Literature Review on the Macroeconomic Impacts of Capital Requirements

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This literature review summarizes the key concepts used in estimating the effect of capital requirements on output, the methodologies used in estimation, and other considerations relevant to assessing increased capital requirements. The basic framework used to model the effects of capital requirements on economic welfare is similar across most papers in the literature. Costs of higher capital are modeled as decreased lending and output through higher borrowing costs. Benefits of higher capital are modeled as decreases in the probability of incurring costs to output due to financial crises. Papers in the literature can be methodologically grouped into structural (DSGE) models, reduced forms models, semi-structural models, as well as a number of other approaches for intermediate estimates. Some papers take into consideration the transition costs associated with the policy change, while others focus only on long-run costs to the economy. With regard to the specific capital requirement reforms of Basel III, most—but not all—papers argue that the benefits outweigh the costs and some argue for even higher capital. The literature also takes a favorable view of countercyclical capital buffers.

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The global financial crisis of 2008 and the subsequent global recession highlighted the interplay between the financial and real sectors of the economy. In response, policymakers discussed and implemented tools designed to mitigate financial sector risks, including increased capital requirements. This reform, among others, generated considerable research and debate on the consequences of capital requirements to the economy as a whole. This literature review summarizes the key concepts used in estimating the effect of capital requirements on output, the methodologies used in estimation, and other considerations relevant to assessing increased capital requirements.

Costs and Benefits

Costs of Capital Requirements

Costs of regulation are generally modeled as a reduction of steady state level of output. Across the literature, costs of increased capital requirements are most commonly translated into output reductions through higher loan spreads and decreased investment. Every paper reviewed that measured costs included this channel. Less frequently, capital regulation is modeled as affecting loan supply not only through changes in loan spreads, but also through changes in underwriting standards or credit rationing, for example, Repullo and Suarez (2015).

Among the most important assumptions made when calculating the costs of capital requirements through their effect on loan spreads is the extent to which banks' costs of funds depend on capital structure. Modigliani and Miller (1958) theoretically demonstrate that increased equity financing reduces the cost of debt and leaves a firm's weighted average cost of capital unchanged. However, market frictions may result in deviations from this result in practice. To the extent that Modigliani and Miller (1958) holds, capital requirements have a smaller effect on banks' cost of capital, lending and ultimately, output.

Most papers take a conservative view and ignore offsetting changes in debt prices resulting from increased capital requirements, biasing results in favor of higher costs. These papers include BCBS (2010a) and Brooke et al (2015). Other papers in the literature allow some potential for debt re-pricing, such as Baker and Wurgler (2013) and Kashyap et al (2010). As expected, ultimate costs are larger in the former set papers than the latter. Arguing in favor of Modigliani and Miller (1958), Gambacorta and Shin (2016) find that a 100 bps increase in the capital ratio[2] decreases—rather than increases—a banks' cost of funds by 2 to 3 bps

Another important consideration on the cost side includes the extent to which banks pass through increased costs on to their borrowers. One method is to calculate the necessary rise in loan spreads

[2] Unless indicated otherwise, this literature review uses the term "capital ratio" to indicate risk-weighted capital ratio. Typically, this translates to TCE/RWA, but is not consistently or clearly defined across all studies cited.

under the assumption that a bank's return on equity (ROE) is unchanged after the rise in capital. Using this approach and fixing the cost of debt, BCBS (2010a) calculates that a 100 bps increase in the capital ratio raises loan spreads by 13 bps. Other models allow bank ROE to adjust in response to increased capital requirements and these models predictably yield smaller effects on loan spreads and effects on output. Using a flexible ROE assumption, Roger and Vlcek (2011) calculate that a 200 bps increase in capital requirement implemented over two years increases short-run spreads by 120 bps and long-run spreads by 15 bps.

Across different assumptions of debt price and ROE adjustments, most of the papers in the literature estimate long-run increases in lending spreads to be in the range of 2-20 bps for a 100 bps increase in capital requirements.[3] However, there are some outliers. IIF (2011) calculates an overall impact of Basel III reforms on loan spreads to be around 300 bps, but it does not separate out the individual effect of capital requirements in obtaining this estimate. On the other end of the spectrum, Miles et al (2013) find long-term increases in lending spreads of only 0.8 bps for a 100 bps increase in capital requirements. Gambacorta and Shin (2016) find lending increases of 60 bps for a 100 bps increase in capital, consistent with their earlier result of a decreased cost of funding.

Increased loan spreads must then be mapped into changes in loan quantities, investments, and ultimately output. In general, papers in the literature take estimated parameters on the elasticity of investment with respect to the cost of capital and embed this into a macroeconomic framework to obtain the ultimate effects on output. Some models, such as Brooke et al (2015) use a simple Cobb-Douglas production function without a financial sector to perform this calculation, while others use a more complex macroeconomic structure with financial sector linkages, as in Angelini et al (2015).

Through higher lending spreads, the cost estimates of a 100 bps increase in required capital are generally in the range of high single digit to low double digit basis point reductions to the long-run level of output. Papers examine these effects across various jurisdictions, including the US, UK, Switzerland, Canada, and Euro area. Angelini et al (2015) estimates thirteen different models across different methodologies and jurisdictions and find effects in the range of 2 bps to 35 bps for a 100 bps increase in risk-weighted capital requirements, with a median estimate of 10 bps for the US. However, they find larger effects when bank liquidity is also tightened. BCBS (2010a, 2010b) similarly place the cost of 100 bps on the order of 12 to 19 bps depending on the horizon and jurisdiction. Similar numbers are obtained in Gambacorta (2011) and Roger and Vlcek, which both find a central estimate of a 10 bps drop in steady state output.

Other jurisdictions produce similar estimates. In the UK, Barrell et al (2009) finds a long run cost of 10 bps when increasing the leverage ratio, rather than the risk-based capital measures, by 100 bps.

[3] Papers in this range include Angelini et al (2015), BCBS (2010a), BCBS (2010b), Brooke et al (2015), Dorich et al (2010), FSB (2015), Gambacorta (2011), Junge and Kugler (2012), King (2010), Roger and Vlcek (2011), Schanz et al (2011), Slovik and Cournède (2011).

Brooke et al (2015) and Schanz et al (2011) find even smaller effects in the UK. Noss and Tofano (2016) finds a slightly larger effect of 25 bps. Estimates in Canada and Switzerland yield long-run output effects in a similar range.[4]

Other papers take a more negative view of Basel III. IIF (2011) calculates that the net effect of the reforms on output level as a reduction of 3.2 percent relative to the baseline level of output after a five year implementation period. In contrast, the comparable number from BCBS (2010b) is a decrease of 0.19 percent. Calculating the joint effect of both liquidity and capital requirements, Covas and Driscoll (2011) find a reduction in long run output of 1.2 percent, or 30 bps per a 100 bps increase in capital.

Benefits of Capital Requirements

The benefits of regulation are modeled as a reduction in the probability of output-destroying financial crises and, in the context of structural models, the volatility of the business cycle. Capturing the probability of financial crises and their costs poses a number of challenges. For a given country, there are few financial crises in the historical data to empirically estimate the effect of capital on the probability of such an event. As a result, papers estimate this effect using either cross-country analyses or simulations.

Unlike the effects of capital requirements on costs of capital and associated falls in output, the effect on the probability of financial crises is non-linear. The marginal effect of capital is highest when capital levels are lowest and diminishes as capital increases. Therefore, the estimated effects depend heavily on the assumed starting value of capital, which varies across countries. Starting at a 6 percent risk-weighted asset ratio, BCBS (2010a) finds that a 100 bps increase in capital requirements is associated with a 260 bps decrease in the probability of a financial crisis, while another 100 bps increase decreases the probability of a financial crisis by 160 bps. Barrell et al (2009) estimates that a 100 bps increase in capital requirements reduces the probability of financial crises by 500 bps in the UK and 2-150 bps across Euro area countries. Kato et al (2010) finds that a similar increase in Japan would reduce the probability of financial crises in Japan by 310 bps. Combining two different methodologies, Brooke et al (2015) finds that at a 3 percent leverage ratio a 100 bps increase in the ratio is associated with a 100 bps decrease in the probability of crisis for the UK (corresponding to an 8 percent risk-weighted starting capital ratio and a 300 bps increase).

Quantifying the benefits of capital requirements through this channel also requires an estimate of the economic costs of these crises. This calculation is ultimately a comparison between realized macroeconomic output following a financial crisis against a counterfactual economy that did not

[4] For Canada, Dorich et al (2010) estimate 26 bps and de Resende et al (2010) estimate 3 bps. For Switzerland, Junge and Kugler (2012) estimate 6 bps.

experience a financial crisis. This may include both short-term losses in output that resemble deep recessions, as well as long-run effects in which the economy never fully recovers.

The depth and persistent effects of financial crises on economic output varies across the limited number of historical observations. More developed countries tend to have lower estimated costs of crises than less developed countries. The limited number of observations of such crises necessitates the use of international data in order to obtain reasonable estimates, though modelers need to take care in selecting a sample of economies appropriate for the analysis. For example, IMF (2009) uses 88 banking and 222 currency crises worldwide, Romer and Romer (2015) considers 24 events over only OECD countries, and Brooke et al (2015) uses an even narrower set of countries whose banking systems and data are deemed more comparable for estimates pertaining to the UK.

The estimated costs of economic crises are large, but vary in magnitude and vary across samples and assumptions about the permanence of the effects. IMF (2009), which includes developing countries, finds effects of 10 percent peak loss of output with a 10 percent loss in long-run output. BCBS (2010a) finds peak and long run losses of output of 9 percent and 6 percent. Using only OECD countries Romer and Romer (2015) finds peak and long-run output losses of 4 percent and 3 percent, respectively. Finally, Brooke et al (2015) finds peak and long-run output losses of 5 percent and 4 percent. Translating these numbers into a present value basis, BCBS (2010a) finds the median estimated cumulative cost of economic crises across comparable approaches to be 63 percent of output.

In addition to avoiding costly crises, decreased bank leverage decreases the volatility of loans and, consequently, the volatility of economic output. Evaluating this effect requires the use of a structural or semi-structural model which makes assumptions about the extent of economic agents' levels of risk aversion. This effect can then be evaluated alongside the level effects of capital requirement on output using cost and benefit estimates from other channels. Over five models, Angelini et al (2015) estimate that a 100 bps increase in capital requirements is associated with a mean decrease in the standard deviation of output of 125 bps. To put this number in perspective, the authors estimate that the welfare losses from decreased output via higher costs of capital combined with gains from decreased volatility yields an annual welfare loss equal to 0.035 percent of US consumption. They note that this is even prior to the consideration of welfare benefits stemming from the decreased likelihood of financial crises.[5]

[5] Some models make alternative assumptions that generate a positive relationship between capital requirements and output volatility. Aliaga-Díaz and Olivero (2012) show this result, though they find that this effect is weak.

Net Benefits

Combining all of the above effects produces estimates of the net effect of capital requirements. The optimal level of capital is a direct corollary of this calculation. Estimated optimal capital ratios may differ due to different parameter estimates in the intermediate steps and assumptions made about other policy tools. For example, Brooke et al (2015) assumes the presence of other loss absorbing capital and an improved resolution regime. Most papers also abstract away from monetary policy considerations, though Angeloni and Faia (2013) demonstrate how monetary policy rules that respond to asset prices or bank leverage could be used to offset some of the costs associated with risk-based capital requirements.

Across papers that quantify the major costs and benefits listed above, the estimated optimal risk-based capital ratios generally fall in the range of 10 percent to 20 percent. Such papers find evidence in favor of capital requirements specified under Basel III. For example, Miles et al (2013) estimates a range of 16 to 20 percent, BCBS (2010b) estimates a range of 16 to 19 percent, Brooke et al (2015) estimates a range of 10 to 14 percent. Barrell et al (2009) find positive output effects for up to a 600 bps increase in capital and liquidity requirements.

IIF (2011) and Cline (2016) are more skeptical of the net benefits of higher capital requirements. The former estimates large costs of the Basel III reforms, while the latter estimates an optimal risk-weighted leverage ratio in the range of 12 to 14 percent.

Methodologies

The literature uses a mix of structural, semi-structural, reduced form, and other methodologies in calculating the effects of capital requirements on output. Depending on the costs or benefits used in a given paper, authors may rely on one or many of the possible approaches within a single paper. For example, the probability of financial crises is generally modelled either using a simulation or using a reduced form empirical estimation technique. Meanwhile, output losses stemming from increased costs of capital are modeled under a number of different approaches. Each method has relative strengths and weaknesses discussed below.

Structural

Structural methodologies are most commonly used in this literature to estimate the output costs of capital requirements through increased loan spreads and, in some cases, the effect of capital requirements on the volatility of output.[6] The main advantage of this approach is the ability to

[6] See Aliaga-Díaz and Olivero (2012), Angelini et al (2015), Angeloni and Faia (2013), Benes and Kumhof (2011), Dorich et al (2010), Gerali et al (2010), MAG (2010a), BCBS (2010b), Repullo and Suarez (2015), and Roger and Vlcek (2011).

conduct internally consistent counterfactuals, including changes to capital and liquidity requirements, as well as the introduction of countercyclical capital buffers. In particular, because agents' behaviors are explicitly modeled, the method enables calculations of how banks respond to policy changes and how those responses flow through to the real economy.

However, structural models have a number of important weaknesses. To remain tractable, structural models require many simplifying assumptions, limiting the channels through which banks, firms, and households make decisions. In addition, structural models generally assume that long-run growth is a function of a technological process that is independent of the other parameters of the model. In addition, these structural models often rely upon linearity around a steady state and do not easily incorporate the non-linearities associated with financial crises. Consequently, these models are poorly suited to capture the effect of capital requirements on the likelihood of financial crises, the primary benefit targeted by these reforms.

Reduced Form

In calculating the cost of capital effects on economic output, reduced form approaches use macroeconometric methods such as vector autoregression (VAR) or vector error correction models (VECM) to estimate the dynamic historic relationships between macroeconomic variables such as output and capital.[7] The leading weakness of reduced form approaches is that the parameters from the estimated models may not be policy invariant (i.e. the Lucas critique). That is, the models estimating the effect of capital requirements on output use data that is generated from a different policy regime. Changes in bank target ROEs or underwriting standards in response to increased capital requirements could alter the empirical relationships observed in the data going forward.

With regard to calculating the benefits of capital requirements, reduced form methodologies similarly assume a policy invariant relationship between capital and financial crises. For example, a number of papers estimate the probability of financial crises by regressing a crisis variable on system-wide capital adequacy and other macroeconomic covariates such as output growth, house price growth, and credit growth, among others.[8] However, capital requirements are generally expected to alter these macroeconomic variables through the channels identified above (e.g. cost of capital). Consequently, the effect of capital requirements on financial crises will likely be understated in a reduced form approach.

[7] See Barrell et al (2009), Berrospide and Edge (2010), Gambacorta (2011), Noss and Tofano (2016) and Yan et al (2015).

[8] See Barrell et al (2009), BCBS (2010b), Kato et al (2010), and Brooke et al (2015).

Semi-Structural

Most central banks have one or more macroeconomic models used in forecasting and policy analysis. These models do not generally feature bank information directly as inputs used to forecast macroeconomic variables. Instead, these models must use inputs such as lending spreads to estimate the effect of capital requirements. Because the effects of capital on spreads must be modeled separately within this class of models, they are not fully structural.[9]

Other Methodologies

Many papers that do not explicitly run a structural or reduced form model nevertheless use estimates from structural models for their calculations of costs. For example, papers that calculate the increased cost of capital on bank lending rely on parameter estimates from elsewhere in the literature to convert the effect of spreads to changes in investment and output.[10]

Some intermediate calculations in the probability of crises also use a stress testing approach. This entails calculating a distribution of bank losses and simulating the probability that aggregate losses exceed system-wide levels of capitalization. This can be done by modeling bank losses explicitly[11] or by simulating losses to output and making modeling assumptions on how these losses flow to bank capital.[12] As in reduced form models, this approach implicitly assumes that the historical processes are invariant to changes in the capital regime.

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[9] For example, BCBS (2010a) and Angelini et al (2015).

[10] For example, see Brooke et al (2015), Miles et al (2013),

[11] As in Brooke et al (2015) and FRB (2015).

[12] As in Miles et al (2013).

Other Considerations

Transitional Costs

Most papers reviewed in the literature note that short-term peak losses may be considerably larger than long-run effects through the increased cost of capital channel. However, a number of papers specifically emphasize the extent of these effects. In one of the papers most critical to the reforms, IIF (2011) highlights transition costs during a weak economic period as a primary concern.

Roger and Vlcek (2011) uses a model that allows banks to meet increases to capital requirements by increasing retained earnings, reducing risk-weighted assets, or issuing new equity. Under each of these alternative margins of adjustments, they find that a longer implementation horizon reduces the magnitude of the output decline by 30 to 50 percent. Similarly, Covas and Driscoll (2011) shows that a longer transitional path for increased capital requirements generates welfare losses 10 to 30 percent smaller when compared to the case of sudden increases.

Countercyclical Buffers

In addition to increased capital requirements and the transition schedule, papers in the literature estimate the effects of the countercyclical capital buffer proposed in BCBS (2010c). The stated objective of the countercyclical capital buffer is to protect the banking sector from periods of excessive credit growth that are associated with aggregate risk. The continued ability to lend through downturns would result in shallower economic contractions. Ancillary proposed benefits are slower credit growth during booms and a dampening of the volatility of the business cycle.

In general, the literature views the general concept of countercyclical capital buffers favorably.[13] However, the absence of historical precedent for these policy tools implies that the estimated effects are more speculative. For example, Angelini et al (2015) find a considerable dampening of output volatility in response to a countercyclical buffer, but they note that under a more flexible monetary policy rule (such as Angelini et al (2010, 2011)), the gains from the countercyclical buffer are greatly diminished. Repullo et al (2015), Benes and Kumhof (2011), Noss and Tofano (2016), Bank of England (2013), and BCBS (2010a) also judge the countercyclical capital buffer favorably.

Monetary Policy

Monetary policy can play an important role in offsetting some of the transitional costs associated with increased capital requirements. However, the majority of papers reviewed ignore this

[13] Repullo and Saurina (2011) critique the design of the countercyclical capital buffer described in BCBS (2010c).

possibility. To the extent that monetary policy is used in conjunction with other macroprudential policies, estimates of the costs of capital requirements may be biased.

Exceptions to this assumption include Angeloni and Faia (2013), Slovik and Cournède (2011) and de Resende et al (2010). Angeloni and Faia (2013) demonstrate that an optimal monetary policy rule responds to asset prices or bank leverage. Meanwhile, Slovik and Cournède (2011) calculate that the drag on output induced by increased costs of capital can be offset by a reduction (or delayed increase) in monetary policy rates of 30 bps to 80 bps. On the other hand, De Resende et al (2010) argue that when rates are at the zero lower bound, monetary policy cannot respond to falls in output induced by capital requirements. Consequently, they suggest that decreases in output from capital requirements are amplified in such environments.

Joint Effects with Liquidity Reforms

This literature largely considers the effects of only capital requirements on output. However, Basel III also stipulates liquidity requirements in the form of the Liquidity Coverage Ratio and the Net-Stable Funding Ratio. In most cases, adding liquidity requirements to capital requirements adds to the output costs associated with the reforms. For example, Angelini et al (2015) finds that the output costs of a 100 bps increase in capital are approximately twice as high when considered alongside changes to liquidity. Similarly, Covas and Driscoll (2011) estimates that the joint effect of capital and liquidity requirements as in Basel III reforms would reduce long-run loans by 5 percent and long-run output by 0.7 percent. On the other hand, Roger and Vlcek (2011) argue that liquidity and capital requirements are complementary in the sense that raising liquidity requirements eases the costs of capital adequacy.

Conclusions

Calculating the economic effects of capital requirements is a challenging task. Even the best papers in the literature produce estimates that are imprecise and subject to many caveats. Nevertheless, the existing literature suggests that the benefits of higher capital regulation outweigh the costs, at least up to the levels specified under Basel III and perhaps beyond.

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