The impact of the 1988 Basel Accord on banks' capital ratios and credit risk-taking: an international study [1]

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Abstract

The purpose of this paper is to see whether and how G-10 banks have complied with the 1988 Basel Accord. The interest of this study lies in the fact that the standardized approach to credit risk in the New Basel Accord is conceptually similar to the 1988 agreement. However, very little is known about the reaction of non-US banks to the imposition of minimum capital requirements that make use of risk-weight categories. Building on previous studies, this paper uses a simultaneous equations model to analyze adjustments in capital and credit risk at banks from G-10 countries over the 1988-95 period. The results show that regulatory pressure was successful in raising the capital to assets ratios of undercapitalized banks in Canada, Japan, the UK and the US but not in France and Italy. In addition, there is no evidence that undercapitalized G-10 banks increased or decreased their credit risk over the period studied. Interestingly, these findings are robust to the inclusion of a variable measuring the role of market discipline in influencing bank capital and risk choices. All in all, the results suggest that the 1988 Basel standards were effective in that, subsequent to their adoption, undercapitalized G-10 banks generally increased their capital but not their credit risk.

Keywords: 1988 Basel Accord, capital requirements, credit risk

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1 Introduction

One of the major developments undergone by the banking industry in the 1990s has been the worldwide implementation of the first Basel Accord that set minimum capital standards for internationally active banks. The Basel guidelines were originally adopted by the central banking authorities from 12 countries (all G-10 countries plus Luxembourg and Switzerland) in July 1988. Their implementation started in 1989 and was completed 4 years later, in 1993. The purpose of the Accord was twofold. First, it aimed at creating a level playing field for banks by raising capital ratios, which were generally perceived as too low in many countries. Second, and linked to this, it aimed at promoting financial stability by adopting a relatively simple approach to credit risk with the potential to distort incentives for bank risk-taking.

More than fifteen years after the adoption of the first Basel Accord and while new regulatory guidelines are about to be implemented, it is fair to say that empirical research has not fully answered the following questions: was the 1988 agreement effective in raising capital ratios among banking institutions falling below the minimum requirements? How did banks respond to the capital adequacy rules, i.e. did they increase their level of capital, forgo risky projects or sell off assets? Did the new guidelines induce banks to modify the credit risk of their portfolio and if so, did they choose to reallocate their assets to riskier categories? Analysis of how G-10 banks have responded to the 1988 risk-based standards is of course crucial if one wants to gain insight into the likely implications of the New Basel Accord.

The lack of answers to the questions raised above is largely due to the limited amount of data on capital levels and risky assets of G-10 banks. Indeed, these data are mainly confidential or hard to obtain on a standardized cross-country basis. Most studies focus on the US, while evidence remains scarce for other countries that were part of the Accord. Therefore, an important contribution of this paper is to shed further light on the impact of the 1988 Basel Accord by using data from six different countries: Canada, France, Italy, Japan, the UK and the US. More precisely, I extend the simultaneous equations model developed by Shrieves and Dahl (1992) to a multi-country setting in order to analyze the relationship between changes in capital and credit risk at the G-10 level. The model also allows for cross-country comparisons of undercapitalized banks' behavior towards capital and risk.

The results show that G-10 banks close to the Basel minimum requirements raised their capital to assets ratios (except in France and Italy) and did not increase or decrease their credit risk following the introduction of the new capital adequacy rules. These findings, which are robust to the inclusion of a variable measuring the role played by market discipline, suggest that the 1988 Basel standards had generally the desired impact on banks' behavior. In addition, I find that changes in capital and risk were unrelated for Canadian, French, Italian and UK banks, positively related for Japanese banks and negatively related for US banks over the period studied. This result, which holds both for adequately capitalized and undercapitalized banks, indicates that banks in different countries adjust their capital and risk levels differently.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature dealing with the effects of capital requirements on banks' behavior. Section 3 presents the data used in this study, while section 4 outlines the empirical methodology. Results are discussed in section 5 and some conclusions are drawn in section 6.

2 Bank capital regulation and its impact on banks' behavior

2.1 Review of the theoretical literature

The main justification for regulating bank capital is the need to avoid the risk-shifting incentive generated by improperly priced deposit insurance. Indeed, although it may promote financial stability in the short-run, risk-insensitive deposit insurance tends to reduce banks' incentives to maintain adequate capital and may thus endanger stability in the long-run. The ability of capital standards to successfully eliminate this moral hazard problem has been at the heart of a theoretical debate for more than 20 years.

A first strand of the literature focuses on utility-maximizing banks using the portfolio approach of Pyle (1971) and Hart and Jaffee (1974). In this framework, Koehn and Santomero (1980) show that the introduction of higher capital ratios will lead banks to shift their portfolio to riskier assets and that the reshuffling effect will be larger for institutions which initially held relatively more risky assets per unit of capital. This effect occurs because flat requirements restrict the banks' risk-return frontier, which leads them to compensate the loss in utility from the upper limit on leverage with the choice of a riskier portfolio. One way to eliminate the risk-shifting incentive is to require banks to meet risk-related capital ratios, as suggested by Kim and Santomero (1988).

These conclusions have been questioned on several grounds. Using an option model, Furlong and Keeley (1989) and Keeley and Furlong (1990) find that a higher capital ratio does not lead banks to increase asset risk. They contend that the utility-maximization framework, which reaches opposite conclusions, is inappropriate because it does not adequately describe the bank's investment opportunity set by neglecting the option value of deposit insurance and the possibility of bank failure. Within the same modeling framework, Gennotte and Pyle (1991) relax the assumption that banks invest in zero net present value assets and find that there are now plausible situations in which an increase in capital requirements results in an increase of asset risk.

The portfolio approach is used again by Rochet (1992) who shows that when the objective of banks is to maximize the market value of their future profits, risk-related capital ratios cannot prevent them from choosing very specialized and very risky portfolios. In this case, risk-based insurance premia are in fact the relevant instrument to limit banks' risk-taking. More recently, Blum (1999) also finds that capital regulation may increase banks' risk-taking but in a dynamic framework. Using a two-period model, he shows that an intertemporal effect has to be considered in addition to the standard negative effect of capital regulation on credit risk. If banks find it too costly to raise additional equity to meet new capital requirements tomorrow or are unable to do so, they will increase risk today. This second effect will reinforce the well-known risk-shifting incentive due to the reduction in profits.

In short, economic theory is unclear on whether imposing harsher capital requirements leads banks to increase the risk structure of their asset portfolio. Ultimately, the question of whether capital adequacy rules limit banks' incentives to engage in moral hazard behavior is an empirical one. The next subsection attempts to clarify the debate about the risk effects of capital regulation by briefly restating the key rules of the 1988 Basel Accord and observing how banks can comply with them.

2.2 Capital requirements in practice: the 1988 Basel Accord

The 1988 Basel standards are almost entirely focused on credit risk, the risk of loss due to borrower or counterparty default. An amendment to incorporate market risk has been issued in 1996, while the Basel Committee on Banking Supervision has submitted a proposal for a New Accord in 1999. This proposal is based on three mutually reinforcing pillars (minimum capital requirements, supervisory review and market discipline) that allow banks and supervisors to evaluate additional types of risks like operational risk, thereby avoiding treating credit and market risks in isolation. Implementation of the New Accord, though probably not by all adopting countries, is expected by year-end 2006.

The key to the 1988 Basel Accord is the obligation for internationally active banks to continually meet two capital adequacy ratios, the so-called tier 1 and total capital ratios. Both ratios have the same denominator, which is a risk-weighted sum of banks' on-balance and off-balance sheet activities. A simplified formula of the risk-weighted assets (RWA) of a bank is given by:[2]

$$RWA = 0*(bucket\ 1) + 0.2*(bucket\ 2) + 0.5*(bucket\ 3) + 1.0*(bucket\ 4) \quad (1)$$

where bucket 1 consists of assets with zero default risk (e.g. cash, government bonds/ securities), bucket 2 of assets with a low rate of default (e.g. loans to OECD banks), bucket 3 of medium-risk assets (essentially residential mortgage loans) and bucket 4 of the remaining assets (in particular loans to non-banks). Thus, the denominator of both capital adequacy ratios represents the accounting value of banks' assets adjusted for their individual risk. The tier 1 ratio and the total capital ratio differ by their numerator. The numerator of the former ratio consists only of tier 1 capital while the numerator of the latter ratio includes both tier 1 and tier 2 capital. Tier 1 capital, also called "core capital", consists mainly of stockholder equity capital and disclosed reserves whereas tier 2 capital or "supplementary capital" includes elements like undisclosed reserves and subordinated term debt instruments provided that their original fixed term to maturity does exceed five years. The difference between tier 1 and tier 2 capital thus reflects the degree to which capital is explicit or permanent. Total capital is the sum of tier 1 and tier 2 capital.

[2] Strictly speaking, formula (1) is only valid for on-balance sheet assets. Off-balance sheet items are also assigned to four risk buckets but they involve additional weights reflecting the nature of the operation. See Dewatripont and Tirole (1994, pp. 52-53) for the precise regulatory definition of RWA.

The 1988 capital adequacy framework requires banks to have a tier 1 ratio of at least 4% and a total capital ratio of at least 8% with the contribution of tier 2 capital to total capital not exceeding 50%, i.e., the following inequalities must hold:

$$\textit{Tier 1 ratio} = \textit{Tier 1 capital} \, / \, \textit{RWA} \geq \textit{0.04} \tag{2}$$

$$\textit{Total capital ratio} = \textit{Total capital} \, / \, \textit{RWA} = (\textit{Tier 1 capital} + \textit{Tier 2 capital}) \, / \, \textit{RWA} \geq \textit{0.08} \tag{3}$$

$$\textit{Tier 1 capital} \geq \textit{Tier 2 capital} \tag{4}$$

The regulation also limits general loan-loss reserves and subordinated debt which are eligible for inclusion in tier 2 capital (see Table 1A in Appendix). The implementation of the Basel guidelines in G-10 countries occurred in two steps. Interim standards of 7.25% for the total capital ratio and 3.25% for the tier 1 ratio had to be met by the end of 1990, whereas full compliance with the definitive standards was expected by year-end 1992.

Banks that wish to raise their capital adequacy ratio to obey the minimum requirements or for other non-regulatory reasons can use three types of balance-sheet adjustments: they can increase their capital level, decrease their risk-weighted assets or sell off their assets. This is summarized in equation (5), which decomposes the growth rate of the capital adequacy ratio of bank i into three terms: the growth rate of capital, the growth rate of the credit risk ratio and the growth rate of total assets (a proof is given in Appendix):

$$\frac{\Delta CAR_{i,t}}{CAR_{i,t}} = \frac{\Delta K_{i,t}}{K_{i,t}} - \frac{\Delta RISK_{i,t}}{RISK_{i,t}} - \frac{\Delta A_{i,t}}{A_{i,t}} \tag{5}$$

where CAR = K / RWA = capital adequacy ratio (tier 1 ratio or total capital ratio)
K = capital (tier 1 capital or total capital)
RISK = RWA / A = credit risk ratio
A = total assets
t denotes time

From equation (5), it can be seen that a mandatory increase in the capital adequacy ratio (K/RWA) does not prevent banks from simultaneously increasing their capital level (K) and their credit risk ratio (RWA/A) provided that the growth rate of the credit risk ratio is lower than the growth rate of capital (holding total assets constant). Thus, banks may well have reacted to the 1988 Basel Accord by engaging in moral hazard behavior as first predicted by Koehn and Santomero (1980).

In the remainder of the paper, I focus on the relationship between changes in the capital to assets ratio (K/A) and the credit risk ratio (RWA/A) of G-10 banks over the 1988-95 period. Furthermore, I analyze the behavior of banks which were close to the minimum regulatory capital requirements, as these banks should have had a stronger response to capital regulation than better capitalized banks if the Basel standards were effective in leveling the playing field for G-10 banks.

2.3 Review of the empirical literature

The main papers that investigated the impact of the Basel capital requirements on banks' behavior are listed in Table 1. With the exception of Ediz et al. (1998), all use the simultaneous equations approach which is described in section 4. This modeling framework allows to compare the behavior of undercapitalized and adequately capitalized banks with respect to changes in capital and risk and to see whether these changes are related. The studies surveyed in Table 1 generally support the idea that undercapitalized banks (i.e., those failing to achieve the Basel requirements) increased their capital to assets ratios in the first half of the 1990s. A similar phenomenon is observed for adequately capitalized institutions, although to a lesser extent. Furthermore, there is little consensus among the papers reviewed on whether banks – adequately capitalized or not – engaged in riskier activities. Finally, changes in capital and credit risk appear to be mostly unrelated.

Results of US studies are difficult to interpret as the implementation of the second stage of the Basel Accord, between end-1990 and end-1992, coincides with the passage of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) in December 1991. Section 131 of FDICIA, Prompt Corrective Action (PCA), goes one step further than the Basel Accord by defining three regulatory ratios (the Basel capital standards plus a leverage requirement) and five categories into which banks are classified according to their compliance with the three ratios. Thus, it is hard to ascribe the findings of the two papers by Aggarwal and Jacques (1997, 2001) to FDICIA or the Basel Accord, as US banks' behavior is likely to have been affected by both regulations over the period that they consider. Jacques and Nigro (1997) avoid this problem by focusing on the years 1990-91, i.e. the period before FDICIA was passed. However, the very small number of undercapitalized institutions in their sample - less than 2% of the total number of banks - may reduce the reliability of some of their estimates.

Three papers present some non-US evidence regarding the relationship between capital and credit risk: Ediz et al. (1998) base their study on confidential UK data whereas Rime (2001) uses Swiss data and Heid et al. (2004) employ German data. Like other studies listed in Table 1, the first of these papers uses a partial adjustment framework but, unlike them, treats changes in capital and risk-taking as two separate decisions. Surprisingly, Ediz et al.'s model leads to the result that banks adjust their capital levels each year by more than the difference between the current level and the target they have in mind, which means that banks overshoot the target (and by a higher amount each year). The study by Rime (2001) is interesting because it provides the first application of the simultaneous-equations model reviewed in section 4 to non-US banks. However, Rime adopts the PCA regulatory classification to measure regulatory pressure on Swiss banks, which might be inappropriate given that the additional requirements set by PCA have not been adopted formally by any other country besides the US.[3] The paper by Heid et al. (2004) investigates the relation between capital and risk levels by looking at a sample of German savings banks over a slightly different period (1993-2000) than the other papers. The main finding of the authors is that the coordination between capital and risk depends on the capital buffer of banks. Banks with low capital buffers attempt to rebuild an appropriate capital buffer by decreasing risk and increasing capital simultaneously while banks with high capital buffers attempt to maintain their capital buffer by increasing risk when capital increases.

Finally, a study by Sheldon (1996) looks at the risk effects of capital adequacy rules on eleven G-10 countries using an option-pricing framework. Sheldon's main result is that the Basel Accord did not have a risk-increasing impact on banks' portfolio but is a bit difficult to interpret as he is does not control for regulatory and non-regulatory influences. Moreover, his sample is not always representative of the banking industry of each G-10 country as some countries are only represented by very small banks.

[3] Rime also uses a regulatory pressure variable similar to mine, which does not alter his results.

Therefore, the main contribution of this study is to extend the empirical literature on the effects of the 1988 Basel Accord by using a simultaneous-equations model for six different countries along with a representative data set, the construction of which is detailed in the next section.

3 Data source and descriptive statistics

3.1 Data source

Data were obtained from *Bankscope*, a database of bank account figures. Consistent with most studies on the impact of the Basel requirements, I chose to restrict the sample to commercial banks over the 1988-95 period.[4] All the variables used in this paper were available on *Bankscope*, except the credit risk ratio of banks. Therefore, capital adequacy ratios (CAR), capital levels (K) and total assets (A) were extracted from the database in order to compute the credit risk ratio (RISK) of bank i at time t using the following formulas:

$$\frac{K_{i,t}}{CAR_{i,t}} = \frac{K_{i,t}}{\frac{K_{i,t}}{RWA_{i,t}}} = RWA_{i,t} \tag{6}$$

$$\frac{RWA_{i,t}}{A_{i,t}} = RISK_{i,t} \tag{7}$$

Equation (6) can be computed in two different ways, either using tier 1 data (i.e., K = tier 1 capital and CAR = tier 1 ratio) or using total capital data (i.e., K = total capital and CAR = total capital ratio). Obviously, both methods yield the same value for risk-weighted assets. In order to check for consistency of the results, I computed the

[4] Data on capital adequacy are not available for years prior to 1988, preventing any comparison with the pre-Basel period. The choice of 1995 is somewhat arbitrary but quite standard given that most studies on the impact of the Basel Accord focus on the first half of the 1990s. In the case of the US, Flannery and Rangan (2002) have shown that none of the 100 largest banking firms appears to have been constrained by regulatory capital requirements since 1995.

credit risk ratio using both methods except for Japanese banks, which generally do not report their total capital.

3.2 Descriptive statistics

Using the data from *Bankscope*, I constructed an unbalanced panel containing 576 commercial banks from six G-10 countries with assets of more than $100 million during the period 1988-95. Banks that did not report their total capital ratio, their tier 1 ratio or their credit risk ratio for at least 2 consecutive years were omitted from the data set. Also, banks with a capital ratio above 50% or a credit risk ratio above 200% were treated as outliers and excluded from the sample.

The second column of Table 2 shows the distribution of banks by country. Unfortunately, *Bankscope* does not contain data on the capital levels of Belgian, Dutch, Luxembourg, German and Swiss commercial banks over the period of interest, which prevents the computation of their risk-weighted assets using equation (6). This explains why the analysis is limited to the remaining six G-10 countries.[5] Unsurprisingly, US and Japanese banking institutions constitute the vast majority of the sample banks. The remainder of Table 2 indicates that the sample is quite representative of each national banking sector. With the exception of the UK, the data set includes at least 7 of the 10 biggest commercial banks (in terms of assets) of each country. Moreover, the sum of the sample banks' assets almost always exceeds half of the total national banking assets.

Tables 3A to 3C show the average total capital to assets ratio, tier 1 capital to assets ratio and credit risk ratio of each country between 1988 and 1995. The comparability of the figures displayed in the tables is not guaranteed since the number of observations is increasing over time.[6] Nevertheless, some tentative remarks can be made. First, looking at Tables 3A and 3B, the total capital to assets ratio and the tier 1 capital to assets ratio of each country are upward trending across the period surveyed. Two groups of countries coexist in the sample: those with relatively low capital to assets ratios throughout the whole period (France, Italy and Japan) and those that exhibit

[5] Data were also available for Sweden but this country was excluded from the sample because of the banking crisis of the early 1990s.

[6] G-10 banks started to implement the Basel standards only gradually, which explains the low number of observations at the end of the 1980s. The slightly lower number of banks in 1994 and 1995 is due to a few mergers, which were not motivated by the level of capitalization of merging banks.

higher values for both capital ratios (Canada, the UK and the US). Second, looking at Table 3C, some countries (Canada, the UK and possibly the US) appear to have experienced a decrease in credit risk whereas others (France, Italy and Japan) have seen credit risk remaining relatively constant. Once again, the sample can be divided into two groups of countries: those with an average credit risk ratio varying between 50% and 60% (France, Italy and perhaps the UK) and those with a credit risk ratio equal to or higher than 70% (Canada, Japan and the US). At first glance, it might be tempting to attribute the higher credit risk ratio of these three countries to their pre-1988 capital adequacy rules. Indeed, until the Basel guidelines were adopted, simple gearing ratios were in force in Canada, Japan and the US (Pecchioli, 1987), which may account for their historically higher level of credit risk. But then, the 1988 Accord should have led to a decrease in the credit risk ratio of these countries as risk-based standards take into account the composition of banks' portfolio when assessing capital charges. However, Table 3C provides mixed support for this hypothesis: Canadian banks did indeed experience a decrease in credit risk whereas the level of risk-taking of Japanese institutions remained fairly constant. The increasing number of observations for US banks prevents any reliable comparison. Overall, Tables 3A to 3C suggest that the six G-10 countries have raised their capital to assets ratios (K/A) during the 1988-95 period whereas no specific trend could be found in the credit risk ratio (RWA/A).

Table 3 (Panels D and E) and Table 4 report additional descriptive statistics on the relationship between capital and risk. Tables 3D and 3E show the total capital to risk-weighted assets ratio and the tier 1 capital to risk-weighted assets ratio of each country, respectively. Both series are upward trending across the years 1988-93 with no significant increase afterwards. On average, banks from all countries except Canada and France already met the minimum requirements of 8% for the total capital ratio and 4% for the tier 1 ratio in 1989. This result is consistent with the idea that banks tend to be well above the minimum requirements for precautionary and/or reputational reasons.[7] Table 4 further decomposes the average annual growth rate of both capital adequacy ratios into three terms, as in equation (5). As can be seen from the table, the growth rate of both ratios over the sample years is roughly similar and is mainly driven by a rise in capital levels, which offsets the rise in total assets. The growth rate of the credit risk ratio is close to zero for all countries except for Canada and the UK, where it is negative.

[7] See Bauman and Nier (2003) and Lindquist (2004) for an investigation of the determinants of banks' capital buffers in the UK and in Norway, respectively.

However, Tables 3 and 4 do not tell us whether $\Delta(K/A)$ and $\Delta(RWA/A)$ are related, nor whether the increase in capital to assets ratios that took place between 1988 and 1995 was due to the introduction of capital adequacy rules. Indeed, it could be the case that banks that were not part of the Basel Accord also decreased their leverage. Figure 1 shows for instance that a rise in the equity to assets ratio[8] was not only experienced by G-10 banks at the beginning of the 1990s, but also by non G-10 banks and even by banks from countries where capital adequacy rules were not put in place before 1993.[9] In a similar way, Figure 2 indicates that the reliance of these three groups of banks on subordinated debt[10] – a key component of tier 2 capital – was roughly similar throughout the period surveyed. Thus, determining whether the Basel agreement caused changes in the capital to assets ratio (K/A) and the credit risk ratio (RWA/A) of G-10 banks and whether these changes were related requires a more complex econometric analysis than just looking at descriptive statistics. The following section sets up a model that aims at assessing the empirical determinants of observed changes in capital and risk with a particular emphasis on the role played by regulatory pressure.

4 Econometric framework

4.1 The model

In order to acknowledge that capital and risk decisions are determined together, I extend the simultaneous equation model developed by Shrieves and Dahl (1992) to a multi-country setting. In this model, observed changes in banks' capital and risk-taking consist of two components, a discretionary adjustment and a change caused by factors exogenous to the bank:

[8] The equity to assets ratio is an approximation of the tier 1 capital to assets ratio as its numerator does not include disclosed reserves.
[9] The use of this third group of banks is motivated by the fact that a large number of non G-10 countries adopted Basel-like rules between 1988 and 1993. I consider that a country has not implemented the Basel Accord before 1993 if its banks did not report a capital adequacy ratio before that year.
[10] Note that Figure 2 does not distinguish between subordinated debt with a term to maturity of less or more than five years. Only the latter category is allowed to count as tier 2 capital, along with other elements (cf. section 2.2).

$$\Delta CAP_{i,t} = \Delta^d CAP_{i,t} + E_{i,t} \tag{8}$$

$$\Delta RISK_{i,t} = \Delta^d RISK_{i,t} + S_{i,t} \tag{9}$$

where $\Delta CAP_{i,t}$ and $\Delta RISK_{i,t}$ are the observed changes in capital and risk levels, respectively, for bank i in period t. The $\Delta^d CAP_{i,t}$ and $\Delta^d RISK_{i,t}$ variables represent discretionary adjustments in capital and risk while $E_{i,t}$ and $S_{i,t}$ are exogenously-determined factors.

Following Shrieves and Dahl (1992), I model the discretionary changes in capital and risk using a partial adjustment framework such that:

$$\Delta^d CAP_{i,t} = \alpha(CAP^*_{i,t} - CAP_{i,t-1}) \tag{10}$$

$$\Delta^d RISK_{i,t} = \beta(RISK^*_{i,t} - RISK_{i,t-1}) \tag{11}$$

where $CAP^*_{i,t}$ and $RISK^*_{i,t}$ are bank *i*'s target capital and risk levels, respectively. Thus, the discretionary changes in capital and risk for bank i are proportional to the difference between the target level in period t and the observed level in period t-1.

Substituting equations (10) and (11) into equations (8) and (9), the changes in capital and risk can be written as:

$$\Delta CAP_{i,t} = \alpha(CAP^*_{i,t} - CAP_{i,t-1}) + E_{i,t} \tag{12}$$

$$\Delta RISK_{i,t} = \beta(RISK^*_{i,t} - RISK_{i,t-1}) + S_{i,t} \tag{13}$$

This means that observed changes in capital and risk are a function of the target capital and risk levels, the lagged capital and risk levels, and any random shocks. In this paper, bank capital (CAP) is defined as the capital to assets ratio (K/A) – either the total capital to assets ratio or the tier 1 capital to assets ratio – while bank risk-taking (RISK) is defined as the credit risk ratio (RWA/A). As shown in equation (5), K/A and RWA/A represent the two variables that banks have at their discretion to adjust their capital adequacy ratio (CAR). It should be pointed out that alternative measures of risk-taking such as value at risk or the volatility of the market price of banks' assets were not available for the sample banks over the period considered. Also, the ratio of non-performing loans to total loans was not considered as a potential measure of credit risk since there remains difficulties in obtaining data that are comparable across countries (Sudararajan et al., 2001). Nevertheless, the choice of RWA/A as a measure of risk-taking can be criticized on the ground that the four risk buckets specified by the Basel Committee only imperfectly capture credit risk (see for instance Jones, 2000). Therefore, one may want to consider that RWA/A is more a measure of portfolio composition ("regulatory risk") than of absolute credit risk ("economic risk").[11] This interpretation is independent of whether RWA/A is correct measure of credit risk.

Although the target capital and risk levels of a bank are not observable, they are assumed to depend on some set of observable variables describing the bank's financial condition and the state of the economy in each country. The variables that I use to approximate the target capital to assets ratio (CAP*) are the size of the bank (SIZE), a measure of its liquidity (LOANS), a measure of its asset quality (LLOSS), a measure of its profitability (ROA), the rate of GDP growth (GROWTH), changes in the credit risk ratio (ΔRISK), country dummies, the degree of regulatory pressure (REG) interacted with country dummies, and year dummies (YEAR). The variables used to proxy the target credit risk ratio (RISK*) are SIZE, LOANS, LLOSS, GROWTH, changes in the capital to assets ratio (ΔCAP), country dummies, REG interacted with country dummies, and YEAR. The explanatory variables can thus be divided into bank-specific and country-specific factors plus year dummies (Table 2A in Appendix shows summary statistics for each variable).

4.2 Bank-specific variables

All the variables presented here have been used in the studies listed Table 1 with the exception of the LOANS variable. SIZE is measured as the natural log of total assets. It is included as a control variable because large banks have an easier access to equity capital markets and are thus expected to have lower capital to assets ratios than smaller banks. In addition, large banks carry out a wider range of activities, which should increase their ability to diversify their portfolio hence to decrease their credit risk. The variable LOANS, defined as the percentage of total assets tied up in loans, is included in

[11] However, Avery and Berger (1991) find that US banks with higher RWA/A exhibit poorer performance thereby supporting the use of this variable as a risk measure.

the system of equations as a measure of the riskiness of the bank. As higher LOANS values correspond to lower investment in non earning assets, they should lead to higher portfolio risk and a greater need for capital. Loan loss provisions as a percentage of total assets, LLOSS, represent funds that banks set aside to cover bad loans. They are included in the capital equation because an increase in provisions may put capital under pressure if banks have not built up a sufficient equity buffer to cope with credit losses. Loan loss provisions are also included in the risk equation because they are deducted from outstanding loans and should therefore lead to a decrease in risk-weighted assets. Consistent with previous studies, the return on assets, ROA, is included in the capital equation as profitable banks may prefer to increase capital through retained earnings rather than through equity issues in the presence of asymmetric information in capital markets.

Finally, the analysis in section 2 indicates that banks' capital and risk choices are interdependent, which suggests the inclusion of ΔRISK in equation (12) and of ΔCAP in equation (13). Looking at equation (13), a positive and significant coefficient for ΔCAP would indicate that G-10 banks increased their capital to assets ratio and their credit risk ratio simultaneously - a result consistent with the unintended effects of more stringent capital requirements - while a negative and significant coefficient would indicate that higher capital to assets ratios give banks greater incentives to decrease credit risk. Section 5 also presents an alternative specification where I interact ΔCAP and ΔRISK with the regulatory pressure variable (cf. below) in order to see if banks with low capital buffers adjust their capital and risk differently from banks with high capital buffers.

4.3 Country-specific variables

Country fixed-effects are included in the model in order to account for factors that are not reflected by the set of bank-specific variables, such as national differences in capital preferences and risk-aversion. The country dummies are also assumed to capture the extent to which national variants of the Basel Accord had an impact on capital and risk. Some countries that were part of the 1988 agreement have indeed supplemented the original guidelines with additional requirements such as slightly different capital thresholds or new regulatory ratios over the period studied (e.g. FDICIA in the US). The rate of GDP growth (GROWTH) is included in the capital and the risk equations in order to take account of country-specific macroeconomic shocks such as changes in the volume or in the structure of loans demand that can affect banks' capital and risk-taking.

Of greater interest here is the regulatory pressure variable (REG), which is interacted with a second set of country dummies. This variable describes the behavior of banks that fell short of the minimum capital requirements. For these banks, not meeting the Basel standards was potentially life threatening as it meant exclusion from international business. Thus, undercapitalized institutions should have increased their capital to assets ratio and/or decreased their credit risk more than well-capitalized institutions if the 1988 Basel Accord was effective in leveling the playing field for G-10 banks. Consistent with most of the studies in Table 1, regulatory pressure is measured by a dummy variable which takes the value of unity if the capital adequacy ratio falls below the Basel minimum requirement plus one bank-specific standard deviation and zero otherwise. The rationale for this definition of regulatory pressure is that banks generally build a buffer above the regulatory minimum for precautionary and/or reputational reasons and that this buffer depends on the volatility of their own capital adequacy ratio. Although the choice of one standard deviation is somehow arbitrary, Table 5 (Panel A) shows that it produces sensible percentages of banks experiencing regulatory pressure in each country (from now on, I use the term "undercapitalized" to describe these bank observations). On average, 17.1% of the bank observations fall below the minimum requirements plus one standard deviation when looking at the total capital ratio and 4.8% when considering the tier 1 ratio. Table 5 (Panel B) further indicates that the percentage of banks falling below the regulatory minimum - without any added standard deviation - was very low over the period surveyed. On average, only 4.2% of the sample banks fell in the undercapitalized category when looking at their total capital ratio and a mere 1.0% when considering their tier 1 ratio. Although this result seems to support the widespread idea that banks were not affected by the Basel standards, it could be the case that lower requirements would have induced banks to hold less capital and that banks actually constructed a buffer above the regulatory minimum. This motivates the addition of one standard deviation to the regulatory minimum.

Nevertheless, the above definition of regulatory pressure has two shortcomings. First, the standard deviation of banks' capital adequacy ratio may be large because banks are precisely increasing their capital adequacy ratio in order to meet the minimum requirements. This may lead to incorrectly classifying banks in the undercapitalized category. As a sensitivity check, I used the standard deviation of several variables which are correlated with banks' capital adequacy ratio (e.g. total assets, return on assets). The percentages of undercapitalized observations, which are not shown here, are relatively similar to those obtained when adding one standard deviation of banks' capital adequacy ratio. A second shortcoming of the REG variable is that the behavior of banks falling below the regulatory minimum plus one standard deviation is likely to be influenced by other factors than regulatory pressure from prudential authorities including market pressure from peer banks, private investors or credit rating agencies. Thus, it may be hard to disentangle the effects of the Basel Accord from increased market discipline (Basel Committee, 1999). In order to mitigate this problem, section 5 presents an alternative specification where I use a dummy variable which is equal to unity if banks had a credit rating from Moody's or S&P or were listed on a stock exchange over the period surveyed and zero otherwise. This variable is interacted with the regulatory pressure variable in order to capture the marginal effect that market discipline has on the relationships between REG and ΔCAP and REG and ΔRISK.

4.4 Year dummy variables

Dummy variables for each year of the reference period - except 1989 in order to avoid perfect collinearity - are added to the specification in order to take account of common country shocks that may have affected banks' capital and credit risk (e.g. end of the implementation period of the Basel Accord in 1992).

4.5 Empirical specification and estimation technique

Based on the variables selected to explain target capital and risk levels, the model defined by equations (12) and (13) is written as follows:

$$\Delta \mathrm{CAP}_{i,t} = \mathrm{a}_0\mathrm{SIZE}_{i,t} + \mathrm{a}_1\mathrm{LOANS}_{i,t} + \mathrm{a}_2\mathrm{LLOSS}_{i,t} + \mathrm{a}_3\mathrm{ROA}_{i,t} + \mathrm{a}_4\mathrm{GROWTH}_{j,t} + \mathrm{a}_5\mathrm{CAP}_{i,t\text{-}1} + \mathrm{a}_6\Delta\mathrm{RISK}_{i,t} + \sum_{\mathrm{j}} \mathrm{a}_{7\mathrm{j}}\mathrm{c}_{\mathrm{j}} + \sum_{\mathrm{j}} \mathrm{a}_{8\mathrm{j}}\mathrm{c}_{\mathrm{j}}\mathrm{REG}_{i,t\text{-}1} + \sum_{\mathrm{t}} \mathrm{a}_{9\mathrm{t}}\mathrm{YEAR}_{t} + E_{i,t} \quad (14)$$

$$\Delta \mathrm{RISK}_{i,t} = \mathrm{b}_0\mathrm{SIZE}_{i,t} + \mathrm{b}_1\mathrm{LOANS}_{i,t} + \mathrm{b}_2\mathrm{LLOSS}_{i,t} + \mathrm{b}_3\mathrm{GROWTH}_{j,t} + \mathrm{b}_4\mathrm{RISK}_{i,t\text{-}1} + \mathrm{b}_5\Delta\mathrm{CAP}_{i,t} + \sum_{\mathrm{j}} \mathrm{b}_{6\mathrm{j}}\mathrm{c}_{\mathrm{j}} + \sum_{\mathrm{j}} \mathrm{b}_{7\mathrm{j}}\mathrm{c}_{\mathrm{j}}\mathrm{REG}_{i,t\text{-}1} + \sum_{\mathrm{t}} \mathrm{b}_{8\mathrm{t}}\mathrm{YEAR}_{t} + S_{i,t} \quad (15)$$

where c_j is country dummy variable (1 if bank i belongs to country j, 0 otherwise)

j is a country index and t is a time index (t= 1990,...1995)

$E_{i,t}$ and $S_{i,t}$ are disturbance terms such that $E_{i,t} = \mu_i + \varepsilon_{i,t}$ and $S_{i,t} = \eta_i + \nu_{i,t}$ with $\mu_i \sim \text{IID}(0,\sigma_\mu^2)$, $\eta_i \sim \text{IID}(0,\sigma_\eta^2)$, $\varepsilon_{i,t} \sim \text{IID}(0,\sigma_\varepsilon^2)$ and $\nu_{i,t} \sim \text{IID}(0,\sigma_\nu^2)$ independent from each other

The coefficients of particular interest in this system of equations are a_{8j} and b_{7j}, which represent, for country j, the impact of regulatory pressure on observed changes in capital and risk, respectively, and a_6 and b_5 that test the overall relationship between changes in capital and risk.

Since the sample consists of 576 banks distributed over six countries, the most efficient way to estimate equations (14) and (15) is to use a methodology which accounts for the clustering of banks within countries. This type of model is usually called a multilevel or hierarchical model (Wooldridge, 2002). More precisely, I estimated a country fixed-effect and bank random-effect model (c_j being the country fixed-effect and μ_i and η_i being the bank random-effects) and I used a likelihood ratio test for comparing this model to ordinary least squares. The small chi2 values of the likelihood ratio test rejected the presence of random effects in the ΔCAP and ΔRISK equations. This means that the gain in efficiency of the multilevel model is limited and that there is no objection to pooling the data and using ordinary least squares with country-specific fixed effects. However, since the right-hand side of both ΔCAP and ΔRISK includes an endogenous variable, the estimation of the system formed by equations (14) and (15) is carried out by three stage least squares (3SLS) in order to obtain consistent parameter estimates. In addition, 3SLS is more efficient than two stage least squares (2SLS) as it exploits error correlation across equations.[12]

Given that US and Japanese banks represent the vast majority of banks in my sample, I also performed a poolability test which rejected the equality of the coefficients of the year dummies and of the control variables in the US, Japanese and non-US/non-Japanese groups. The system formed by equations (14) and (15) is therefore estimated separately for three groups of banks: Canadian, French, Italian and UK banks (Table 6A), Japanese banks (Table 6B) and US banks (Table 6C). In the case of US and Japanese banks, the country dummies are replaced by a constant.

[12] However, 3SLS may be sensitive to misspecification or measurement error. This suggests comparison with 2SLS estimates as a specification check. Estimation of equations (14) and (15) using 2SLS produces very similar results to 3SLS.

5 Results

5.1 Baseline specification

Tables 6A to 6C show the results of the system described by equations (14) and (15). The variable CAP is defined as the total capital to assets ratio in the first two columns of each table and as the tier 1 capital to assets ratio in the remaining two columns.

I start by presenting the results for Canada, France, Italy and the UK (Table 6A). The time dummies in the ΔCAP equations are all insignificant, which suggests that target capital levels were relatively constant across years once controlling for other determinants of capital to assets ratios. The time dummies in the ΔRISK equations are significantly negative for the years 1991-95 when CAP is defined as the total capital to assets ratio and for the years 1990 and 1992-1995 when CAP is defined as the tier 1 capital to assets ratio.[13] This result provides evidence that banks in Canada, France, Italy and the UK lowered credit risk at the beginning of the 1990s, *ceteris paribus*. Next, the country dummy variables, used alone, reflect the expected change in capital and risk for the respective countries over 1988-95. The country dummies in the ΔCAP and ΔRISK equations are significant in France and Italy.[14] Their magnitude is roughly identical in the capital equations (+1.6 percentage points when CAP is defined as the total capital to assets ratio and +1.5 percentage points when CAP is defined as the tier 1 capital to assets ratio) and in the risk equations (+8.5 percentage points), suggesting that banks in these two countries experienced a similar increase in capital and risk over the period surveyed. Looking at Table 6B, the constant and the country dummies are negative and significant in the risk equation, indicating that Japanese banks decreased their credit risk at the beginning of the 1990s and that target risk ratios were below those of the excluded year, *ceteris paribus*.[15] The constant and the year dummies are not significant in Table 6C.

[13] An F-test does not reject the null hypothesis that the coefficients of the time dummies are equal for these years (the test statistic is 5.46 with associated probability of 0.25 in the first system of equations and 7.34 with associated probability of 0.12 in the second system of equations).
[14] The country dummies for Canada and the UK are only marginally significant in the capital and/or risk equations.
[15] In the case of Japanese banks, I always focus on the system of equations where CAP is defined as the tier 1 capital to assets ratio since the first system is only based on 48 observations.

Before analyzing the regulatory pressure brought about by the Basel Accord and the overall relationship between capital and risk, I briefly discuss the sign of the remaining control variables (lower panel of Tables 6A to 6C). The parameter estimates on lagged capital and risk are negative and significant, with values lying in the ranges [-0.185; -0.135] in Table 6A, [-0.139; -0.079] in Table 6B and [-0.174; -0.161] in Table 6C. These figures indicate that G-10 banks were adjusting their capital and risk to desired levels relatively rapidly in the first half of the 1990s. Typically, shocks to capital and risk were halved within 3 and 5 years for Canadian, French, Italian and UK banks, within 4 and 9 years for Japanese banks and within 3 and 4 years for US banks. Other control variables display various levels of significance in Tables 6A to 6C. Bank size (SIZE) has generally a negative and significant effect on capital to assets ratios and a positive and significant effect on credit risk ratios. Possible interpretations are that large banks have easier access to capital markets and can therefore operate with lower amounts of capital or that they feel less pressure to increase their capital to assets ratio because of a "too-big-to-fail" effect. A larger size also allows a greater diversification to mitigate the credit risk exposure. As hypothesized, loans as a percentage of total assets (LOANS) are a good proxy of the target risk profile of a bank as they always increase the credit risk ratio significantly. However, their impact on capital to assets ratios is not always significant. The return on assets (ROA) has a positive and significant effect on banks' capital to assets ratios, a result consistent with the hypothesis that banks with higher earnings can retain more capital. Loan loss provisions as a percentage of total assets (LLOSS) have no effect on target capital and risk levels overall, while GDP growth (GROWTH) has a positive and significant effect on the credit risk ratio of Canadian, French, Italian and UK banks and a negative and significant effect on the tier 1 capital to assets ratio of Japanese banks. More importantly, Tables 6A to 6C provide some insights on the behavior of banks experiencing regulatory pressure and on the overall relationship between ΔCAP and ΔRISK.

Impact of the Basel Accord on bank capital and credit risk-taking

In this study, the impact of the Basel Accord on bank capital and credit risk is measured trough a dummy variable which is equal to unity if the capital adequacy ratio falls below the minimum requirement plus one bank-specific standard deviation and zero otherwise. If regulatory pressure brought about by the 1988 capital standards was effective, undercapitalized banks should have increased their capital to assets ratio and/or decreased their credit risk ratio more than adequately capitalized banks. Looking at the behavior of undercapitalized institutions in Tables 6A to 6C, two groups of countries can be distinguished: (1) France and Italy and (2) Canada, Japan, the UK and the US.

In France and Italy, undercapitalized banks did not behave significantly differently from adequately capitalized banks. That is, the regulatory pressure variable interacted with the country dummies is insignificant, both in the ΔCAP and ΔRISK equations. The results for France are not surprising given that some undercapitalized banks (e.g. Crédit Lyonnais) were still state-owned at the beginning of the 1990s and thus found it difficult to increase shareholders' equity. In the case of Italy, some troubled banking institutions (e.g. Banco di Napoli) not only fell below the regulatory threshold but also saw their capital position deteriorate over the period studied, which explains why regulatory pressure has no impact on banks' capital to assets ratio. The insignificance of the regulatory pressure variable in the risk equations further indicates that undercapitalized banks in France and Italy did not increase or decrease the riskiness of their portfolio compared to other banks. These results represent new evidence on the impact of the 1988 capital standards.

In the remaining four countries (Canada, Japan, the UK and the US), the regulatory pressure variable had a positive and significant impact on the tier 1 capital to assets ratio and/or the total capital to assets ratio but no significant impact on the credit risk ratio. *Ceteris paribus*, Canadian banks close to the legal minimum requirements increased their total capital to assets ratio by 0.8 percentage points more than other Canadian banks, while UK banks below the minimum requirements plus one standard deviation increased their total capital to assets ratio by 0.9 percentage points more than other UK banks (the latter result is only marginally significant). These findings are consistent with Illing and Paulin (2004) who provide informal evidence showing that the 1988 standards had a positive effect on Canadian banks' capital adequacy ratios, and with Ediz et al. (1998) who found that UK banks responded to the Basel requirements by raising additional capital without relying significantly on substitution away from high risk-weight assets. The latter paper also finds that UK banks below the minimum requirements plus one standard deviation increased their total capital adequacy ratio by 0.4 percentage point per quarter, an adjustment which is higher than the one suggested by the coefficient of REG*UK in Table 6A (0.9 percentage points on an annual basis).

Looking at Table 6B, we see that Japanese banks falling below the minimum legal requirements plus one standard deviation increased their tier 1 capital to assets ratio by only 0.3 percentage points more than other Japanese banks, *ceteris paribus*. It is well-known that one of the goals of the 1988 Basel Accord was to create a level playing field by eliminating the funding-cost advantage enjoyed by Japanese banks which operated with significantly lower capital ratios compared to their competitors in other G-10 countries (Wagster, 1996). The size of the coefficient of the REG variable tends to indicate that only part of this competitive advantage was reduced following the introduction of the Basel guidelines. The results for Japan contrast with Ito and Sasaki (1998) and Montgomery (2005) who show that undercapitalized Japanese banks tended to issue more subordinated debt (an increase in tier 2 capital, hence in total capital) while leaving their tier 1 capital relatively unchanged. A possible explanation is that both papers focus on slightly different time periods (1990-92 for the first study and 1988-99 for the second study). Montgomery (2005) also finds that banks with relatively low tier 1 capital ratios tended to shift their asset portfolio out of heavily-weighted risky assets such as corporate bonds and into zero-weighted riskless assets such as government bonds. This effect is not observed here, probably because RWA/A is a broader measure of credit risk.

Looking at Table 6C, we observe that undercapitalized US banks increased their total capital to assets ratio by 0.9 percentage points and their tier 1 capital to assets ratio by 1.5 percentage points more than other US banks, *ceteris paribus*. This finding is consistent with Aggarwal and Jacques (2001) who focus on the 1990-96 period, although their estimates of the impact of regulatory pressure on banks' capital are about twice as high as those presented in this paper. A possible explanation is that the authors use a different definition of the REG variable.

The results so far indicate that Canadian, Japanese, UK and US banks below the minimum requirements plus one standard deviation improved their tier 1 capital to assets ratio and/or their total capital to assets ratio in order to avoid the penalties implied by a breach of the Basel guidelines. The impact of regulatory pressure was the largest for US banks (1.5 percentage points per annum for the tier 1 capital to assets ratio) and the smallest for Japanese banks (0.3 percentage points per annum for the tier 1 capital to assets ratio). However, regulatory pressure did not have any impact on the capital to assets ratios of French and Italian banks. Also, there is no evidence that undercapitalized G-10 banks increased or decreased their portfolio risk over the period surveyed.

Overall relationship between changes in capital and credit risk

With respect to the overall relationship between ΔCAP and ΔRISK, the results in Table 6A show that changes in capital and credit risk were not related in Canada, France, Italy and the UK over the 1988-95 period. The results in Tables 6B and 6C are different in comparison. Changes in capital and credit risk were positively related for Japanese banks and negatively related for US banks at the beginning of the 1990s.

In the case of Japanese banks, an increase of 1 percentage point in the tier 1 capital to assets ratio increased the credit risk ratio by about 1.6 percentage points while a similar increase in the credit risk ratio had only a very small, though significant, effect on tier 1 capital. Thus, Japanese banks appear to have raised their capital and risk simultaneously, a result consistent with Koehn and Santomero (1980) who argue that more stringent capital regulation will cause a utility maximizing bank to increase asset risk. This finding may also be explained by various theories providing a rationale for a positive relationship between changes in capital and risk, including the "bankruptcy cost avoidance" theory and the "managerial risk aversion" theory (see Shrieves and Dahl, 1992). In the case of US banks, an increase of 1 percentage point in both capital to assets ratios decreased the credit risk ratio by about 1.5 percentage points whereas a similar increase in the credit risk ratio had only a very small, though significant, effect on both capital to assets ratios. The negative association between changes in capital and risk might be due to subsidized deposit insurance, which gives value-maximizing banks an incentive to increase both portfolio risk and leverage risk.

5.2 Alternative specification

Tables 7A to 7C present an alternative specification where regulatory pressure is interacted with a variable capturing whether banks experience some market pressure or not. This variable (MARKET) is a dummy which is equal to unity if banks had a credit rating from Moody's or S&P or were listed on a stock exchange over the period surveyed and zero otherwise. The aim is to capture the marginal effect that market pressure has on the relationships between REG and ΔCAP and REG and ΔRISK. More precisely, the specification in Tables 7A to 7C includes three interaction terms between REG (or 1-REG) and MARKET (or 1-MARKET), whose effect must be interpreted with respect to the omitted category of banks (for ease of interpretation, REG is not interacted with country dummies in Table 7A). For instance, the coefficient of REG*(1-MARKET) indicates by how much banks which experience regulatory pressure but no market pressure modify their capital and risk levels compared to banks which do not experience either form of pressure. In addition, the specification in Tables 7A to 7C interacts ΔCAP and ΔRISK with REG in order to investigate whether banks with low capital buffers adjust their capital and risk differently from banks with high capital buffers (Heid et al., 2004).

Since most of the control variables in Tables 7A to 7C display the same sign and level of significance as in Tables 6A to 6C, I focus on the variables of interests i.e. the variables interacted with the REG dummy. I start by presenting the results for Canadian, French, Italian and UK banks. Looking at Table 7A, the coefficients of REG*(1-MARKET), REG*MARKET and (1-REG)*MARKET are insignificant, which implies that banks which experienced regulatory and/or market pressure in these four countries did not behave significantly differently from banks which did not experience either form of pressure. The results in Table 7B are quite different. The coefficient of REG*(1-MARKET) is positive and significant in the capital equation but insignificant in the risk equation. *Ceteris paribus*, Japanese banks which experienced regulatory pressure but no market pressure increased their tier 1 capital to assets ratio by 0.4 percentage points more than Japanese banks which did not experience either form of pressure. This estimate represents the true impact of regulatory pressure since it does not include the contribution of market pressure. Interestingly, the coefficient of REG*MARKET is also positive and significant in the capital equation and insignificant the risk equation. *Ceteris paribus*, Japanese banks which experienced both regulatory and market pressures increased their tier 1 ratio by 0.2 percentage points more than Japanese banks which did not experience either form of pressure. An F-test further rejects the null hypothesis that the coefficients of REG*(1-MARKET) and REG*MARKET are equal in the capital equation,[16] meaning that the marginal impact of market pressure on the relationship between REG and ΔCAP is negative and significant. Furthermore, the coefficient of (1-REG)*MARKET is negative and significant in the capital equation, implying that

[16] The test statistic is 7.42 with associated probability of.0.01.

Japanese banks which experienced market pressure but no regulatory pressure lowered their tier 1 capital ratio compared to Japanese banks which did not feel either form of pressure. However, the size of the effect is very small (less than 0.05 percentage points).

Looking at Table 7C, the coefficient of REG*(1-MARKET) is positive and significant in the capital equations but insignificant in the risk equations. *Ceteris paribus*, US banks which experienced regulatory pressure but no market pressure increased their total capital to assets ratio by 0.6 percentage points and their tier 1 capital to assets ratio by 1.2 percentage points more than US banks which did not experience either form of pressure. The coefficient of REG*MARKET is positive and significant in the capital equation and in the risk equation (but only when CAP is defined as the total capital to assets ratio). *Ceteris paribus*, US banks which experienced both regulatory and market pressures increased their total capital to assets ratio by 1.0 percentage points and their credit risk ratio by 2.7 percentage points more than US banks which did not experience either form of pressure. An F-test further fails to reject the null hypothesis that the coefficients of REG*(1-MARKET) and REG*MARKET are equal in the capital equation where CAP is defined as the total capital to assets ratio,[17] meaning that the marginal impact of market pressure on the relationship between REG and ΔCAP is not statistically different from zero. Finally, the coefficient of (1-REG)*MARKET is negative and significant in the risk equation where CAP is defined as the tier 1 capital to assets ratio, implying that US banks which experienced market pressure but no regulatory pressure somehow lowered their risk-taking compared to US banks which did not feel either form of pressure.

To sum up, the results show that regulatory pressure was effective in raising the tier 1 capital to assets ratio and/or the total capital to assets ratio of US and Japanese banks, while preventing them from shifting their portfolio towards riskier assets. This increase in capital to assets ratios reflects the true effect of the Basel standards since the marginal contribution of market pressure in the capital equations is either insignificant or negative. In addition, market pressure appears to have increased the risk-taking of US banks that were undercapitalized but to have lowered the risk-taking of US banks that were adequately capitalized.

With respect to the overall relationship between capital and risk, the results in the lower panel of Tables 7A to 7C only weakly support the hypothesis that undercapitalized

[17] The test statistic is 1.87 with associated probability of.0.17.

banks adjusted their capital and risk differently from well-capitalized banks. In Table 7A, the relationship between capital and risk is mostly insignificant except in the second system of equations, where it is insignificant for well-capitalized banks and negative and significant for undercapitalized banks. In Table 7B, the coefficients of ΔCAP and ΔRISK are positive and significant but the coefficients of these two variables interacted with REG are insignificant, suggesting that the relationship between capital and risk was not different for undercapitalized and well-capitalized Japanese banks. Finally, in Table 7C, the coefficients of ΔCAP, ΔRISK and of these two variables interacted with REG are generally negative and significant, indicating that the relationship between capital and risk was negative both for undercapitalized and well-capitalized US banks. However, the relationship between capital and risk was comparatively more negative for undercapitalized US banks, probably because these banks tried to increase their capital to risk-weighted assets ratios more strongly than well-capitalized banks. Thus, the findings at the bottom of Tables 7A to 7C contrast with Heid et al. (2004), who find a positive relationship between ΔCAP and ΔRISK for well-capitalized banks and a negative relationship between these two variables for undercapitalized banks in Germany.

6 Conclusion

This paper documents the behavior of banks from six G-10 countries toward capital and risk between 1988 and 1995 by using a modified version of the model developed by Shrieves and Dahl (1992). Prior research, both at the theoretical and empirical levels, indicates that banks may well respond to an increase in capital requirements by a corresponding increase in the credit risk of their portfolio.

The evidence presented here shows that the impact of the 1988 Basel standards was not uniform across countries. In Canada, Japan, the UK and the US, banks within one standard deviation of the minimum regulatory capital requirement improved their tier 1 capital to assets ratio and/or their total capital to assets ratios in order to comply with the new capital adequacy rules. However, regulatory pressure had no impact on the capital to assets ratios of French and Italian banks. The results also show that G-10 banks experiencing regulatory pressure did not modify their credit risk exposure, which suggests that banks that had to raise their capital adequacy ratios drastically did not substitute away from riskier assets or engage in riskier activities. Interestingly, the above findings are robust to the inclusion of a variable which measures the marginal contribution that market pressure had on banks' capital and risk levels. Thus, it is regulatory pressure - i.e. the extent to which prudential authorities threaten to or actually impede banks' operations - and not market discipline which was effective in raising banks' capital buffers across the G-10. In addition, changes in capital and risk were unrelated for Canadian, French, Italian and UK banks, positively related for Japanese banks and negatively related for US banks over the 1988-95 period. These results hold both for adequately capitalized and undercapitalized banks.

All in all, the evidence presented here indicates that the 1988 Basel Accord was generally effective in increasing capital buffers and preventing banks from engaging in riskier activities. These findings have important policy implications for regulators as they suggest that the use of risk buckets to assess and limit credit risk-taking is likely to produce the desired effect. This framework is currently being refined under the standardized approach to credit risk in the New Basel Accord.[18] This approach is likely to be adopted by many G-10 banks which do not have the resources to use one of the more advanced internal ratings-based approaches (Basel Committee, 2004).

Three caveats are in order, however. First, as pointed out earlier, results for US banks should be interpreted with care given that the implementation of the second stage of the Basel Accord coincides with the passage of FDICIA. Thus, it is difficult to assess the impact of the Basel standards in the US and the regulatory pressure variable used in this study should be interpreted as reflecting the effect of capital regulation in a broad sense. Second, banks may have attempted to arbitrage between economic capital and regulatory capital by either boosting capital ratios through cosmetic arrangements or by exploiting shortcomings in the measure of credit risk. Although the lack of data prevents measuring the extent to which these techniques were used by banks in the 1990s (Basel Committee, 1999), one should be aware that observed changes in capital and risk may only partially reflect actual changes in capital and risk. Third, the paper analyzes credit risk in isolation from other types of risks, like market risk or interest rate risk. It could be that undercapitalized banks chose not to modify their portfolio risk in order to

[18] Under the standardized approach to credit risk, wholesale exposures are assigned to five risk buckets (from 0% to 150%) according to the nature of the claim and the assessment of external agencies, while retail exposures receive a 75% risk weight. The internal ratings-based approaches allow banks to determine their own risk weights through the combination of their quantitative inputs and formulas specified by the Basel Committee.

comply with the Basel guidelines, but increased their interest or market exposure. However, evidence on the existence of such a trade-off is scarce.[19] Moreover, the fact that credit risk is still the biggest risk faced by banks strengthens confidence in the conclusion that undercapitalized banks did not become riskier in the first half of the 1990s.

[19] This is mainly due to a lack of data. Typically, estimating interest-risk exposure requires data on the duration of banks' assets. This information is almost impossible to obtain on a standardized cross-country basis. In the case of the US, Allen et al. (1996) provide some evidence that substitution of unpriced interest rate risk for priced credit risk did occur. However, they do not allow for other features of banks' books, which makes their results difficult to interpret.

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Table 1: Previous studies on the impact of capital adequacy regulation on bank capitalization and credit risk-taking

Author(s) (Year of Publication)	Sample and period	Impact of regulatory pressure on ΔCAP	Impact of regulatory pressure on ΔRISK	Relationship between ΔCAP and ΔRISK
Jacques and Nigro (1997)	2,570 US commercial banks with assets > $100 million over 2 years (1990-91) – First step in the implementation process	+ for A 0 / – for U	– for A 0 for U	mostly 0
Aggarwal and Jacques (1997)	2,849 US commercial banks with assets > $100 million over 3 years (1991-93) – Second step in the implementation process	+ for A in 93 + for U	+ in 91 / – in 92-93 for A and U	– in 91-92 / + in 93
Ediz et al. (1998)	94 UK banks over 25 quarters (4th quarter 1989 - 4th quarter 1995)	+ for U	0 for U	not studied
Rime (2001)	154 Swiss banks over 7 years (1989-95)	0 for A + for U	0 for A and U	0 / +
Aggarwal and Jacques (2001)	1,685 US commercial banks with assets > $100 million over 6 years (1991-96)	+ for A and U	+ in 91 / 0 in 92 / – in 93-96 for A and U	+ and – in 91-92 / + in 93-96
Heid et al. (2004)	570 local German savings banks over 8 years (1993-2000)	Mostly 0	Mostly 0	+ for A – for U

Note: +: significantly positive; –: significantly negative; 0: insignificant.
A: adequately capitalized banks; U: undercapitalized banks.

Table 2: Representativeness of the sample

Country	Number of banks	Number of banks from the national top-10 [a]	Sample bank assets / Total national banking assets [a]
Canada	7	7	0.92
France	9	7	0.49
Italy	16	9	0.74
Japan	76	9	0.84
United Kingdom	9	6	0.70
United States	459	10	0.91

Note: [a] As of December 1995

Table 3A: Total capital to assets ratio (K/A) in % – number of observations in parenthesis

	1988	1989	1990	1991	1992	1993	1994	1995
Canada	6.94 (6)	7.02 (7)	7.03 (7)	7.38 (7)	7.19 (7)	7.35 (7)	7.11 (7)	6.05 (7)
France	4.27 (1)	3.93 (5)	4.24 (8)	4.58 (9)	4.76 (9)	5.03 (9)	5.25 (7)	5.10 (7)
Italy	-	5.65 (1)	5.79 (2)	5.79 (6)	5.63 (10)	5.58 (14)	6.28 (16)	6.36 (14)
Japan	-	-	6.58 (5)	6.08 (11)	7.02 (11)	7.12 (11)	6.60 (11)	6.65 (11)
United Kingdom	8.90 (1)	8.01 (5)	8.70 (6)	8.73 (7)	7.98 (8)	8.43 (8)	8.43 (9)	8.20 (9)
United States	-	8.54 (1)	7.49 (157)	7.71 (157)	8.35 (453)	8.83 (457)	8.76 (430)	9.25 (399)
All countries	6.85 (8)	6.48 (19)	7.33 (185)	7.44 (197)	8.18 (498)	8.61 (506)	8.54 (480)	8.96 (447)

Table 3B: Tier 1 capital to assets ratio (K/A) in % – number of observations in parenthesis

	1988	1989	1990	1991	1992	1993	1994	1995
Canada	4.74 (6)	4.88 (7)	4.91 (7)	5.09 (7)	4.96 (7)	4.96 (7)	4.84 (7)	4.77 (7)
France	2.29 (1)	2.72 (4)	2.51 (8)	2.62 (9)	2.86 (9)	2.94 (9)	3.04 (7)	3.06 (7)
Italy	-	4.22 (1)	4.93 (2)	4.70 (6)	4.48 (9)	4.40 (14)	4.97 (16)	5.18 (13)
Japan	3.25 (37)	3.62 (51)	3.78 (74)	3.84 (75)	4.08 (76)	4.13 (76)	4.20 (76)	4.11 (72)
United Kingdom	4.89 (1)	4.69 (5)	5.11 (6)	5.31 (7)	4.59 (7)	5.17 (8)	5.42 (9)	5.32 (9)
United States	-	5.07 (1)	5.54 (3)	6.35 (157)	7.14 (453)	7.57 (457)	7.40 (430)	7.81 (399)
All countries	3.46 (45)	3.80 (69)	3.91 (100)	5.40 (261)	6.55 (561)	6.90 (571)	6.76 (545)	7.07 (507)

Table 3C: Credit risk ratio (RWA/A) in % – number of observations in parenthesis

	1988	1989	1990	1991	1992	1993	1994	1995
Canada	97.65 (6)	93.27 (7)	89.40 (7)	83.59 (7)	79.78 (7)	74.58 (7)	71.64 (7)	68.37 (7)
France	71.70 (1)	55.59 (5)	58.57 (8)	58.82 (9)	58.64 (9)	57.16 (9)	54.59 (7)	53.06 (7)
Italy	-	58.08 (1)	55.89 (2)	57.45 (6)	60.13 (9)	55.48 (14)	54.60 (16)	57.48 (13)
Japan	66.78 (37)	68.45 (51)	67.81 (74)	68.23 (75)	69.78 (76)	68.72 (76)	68.36 (76)	67.95 (72)
United Kingdom	75.17 (1)	79.33 (4)	76.30 (6)	74.02 (7)	65.62 (8)	65.00 (8)	62.72 (9)	61.57 (9)
United States	-	92.12 (1)	85.80 (3)	78.96 (156)	69.96 (418)	69.30 (444)	70.89 (428)	72.93 (397)
All countries	71.19 (45)	70.86 (69)	69.39 (100)	74.66 (260)	69.64 (527)	68.68 (558)	69.72 (543)	71.28 (505)

Table 3D: Total capital ratio (K/RWA) in % – number of observations in parenthesis

	1988	1989	1990	1991	1992	1993	1994	1995
Canada	7.14 (6)	7.59 (7)	7.89 (7)	8.86 (7)	9.01 (7)	9.84 (7)	9.94 (7)	9.91 (7)
France	6.00 (1)	7.03 (7)	7.34 (9)	7.72 (9)	8.26 (9)	8.80 (9)	9.65 (9)	9.41 (9)
Italy	10.02 (1)	8.84 (3)	8.97 (6)	9.75 (8)	9.32 (11)	10.15 (14)	11.69 (16)	11.33 (16)
Japan	9.24 (37)	8.61 (51)	8.93 (74)	8.49 (75)	9.23 (76)	9.60 (76)	9.24 (76)	9.58 (72)
United Kingdom	10.95 (2)	9.91 (6)	11.31 (7)	12.16 (7)	12.22 (9)	12.59 (9)	13.71 (9)	13.55 (9)
United States	-	9.30 (1)	8.90 (3)	10.08 (156)	12.30 (418)	13.10 (444)	12.63 (429)	13.01 (399)
All countries	8.99 (47)	8.49 (75)	8.88 (106)	9.56 (262)	11.68 (530)	12.43 (559)	12.06 (546)	12.38 (512)

Table 3E: Tier 1 ratio (K/RWA) in % – number of observations in parenthesis

	1988	1989	1990	1991	1992	1993	1994	1995
Canada	4.84 (6)	5.33 (7)	5.54 (7)	6.07 (7)	6.23 (7)	6.67 (7)	6.76 (7)	6.97 (7)
France	3.20 (1)	4.34 (5)	4.41 (8)	4.58 (8)	5.11 (8)	5.41 (8)	5.95 (8)	5.89 (8)
Italy	8.88 (1)	7.31 (3)	7.76 (4)	7.85 (8)	7.37 (10)	8.00 (14)	9.28 (16)	8.96 (14)
Japan	4.91 (37)	5.30 (51)	5.61 (74)	5.66 (75)	5.89 (76)	6.07 (76)	6.21 (76)	6.12 (72)
United Kingdom	6.05 (2)	5.72 (6)	6.68 (7)	7.47 (7)	7.14 (8)	7.72 (9)	8.85 (9)	8.89 (9)
United States	-	5.50 (1)	6.47 (3)	8.37 (156)	10.56 (418)	11.34 (444)	10.79 (429)	11.13 (399)
All countries	5.00 (47)	5.36 (73)	5.69 (103)	7.37 (261)	9.63 (527)	10.34 (558)	9.95 (545)	10.19 (509)

Table 4: Decomposition of the average annual growth rate of CAR for the period 1988-95 (%)

Panel A: CAR = Total capital ratio; K = Total capital

	$\frac{\Delta CAR_t}{CAR_t}$	$\frac{\Delta K_t}{K_t}$	$\frac{\Delta RISK_t}{RISK_t}$	$\frac{\Delta A_t}{A_t}$	Number of observations
Canada	4.56	8.67	-4.23	8.33	48
France	4.55	7.76	-1.57	4.77	46
Italy	-1.68	1.92	0.75	2.85	45
Japan	1.55	5.02	0.32	3.15	49
United Kingdom	3.16	4.96	-4.04	5.85	43
United States	3.34	13.93	0.68	9.91	1,385
All countries	3.14	12.48	0.33	9.01	1,616

Panel B: CAR = Tier 1 ratio; K = Tier 1 capital

	$\frac{\Delta CAR_t}{CAR_t}$	$\frac{\Delta K_t}{K_t}$	$\frac{\Delta RISK_t}{RISK_t}$	$\frac{\Delta A_t}{A_t}$	Number of observations
Canada	4.56	8.67	-4.23	8.33	48
France	5.47	8.50	-2.00	5.03	40
Italy	-5.01	-1.40	0.75	2.85	45
Japan	2.24	9.32	0.26	6.82	461
United Kingdom	3.98	5.98	-3.91	5.90	42
United States	3.00	13.59	0.68	9.91	1,385
All countries	2.71	11.72	0.32	8.69	2,021

Table 5: Percentage of observations with CAR < Threshold

Panel A: Threshold = minimum capital requirements + one bank-specific standard deviation

	CAR = Total capital ratio				CAR = Tier 1 capital ratio			
	Total obs.		Undercap. obs.		Total obs.		Undercap. obs.	
Canada	48	(100)	30	(62.5)	48	(100)	8	(16.7)
France	53	(100)	38	(71.7)	46	(100)	18	(39.1)
Italy	59	(100)	22	(37.3)	56	(100)	5	(8.9)
Japan	465	(100)	146	(31.4)	465	(100)	37	(8.0)
United Kingdom	49	(100)	4	(8.2)	48	(100)	4	(8.3)
United State	1,451	(100)	123	(8.5)	1,451	(100)	30	(2.1)
All countries	2,125	(100)	363	(17.08)	2,114	(100)	102	(4.82)

Panel B: Threshold = minimum capital requirements

	CAR = Total capital ratio				CAR = Tier 1 capital ratio			
	Total obs.		Undercap. obs.		Total obs.		Undercap. obs.	
Canada	48	(100)	14	(29.2)	48	(100)	1	(2.1)
France	53	(100)	19	(35.9)	46	(100)	6	(13.0)
Italy	59	(100)	8	(13.6)	56	(100)	1	(1.8)
Japan	465	(100)	31	(6.7)	465	(100)	12	(2.6)
United Kingdom	49	(100)	1	(2.0)	48	(100)	0	(0.0)
United State	1,451	(100)	17	(1.2)	1,451	(100)	2	(0.1)
All countries	2,125	(100)	90	(4.24)	2,114	(100)	22	(1.04)

Table 6A: Baseline specification (non-US and non-Japanese banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Year dummies	1990	-0.410	-2.977	-0.280	-3.161*
		(1.02)	(1.62)	(0.99)	(1.69)
	1991	0.081	-4.068**	0.014	-3.227
		(0.20)	(2.15)	(0.05)	(1.59)
	1992	-0.156	-5.650***	-0.305	-5.358***
		(0.39)	(3.26)	(1.05)	(2.80)
	1993	0.095	-5.866***	-0.156	-6.094***
		(0.23)	(3.34)	(0.52)	(3.30)
	1994	0.136	-7.552***	-0.062	-7.459***
		(0.30)	(4.40)	(0.19)	(4.12)
	1995	-0.257	-6.198***	-0.200	-6.435***
		(0.62)	(3.43)	(0.68)	(3.42)
Country dummies	Canada	0.539	4.860	1.187*	4.887
		(0.57)	(1.17)	(1.71)	(1.07)
	France	1.692*	9.205**	1.553**	8.516**
		(1.71)	(2.37)	(2.31)	(2.04)
	Italy	1.595*	8.645**	1.548**	8.400**
		(1.69)	(2.35)	(2.30)	(2.08)
	UK	1.296	6.330*	1.224*	6.357
		(1.38)	(1.70)	(1.86)	(1.53)
Regulatory pressure Country dummies*	REG * Canada	0.781***	0.013	0.234	1.878
		(2.60)	(0.01)	(0.90)	(1.00)
	REG * France	-0.048	-2.088	0.016	-1.463
		(0.15)	(1.59)	(0.07)	(1.02)
	REG * Italy	-0.266	-1.319	-0.428	1.433
		(0.92)	(1.03)	(1.21)	(0.54)
	REG * UK	0.898*	-3.262	0.298	-2.811
		(1.92)	(1.28)	(0.88)	(1.21)
Control variables	SIZE	-0.136**	0.033	-0.107**	0.032
		(2.23)	(0.13)	(2.33)	(0.12)
	LOANS	0.018*	0.159***	0.007	0.157***
		(1.79)	(4.51)	(0.97)	(4.23)
	LLOSS	-0.117	-0.451	-0.098	-1.033
		(0.61)	(0.58)	(0.73)	(1.24)
	ROA	0.615***		0.468***	
		(3.50)		(3.24)	
	GROWTH	0.052	0.619**	0.035	0.770***
		(0.80)	(2.38)	(0.71)	(2.88)
	CAP(-1)	-0.168***		-0.135***	
		(2.87)		(3.02)	
	ΔRISK	-0.012		-0.020	
		(0.27)		(0.63)	
	RISK(-1)		-0.185***		-0.185***
			(5.70)		(5.31)
	ΔCAP		1.124		0.194
			(0.98)		(0.10)
R-squared		0.258	0.530	0.149	0.476
Number of observations		179	179	173	173

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6B: Baseline specification (Japanese banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Constant		-13.862	-13.180**	0.141	-6.750***
		(1.20)	(2.34)	(0.83)	(5.32)
Year dummies	1993	-1.427	-1.441	-0.024	-2.157***
		(0.74)	(1.11)	(0.47)	(8.06)
	1994	-0.786	-0.290	0.004	-1.727***
		(0.64)	(0.26)	(0.10)	(6.86)
	1995	-0.619	-0.248	-0.055	-1.270***
		(0.52)	(0.24)	(1.64)	(4.15)
Regulatory pressure	REG	1.079	1.216	0.255***	-0.068
		(0.62)	(0.95)	(6.79)	(0.18)
Control variables	SIZE	1.011	0.836**	-0.004	0.664***
		(1.37)	(2.21)	(0.44)	(7.22)
	LOANS	0.158*	0.113*	0.004**	0.154***
		(1.71)	(1.91)	(2.11)	(7.23)
	LLOSS	-0.307	-0.475	-0.001	0.019
		(0.47)	(1.11)	(0.33)	(0.68)
	ROA	-0.330		0.591***	
		(0.86)		(10.70)	
	GROWTH	0.387	0.752*	-0.027***	-0.039
		(0.51)	(1.89)	(3.75)	(0.68)
	CAP(-1)	-1.321**		-0.079***	
		(2.54)		(4.45)	
	ΔRISK	-0.908		0.040**	
		(0.99)		(2.49)	
	RISK(-1)		-0.065		-0.139***
			(1.58)		(6.45)
	ΔCAP		0.314		1.566**
			(1.00)		(2.32)
R-squared		0.052	0.601	0.496	0.326
Number of observations		48	48	455	455

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%
Year dummies for 1990, 1991 and 1992 are not included because of a lack of data

Table 6C: Baseline specification (US banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Constant		1.665	-3.203	1.825	-2.548
		(1.35)	(0.59)	(1.57)	(0.47)
Year dummies	1992	-1.484	-7.076	-0.949	-7.256
		(0.61)	(0.66)	(0.42)	(0.70)
	1993	-1.073	-3.857	-0.522	-3.537
		(0.51)	(0.41)	(0.26)	(0.39)
	1994	-2.621	-8.629	-1.574	-8.163
		(0.85)	(0.63)	(0.54)	(0.61)
	1995	-0.961	-2.554	-0.396	-2.243
		(0.44)	(0.26)	(0.19)	(0.24)
Regulatory pressure	REG	0.931***	0.096	1.523***	1.576
		(5.15)	(0.09)	(5.50)	(0.96)
Control variables	SIZE	-0.078**	0.498***	-0.072**	0.480***
		(2.12)	(2.76)	(2.07)	(2.70)
	LOANS	0.006*	0.164***	0.002	0.156***
		(1.86)	(9.93)	(0.66)	(9.43)
	LLOSS	0.010	-0.070	0.008	-0.070
		(0.79)	(1.32)	(0.71)	(1.34)
	ROA	0.152***		0.141***	
		(3.97)		(3.87)	
	GROWTH	0.743	3.321	0.417	3.145
		(1.20)	(1.21)	(0.71)	(1.18)
	CAP(-1)	-0.170***		-0.161***	
		(7.79)		(7.93)	
	ΔRISK	-0.065***		-0.076***	
		(2.91)		(3.80)	
	RISK(-1)		-0.174***		-0.174***
			(10.44)		(10.89)
	ΔCAP		-1.387**		-1.596***
			(2.35)		(2.75)
R-squared		0.091	0.093	0.115	0.053
Number of observations		1,345	1,345	1,345	1,345

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%
Year dummies for 1990 and 1991 are not included because of a lack of data

Table 7A: Alternative specification (non-US and non-Japanese banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Year dummies	1990	-0.317	-6.248*	-0.284	-3.984*
		(0.89)	(1.87)	(0.95)	(1.86)
	1991	-0.130	-6.025*	-0.051	-5.171**
		(0.36)	(1.69)	(0.17)	(2.30)
	1992	-0.044	-9.200***	-0.355	-6.378***
		(0.12)	(2.76)	(1.18)	(2.89)
	1993	0.038	-8.485***	-0.231	-7.613***
		(0.11)	(2.61)	(0.75)	(3.68)
	1994	0.308	-9.933***	-0.167	-8.614***
		(0.76)	(3.04)	(0.51)	(4.14)
	1995	-0.186	-10.891***	-0.291	-7.900***
		(0.50)	(3.04)	(0.97)	(3.72)
Country dummies	Canada	0.741	10.866	1.083	2.845
		(0.90)	(1.35)	(1.53)	(0.50)
	France	1.167	14.888**	1.496**	6.283
		(1.46)	(1.98)	(2.23)	(1.21)
	Italy	0.947	14.622*	1.433**	6.130
		(1.15)	(1.90)	(2.06)	(1.18)
	UK	1.219	12.325	1.110	3.963
		(1.50)	(1.60)	(1.63)	(0.73)
Regulatory pressure and market pressure	REG * (1-MARKET)	-0.056	-0.605	0.008	-3.027
		(0.17)	(0.02)	(0.02)	(0.85)
	REG * MARKET	0.113	-1.887	-0.105	-1.870
		(0.42)	(0.71)	(0.46)	(1.12)
	(1-REG) * MARKET	0.026	-1.972	0.006	-1.728
		(0.12)	(0.88)	(0.03)	(1.25)
Control variables	SIZE	-0.100*	0.073	-0.104**	0.417
		(1.71)	(0.12)	(2.05)	(1.00)
	LOANS	0.009	0.245***	0.008	0.187***
		(1.03)	(3.39)	(1.17)	(4.21)
	LLOSS	0.049	-2.680**	-0.075	-1.721*
		(0.26)	(1.96)	(0.52)	(1.94)
	ROA	0.591***		0.536***	
		(3.90)		(3.96)	
	GROWTH	-0.042	0.544	0.040	0.606**
		(0.73)	(1.10)	(0.89)	(2.05)
	CAP(-1)	-0.096*		-0.133***	
		(1.94)		(3.01)	
	ΔRISK	0.132*		-0.006	
		(1.78)		(0.15)	
	ΔRISK * REG	-0.139**		-0.068**	
		(2.25)		(2.19)	
	RISK(-1)		-0.270***		-0.191***
			(3.95)		(4.73)
	ΔCAP		-3.638		1.206
			(0.85)		(0.43)
	ΔCAP * REG		-0.196		-4.960*
			(0.05)		(1.85)
R-squared		0.376	0.252	0.175	0.495
Number of observations		179	179	173	173

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Table 7B: Alternative specification (Japanese banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Constant		-6.764***	-18.244***	0.145	-6.451***
		(3.26)	(2.97)	(0.88)	(4.99)
Year dummies	1993	-0.469	-1.246	-0.033	-2.175***
		(0.95)	(0.88)	(0.62)	(8.02)
	1994	-0.534	-0.340	-0.002	-1.749***
		(1.35)	(0.30)	(0.06)	(6.86)
	1995	-0.345	-0.194	-0.054	-1.329***
		(0.82)	(0.19)	(1.59)	(4.30)
Regulatory pressure and market pressure	REG * (1-MARKET)	-	-	0.365***	-0.738
		-	-	(5.26)	(1.08)
	REG * MARKET	-0.354	-0.199	0.174***	-0.380
		(0.70)	(0.10)	(3.28)	(0.81)
	(1-REG) * MARKET	-0.504***	-1.543*	-0.045**	-0.261
		(1.99)	(1.77)	(1.97)	(1.33)
Control variables	SIZE	0.645***	1.467***	-0.001	0.676***
		(4.42)	(3.09)	(0.15)	(7.09)
	LOANS	0.097***	0.162***	0.004**	0.158***
		(5.38)	(2.89)	(2.11)	(7.53)
	LLOSS	0.058	-0.205	-0.001	0.020
		(0.36)	(0.48)	(0.24)	(0.71)
	ROA	-0.225		0.619***	
		(0.60)		(10.91)	
	GROWTH	-0.039	0.749	-0.029***	-0.041
		(0.26)	(1.49)	(3.97)	(0.71)
	CAP(-1)	-1.057***		-0.078***	
		(9.57)		(4.22)	
	ΔRISK	-0.302**		0.038**	
		(2.51)		(2.11)	
	ΔRISK * REG	0.162		-0.004	
		(1.16)		(0.15)	
	RISK(-1)		-0.133***		-0.146***
			(3.10)		(6.77)
	ΔCAP		0.216		1.330**
			(0.67)		(1.97)
	ΔCAP * REG		0.195		0.708
			(0.15)		(0.71)
R-squared		0.685	0.608	0.513	0.356
Number of observations		48	48	455	455

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%
Year dummies for 1990, 1991 and 1992 are not included because of a lack of data

Table 7C: Alternative specification (US banks)

		CAP = Total capital to assets ratio		CAP = Tier 1 capital to assets ratio	
		ΔCAP	ΔRISK	ΔCAP	ΔRISK
Constant		1.754	-2.259	2.592**	-2.073
		(1.44)	(0.41)	(2.36)	(0.40)
Year dummies	1992	-1.522	-7.195	-0.307	-7.030
		(0.64)	(0.68)	(0.14)	(0.70)
	1993	-1.101	-3.860	-0.121	-3.239
		(0.53)	(0.42)	(0.06)	(0.37)
	1994	-2.727	-8.727	-0.935	-7.481
		(0.89)	(0.64)	(0.34)	(0.58)
	1995	-1.026	-2.567	-0.021	-1.941
		(0.47)	(0.27)	(0.01)	(0.21)
Regulatory pressure and market pressure	REG * (1-MARKET)	0.641***	0.632	1.180***	0.843
		(3.06)	(0.62)	(3.54)	(0.94)
	REG * MARKET	1.024***	2.665**	0.567	0.046
		(4.08)	(2.16)	(1.19)	(0.09)
	(1-REG) * MARKET	0.059	0.504	-0.018	-0.789***
		(0.60)	(1.15)	(0.21)	(2.67)
Control variables	SIZE	-0.089**	0.397**	-0.147***	0.390**
		(2.20)	(2.05)	(4.00)	(2.14)
	LOANS	0.005	0.168***	-0.002	0.157***
		(1.59)	(10.14)	(0.65)	(9.91)
	LLOSS	0.012	-0.064	0.011	-0.066
		(1.00)	(1.21)	(0.98)	(1.31)
	ROA	0.152***		0.173***	
		(3.84)		(4.57)	
	GROWTH	0.767	3.354	0.249	3.006
		(1.25)	(1.23)	(0.45)	(1.17)
	CAP(-1)	-0.168***		-0.201***	
		(7.69)		(9.58)	
	ΔRISK	-0.044*		-0.044**	
		(1.74)		(2.44)	
	ΔRISK * REG	-0.058**		-0.101***	
		(2.19)		(2.99)	
	RISK(-1)		-0.182***		-0.175***
			(10.89)		(11.37)
	ΔCAP		-1.459**		-1.301***
			(2.31)		(2.70)
	ΔCAP * REG		-0.555		-1.764***
			(0.81)		(2.69)
R-squared		0.130	0.030	0.347	0.312
Number of observations		1,345	1,345	1,345	1,345

Note: Absolute t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%
Year dummies for 1990 and 1991 are not included because of a lack of data

Figure 1: Median of the equity to assets ratio

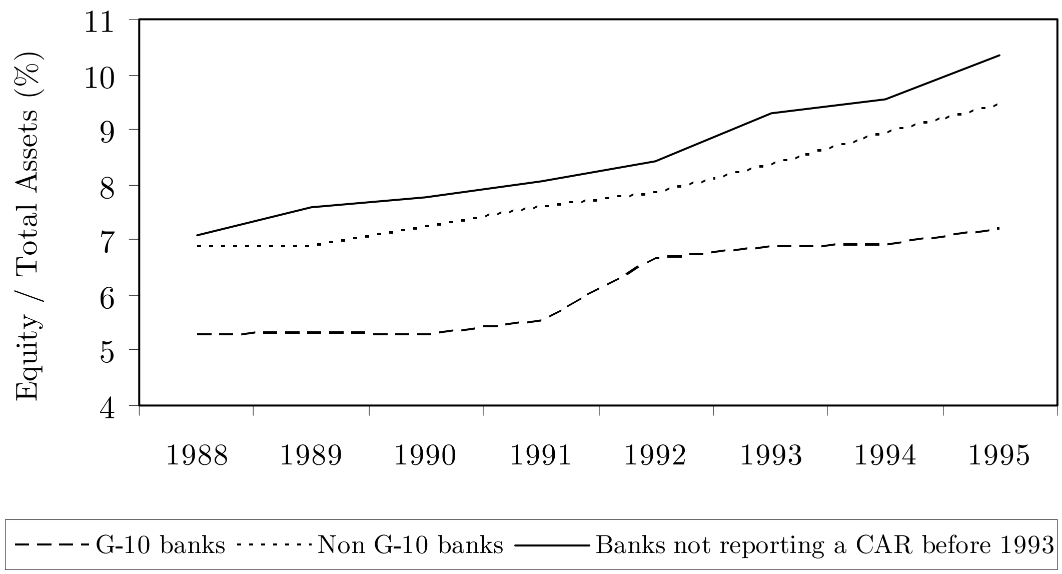
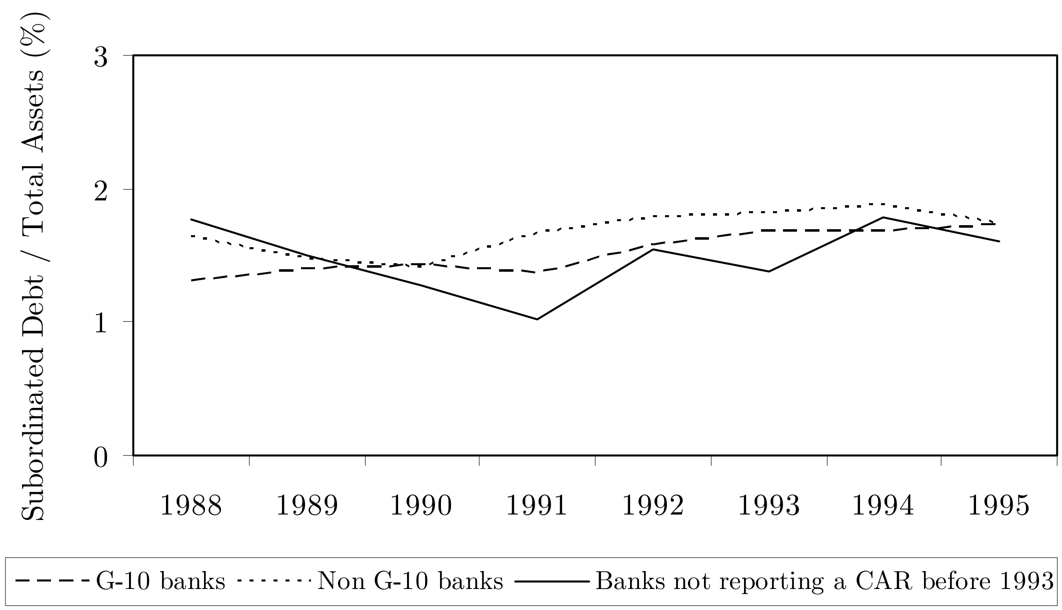


Figure 2: Median of the subordinated debt to assets ratio



Source: Bankscope, update 77 (December 1996)

Appendix

Table 1A: The 1988 Basel Accord (transitional and implementing arrangements)

		End-1990	End-1992
1.	Total capital ratio	7.25 %	8 %
2.	Tier 1 ratio	3.25 %	4%
3.	Limit on general provision (or general loan loss reserves) in Tier 2 capital [a]	Maximum 1.5 % or, exceptionally, up to 2% of Tier 2 capital	Maximum 1.5 % or, exceptionally and temporarily, up to 2% of Tier 2 capital
4.	Limit on term subordinated debt in Tier 2 capital	No limit (at discretion)	Maximum 50% of Tier 1 capital
5.	Deduction for goodwill	Deducted from Tier 1 capital (at discretion)	Deducted from Tier 1 capital

Note: [a] In the event that no agreement was reached on the definition of unencumbered resources eligible for inclusion in Tier 2 capital

Source: Basel Committee on Banking Supervision (1988)

Table 2A: Summary statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
ΔCAP	1,566	0.32	1.40	-11.51	18.71
CAP(-1)	1,566	8.28	2.20	1.69	29.18
ΔTIER	1,973	0.21	1.15	-12.26	17.06
TIER(-1)	1,973	6.21	2.20	1.04	22.59
ΔRISK	1,973	0.19	5.53	-54.43	40.06
RISK(-1)	1,973	70.15	14.33	23.88	147.45
REG	1,973	0.17	0.38	0	1
MARKET	1,973	0.52	0.50	0	1
SIZE	1,973	8.91	1.58	4.38	13.63
LOANS	1,973	61.84	13.68	0.08	98.37
LLOSS	1,973	0.64	3.14	-5.70	99.67
ROA	1,973	0.88	0.87	-4.04	9.37
GROWTH	1,973	2.07	1.35	-3.98	5.17

Note: CAP = Total capital to assets ratio; TIER = Tier 1 capital to assets ratio
All variables in % except SIZE (log of total assets) and REG and MARKET

Proof of equation (5)

As $CAR_{i,t} = \frac{K_{i,t}}{RWA_{i,t}}$ and $RISK_{i,t} = \frac{RWA_{i,t}}{A_{i,t}}$

We have that $CAR_{i,t} = \frac{K_{i,t}}{RISK_{i,t}.A_{i,t}}$

Taking logs and differentiating with respect to time:

$$\frac{dlog(CAR_{i,t})}{dt} = \frac{dlog(K_{i,t})}{dt} - \left[\frac{dlog(RISK_{i,t})}{dt} + \frac{dlog(A_{i,t})}{dt}\right]$$

We obtain easily that $\frac{\dot{CAR}_{i,t}}{CAR_{i,t}} = \frac{\dot{K}_{i,t}}{K_{i,t}} - \frac{\dot{RISK}_{i,t}}{RISK_{i,t}} - \frac{\dot{A}_{i,t}}{A_{i,t}}$

Note that equation (5) uses discrete time changes rather than time derivatives and is therefore only an approximation of the correct formula for the growth rate of capital adequacy ratios.