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Basel III and its Effects on Banking Performance: Investigating Lending Rates and Loan Quantity

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Abstract

In late 2010, the Basel Committee on Banking Supervision issued the Basel III document enumerating measures focused on improvements in the definition of regulatory capital, introduction of a leverage ratio as a backstop for risk-based capital requirement, capital buffers, enhancement of risk coverage through improvements in the methodology to measure counterparty credit risk and liquidity measurement standards. This study investigates the impact of the new capital requirements introduced under the Basel III framework on bank lending rates and loan growth. Higher capital requirements, by raising banks' marginal cost of funding, lead to higher lending rates. The data presented in the paper suggest that assuming a 1.3 percentage point increase in the equity-to-asset ratio to meet the Basel III regulations, the country-by-country estimations imply a reduction in the volume of loans by an average 4.97 percent in the long run for the banks in countries that experienced a crisis and by 18.67 percent for the banks in countries that did not experience a crisis. The wide variance in the results reflects cross-country differences in the elasticity of loan demand with respect to loan interest rateand bank's net cost of raising equity.

Keywords: Basel III, capital requirements, banking performance

GEL: C4, E44, E5, G21

1. Introduction

Towards the end of 2008, it became clear that weaknesses in financial sector regulation and supervision had significantly contributed to the crisis.

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The efforts to reform the financial sector regulation began under the aegis of G20, and both the Financial Stability Board and the Basel Committee on Banking Supervision (BCBS) embarked on an ambitious agenda for regulatory reforms (FSI, 2010). During the next two years a number of initiatives were taken by the BCBS with the objective of improving the banking sector's ability to absorb shocks arising from financial and economic stress and to reduce the risk of spill-over from the financial sector to the real economy.

The first installment of these measures announced in July 2009 (Basel II) included strengthening of the trading book capital requirements, higher capital requirements for re-securitization products held in both the banking book and trading book and strengthening of guidance on Pillar II (supervisory review process). In late 2010 the BCBS issued the Basel III document enumerating measures focused on improvements in the definition of regulatory capital, introduction of a leverage ratio as a backstop for risk-based capital requirement, capital buffers, enhancement of risk coverage through improvements in the methodology to measure counterparty credit risk and liquidity measurement standards (Hakura&Cosimano, 2011).

The reforms focus firstly on the micro-prudential (bank-level) regulations which will help raise the resilience of individual banking institutions during periods of stress; secondly, on macro-prudential regulations involving system-wide risks that can build up across the banking sector as well as the procyclical amplification of these risks over time (BIS, 2010b). The new regulations tighten the definition of bank capital and require that banks hold a larger amount of capital for a given amount of assets and expand the coverage of bank assets. The purpose of this paper is to estimate whether and to what extent these higher capital requirements will lead to higher loan rates and slower credit growth.

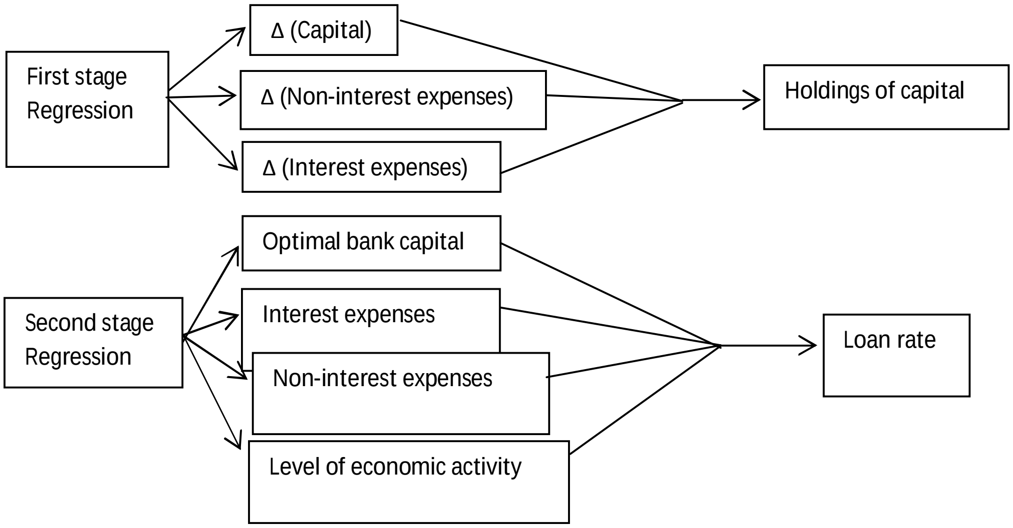
This paper aims to broaden and deepen the understanding of the likely impact of the new capital requirements on bank lending and volume of lending, introduced under the Basel III framework rates. Complementing the studies mentioned above, the contribution of this paper is twofold concerning the understanding and testing of the impact of the new regulations on the banks.

Firstly, the paper derives empirically testable relations from a structural model of the capital channel of monetary policy developed by Chami and Cosimano (2010). In doing so it follows Barajas et al. (2010) analysis of large bank holding companies in the United States. In this model, loan demand shocks are transmitted to the credit supply via the regulatory capital constraint. In particular, a bank's decision to hold capital is modeled as a call option on the optimal future loans issued by the bank. This option value of the bank's capital increases when the expected level of loans and the amount of capital required by the regulator increase. The bank's choice of capital influences its loan rate since the marginal cost of loans is a weighted average of the marginal cost of deposits and equity. Consequently, the loan rate raises with an increase in required capital as long as the marginal cost of equity exceeds the marginal cost of deposits.

Another contribution of this paper is that it considers two different groupings of banks: (i) commercial banks in advanced European economies that experienced a banking crisis between 2007 and 2010; and (ii) commercial banks in advanced European economies that did not experience a banking crisis between 2007 and 2010. It would have been preferable to extend the time range but there was a lack of appropriate data for the next two years (2011 and 2012).

The empirical estimation of our data relies on a Generalized Method of Moment (GMM) estimation procedure which captures the banks' simultaneous decisions on how much capital to hold, at what level to set the loan rate and the size of their loan portfolio (Gropp&Heider, 2010; Miller et al., 2010; Hall, 2005). In line with Cosimano and Hakura (2011) the first stage regression for banks' holdings of capital is specified in terms of previous-period changes in capital, interest expenses (interest payables) and non-interest expenses (figure 1). The hypothesis is that there is a negative and convex relationship between a bank's capital and each of these factors. In particular, an increase in the future marginal cost of loans results in the bank issuing fewer loans so that the need for equity fades. The loan rate is the dependent variable in the second stage regression and is specified in terms of the optimal bank capital predicted by the first stage regression as well as interest and non-interest expenses and the level of economic activity.

Figure 1: The Generalized Method of Moment (GMM) Estimation Procedure



The key findings of the paper are as follows. First, a 1 percent increase in the equity-to-asset ratio is associated with a 0.05 percent average increase in the loan rate for banks in countries that experienced a banking crisis during 2007-2010. For banks in countries that did not experience a banking crisis during 2007-2010 it is associated with a 0.02 percent average increase. Secondly, assuming a 1.3 percentage point increase in the equity-to-asset ratio to meet the Basel III regulations, the country-by-country estimations imply a reduction in the volume of loans by an average 4.97 percent in the long run for the banks in countries that experienced a crisis and by 18.67 percent for the banks in countries that did not experience a crisis. The wide variance in the results reflects cross-country differences in the elasticity of loan demand with respect to loan interest rate[3]and bank's net cost of raising equity. The authors' model shows that the estimated elasticity of loan demand ranges from -1.00 percent for Ireland to -6.59 percent for Denmark. An upper bound on the net cost of raising equity (i.e. the return on equity relative to the marginal cost of deposits) is estimated to range from 0.01 basis points in Sweden to 20 basis points in Ireland.

3 The basic idea is simply that for banks which are not liquidity constrained, loan demand should be a function of the price of the loan (the interest rate). If a bank faces a loan demand curve which has the reciprocal of the interest rate elasticity everywhere larger than that of another bank, we can unambiguously conclude that the former bank possesses greater market power than the latter bank. Wong (1997) argued that this suggests a way to study the effect of market power on the optimal bank interest margin.

The remainder of the paper is organized as follows. Section 2 refers to related literature. Section 3 presents some descriptive statistics for the two groupings of banks examined in the paper. Section 3 describes the structural model for banks' optimal holding of capital and presents the specification of the empirical tests for bank capital, lending rates and loans. The core principals of the GMM estimator are presented in section 4. Section 5 reports the results. Finally, the conclusion is presented in section 6.

2. Related Literature

There are several studies which have handled the effects of capital requirements upon banking performance. To begin with some of them seek the degree on which capital requirement levels affect the profitability of commercial banks. For example, Rojas-Suarez (2002) argued that capital standards are not found to strengthen banks in emerging countries when Chiuri et al. (2002) found that the enforcement of capital requirements is found to reduce the supply of finance; to help prevent negative macroeconomic effects, capital requirements should be phased in gradually. The worst impact is usually felt when capital requirements are implemented in the aftermath of a crisis. In response to the deposit insurance post crisis, Demirguc-Kunt and Kane (2002) challenge the rationale of encouraging countries to adopt explicit deposit insurance without first addressing supervisory and institutional financial weaknesses. 'Weak' countries that adopt explicit deposit insurance usually find that the economic conditions subsequently suffer because private sector monitoring is replaced with poor-quality government monitoring (Cullet al., 2002; Laeven, 2002).

Several studies in this category offer a descriptive debate over arbitrary balance of regulation (e.g. Di Noia& Di Giorgio, 1999; De Bondt&Prast, 2000 inter alia). Ferri et al. (2001) argue that the linking of bank capital requirements to private sector ratings would prove undesirable for non-high-income countries. Corporate and bank ratings in low-income countries are not updated as often or as extensively as high-income countries. Accordingly, banks in lower-income countries with improved asset quality would be disadvantaged.

Analysis of explicit or implicit deposit insurance is a familiar regulatory theme in regard to risk-shifting within an economy.

Explicit deposit insurance occurs when a government guarantees the safety of bank deposits. The level of coverage may vary between different types of depositors and banks to avoid bank runs but not without moral hazard issues to contend (Laeven, 2002). Implicit deposit insurance entails uninsured deposits. The expectation of government bailout of the depositor is extremely high in Eastern Europe and Latin America and moderately high in Asia and Africa (Hovakimian et al., 2003). It is recommended that banking supervision should be assigned to an agency formally separated from the central bank because the inflation rate is higher and more volatile in countries where the central bank acts as a monopolist regulator. Not all countries can afford deposit insurance, especially those with weak banks and regulators (Di Noia& Di Giorgio, 1999).

Moreover, one part of literature argues that there are significant macroeconomic benefits from raising bank equity. Higher capital requirements lower leverage and the risk of bank bankruptcies (e.g. Admati et al., 2010). Another part of literature points out that there could be a significant cost of implementing a regime with higher capital requirements (i.e. BIS, 2010a). Higher capital requirements will increase banks' marginal cost of loans if the marginal cost of capital is greater than the marginal cost of deposits, i.e. if there is a net cost of raising capital. In that case, a higher cost of equity financing relative to debt financing would lead banks to raise the price of their lending and could slow loan growth and hold back the economic recovery (Angelini et al., 2011).

Other studies have examined the impact of higher capital requirements on bank lending rates and the volume of lending. Kashyap et al. (2010) calibrate key parameters of the United States' banking system to identify the impact of an increase in the equity-to-asset ratio. They find an upper bound of 6 basis points for the increase in U.S. banks' lending spreads following an increase in the capital-to-asset ratio in line with that required under Basel III. BIS (2010a) estimates a significantly higher increase in the lending spread on the order of between 12.2 and 15.5 basis points, based on simulations with 38 macroeconomic models maintained by the central banks of advanced economies. Angelini et al. (2011) reports similar findings. Similarly with the help of aggregate banking data Slovik and Cournede (2011) use accounting relations to find that lending spreads could be expected to increase by about 15 basis points.

Several papers have analyzed the impact of monetary policy on banks with capital constraints ending in differing conclusions. Whether monetary policy affects bank lending or not depends on the assumption that bank loans are financed by reservable deposits or on the imperfect elasticity of the supply of non-reservable deposits. For example, Labadie (1995) using an overlapping generations framework shows that the addition of capital constraints on banks has no real effect. This result hinges on the assumption that banks can costlessly raise equity or external funds. On the other hand Kopecky and VanHoose (2004a, 2004b) following deterministic models assume an increasing marginal cost of equity in a competitive banking industry with capital constraints binding in the short term; monetary policy in their framework has real effects. Thakor (1996) uses an asymmetric information model of bank lending but maintains the assumption of costly external funds. He shows that monetary policy impacts bank lending.

Furthermore, Bolton and Freixas (2006) provide an asymmetric information explanation for the high cost of external funds for banks. In a general equilibrium model they demonstrate how an open market sale of securities decreases the net interest margin for the bank which shifts lending away from firms with poor projects. On the other hand, firms with positive net present value projects as well as banks shift away from bonds since they are crowded out by government bonds. However, with the total capital constraint always binding, the total amount of lending does not change. Finally, Van den Heuvel (2002) using a dynamic model of banking analyses the role of bank capital channel in the transmission of monetary policy. He shows simulations in which the resulting interest rate mismatch implies that monetary policy affects the supply of loans through its impact on the value of bank capital.

3. Data and Descriptive Statistics

Annual data regarding commercial banks for a number of advanced European countries are obtained from the Bankscope database for the 2003-2010 period. Two different groupings of banks are examined. The first grouping includes the commercial banks in a group of European economies that experienced a banking crisis between 2007 and 2010. The second grouping includes the commercial banks in a group of European economies that did not experience a banking crisis between 2007 and 2010.

The sample consisted of advanced European economies where the amount of available information was sufficient for performing all necessary calculations.

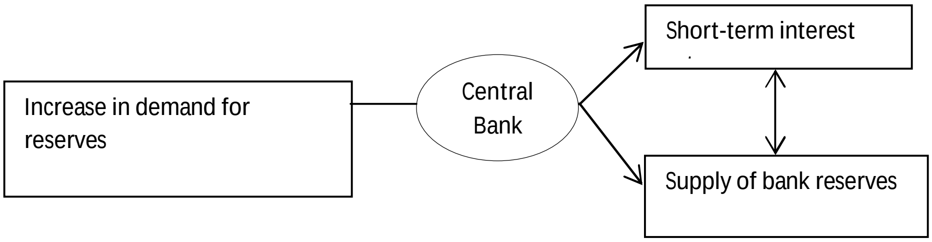
How may one define a banking crisis? The IMF (1998) defines a banking crisis as a situation in which bank runs and widespread failures induce banks to suspend the convertibility of their liabilities or which compels the government to intervene in the banking system on a large scale. To identify banking crises existing empirical studies (Kaminsky& Reinhart, 1999; Glick & Hutchison, 2001; Bordo et al., 2001 inter alia) rely on the observation of certain events such as forced bank closures, mergers, runs on financial institutions and government emerging measures. For instance, Demirguc-Kunt and Detragiache (1998) identify an episode as a crisis when at least one of the following conditions holds: (i) the ratio of non-performing assets to total assets in the banking system exceeded 10%; (ii) the cost of the rescue operation was at least 2% of the GDP; (iii) banking sector problems resulted in a large-scale nationalization of banks; (iv) extensive bank runs took place or emergency measures such as deposit freezes, prolonged bank holidays, or generalized deposit guarantees were enacted by the government in response to the crisis.

According to Von Hagen and Ho (2007) such observation has several shortcomings. First, it tends to identify banking crises too late. For example, the cost of a bailout is available only after a crisis and with a time lag. Events such as the nationalization of banks and bank holidays are likely to occur only when a crisis has already spread to the whole economy. Governments may provide hidden support to banks at the early stages of a crisis for political reasons; that is early policy interventions may not be observable. Second, there are few objective standards for deciding whether a given policy intervention is 'large'. Third, the timing of crisis periods on this basis is difficult because the exact date of policy interventions is often uncertain or unclear (Caprio&Klingebiel, 1996). Fourth, such a method identifies crises only when they are severe enough to trigger market events. Crises successfully contained by prompt corrective policies are neglected.

The index of money market pressure (IMP), developed by Von Hagen and Ho (2007) has been used in order to identify banking crises. They define the reserves-to-bank deposits ratio γ as the ratio of total reserves held by the banking system to total non-bank deposits in the banking sector.

In a period of high tension in the money market this ratio increases either because the central bank makes additional reserves available to the banking system or because depositors withdraw their funds from the banks. Actually, the IMP denotes the weighted average of changes in the ratio of reserves to bank deposits and changes in the short-term real interest rate (the real interest rate on short term loans), (figure 2).

Figure 2: Ways of Reaction for the Central Bank, in Case of Increase in the Demand for Reserves



The weights are the sample standard deviations of the two components. Thus, the index is defined as:

$$IMP_t = \frac{\Delta\gamma_t}{\sigma_{\Delta\gamma}} + \frac{\Delta r_t}{\sigma_{\Delta r}} \qquad (1)$$

where $\Delta\gamma$ is the change in total bank reserves relative to non-bank deposits, Δr is the change in the short term real interest rate and σ refers to the standard deviation of each variable. Table 1 reports the year and quarter in which IMP meets two criteria: (i) it exceeds the 98.5 percentile, 97 percentile, and 95 percentile of the sample distribution of IMP for each advanced economy; and (ii) there is an increase in IMP by at least five percent from the previous period. The first condition assures that only exceptional events are identified as crises. However, since every empirical distribution must have a 98.5 percentile, the second condition is used to allow for the possibility that countries had no banking crisis during the sample period. Note that relaxing the first condition and using a lower percentile raises the risk of calling too many episodes crises, while tightening it increases the risk of missing true crises[4].

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[4] The empirical analysis indicates that raising the threshold to the 99.5 percentile does not change the results significantly, while lowering it to the 95 percentile causes the regressions to lose explanatory power. Similarly,

Table 1 identifies banking crises in European economies using the IMP. Based on this index, Austria, Belgium, Germany, Greece, Netherlands, Sweden, Spain, Italy, and the United Kingdom are identified as having experienced a banking crisis between 2007 and 2010 when the cutoff is the 98.5 percentile (shown in faded color).

Table 1: Banking Crises in European Economies Identified Using the Von Hagen and Ho (2007) Index of Money Market Pressure.

	Thresholds		
Country	98.5%	97%	95%
Austria	2008q4	1994q4,2008q4	1994q4,1995q4,1999q3,2008q4
Belgium	2006q4,2008q3	2005q4,2006q4,2008q3	1997q4,2005q4,2006q4,2008q3
Czech Republic	1997q2,1997q4	1997q2,1997q4,2008q4	1994q1,1997q2,1997q4,2008q4
Denmark	1993q1,1993q3	1993q1,1993q3,2000q3	1993q1,1993q3,2000q3,2008q3
Finland	1992q3,1999q4	1992q3,1999q4,2008q3	1992q3,1999q4,2000q3,2008q3
France	1992q3,1993q3	1992q3,1993q3	1992q3,1993q3,2008q3
Germany	2008q3	1997q4,2008q3	1997q4,2000q4,2008q3
Greece	2008q4,2010q1	1993q1,2008q4,2010q1	1993q1,1998q3,2008q4,2010q1
Ireland	1992q3	1992q3	1992q3,2008q3,2009q1
Italy	1992q3,2008q4	1992q3,2000q2,2008q4	1992q3,1999q4,2000q2,2008q4
Netherlands	2008q3	2003q3,2008q3	2001q3,2003q3,2008q3,2009q3
Portugal	1992q3,1994q2	1992q3,1994q2,2008q3	1992q3,1994q2,2007q3,2008q3
Spain	1992q4,2008q3	1992q4,2007q3,2008q3	1992q4,1995q2,2007q3,2008q3
Sweden	2008q4	2008q4	2008q4,2009q3
United Kingdom	2008q3,2009q2	1993q3,2008q3,2009q2	1993q3,2007q3,2008q3,2009q2

Note: Each column reports the year and the quarter in which the Von Hagen and Ho (2007) index of money market pressure (IMP) meets two criteria: (i) it exceeds the 98.5 percentile, 97 percentile, and 95 percentile of the sample distribution of IMP for each advanced economy in the sample; and (ii) the increase in IMP from the previous period is by at least five percent (see text for explanation). Faded countries represent advance European economies identified as having experienced a banking crisis between 2007 and 2010.

A possible objection against this method might be that modern banking crises are asset-side rather liability-side crises. An example is that a banking crisis caused primarily by a collapse in real estates' prices (e.g. USA in 2007 or China in 2013) or a wave of corporate bankruptcies. But if the demand for reserves increases when the quality of bank assets deteriorates, such a dichotomy is irrelevant for the purposes of this study. A second objection is that this method is not applicable to environments where interest rates are controlled by the central bank.

tightening the second condition increases the risk of missing true crisis episodes. In the empirical work, using a 10% minimum increase would exclude some well-known crisis episodes in the data.

But the IMP has the advantage that its quality does not depend on the flexibility of interest rates as long as the central bank's interest rate management relies on market measures to control the interest rate. A third objection might be that using the IMP, one can identify the beginning but not the end of a banking crisis. This is true, but after studying the more relevant literature it seems that there is no consensus on what kind of criteria one should use to declare that a crisis is over. Such issue is recommended for further research.

Later on, in tables 2-3 bank profitability is examined and represented by the return on equity (ROE). It seems that this measurement was markedly affected by the 2007-2010 financial crisis for each grouping of banks. Further insight into the changes in the banks' profitability can be obtained from the equation expressing the ROE as the product of the equity multiplier[5](A/E) and the return on assets (ROA). The ROA can be decomposed using methodology of Koch and MacDonald (2007) as follows:

$$ROE = \frac{A}{E} ROA = \frac{A}{E}\left[\frac{NIM}{A} + \frac{NII}{A} - \frac{NIE}{A} + \frac{SG}{A} - \frac{PLL}{A} - \frac{TAX}{A}\right] \quad (2)$$

, where E is equity; A is total assets; NIM is the net interest margin[6]calculated as the difference between interest income (II) and interest expense (IE); NII is non–interest income; SG is security gains (or losses)[7]; NIE is non–interest expense; PLL is provisions for loan losses, and TAX is the taxes paid.

Table 2 shows the degree of banks' profitability - as measured by the ROE - in European economies that registered a financial crisis between 2007 and 2010.These banks only registered a negative ROE in 2009 (shown in faded color). The decline in these banks profitability is largely attributable to the decline in (NII+SG-TAX)/A stemming from losses on securities (a small percentage of the decline can also be attributed to NII because of the decline in off-balance sheet assets; it is presumed that taxes did not change appreciably over this period and the 0.4 percentage point increase in the loan loss provision ratio that are amplified by the sharp increase in the equity multiplier between 2007 and 2010.

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5 Like all debt management ratios, the equity multiplier is a way of examining how a bank uses debt to finance its assets. It is also known as the financial leverage ratio or leverage ratio.

6A bank's main operations involve interest expense on its depositors' savings accounts and interest revenues on its loans and bond investments.

7 A security gain/loss is an increase (or decrease) in the value of a security.

The equity multiplier for this group of banks increases substantially in 2009. Furthermore, the noninterest expense ratio declined by almost one percentage point between 2007 and 2010.

Table 2: Banking Indicators for European Economies that had a Banking Crisis in 2007-2010

	2007	2008	2009	2010
Equity-asset ratio				
Mean	14.2	13.5	11.2	10.9
Median	8.7	7.9	8.1	8.2
Std. Dev.	17.1	17.4	12.8	12.6
No. of Obs.	892	929	497	484
Total capital ratio				
Mean	18.1	14.8	14.9	14.8
Median	12.2	12.4	12.9	12.8
Std. Dev.	29.1	9.7	8.3	8.2
No. of Obs.	364	461	101	95
Tier 1 capital ratio				
Mean	15.7	12.4	12.4	12.4
Median	9.6	10.6	10.8	10.6
Std. Dev.	30.7	9.5	7.5	7.3
No. of Obs.	344	424	317	296
Return on average equity (ROE)				
Mean	9.8	3.4	-0.5	0.3
Median	8.2	4.4	4.1	3.9
Std. Dev.	17.5	28.3	24.1	23.8
No. of Obs.	911	937	492	488
Decomposition of bank profitability				
Equity multiplier (A/E)	7.2	7.4	8.5	8.1
Net interest margin (NIM/A)	3.2	2.6	3.1	2.9
Interest expense to total assets (IE/A)	3.3	2.6	1.7	1.5
Noninterest expenses (NIE/A)	5.2	5.1	4.0	3.8
Loan loss provisions (PLL/A)	0.4	0.5	0.9	0.7
Noninterest income plus securities gains, net of taxes $(NII + SG - TAX)/A$	4.1	3.4	2.1	1.8
Off-balance sheet items to total assets				
Mean	21.4	18.3	19.3	18.5
Median	6.5	5.1	9.1	8.8
Std. Dev.	61.6	55.3	36.8	32.3
No. of Obs.	701	744	426	389

Similar results are reported in table 3 for the banks in European countries that did not experience a financial crisis with the exception of the decline in ROE being larger for this group of banks (shown in faded color) due to their larger equity multiplier.

Table 3: Banking Indicators for European Economies that did not have a Banking Crisis in 2007-2010

	2007	2008	2009	2010
Equity-asset ratio				
Mean	8.7	7.6	7.3	7.1
Median	6.3	5.6	5.4	5.1
Std. Dev.	8.8	8.3	8.9	8.2
No. of Obs.	333	333	224	218
Total capital ratio				
Mean	13.9	13.5	14.1	13.8
Median	11.2	10.9	12.1	11.7
Std. Dev.	18.6	16.8	16.9	16.7
No. of Obs.	231	242	264	255
Tier 1 capital ratio				
Mean	11.1	10.9	11.5	11.1
Median	8.5	9.2	9.5	9.3
Std. Dev.	18.8	17.3	17.4	17.3
No. of Obs.	221	239	203	188
Return on average equity (ROE)				
Mean	8.9	2.7	-5.1	3.4
Median	8.6	4.5	1.3	1.1
Std. Dev.	18.6	30.5	38.4	37.8
No. of Obs.	351	351	256	222
Decomposition of bank profitability				
Equity multiplier (A/E)	11.1	12.1	12.8	12.1
Net interest margin (NIM /A)	2.3	2.3	2.0	1.9
Interest expense to total assets (IE/A)	2.1	2.2	1.0	1.0
Noninterest expenses (NIE /A)	2.2	2.2	2.6	2.5
Loan loss provisions (PLL/A)	0.1	0.2	0.6	0.3
Noninterest income plus securities gains, net of taxes (NII + SG - TAX)/A	1.4	1.3	1.3	1.3
Off-balance sheet items to total assets				
Mean	20.1	17.8	13.1	13.1
Median	8.3	6.2	2.6	2.2
Std. Dev.	38.1	32.2	31.4	31.2
No. of Obs.	337	337	227	211

In summary, the information derived from table 2 and table 3 suggests that the financial crisis had a significant negative impact on bank profitability including banks in countries that did not experience a crisis. The decline was directly associated mostly with capital losses on marketable securities. As a consequence banks experienced a significant deterioration in their equity-to-asset ratios.

4. Specification of Empirical Results

Following Greene (2012), Cosimano and Hakura (2011) and Chami and Cosimano (2010), the level of capital held by banks depends on the banks' anticipation of their optimal loans in the future. Capital is seen as a call option in which the strike price is the difference between the expected optimal loans and the amount of loans supported by the capital. The capital limits the amount of loans since a fraction of the total loans must be held as capital. If the optimal amount of loans during the next period exceeds this limit, then the bank would suffer a lost opportunity which is measured by the shadow price on the capital constraint (Greene, 2012). In this case the total capital has a positive option value and the bank will tend to hold more capital than required in order to gain flexibility to increase its supply of loans in the future. If on the other hand there is a low demand for loans in the future such that the shock to demand is below the critical level, the total capital serves no purpose resulting in zero payoffs.

Thereinafter, banks with more capital will have a higher strike price since their loan capacity is greater. As a result, an increase in capital leads to a decrease in the demand for future capital, *K'*. An increase in the marginal cost of loans leads an impending forecast of a higher marginal cost by the bank since such changes tend to persist into the future. Consequently, a bank anticipates a decrease in their optimal future loans and will in turn reduce their holding of capital at present. Similarly - as stated in Cosimano and Hakura (2011) - an increase in marginal revenue related to stronger economic activity will lead to an increase in optimal loans so that the optimal capital goes up.

In view of this and following Barajas et al. (2010), the relation for the banks' choice of capital is specified as:

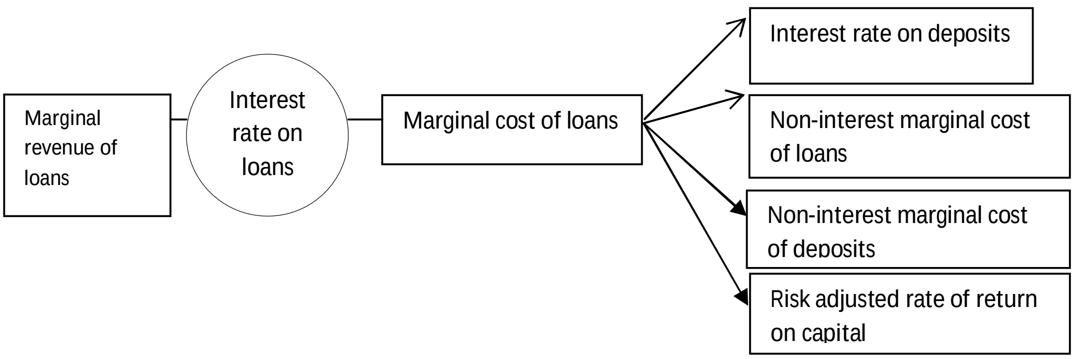
$$\frac{K'}{A} = \alpha_0 + \left(\alpha_1 + \alpha_2 \frac{K}{A}\right)\Delta\frac{K}{A} + \left(\alpha_3 + \alpha_4 \frac{K}{A}\right) r^D + \left(\alpha_5 + \alpha_6 \frac{K}{A}\right)(C_L + C_D) + \alpha_7 \log(A) + \varepsilon \qquad (3)$$

Here, K is total current capital, K' is future capital, A is total assets, r^D is the interest rate on deposits, C_L is the non-interest marginal factor cost of loans and C_D is the non- $\left(\alpha_1+\alpha_2\frac{K}{A}\right)<0$ interest marginal factor cost of deposits. Call options are generally decreasing and convex in the strike price (Kolb &Overdahl, 2010). As a result it is expected that such that $\alpha_1<0$, $\alpha_2>0$. Similarly, it is expected that $\alpha_3<0$, $\alpha_4>0$, $\alpha_5<0$ and

$\alpha_6>0$. Consequently, a decrease in past capital which lowers the strike price should lead to a significant increase in total current capital. This impact should be smaller when the bank has more initial capital consistent with the convex property of call options (Hull, 2012). In addition, a decrease in interest and non-interest expenses should lead to an increase in bank capital at a decreasing rate[8].

Banks are assumed to have some monopoly power so that they choose the interest rate on loans (r^L) such that the marginal revenue of loans equals to its marginal cost (Claessens&Laeven, 2004). The marginal cost consists of the interest rate on deposits $\frac{A-D}{A}r^K$ (r^D) and the non-interest marginal cost of loans and deposits respectively $C_L$and C_D. The marginal cost of loans also depends on the risk adjusted rate of return on capital (RAROC) (see figure 3).

Figure 3: Relationship of Marginal Revenue and Cost of Loans



Thus, following Cosimano and Hakura (2011) total marginal cost (MC) is given by

8 This convex property predicted by the call option view of bank capital distinguishes this model from the partial adjustment model of bank capital estimated by Flannery and Rangan (2008), Berrospide and Edge (2010), Francis and Osborne (2009).

$$MC = \frac{D}{A}\left(r^D + C_D\right) + C_L + \frac{A-D}{A} r^K \qquad (4)$$

Here r^K is the return on equity (ROE), A is total assets and D is deposits so that bank capital is $K' = A - D$. As a result the marginal cost raises with an increase in bank capital only if $r^K > (r^D + C_D)$. Moreover the marginal revenue of loans depends on economic activity M as it impacts the demand for loans. Following Fase (1995) the optimal loan rate is given by:

$$r^L = b_0 + b_1 r^D + b_2 \left(C_L + C_D\right) + b_3 \frac{K'}{A} + b_4 \log(A) + b_5 M + \varepsilon_1 \qquad (5)$$

An increase in the deposit rate, the non-interest cost of deposits and the provision for loan losses would lead to an increase in the loan rate since the marginal cost of loans would increase. The marginal cost also increases with an increase in RAROC. This effect is measured by the optimal capital asset ratio $\frac{K'}{A}$

as given in Equation 5 above. An increase in the demand for loans would raise both marginal revenue and the loan rate. This effect is captured by the level of economic activity (M) as measured by real GDP and the inflation rate. Finally, ε_1 denotes the estimation error.

With monopoly power the demand for loans (L) depends on the optimal loan rate of the bank as determined in (5) above and the level of economic activity (M). As a result the demand for loans (L) can be modeled as:

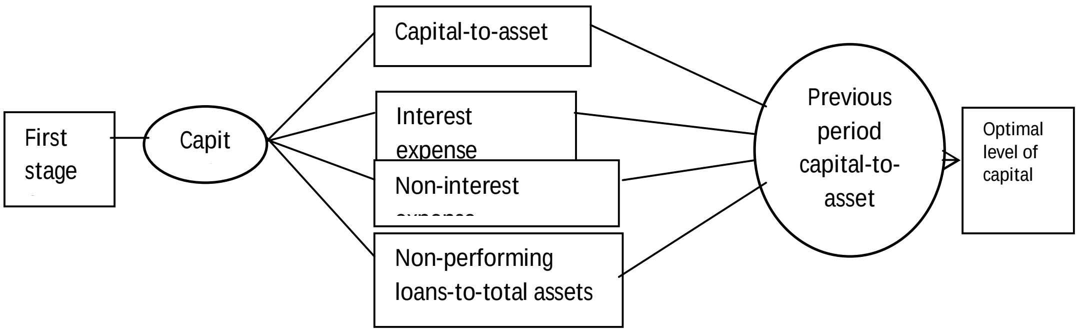
$$L = c_0 - c_1 r^L + c_2 M + \varepsilon_2 \qquad (6)$$

, where c_i, (i=0,1,2) are parameters to be estimated. It is expected that an increase in the loan rate would reduce the demand for loans and hence loans issued by the bank. On the other hand an increase in economic activity is expected to raise the demand for loans. Note that c_1 and c_2 capture the long-run responses of loans to changes in loan rates and the level of economic activity.

Hull (2012) argues that banks simultaneously choose the optimal amount of capital to hold, the loan rate, and the quantity of loans. Because of this simultaneity a GMM estimation procedure is properly used.

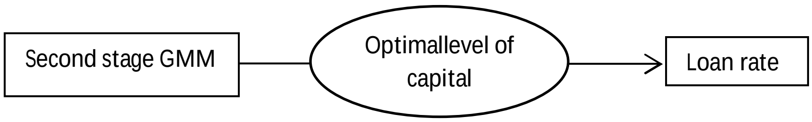
In the first stage (figure 4) the capital regression is estimated to determine the bank's optimal (or projected) level of capital (equation 3). The change in the capital-to-asset ratio, the interest expense ratio, the non-interest expense ratio and the non-performing loans-to-total assets ratio as well as the interaction of each of these variables with the previous period capital-to-asset ratio are assumed to be instruments for the optimal capital ratio.

Figure 4: First stage in the Generalized Method of Moment procedure



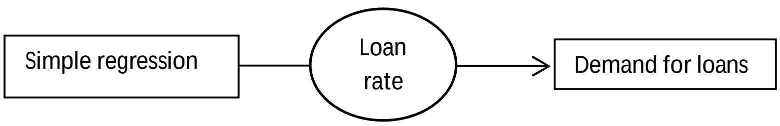
The predicted demand for capital is then used in the second-stage regression (equation 5) for the bank's loan rate (figure 5).

Figure 5: Second stage in the Generalized Method of Moment Procedure



The GMM estimations are conducted following Greene (2012) and Zeileis (2004) using the Bartlett kernel function (analyzed in the following section) thereby yielding heteroskedasticity - autocorrelation-consistent (HAC) standard errors (using Matlab R2011b software). Lastly the regression for the demand for loans (equation 6) is estimated using the loan rates predicted by the GMM estimations as an explanatory variable (figure 6).

Figure 6: Regression for the Demand for Loans



The estimations for the two grouping of banks are conducted using data for the 2003 to 2010 period[9]. The estimations are conducted on a country-by-country basis. The number of banks included in every assessment depends on the degree of concentration of the banking system in each country and the availability/accessibility of the data in the Bankscope database.

5. Heteroskedasticity and Autocorrelation Consistent (HAC) Standard Errors

Following Laszlo (1999) the following equation shows how the asymptotic covariance matrix of the GMM estimator could be derived in the presence of conditional heteroskedasticity[10]:

$$\hat{S} = \frac{1}{n}\sum_{i=1}^{n}\hat{u}_i^2 Z_i' Z_i = \frac{1}{n}\left(Z'\hat{\Omega}Z\right) \qquad (7)$$

where $\hat{\Omega}$ is the diagonal matrix of squared residuals $\hat{u}_i^2$ from $\tilde{\beta}$, the consistent but not necessarily efficient first-step GMM estimator. The resulting estimate $\hat{S}$ can be used to conduct consistent inference for the first-step estimator or it can be used to obtain and conduct inference for the efficient GMM estimator.

The estimator is now further extended to handle the case of non-independent errors in a time series context. The notation is correspondingly changed so that $E(g_t g_s') \neq 0, t \neq s$ observations are indexed by *t* and *s* rather than *i*. In the presence of serial correlation . In order to derive consistent estimates of S, $\Gamma_j = E(g_t g_{t-j}')$ is defined as the auto-covariance matrix for lag *j*. The long-run covariance matrix can be then written

$$S = AVar(\bar{g}) = \Gamma_0 + \sum_{j=1}^{\infty}\left(\Gamma_j + \Gamma_j'\right) \qquad (8)$$

, which may be seen as a generalization of equation (7) with $\Gamma_0 = E(g_i g_i')$ and $\Gamma_j = E(g_t g_{t-j}')$, $j = \pm 1, \pm 2, \ldots$

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[9] The regressions are estimated including year dummies.
[10] See Appendix for the proof of it.

is defined as the product of Z_t and u_t, the auto-covariance matrices may be expressed as

$\Gamma_j = \mathrm{E}(u_t u_{t-j} Z_t' Z_{t-j})$. u_t $\hat{\Gamma}_j$ and u_{t-j} are then replaced by consistent residuals from first-stage estimation to compute the sample auto-covariance matrices defined as

$$\hat{\Gamma}_j = \frac{1}{n}\sum_{t=1}^{n-j} \hat{g}_t \hat{g}_{t-j} = \frac{1}{n}\sum_{t=1}^{n-j} Z_t' \hat{u}_t \hat{u}_{t-j} Z_{t-j} \qquad (9)$$

There is no existence of an infinite number of sample autocovariances to insert into the infinite sum in equation (8). Furthermore, it is not possible to simply insert all the autocovariances from 1 through *n* because this would imply that the number of sample orthogonality conditions $\hat{g}_i$ is going off to infinity with the sample size which precludes obtaining a consistent estimate of *S*. The autocovariances must converge to zero asymptotically as *n* increases. One way to handle this in would be for the summation to be truncated at a specified lag *q*. Thus the *S* matrix can be estimated by

$$\hat{S} = \hat{\Gamma}_0 + \sum_{j=1}^{q} k\left(\frac{j}{q_n}\right)\left(\hat{\Gamma}_j + \hat{\Gamma}_j'\right) \qquad (10)$$

, where u_t and u_{t-j} are replaced by consistent estimates from first-stage estimation. The kernel function,
$k\frac{j}{q_n}$ applies appropriate weights to the terms of the summation with q_n defined as the bandwidth of the kernel possibly as a function of *n* (Hayashi, 2000). In many kernels consistency is obtained by having the weight $\hat{s}$ fall to zero after a certain number $\left[1 - {j}/{q_n}\right]$ of lags. One important and frequently used approach to this problem is that of Newey and West (1987) which generates using the Bartlett kernel function and a user-specified value of *q*. For the Bartlett kernel
$k(\cdot) =$

if $j \le q_n - 1$, 0 otherwise. These estimates are said to be HAC as they incorporate equation7 in computing.

The Newey–West (Bartlett kernel function) specification is only one of many feasible HAC estimators of the covariance matrix. Andrews (1991) shows that in the class of positive semi-definite kernels the rate of convergence of $\hat{S} \to S$ depends on the choice of kernel and bandwidth. The Bartlett kernel's performance is improved by those in a subset of this class including the Quadratic Spectral (QS) kernel. Most (but not all) of these kernels guarantee that the estimated $\hat{S}$ is positive, definite and therefore always invertible (Hall, 2005).

Under conditional homoskedasticity the expression for the autocovariance matrix simplifies:

$$\Gamma_j = \mathrm{E}\left(u_t u_{t-j} Z_t' Z_{t-j}\right) = \mathrm{E}\left(u_t u_{t-j}\right)\mathrm{E}\left(Z_t' Z_{t-j}\right) \qquad (11)$$

and the calculations of the corresponding kernel estimators also simplify (Hayashi, 2000). These estimators may perform better than their heteroskedastic/robust counterparts in finite samples.

6. Cross-Country Estimation Results

6.1Impact of Basel III on Banking Performance

Table 4 reports the results of estimating equation (3) as the first stage in the GMM procedure on a country by country basis for the two groupings of banks. Due to the availability of data for countries that experienced a financial crisis between 2007 and 2010, results are reported for Germany, the United Kingdom, Greece and Sweden. On the other hand, France, Netherlands and Austria were excluded because of insufficient data. For the second grouping of banks in countries which did not experience a crisis, results are reported for Czech Republic, Denmark and Ireland. Even though the change in the equity-to-asset ratio has the predicted sign a_1<0 for the U. K., Greece, Denmark and Ireland, it is statistically significant for only two countries (the U.K. and Denmark). The estimated coefficients on this variable for the other countries have the wrong sign and are statistically insignificant except for Sweden.

The interaction term $a_2>0$ has the correct sign for the U.K., Greece, Denmark, and Ireland; however only the U.K., Denmark and Ireland are statistically significant. The other countries have the wrong sign with Germany and Sweden being statistically significant. The results for the interest expense-to-asset ratio are more consistent with the theory. All the countries that experienced a crisis have the correct signs $a_3<0$ and $a_4>0$ which are all statistically significant except Greece. Among the counties that did not experience a crisis, Denmark, Czech Republic, and Ireland had correctly signed and significant coefficients.

Furthermore, the non-interest expense ratio has statistically significant and correct signs $a_5<0$ and $a_6>0$ for the U.K., Greece, Sweden, and Denmark. Non-performing loans have significant and correct signs for none of the countries. The logarithm of total assets is only significant at the one percent level for the U.K. The coefficient on the logarithm of assets is negative for most of the countries implying that larger banks have smaller equity-to-asset ratios. Overall, the results are consistent with equation (3).

The estimates for equation (5) for the two country groupings are provided in Table 5. Equity and interest expense ratios have the predicted signs and are statistically significant at the five percent level. The non-interest expense-to-asset ratio has the correct positive effect on the loan income of the banks for all countries. They are statistically significant except for Denmark and Ireland. The results for non-performing loans-to-assets are insignificant for most of the countries.

Furthermore, table 6 reports the results of estimating the long run loan demand equation (6) for the country-by-country estimations. For most of the countries the loan rate has the expected negative impact on the loans issued by the bank. Given the mean predicted loan rate and loans for the banks in each respective country, the elasticity of loan demand with respect to the predicted loan rate in table 7 is estimated to range from 1.00 percent in Ireland to 6.59 percent in Denmark. Consequently, the banks across most of these countries operate at loan levels associated with positive marginal revenue.

Table 7: Impact of a 1.3 Percentage Point Increase in the Equity-Asset Ratio on Loans Based on Regressions for 2003–2010

	Impact on loan rate *	Net Cost of Raising Equity **	Elasticity of Loan Demand ***	Percentage change in loans ****
Crisis countries				
Germany	0.13	0.11	-1.79	-7.11
Sweden	0.04	0.01	-5.88	-3.64
U.K.	0.06	0.04	-2.46	-4.16
Average	0.13	0.16	-3.37	-4.97
Other countries				
Denmark	0.23	0.17	-6.59	-31.11
Ireland	0.21	0.20	-1.00	-6.23
Average	0.22	0.18	-3.79	-18.67

Source: Authors calculations

* Based on estimates reported in table 5.

** Impact on loan rate times the change in asset-to-equity ratio (equity multiplier).

***The elasticity of loan demand for each country banks is calculated by multiplying the estimated coefficient for the loan rate reported in table 6 by the average loan rate divided by average level of loans in the sample.

**** This is calculated as the product of the percentage increase in the loan rate times the elasticity of loan demand with respect to changes in the loan rate.

Table 8 summarizes the results when the estimations are conducted excluding the crisis period from the data. The average impact of the equity-to-asset ratio on the loan rate is slightly smaller when the crisis period is excluded for all countries. The elasticity of loan demand is on average lower in crisis countries and higher for non-crisis countries when the crisis period is excluded. This result might imply that the banks' customers in crisis (non crisis) countries had a bigger (smaller) change in their demand for loans during the financial crisis.

Table 8: Impact of a 1.3 Percentage Point Increase in the Equity-Asset Ratio on Loans Based on Regressions for 2003–2007

	Impact on loan rate	Net Cost of Raising Equity *	Elasticity of Loan Demand **	Percentage change in loans ***
Crisis countries				
Germany	0.11	0.09	-2.09	-7.63
U.K.	0.02	0.02	-2.14	-2.16
Average	0.06	0.05	-2.11	-4.89
Other countries				
Denmark	0.19	0.13	-9.66	-39.23

Source: Authors calculations
* Impact on loan rate times the change in asset-to-equity ratio (equity multiplier).
** The elasticity of loan demand for each country banks is calculated by multiplying the estimated coefficient for the impact of the predicted loan rate from the second-stage GMM regression on loan demand by the average loan rate divided by average level of loans in the sample.
*** This is calculated as the product of the percentage increase in the loan rate times the elasticity of loan demand with respect to changes in the loan rate.

6.2 Comparing the Results with those of Other Studies

To phase in the new regulations in a manner that is compatible with the global economic recovery, the Bank of International Settlements (BIS) and the Financial Stability Board (FSB) undertook studies to assess the macroeconomic effects of the transition to higher capital and liquidity requirements (Sinha, 2012). In February 2010, a Macroeconomic Assessment Group (MAG) was set up by the BCBS (Basel Committee on Banking Supervision) and FSB which submitted an interim report in August 2010 (BIS, 2010a) and a final report in December 2010 (BIS, 2010c). The MAG's quantitative analysis was complemented by consultations with academics and experts in the private sector as well as with the IMF. The MAG applied common methodologies based on a set of scenarios[11]for shifts in capital and liquidity requirements over different transition periods.

[11] These scenarios served as inputs into a broad range of models (semi-structural large-scale models, reduced-form models and bank augmented DSGE models) developed for policy analysis in central banks and international organizations.

The MAG analysis proceeds on the basis that since it is more expensive for banks to fund assets with capital than with deposits or wholesale debt, banks facing stronger capital requirements will seek to use a combination of increasing retained earnings and issuing equity as well as reducing Risk Weighted Assets(RWAs)[12], (Cornford, 2010). The approach will depend at least partially on the length of time over which capital needs to be increased. If the time span is shorter, banks are likely to emphasise equity issuance, shift in asset composition and reduced lending. In a longer implementation schedule banks will have more flexibility with regard to mechanisms and they may place more reliance on raising additional capital primarily through retained earnings which will substantially mitigate the impact on credit supply and eventually on aggregate activity. Based on evidence from past episodes the MAG analysis assumes that banks will initially increase lending margins and reduce the quantity of new lending. Any increase in the cost and decline in the supply of bank loans could have a transitory impact on growth especially in sectors that rely heavily on bank credit. In the longer term, however, as banks become less risky both the cost and quantity of credit should recover, reversing the impact on consumption and investment.

Based on the above intuition the MAG analysis was largely formulated on a two-step approach. The first step involves estimating the effect of higher capital targets on lending spreads and lending volumes using statistical relationships and accounting identities to predict how banks will adjust. The second step takes these forecast paths for lending spreads and volumes as inputs into standard macroeconomic forecasting models in use at central banks and regulatory agencies. These models are then used to estimate the effects of changes to lending spreads and bank lending standards on consumption, investment and other macroeconomic variables.

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[12] In terms of the minimum amount of capital that is required within banks, based on a percentage of the assets, weighted by risk. The idea of risk-weighted assets is a move away from having a static requirement for capital. Instead, it is based on the riskiness of a bank's assets. For example, loans that are secured by a letter of credit would be weighted riskier than a mortgage loan that is secured with collateral.

In particular the 2009 Tier 1 ratio for Group 1 banks in the BIS study is 10.5 percent. It is interesting to note that this study's 5.1 ROE is identical to the net equity-to-risk weighted asset (CET1) ratio[13] for their Group 1 banks (banks that have over three billion Euros of Tier 1 capital) while it is 11.1 percent before the changes in regulation (i.e. for the gross common equity tier 1 ratio) in the BIS study. This result suggests that the new equity to risk-weighted asset ratio is close to a pure equity-to-asset ratio. The BIS estimates that under Basel III the equity to risk-weighted asset (CET1) ratio would fall to 5.7 percent from 11.1 percent for the gross CET1 ratio (pre-Basel III ratio) for Group 1 banks. Following Cosimano and Hakura (2011) it would be assumed that most of this decline is associated with tighter standards on bank equity with the removal of goodwill being the most important one. The rest of the decline arises from stricter rules on RWAs. The biggest contributors to this increase are adjustments for counterparty risk and the application of the capital definition.

Table 7 reports calculations assuming capital shortfall of 1.3 percentage points under Basel III for the cross-country results. For the crisis countries a 1.3 percentage point increase in equity-asset ratio is estimated to have a more substantial impact on loans (5.07%). The impact of Basel III is largest in the non-crisis Denmark since it is estimated to have both a relatively high elasticity of loan demand with respect to changes in the loan rate and a high net cost of raising equity.

If the crisis period is excluded from the estimation period (table 8) then the impact of Basel III in the crisis countries is slightly smaller following the lower elasticity of demand across these countries. On the other hand, the average elasticity of loan demand is larger for the non-crisis countries which dominate the decline in the cost of equity under the shorter time period.

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13 In addition to meeting the Basel III requirements, global systemically important financial institutions (SIFIs) must have higher loss absorbency capacity to reflect the greater risks that they pose to the financial system. The Committee has developed a methodology that includes both quantitative indicators and qualitative elements to identify global SIFIs. The additional loss absorbency requirements are to be met with a progressive CET1 capital requirement ranging from 1% to 2.5%, depending on a bank's systemic importance. A consultative document was submitted to the Financial Stability Board, which is coordinating the overall set of measures to reduce the moral hazard posed by global SIFIs.

The results for the loan rates reported in column 1 in table 7 are broadly consistent with the findings from BIS (2010c) for the loan rate which showed that the mean lending rate (weighted by GDP) would increase (across 53 models) by 16.7 basis points over eight years and 15 basis points respectively. However the magnitude is significantly above the upper bound of 6 basis points calibrated in Kashyap et al. (2010).

7. Conclusions

Basel III was developed in response to the deficiencies in financial regulation revealed by the late2000s financial crisis and the flaws spotted in Basel II as discussed in this paper. It is a global regulatory standard on bank capital adequacy, stress testing and market liquidity risk agreed upon by the members of the Basel Committee on Banking Supervision in 2010-2011. This innovative framework strengthens bank capital requirements and introduces new regulatory requirements on bank liquidity and bank leverage. The change in the calculation of loan risk in Basel II for instance which some consider a causal factor in the credit bubble prior to the 2007-2008 collapse (in Basel II one of the principal factors of financial risk management was out-sourced to companies that were not subject to supervision i.e. credit rating agencies). Ratings of creditworthiness and bonds, financial bundles and various other financial instruments were conducted by official agencies without supervision thus leading to AAA ratings on mortgage-backed securities, credit default swaps, and other instruments that proved in practice to be extremely bad credit risks. In Basel III a more formal scenario analysis is applied.

This paper aims to broaden and deepen the understanding of the likely impact of the new capital requirements introduced under the Basel III framework on bank lending rates and volume of lending. The contribution of this paper is threefold concerning the understanding and testing of the impact of the new regulations on the banks. Firstly, the paper derives empirically testable relations from a structural model of the capital channel of monetary policy developed by Chami and Cosimano (2010). In doing so it follows Barajas et al. (2010) analysis of large bank holding companies in the United States. In this model loan demand shocks are transmitted to the credit supply via the regulatory capital constraint. In particular, a bank's decision to hold capital is modeled as a call option on the optimal future loans issued by the bank. This option value of the bank's capital increases when the expected level of loans and the amount of capital required by the regulator increase.

The bank's choice of capital influences its loan rate since the marginal cost of loans is a weighted average of the marginal cost of deposits and equity. Consequently the loan rate increases with an increase in required capital as long as the marginal cost of equity exceeds the marginal cost of deposits.

On this basis, the paper's results suggest that banks' responses will vary considerably from one European economy to another reflecting cross-country variations in the tightness of capital constraints, banks' net cost of raising equity, and elasticities of loan demand with respect to changes in loan rates. The country-by-country estimations which include both large and small banks for which data is available in each country suggest that the net cost of raising equity by 1.3 percentage points ranges from 1 basis point in Sweden to 20 basis points in Ireland. Similarly the estimated elasticities of loan demand range from 1.0 percent in Ireland to 6.59 percent in Denmark. As a result the average impact of a 1.3 percentage point increase in the equity-asset ratio on loan growth for the crisis countries is 5.07 percent. This impact is significantly higher in the non-crisis countries such as Ireland and Denmark. The potential for a substantial impact of capital requirements makes it even more important for policy makers in these countries to identify exactly why the elasticity of loan demand or cost of equity is so high in these economies.

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Table 4: GMM First-Stage Regressions for Holdings of Capital

	Dependent Variable: Equity-to-Asset Ratio						
	Countries which experienced a banking crisis in 2007-2010				Other countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Germany	U.K.	Greece	Sweden	Czech Republic	Denmark	Ireland
Change in equity-to-asset ratio (lagged)	0.843*	-0.726***	-0.0873	1.055**	0.0161	-1.204***	-0.822
	(0.447)	(0.154)	(0.121)	(0.416)	(0.226)	(0.408)	(0.811)
Change in equity-to-asset ratio (lagged)*initial equity-to-asset ratio	-0.203***	0.0279*	0.00641	-0.122***	-0.0300	0.0878**	0.137
	(0.063)	(0.011)	(0.012)	(0.013)	(0.031)	(0.033)	(0.085)
Interest expense ratio	-1.022***	-1.677***	-0.813	-0.574	-2.315***	-2.310***	-1.025*
	(0.335)	(0.221)	(0.529)	(0.419)	(0.563)	(0.444)	(0.513)
Interest expense ratio*initial equity-to-asset ratio	0.213***	0.184***	0.175	0.0880*	0.275***	0.239***	0.271***
	(0.042)	(0.011)	(0.074)	(0.042)	(0.043)	(0.047)	(0.046)
Non interest expense ratio	-0.333	-1.052**	-2.067*	-2.261***	-0.165	-1.368***	0.159
	(0.634)	(0.399)	(1.142)	(0.366)	(0.514)	(0.149)	(0.472)
Noninterest expense ratio*initial equity-to-asset ratio	0.0877	0.0755**	0.120	0.388***	0.0162	0.112***	-0.032
	(0.126)	(0.028)	(0.086)	(0.062)	(0.038)	(0.018)	(0.068)
Ratio of nonperforming loans to assets	0.000478	-0.000652	0.00321	0.00124	-0.00173	-0.000274	-0.000466
	(0.001)	(0.001)	(0.002)	(0.005)	(0.001)	(0.001)	(0.001)
Nonperforming loans ratio*initial equity-to-asset ratio	-0.0000962	0.000106	-0.000173	0.000412	0.000663***	-0.000000805	0.00155
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Logarithm of assets	-0.0621	-0.523***	0.00799	-0.1701	0.0833	-0.232**	-0.0574
	(0.152)	(0.115)	(0.408)	(0.227)	(0.143)	(0.108)	(0.268)
Constant	5.653*	14.54***	9.269	8.005*	7.674***	10.366***	3.522
	(2.635)	(2.216)	(5.832)	(3.37)	(2.038)	(1.415)	(4.632)
Observations	41	176	30	21	52	83	19
R-squared	0.933	0.811	0.705	0.967	0.935	0.911	0.863
Adjusted R-squared	0.8225	0.8163	0.6224	0.9331	0.9281	0.9271	0.7281

Note: The table shows the first stage GMM regression for the equity-asset ratio. Heteroskedasticity- and autocorrelation-consistent standard errors are shown in parentheses; significances of 1 (***), 5(**), and 10 (*) percent are indicated.

Table 5: GMM Second-Stage Regressions for Loan Rate

	Dependent Variable: Loan Rate						
	Countries which experienced a banking crisis in 2007-2010 Other countries						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Germany	U.K.	Greece	Sweden	Switzerland	Czech Republic	Denmark
Equity-asset ratio	0.104***	0.0616***	0.0766**	0.0188***	0.00832**	0.117***	0.184***
	(0.0078)	(0.0111)	(0.0371)	(0.00721)	(0.00374)	(0.0321)	(0.0546)
Interest expense ratio	1.263***	1.167***	0.824***	0.822***	0.922***	0.736***	0.516***
	(0.0475)	(0.118)	(0.0629)	(0.0317)	(0.0421)	(0.126)	(0.135)
Noninterest expense ratio	0.515***	0.318***	0.216*	0.174***	0.00425	0.584***	0.0438
	(0.0841)	(0.0810)	(0.127)	(0.0511)	(0.0146)	(0.175)	(0.147)
Ratio of nonperforming loans to assets	0.000241	-0.0000853	0.000132	0.000845	0.000373**	0.000183	0.00128**
	(0.000213)	(0.0000633)	(0.000404)	(0.000711)	(0.000141)	(0.000713)	(0.000663)
Logarithm of assets	0.0174	0.0278	0.324***	-0.184***	-0.0415	0.216*	-0.0482
	(0.0236)	(0.0377)	(0.0710)	(0.0179)	(0.0285)	(0.113)	(0.0738)
year1	-0.0299	-0.0128	0.674***	0.315***	0.102	-0.0600	-0.473**
	(0.0913)	(0.472)	(0.227)	(0.0722)	(0.151)	(0.185)	(0.218)
year2	-0.0922	-0.128	0.488***	0.311***	0.188	0.158	-0.163
	(0.0917)	(0.513)	(0.0865)	(0.0751)	(0.154)	(0.185)	(0.271)
year3	0.0194	-0.223	0.411***	0.612***	0.139	0.361	0.214
	(0.0715)	(0.521)	(0.146)	(0.077)	(0.147)	(0.236)	(0.288)
year4	0.133	0.0720	0.401***	0.604***	0.0414	0.0953	-0.576**
	(0.0887)	(0.377)	(0.137)	(0.068)	(0.141)	(0.327)	(0.247)
year5	0.147*	0.0163	0.411***	0.601***	0.0861	-0.253	-0.426*
	(0.0933)	(0.351)	(0.133)	(0.054)	(0.159)	(0.164)	(0.235)
year6	0.0375	-0.0305	0.338***	0.582***	0.131	-0.0814	-0.259**
	(0.0775)	(0.232)	(0.139)	(0.071)	(0.176)	(0.139)	(0.138)
year7	0.0422	-0.0311	0.322***	0.523***	0.106	-0.0835	-0.237**
	(0.0737)	(0.283)	0.491***	0.691***	(0.177)	(0.141)	(0.108)
Observations	31	162	24	17	267	37	75
R-squared	0.923	0.732	0.844	0.963	0.639	0.723	0.552
Adjusted R-squared	0.9526	0.7855	0.8622	0.9517	0.6377	0.7150	0.5013

Note: The table shows the second stage GMM regression for the loan rate. Heteroskedasticity- and autocorrelation-consistent standard errors are shown in parentheses; significances of 1 (***), 5(**), and 10 (*) percent are indicated.

Table 6: Loan Demand Equations

Dependent Variable: Loans	Countries which experienced a banking crisis in 2007-2010					Other countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Germany	U.K.	Greece	Sweden	Switzerland	Czech Republic	Denmark	Ireland
Real GDP	0.00136	0.0088**	-0.0313	0.00813***	-0.00578	-0.0000663	0.000389	0.0188
	(0.00510)	(0.00413)	(0.0188)	(0.00211)	(0.00488)	(0.000118)	(0.00222)	(0.0181)
CPI	-0.0677	0.00713	0.0267	0.0411	0.0585	0.00515	0.0217	0.103
	(0.0868)	(0.0315)	(0.0190)	(0.0427)	(0.0615)	(0.00511)	(0.0236)	(0.126)
Predicted loan rate	-0.582**	-0.405***	0.158***	-0.688***	0.0862*	0.00917	-0.328***	-0.193*
	(0.216)	(0.101)	(0.0274)	(0.217)	(0.0417)	(0.00913)	(0.113)	(0.111)
Constant	7.716	-11.63***	1.672	-27.63**	-3.183	-0.336	-1.274	-13.61
	(7.442)	(3.271)	(2.005)	(9.520)	(4.770)	(0.243)	(1.672)	(11.63)
Observations	37	175	29	24	373	51	84	21
R-squared	0.173	0.147	0.274	0.444	0.017	0.084	0.227	0.104

Note: Robust standard errors are shown in parentheses, and significances of 1 (***), 5 (**), and 10 (*) percent are indicated.

Appendix

The Generalized Method of Moments was introduced by Hansen, (1982). The equation to be estimated is, in matrix notation, $y = X\beta + u$ with typical row $y_i = X_i\beta + u_i$. The matrix of regressors X is $n \times K$, where n is the number of observations. Some of the regressors are endogenous, so that $\mathrm{E}(X_i u_i) \neq 0$. The set of regressors are being partitionedinto [X_1 X_2], with the K_1 regressors X_1 assumed under the null to be endogenous and the $K_2 \equiv (K - K_1)$ remaining regressors X_2 assumed exogenous, giving $y_i = [X_1 X_2][\beta_1' \beta_2']' + u$.

The set of instrumental variables is Z and is $n \times L$. This is the full set of variables that are assumed to be exogenous, i.e. $\mathrm{E}(Z_i u_i) = 0$. The instruments are partitioned into [Z_1 Z_2], where the L_1 instruments Z_1 are excluded instruments and the remaining $L_2 \equiv (L - L_1)$ instruments $Z_2 \equiv X_2$ are the included instruments/exogenous regressors (Baum, 2006):

Regressors $X = [X_1\ X_2] = [X_1\ Z_2]$ = [Endogenous Exogenous]

Instruments $Z = [Z_1\ Z_2]$ = [Excluded Included]

The order condition for identification of the equation is $L \geq K$ implying there must be at least as many excluded instruments (L_1) as there are endogenous regressors (K_1) as Z_2 is common to both lists. If $L = K$, the equation is exactly identified by the order condition; if L > K, the equation is over-identified. The order condition is necessary but not sufficient for identification.

The assumption that the instruments Z are exogenous can be expressed as $E(Z_i u_i) = 0$. In the case of linear GMM the L instruments give a set of L moments: $g_i(\beta) = Z_i' u_i = Z_i'(y_i - X_i\beta)$, where g_i is $L \times 1$. The exogeneity of the instruments means that there are L moment conditions, or orthogonality conditions, that will be satisfied at the true value of β: $\mathrm{E}(g_i(\beta)) = 0$. Each of the L moment equations corresponds to a sample moment. For some given estimator $\hat{\beta}$, these L sample moments could be written as $\bar{g}(\hat{\beta}) = \frac{1}{n}\sum_{i=1}^{n} g_i(\hat{\beta}) = \frac{1}{n}\sum_{i=1}^{n} Z_i'(y_i - X_i\hat{\beta}) = \frac{1}{n} Z'\hat{u}$.

The intuition behind GMM is to choose an estimator for β that brings $\bar{g}(\hat{\beta})$ as close to zero as possible. If the equation to be estimated is exactly identified, so that $L = K$, then there are as many equations (the L moment conditions) as unknowns: the K coefficients in $\hat{\beta}$. In this case it is possible to find a $\hat{\beta}$ that solves $\bar{g}(\hat{\beta}) = 0$.

If the equation is over-identified, however, so that $L > K$, then there are more equations than unknowns. In general it will not be possible to find a $\hat{\beta}$ that will set all L sample moment conditions exactly to zero. In this case, an $L \times L$ weighting matrix W is used in order to construct a quadratic form in the moment conditions. This gives the GMM objective function: $J(\hat{\beta}) = n\bar{g}(\hat{\beta})' W \bar{g}(\hat{\beta})$. A GMM estimator for β is the $\hat{\beta}$ that minimizes $J(\hat{\beta})$:

$$\hat{\beta}_{\text{GMM}} \equiv \arg\min_{\hat{\beta}} J(\hat{\beta}) = n\bar{g}(\hat{\beta})' W \bar{g}(\hat{\beta}).$$

In the linear case, deriving and solving the K first order conditions $\frac{\partial J(\hat{\beta})}{\partial \hat{\beta}} = 0$ (treating W as a matrix of constants) yields the GMM estimator (The results of the minimization, and hence the GMM estimator, will be the same for weighting matrices that differ by a constant of proportionality).

$$\hat{\beta}_{\mathrm{GMM}} = \left(X'ZWZ'X\right)^{-1} X'ZWZ'y \qquad \text{(a)}$$

The GMM estimator is consistent for any symmetric positive definite weighting matrix *W*, and thus there are as many GMM estimators as there are choices of weighting matrix *W*. Efficiency is not guaranteed for an arbitrary *W*, so the estimator defined in Equation (a) is referred as the possibly inefficient GMM estimator.

The authors are particularly interested in efficient GMM estimators, namely GMM estimators with minimum asymptotic variance. Moreover, for any GMM estimator to be useful, inference should be conducted and for that,estimates of the variance of the estimator are needed. Both require estimates of the covariance matrix of orthogonality conditions, a key concept in GMM estimation.

Denoting by S the asymptotic covariance matrix of the moment conditions g: $S = AVar(\bar{g}(\beta)) = \lim_{n\to\infty} \frac{1}{n} \mathrm{E}(Z'uu'Z)$ where S is an L×L matrix and $\bar{g}(\beta) = \frac{1}{n} Z'u$. That is, S is the variance of the limiting distribution of $\sqrt{n}\bar{g}$. The asymptotic distribution of the possibly inefficient GMMestimator can be writtenas follows. Let $Q_{XZ} \equiv \mathrm{E}(X_i'Z_i)$. The asymptotic variance of the inefficient GMMestimator defined by an arbitrary weighting matrix W is given by:

$$\mathrm{V}\hat{\beta}_{\mathrm{GMM}} = \left(Q_{XZ}'WQ_{XZ}\right)^{-1}\left(Q_{XZ}'WSWQ_{XZ}\right)^{-1}\left(Q_{XZ}'WQ_{XZ}\right)^{-1} \qquad \text{(b)}$$

Under standard assumptions the inefficient GMM estimator is “$\sqrt{n}$ consistent”. That is, $\sqrt{n}\left(\hat{\beta}_{\mathrm{GMM}} - \beta\right) \rightarrow N\left[0, \mathrm{V}(\hat{\beta}_{\mathrm{GMM}})\right]$, where $\rightarrow$ denotes convergence in distribution.Strictly speaking, therefore, hypothesis tests should be performed on GMM, usingequation (b) for the variance-covariance matrix. Standard practice, however, is totransform the variance-covariance matrix (b) rather than the coefficient vector (a). This is done by normalizing $\mathrm{V}\hat{\beta}_{\mathrm{GMM}}$ by 1/n, so that the variance-covariance matrixis in fact

$$\mathrm{V}\left(\tfrac{1}{\sqrt{n}}\hat{\beta}_{\mathrm{GMM}}\right) = \tfrac{1}{n}\left(Q_{XZ}'WQ_{XZ}\right)^{-1}\left(Q_{XZ}'WSWQ_{XZ}\right)\left(Q_{XZ}'WQ_{XZ}\right)^{-1} \qquad \text{(c)}$$

The efficient GMM estimator (EGMM) makes use of an optimal weighting matrix W which minimizes the asymptotic variance of the estimator.

This is achieved by choosing W = S−1. Substituting this into Equation (a) and Equation (c), the efficient GMM estimator is obtained:

$$\hat{\beta}_{\mathrm{EGMM}} = \left(X'ZS^{-1}Z'X\right)^{-1} X'ZS^{-1}Z'y \qquad \text{(d)}$$

with asymptotic variance $V(\hat{\beta}_{\mathrm{EGMM}}) = \left(Q'_{XZ}S^{-1}Q_{XZ}\right)^{-1}$. Similarly, $\sqrt{n}\left(\hat{\beta}_{\mathrm{EGMM}} - \beta\right) \rightarrow N\left[0, V(\hat{\beta}_{\mathrm{EGMM}})\right]$. If an estimate of S exists, therefore, asymptotically correct inference for any GMM estimator could be conducted, efficient or inefficient. An estimate of S also makes the efficient GMM estimator a feasible estimator. In two-step feasible efficient GMM estimation an estimate of S is obtained in the first step and in the second step the estimator and its asymptotic variance is calculated using Equation (d).

The first-step estimation of the matrix *S* requires the residuals of a consistent GMM estimator $\tilde{\beta}$. Efficiency is not required in the first step of two-step GMM estimation, which simplifies the task considerably. But to obtain an estimate of *S* some further assumptions should be made. This is illustrated using the case of independent but possibly heteroskedastic disturbances. If the errors are independent, $E(g_i g'_j) = 0$ for $i \neq j$, and so $S = AVar(\bar{g}) = E(g_i g'_i) = E(u_i^2 Z'_i Z_i)$.This matrix can be consistently estimated by an Eicker–Huber–White robust covariance estimator:

$$\hat{S} = \frac{1}{n}\sum_{i=1}^{n} \hat{u}_i^2 Z'_i Z_i = \frac{1}{n}\left(Z'\hat{\Omega}Z\right).$$