, and beween 10 and 100 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, by placing an upper limit of 100 billion, it excludes several extremely large banks later in the sample (these first show up in 2008 Q4). Thirdly, the more detailed information from the call report also reduced the available time period, and the series thus runs only from 1996 Q1 to 2013 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. Table 6 reports the results for the equity ratio. Since the cross correlations are small and statistically insignificant, there is not much to discuss. Note that this table uses a shorter sample (1996–2013) that Table 2, and so the lack of cyclicality in the equity to assets ratio seems robust across time periods. The results for Tier 1 capital to risk weighted assets, reported in Table 7 and in Figure 14 are notably different, being large and significant. Small banks overall appear the most procyclical, and though the correlations are rather flat, there is some evidence that the Tier 1 ratio leads real GDP, with the largest correlation being between $RGDP_t$ and the Tier 1 ratio at x_{t-2}. The two largest categories of banks, between 1 and 10 billion, and between 10 and 100 billion, show less statistical significance and show more counter-cyclicality, particularly at larger leads.

7. Conclusion

Whether bank capital ratios are cyclical depends on the time period considered and the definition of capital ratio. With recent quarterly data, Tier 1 to risk weighted assets looks moderately pro-cyclical, showing significant positive cross correlations with real GDP, and in addition exhibiting a good deal of power in business cycle frequencies, even showing a cyclical peak. For the quarterly data, the equity to assets ratio does not show any cyclicality. The results for the annual data are somewhat mixed, and while there is little power at business cycle frequencies, cross correlations do show some counter-cyclicality.

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Table 1: Average Capital Ratio by Contraction and Expansion

Equity to assets ratio, percent			
		contraction	expansion
Full Millennial		19.2	17.3
	Pre-Fed	26.2	30.4
	Post-Fed	10.6	27.9
	PreFDIC	22.9	26.6
	Post-FDIC	8.0	25.3
Smith and Hengren			
	Total Assets	21.5	16.5
	Risky Assets	31.9	28.2
Quarterly Data			
Equity/total asssets		8.20	8.81
Tier 1/RWA		14.13	15.37

source; Millennial Statistics, Smith and Hengren

Table 2: Cyclical Behavior of Capital Ratio, Deviation from HP Trend
Cross Correlation of RGDP, 1959 Q4–2013 Q4

series	x_{t-8}	x_{t-7}	x_{t-6}	x_{t-5}	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}	x_{t+5}	x_{t+6}	x_{t+7}	x_{t+8}
RGDP	-0.292	-0.213	-0.094	0.053	0.25	0.458	0.682	0.870	1.00	0.870	0.682	0.458	0.25	0.053	-0.094	-0.213	-0.292
Cross	**0.296**	**0.274**	**0.276**	**0.274**	0.234	0.176	-0.090	-0.040	-0.010	0.041	0.101	-0.106	-0.155	-0.238	**-0.305**	**-0.319**	**-0.308**
T-stat	2.33	2.15	2.17	2.16	1.84	1.39	-0.71	-0.31	-0.07	0.32	0.79	-0.83	-1.22	-1.86	-2.40	-2.51	2.42
Prob	0.020	0.033	0.031	0.032	0.068	0.168	0.479	0.753	0.937	0.747	0.428	0.404	0.223	0.063	0.017	0.013	0.016
				auto-correlation													
RGDP	0.87	0.682	0.458	0.25	0.053	-0.094	-0.213	-0.292	-0.335	-0.378							
Caprat	0.602	0.495	0.282	0.232	-0.034	-0.104	-0.200	-0.137	-0.361	-0.359							

source; BEA, FFIEC

Significant at 5% or higher in bold.l

Table 3: Cyclical Behavior of Tier 1 Capital to RWA, Deviation from HP Trend

Cross Correlation of RGDP, 1996 Q1–2013 Q4

series	x_{t-8}	x_{t-7}	x_{t-6}	x_{t-5}	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}	x_{t+5}	x_{t+6}	x_{t+7}	x_{t+8}
RGDP	-0.237	-0.178	0.015	0.169	0.351	0.529	0.721	0.880	1.00	0.880	0.721	0.529	0.351	0.169 0.015	-0.117	-0.237	
Caprat	**0.526**	**0.573**	**0.584**	**0.560**	**0.475**	0.408	0.305	0.160	-0.052	-0.207	-0.363	-0.481	**-0.606**	**-0.671**	**-0.666**	**-0.629**	**-0.598**
	(2.027)	(2.208)	(2.251)	(2.158)	(1.831)	(1.572)	(1.175)	(0.617)	(-0.200)	(-0.798)	(-1.399)	(-1.854)	(-2.336)	(-2.586)	(-2.567)	(-2.424)	(-2.305)
Capital	0.159	0.237	0.285	0.263	0.200	0.128	0.072	0.008	-0.034	0.004	0.045	0.101	0.083	0.106	0.096	0.058	-0.034
t-stat	(0.724)	(1.080)	(1.299)	(1.199)	(0.912)	(0.583)	(0.328)	(0.037)	(-0.155)	(0.018)	(0.205)	(0.460)	(0.378)	(0.483)	(0.437)	(0.264)	(-0.155)
RWA	-0.149	-0.101	-0.063	-0.068	-0.078	-0.105	-0.097	-0.073	0.008	0.132	0.257	0.372	0.421	0.473	0.456	0.396	0.288
	(-0.591)	(-0.400)	(-0.250)	(-0.270)	(-0.309)	(-0.416)	(-0.384)	(-0.289)	(0.032)	(0.523)	(1.019)	(1.475)	(1.669)	(1.875)	(1.808)	(1.570)	(1.142)
RWA/Tot	-0.005	0.049	0.098	0.088	0.040	-0.033	-0.095	-0.147	-0.169	-0.133	-0.034	0.069	0.126	0.198	0.239	0.218	0.154
	(-0.021)	(0.208)	(0.417)	(0.374)	(0.170)	(-0.140)	(-0.404)	(-0.625)	(-0.719)	(-0.566)	(-0.145)	(0.293)	(0.536)	(0.842)	(1.016)	(0.927)	(0.655)
				auto-correlation													
RGDP	0.893	0.735	0.536	0.355	0.172	0.022	-0.111	-0.226	-0.315	-0.423							
Caprat	0.794	0.655	0.500	0.378	0.084	-0.145	-0.318	-0.429	-0.609	-0.658							

source; BEA, FFIEC

Significant at 5% or higher in bold.l

Table 4: Cyclical Behavior of Capital Ratio, Deviation from HP Trend,1834–1980

	cross correlation of RGDP								
series	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}
RGDP	-0.265	-0.417	-0.274	0.148	1.00	0.148	-0.274	-0.417	-0.265
Cap ratio	0.055	0.101	0.120	0.005	**-0.189**	-0.098	-0.064	-0.034	0.012
	(0.577)	(1.060)	(1.267)	(0.055)	(-1.997)	(-1.031)	(-0.673)	(-0.353)	(0.122)
Capital	-0.139	-0.123	-0.083	-0.016	0.044	**0.206**	0.022	-0.052	-0.033
	(1.458)	(1.292)	(0.873)	(0.167)	(0.466)	(2.158)	(0.227)	(0.549)	(0.341)
Assets	-0.127	**-0.304**	**-0.298**	-0.086	**0.263**	**0.346**	**0.214**	0.045	-0.167)
	(1.378)	(2.858)	(2.798)	(0.811)	(2.467)	(3.248)	(2.015)	(0.419)	(1.565)

correlation of (hp filter of log)$RGNP_t$ with capital ratio denoted $x_i$source;
Millennial Statistics
Significant at 5% or higher in bold.l

Table 5: Cyclical Behavior of Capital Ratio, deviation from HP trend,1875–1946

	cross correlation RGDP								
series	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}
RGDP	-0.265	-0.417	-0.247	0.148	1.00	0.148	-0.247	-0.417	-0.265
Cap ratio	0.177	0.239	0.189	-0.236	**-0.422**	-0.153	0.128	0.158	0.182
	(1.042)	(1.407)	(1.109)	(-1.389)	(-2.483)	(-0.898)	(0.752)	(0.92)9	(1.068)
Risk ratio	0.117	0.073	0.156	0.087	-0.267	-0.206	0.038	0.051	0.033
	(0.693)	(0.432)	(0.921)	(0.512)	(-1.581)	(-1.216)	(0.225)	(0.302)	(0.195)
Capital	-0.125	-0.194	-0.317	-0.254	0.098	**0.386**	0.244	0.041	-0.054
	(0.787)	(1.221)	(1.994)	(1.595)	(0.617)	(2.428)	(1.533)	(0.258)	(0.338)
Assets	-0.165	**-0.390**	**-0.424**	-0.018	**0.533**	**0.478**	0.093	-0.175	-0.247
	(1.203)	(2.404)	(2.615)	(0.110)	(3.284)	(2.948)	(0.576)	(1.078)	(1.523)

source; Smith & Hengren
Significant at 5% or higher in bold.l

Table 6: Cyclical Behavior of Capital Ratio, Deviation from HP Trend

Cross-correlation of Capital Ratio and RGDP

Series	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}
All Banks	-0.046	-0.121	-0.181	-0.287**	-0.368***	-0.370***	-0.350***	-0.287**	-0.182
	(0.365)	(0.970)	(1.449)	(2.297)	(2.947)	(2.965)	(2.805)	(2.295)	(1.454)
Less than $100 million	-0.155	-0.128	-0.081	-0.047	0.013	0.040	0.021	0.026	0.056
	(1.291)	(1.068)	(0.674)	(0.389)	(0.108)	(0.334)	(0.175)	(0.218)	(0.463)
$100 million-$1 billion	-0.031	-0.040	-0.035	-0.045	-0.052	-0.016	-0.028	0.002	0.033
	(0.316)	(0.416)	(0.356)	(0.462)	(0.533)	(0.164)	(0.288)	(0.016)	(0.337)
$1 billion-$10 billion	-0.013	-0.091	-0.140	-0.216*	-0.262**	-0.289**	-0.284**	-0.212*	-0.105
	(0.104)	(0.719)	(1.107)	(1.713)	(2.075)	(2.291)	(2.249)	(1.682)	(0.832)
Greater than $10 Billion	-0.055	-0.098	-0.154	-0.238*	-0.312**	-0.335***	-0.327***	-0.295**	-0.226*
	(0.429)	(0.759)	(1.188)	(1.840)	(2.406)	(2.591)	(2.522)	(2.279)	(1.745)

Source; BEA, FFIEC

Note: T-statistics are in parenthesis.
*,**,***-Significant at 10%, 5% and 1% level

Table 7: Cyclical Behavior of Tier 1 Capital to RWA, Deviation from HP Trend

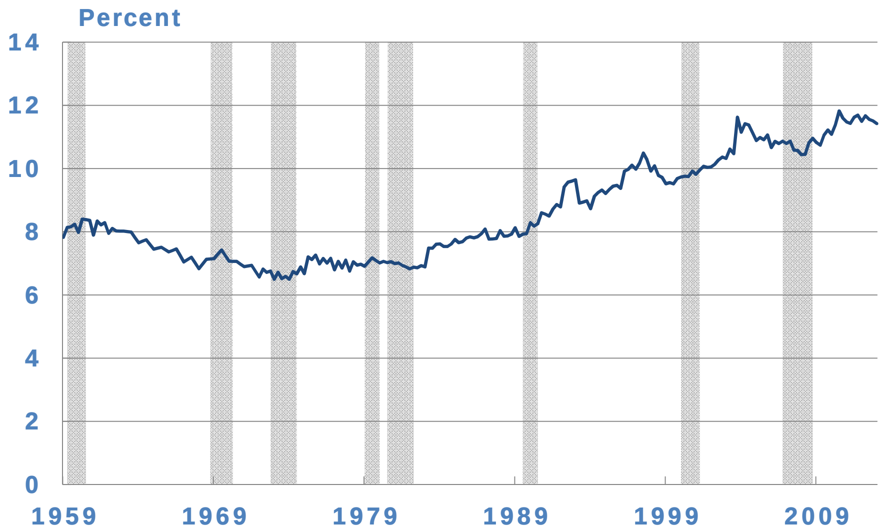
Cross-correlation of RGDP and Tier 1 Capital Ratio

Series	x_{t-4}	x_{t-3}	x_{t-2}	x_{t-1}	x_t	x_{t+1}	x_{t+2}	x_{t+3}	x_{t+4}
All Banks	0.475*	0.408	0.305	0.160	-0.052	-0.207	-0.363	-0.481*	-0.606**
	(1.831)	(1.572)	(1.1756)	(0.617)	(-0.200)	(-0.798)	(1.399)	(1.854)	(2.336)
Less than $100 million	0.335	0.519*	0.671**	0.771***	0.804***	0.785***	0.696***	0.574**	0.406
	(1.223)	(1.907)	(2.465)	(2.832)	(2.954)	(2.884)	(2.557)	(2.109)	(1.492)
$100 million-$1 billion	0.644**	0.647**	0.594**	0.511*	0.348	0.199	0.028	-0.107	-0.297
	(2.429)	(2.441)	(2.241)	(1.928)	(1.313)	(0.751)	(0.105)	(0.404)	(1.120)
$1 billion-$10 billion	0.274	0.199	0.099	-0.041	-0.204	-0.317	-0.444*	-0.550**	-0.668***
	(1.042)	(0.757)	(0.376)	(-0.156)	(0.776)	(1.205)	(1.688)	(2.090)	(2.540)
Greater than $10 Billion	0.291	0.183	0.029	-0.115	-0.333	-0.460*	-0.536**	-0.562**	-0.568**
	(1.217)	(0.765)	(0.121)	(-0.481)	(-1.393)	(-1.924)	(-2.242)	(-2.350)	(-2.375)

Source; BEA, FFIEC

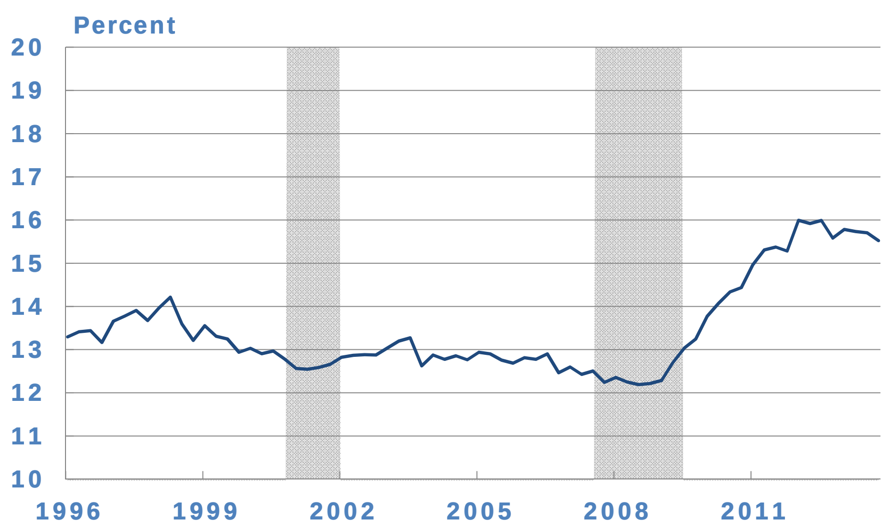
Note: T-statistics are in parenthesis.
*,**,***-Significant at 10%, 5% and 1% level

Figure 1: Equity to Total Assets, 1959-2013



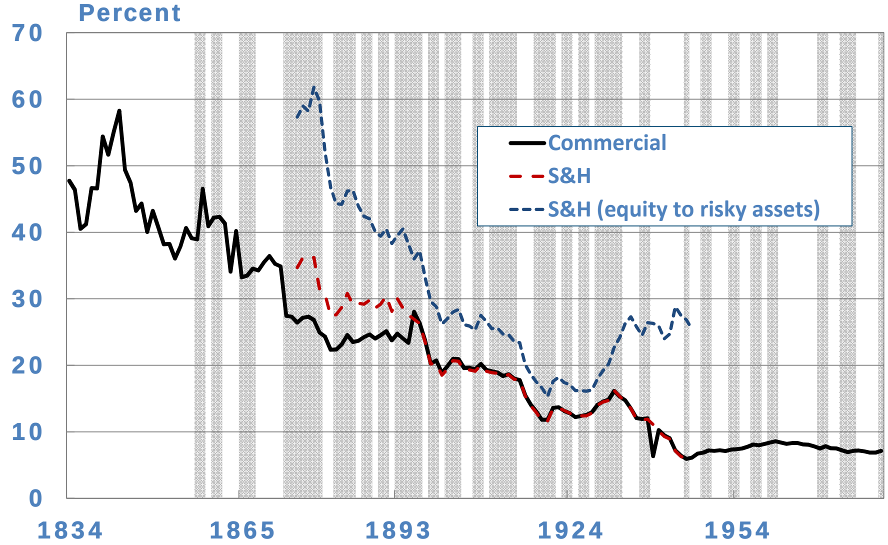
Source: Call Reports; Bureau of Economic Analysis
Note: Data is quarterly and is the quotient of the sum of all banks' total equity capital (RCON3210) and total assets (RCON2;170).

Figure 2: Tier 1 Capital to RWA, 1996-2013



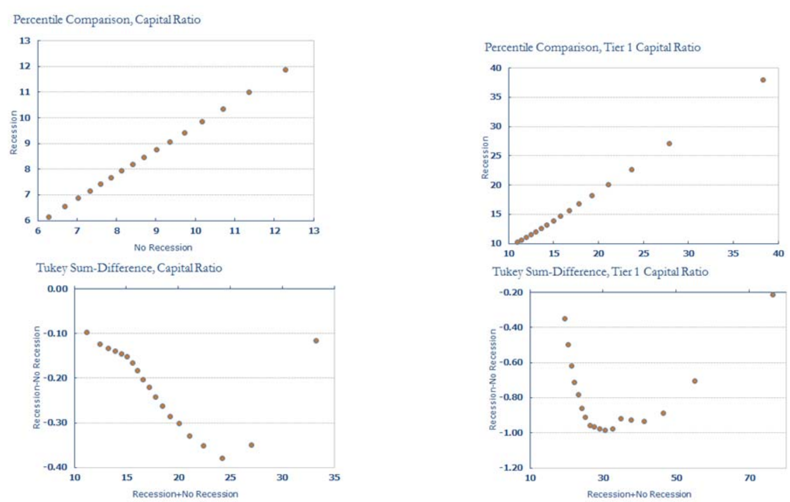
Source: Call Reports; Bureau of Economic Analysis
Note: Data is quarterly and is the quotient of the sum of all banks' tier 1 capital (RCON8274) and risk-weighted assets (RCONA223).

Figure 3: Equity to Total Assets



3

Figure 4: Percentile Comparison Plots; recession vs no recession



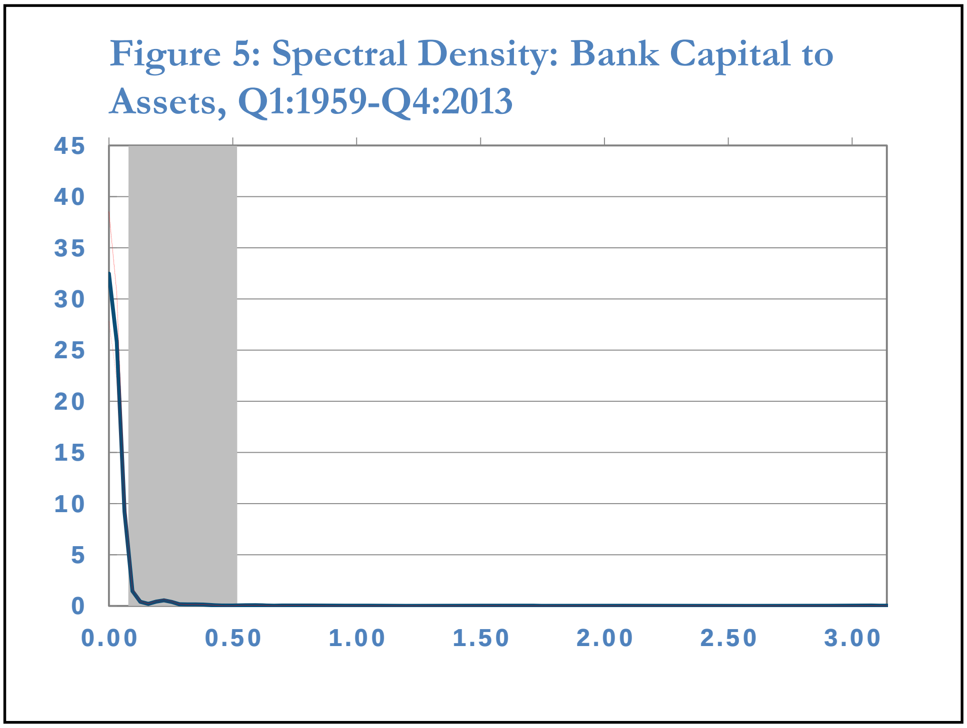


Figure 5: Spectral Density: Bank Capital to Assets, Q1:1959-Q4:2013
45
40
35
30
25
20
15
10
5
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00

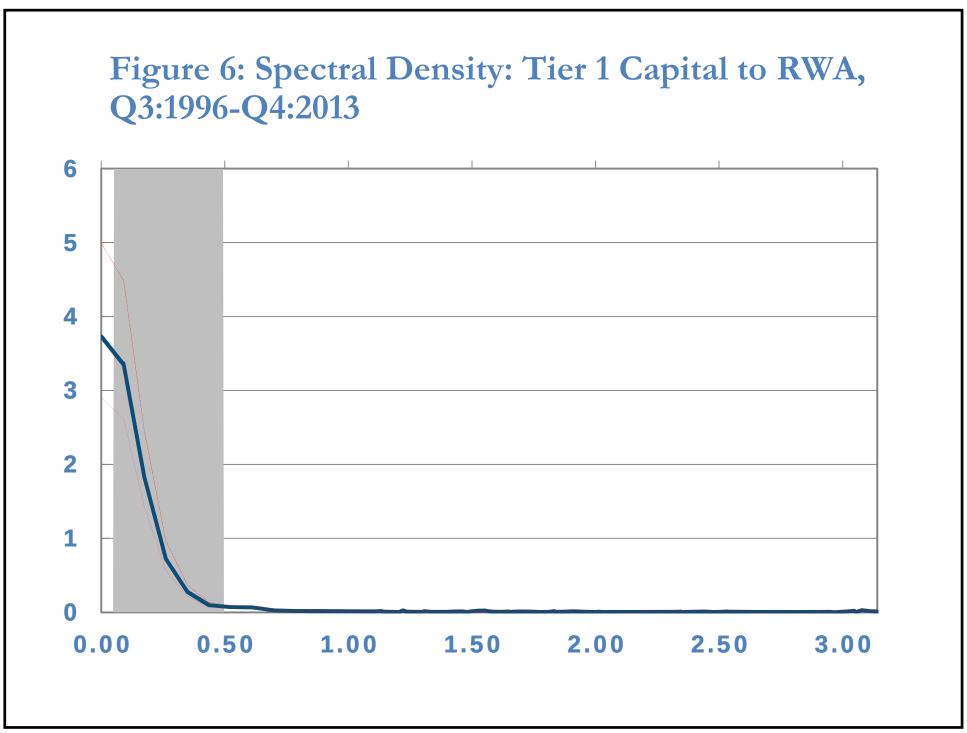


Figure 6: Spectral Density: Tier 1 Capital to RWA, Q3:1996-Q4:2013
6
5
4
3
2
1
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00

Figure 7: Spectral Density: Bank Capital to Assets (Commercial Banks), 1834-1980

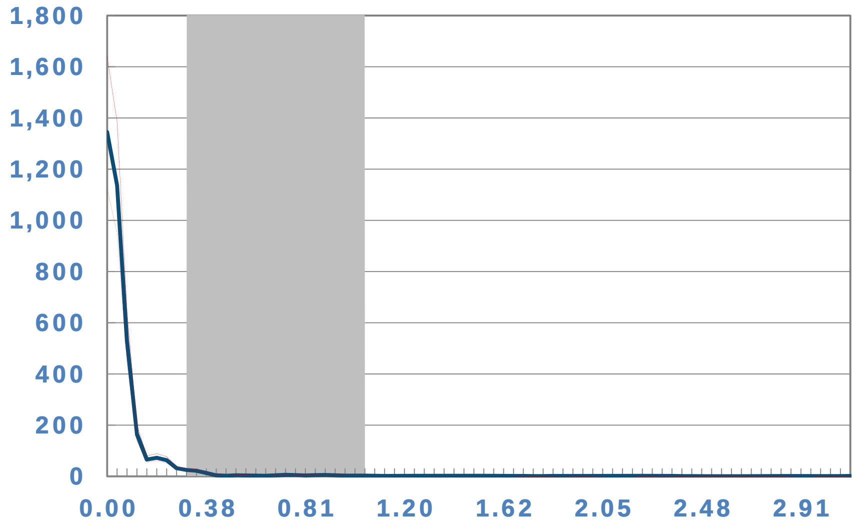


Figure 8: Spectral Density: Bank Capital to Total Assets (S&H), 1875-1946

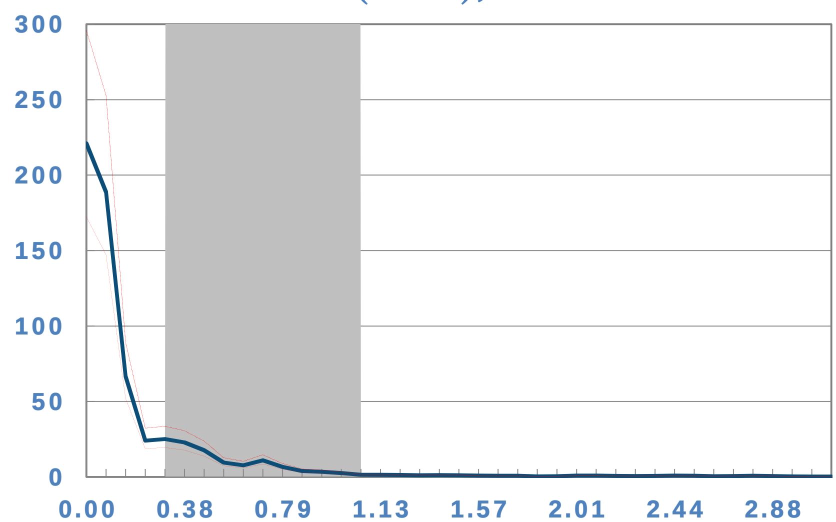
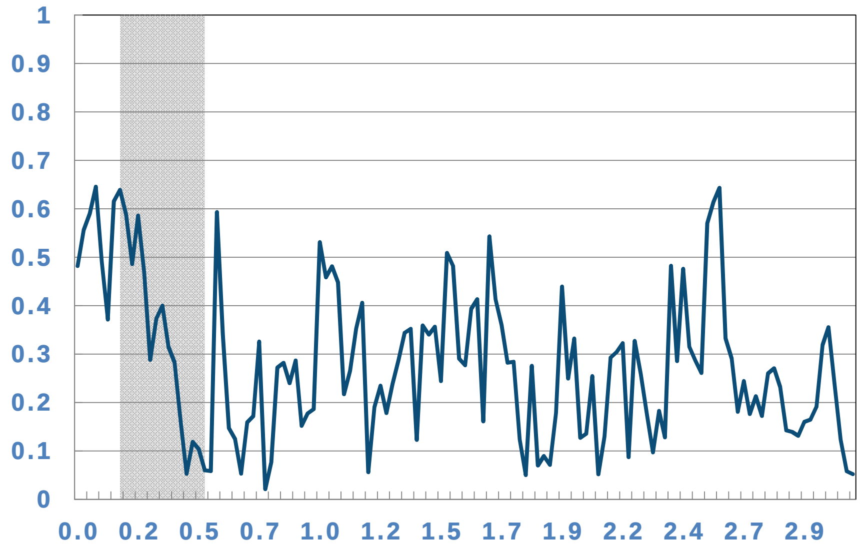
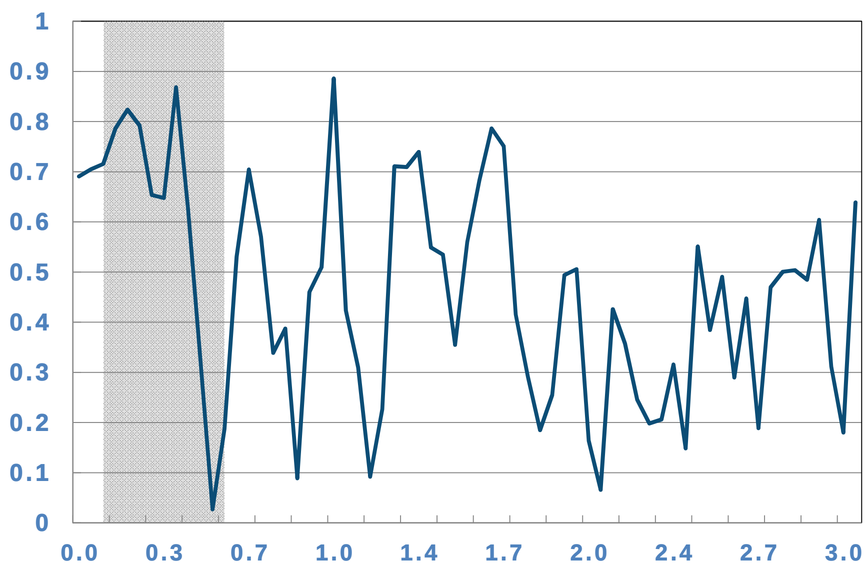


Figure 9: Coherence: Bank Capital to Assets, 1959-2013



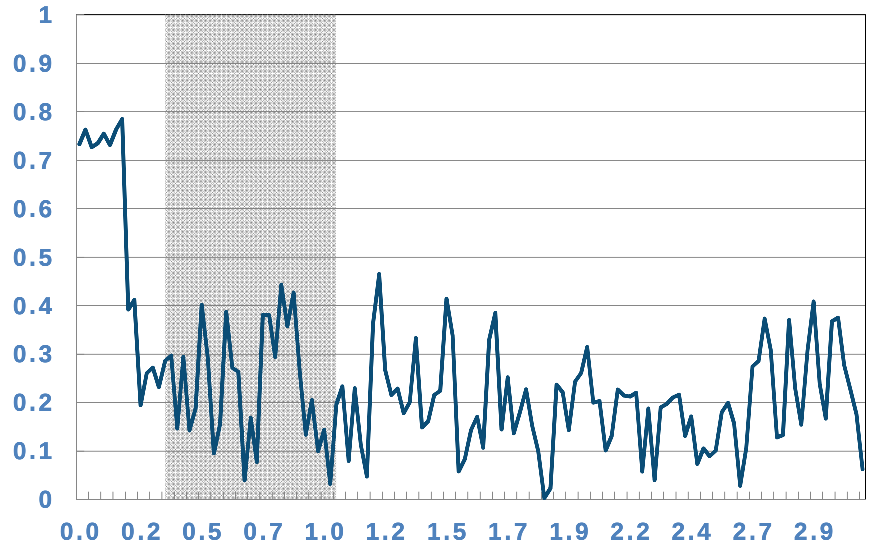
Source: Authors' Calculation

Figure 10: Coherence: Tier 1 Capital to RWA



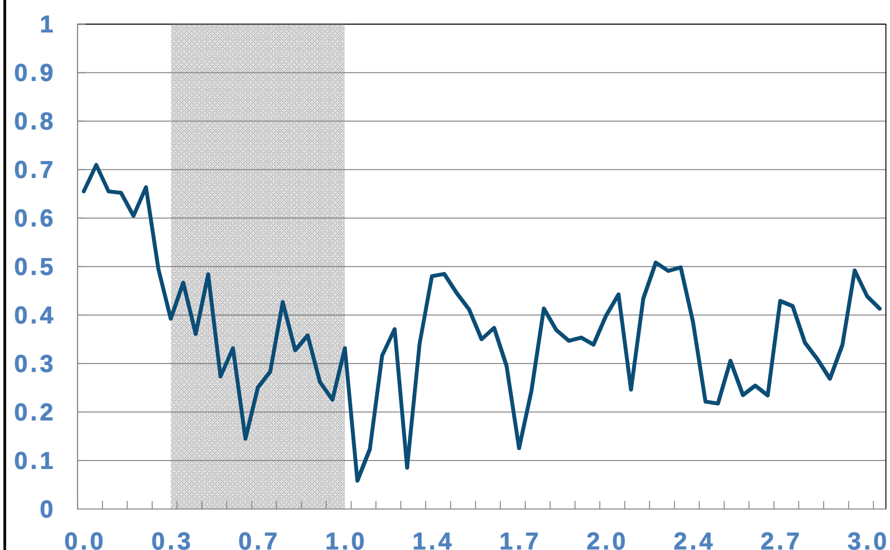
Source: Authors' Calculation

Figure 11: Coherence: Bank Capital to Assets (Commercial Banks), 1834-1980



Source: Authors' Calculation

Figure 12: Coherence: Smith & Hengren Data



Source: Authors' Calculation

Figure 13:Cross-Correlations: Capital Ratio & Real GDP, 1996-2013

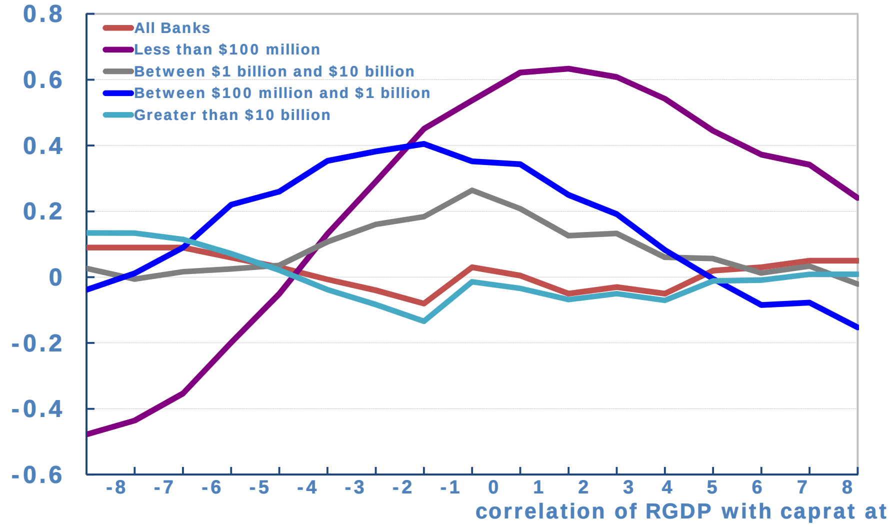


Figure 14: Cross-correlations: Tier 1 Ratio & RGDP, 1996-2014