Capital Requirements and Bank Behavior in the Early 1990s: Cross-Country Evidence*

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This paper uses a simultaneous-equations model to investigate how banks from six G-10 countries adjusted their capital and their risk-weighted assets after the passage of the 1988 Basel Accord. In particular, the analysis tests whether weakly capitalized banks increased their capital or decreased their risk-weighted assets more rapidly than did well-capitalized banks. If so, did market discipline play a significant role? The results suggest that only in the United States were weakly capitalized banks observed to increase their capital ratios faster than well-capitalized banks; however, the weakly capitalized U.S. banks did not modify their risk-weighted assets at different rates from other U.S. banks. In addition, market discipline appears to have played an essential role: weakly capitalized U.S. banks that did not also face market pressure did not increase their capital ratios faster than other U.S. banks. This suggests that market pressure was an important factor in the capital build-up of the early 1990s.

JEL Codes: G21, G28.

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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 1988 Basel Accord that set minimum capital standards for internationally active banks. The Basel guidelines were initially adopted by the central banking authorities from the G-10 countries. Their implementation started in 1989 and was completed four 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 some G-10 countries. Second, and connected to this, it aimed at promoting financial stability by linking the required amount of capital to a measure of the bank's risk-weighted assets. However, the relatively simple approach to calculating risk-weighted assets had the potential for distorting incentives for bank risk taking.

Twenty years after the adoption of the 1988 Basel standards, though still at the beginning of the implementation of the Basel II framework, 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, especially those whose initial ratios fell close to the minimum of the requirements? For banks that increased their capital adequacy ratios, did regulatory pressure play a greater role than market discipline? Analysis of how G-10 banks respond to capital standards is important given that some parts of the Basel II framework—e.g., the standardized approach to credit risk—represent a refinement of the 1988 standards.

The lack of answers to the questions raised above is mainly due to data limitations. Indeed, data on capital and credit risk of G-10 banks are often confidential or hard to obtain on a standardized cross-country basis. Existing studies on the impact of the 1988 Basel Accord focus on Japan, Switzerland, the United Kingdom, and the United States, 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 bank capital requirements in a number of G-10 countries for which studies have not yet been undertaken.

More precisely, this paper uses the simultaneous-equations model developed by Shrieves and Dahl (1992) to analyze adjustments in capital and credit risk at banks from six G-10 countries (Canada, France, Italy, Japan, the United Kingdom, and the United States) between 1988 and 1995. Credit risk, which is defined as the ratio of risk-weighted assets to total assets, is the only type of risk analyzed here since it was the main focus of the 1988 Basel Accord.[1]

Shrieves and Dahl's model has been used by several other studies documenting the impact of capital requirements on bank capital and credit risk, including Aggarwal and Jacques (1997, 2001) and Jacques and Nigro (1997) for the United States, and Rime (2001) for Switzerland.[2] These studies find little evidence that weakly capitalized banks adjust their ratio of risk-weighted assets to total assets following the introduction of bank capital requirements, but they find support for the hypothesis that these banks increase their capital-to-assets ratios faster than well-capitalized banks. The latter result is consistent with increased pressure from regulators or market participants following the introduction of bank capital requirements (Basel Committee on Banking Supervision 1999). However, the above-mentioned studies do not distinguish between both types of pressures, and they interpret their results as a sign of increased regulatory pressure.

In addition to focusing on a different set of countries, this paper contributes to the existing literature on the effects of capital requirements by disentangling the impact of regulatory and market pressures on bank capital and credit risk taking. In the analysis, regulatory pressure is measured by a dummy variable equal to one if a bank's capital ratio falls below some threshold and zero otherwise, while market pressure is measured by a dummy variable equal to one if a bank is listed or rated and zero otherwise.

[1] It is possible that G-10 banks modified other risks, such as interest or market risk, following the introduction of the Basel capital requirements. However, there is little empirical evidence on this (Basel Committee on Banking Supervision 1999).

[2] In the United States, it is difficult to distinguish between the effects of the 1988 Basel standards and the effects of the Federal Deposit Insurance Corporation Improvement Act (FDICIA), which was passed three years later.

Identifying the impact of regulatory and market pressures on bank capital and credit risk is not only important in the context of the 1988 capital adequacy rules but is also relevant for the Basel II framework. Indeed, the first pillar of the New Accord (minimum capital requirements) is supplemented by two other pillars, where the third (market discipline) is intended to promote higher disclosure standards and reinforce market pressure on banks to hold adequate capital ratios. However, very little is known about the effectiveness of market discipline in complementing regulatory pressure in order to increase capital and decrease risk taking among banks.

Consistent with the existing literature, this paper finds that, ceteris paribus, weakly capitalized U.S. banks increased their total capital ratio faster than did well-capitalized U.S. banks in the early 1990s. However, and contrary to previous studies, the analysis suggests that this increase was due to both regulatory and market pressures rather than regulatory pressure alone.

As regards the other G-10 countries included in the study, little evidence is found that weakly capitalized banks raised their capital-to-assets ratios at a faster rate than well-capitalized banks. In addition, no evidence is found that U.S. or non-U.S. weakly capitalized banks modified their ratio of risk-weighted assets to total assets differently from well-capitalized banks.

Taken as a whole, these results suggest that the effectiveness of the 1988 bank capital requirements to increase capital and/or reduce credit risk was rather limited outside the United States, where it reflected both regulatory and market pressures.

The remainder of the paper is organized as follows. Section 2 briefly reviews the literature on the impact of capital requirements on bank capital and credit risk and summarizes the 1988 capital standards. Section 3 presents the data used in the analysis, while section 4 describes the methodology. Results are presented in section 5 and conclusions are drawn in section 6.

2. Capital Requirements and Bank Behavior

2.1 Review of the Theoretical Literature

One of the main justifications for regulating bank capital is the need to avoid the risk-shifting incentive generated by improperly

priced deposit insurance. Although it may promote financial stability in the short run, risk-insensitive deposit insurance tends indeed 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 twenty-five years.

A first strand of the literature focuses on utility-maximizing banks using the portfolio approach of Pyle (1971) and Hart and Jaffee (1974), which explains the existence of financial intermediaries within a mean-variance framework. In this setting, Koehn and Santomero (1980) show that the introduction of higher capital-to-assets ratios will lead banks to shift their portfolio to riskier assets and that this reshuffling effect will be larger for institutions that initially held relatively more risky assets per unit of capital.

This conclusion has been challenged by Furlong and Keeley (1989) and Keeley and Furlong (1990), who use an option model and find that a higher capital ratio does not lead banks to increase asset risk. Both papers contend that the mean-variance 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.

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). However, Rochet (1992) 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 a nutshell, theoretical contributions do not agree on whether imposing harsher capital requirements leads banks to increase the risk structure of their portfolios. However, these studies suggest that the impact of capital requirements on bank capital and credit risk depends on the extent to which such requirements are binding. Moreover, the degree of response of capital and credit risk to capital requirements may be affected by the presence of market discipline (Basel Committee on Banking Supervision 1999).

The next section attempts to clarify further the relation between capital and credit risk taking by briefly restating the key rules of the 1988 Basel Accord and analyzing how banks can comply with them.

2.2 The 1988 Basel Accord

As mentioned above, the 1988 Basel standards were entirely focused on credit risk. An amendment to incorporate market risk was included in 1996, and the Basel Committee on Banking Supervision issued a revised capital adequacy framework in June 2004. This new framework, which replaces the 1988 standards, is based on three mutually reinforcing pillars that allow banks and supervisors to evaluate additional types of risks such as operational risk (Basel Committee on Banking Supervision 2004). The implementation of the Basel II framework began in 2007 in Europe and in 2008 in the United States.

Under the 1988 Basel Accord, internationally active banks were required to meet two capital adequacy ratios: the tier 1 and total capital ratios.

The tier 1 ratio is equal to tier 1 capital divided by risk-weighted assets. Tier 1 capital consists mainly of stockholder equity capital and disclosed reserves, while risk-weighted assets are calculated by assigning each asset and off-balance-sheet item to one of four broad risk categories. These categories receive risk weights of 0 percent, 20 percent, 50 percent, and 100 percent, with riskier assets being placed in the higher-percentage categories. For example, the 0 percent category consists of assets with zero default risk (e.g., cash, government bonds/securities), the 20 percent category consists of assets with a low rate of default (e.g., loans to OECD banks), the 50 percent category consists of medium-risk assets (essentially residential mortgage loans), and the 100 percent category consists of the remaining assets (in particular, loans to nonbanks).

The total capital ratio is the sum of tier 1 and tier 2 capital divided by risk-weighted assets. Tier 2 capital includes elements like undisclosed reserves and subordinated term debt instruments, provided that their original fixed term to maturity does not exceed five years.

The 1988 Basel standards required banks to have a tier 1 ratio of at least 4 percent and a total capital ratio of at least 8 percent,

with the contribution of tier 2 capital to total capital not exceeding 50 percent.[3]

As shown in the appendix, banks that wish to raise their capital adequacy ratio (for regulatory or nonregulatory 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 (1), which decomposes the growth rate of the capital adequacy ratio into three terms: the growth rate of capital, the growth rate of the credit-risk ratio, and the growth rate of total assets:

$$\frac{\dot{CAR}}{CAR} = \frac{\dot{K}}{K} - \frac{\dot{RISK}}{RISK} - \frac{\dot{A}}{A}, \tag{1}$$

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 = risk-weighted assets/total assets = credit-risk ratio; and A = total assets. The dots denote time derivatives.

Thus, banks can increase their capital adequacy ratio (CAR) by raising their capital level (K), lowering their credit-risk ratio (RISK), or lowering their total assets (A). In a nutshell, the impact of an increase in capital requirements on bank capital and risk choices is not clear a priori. This paper attempts to clarify this impact by focusing on the behavior of weakly capitalized banks, which are under regulatory pressure to increase their capital adequacy ratios.

In the analysis, capital is defined as the capital-to-assets ratio (K/A) and risk as the credit-risk ratio (RWA/A) of banks. I adopt these definitions for the purpose of understanding how G-10 banks adjusted the numerator of their capital adequacy ratio following changes in its denominator, and vice-versa.[4] However, it is well

[3]Following the passage of FDICIA in 1991, U.S. banks were also required to comply with a third ratio—namely, a tier 1 leverage ratio of at least 4 percent. Under FDICIA, banks are classified in three main categories: (i) well-capitalized (total capital ratio $\geq$ 10 percent, tier 1 ratio $\geq$ 6 percent, and tier 1 leverage ratio $\geq$ 5 percent), (ii) adequately capitalized (total capital ratio $\geq$ 8 percent, tier 1 ratio $\geq$ 4 percent, and tier 1 leverage ratio $\geq$ 4 percent), and (iii) undercapitalized (total capital ratio $<$ 8 percent, tier 1 ratio $<$ 4 percent, or tier 1 leverage ratio $<$ 4 percent).

[4]Alternative measures of risk taking such as value-at-risk (VaR) or the volatility of the market price of bank assets were not available for the period considered.

known that RWA/A is a very crude measure of credit risk and that the four risk categories specified by the 1988 Basel Accord only imperfectly reflect the actual credit risk taking of banks (Jones 2000). One may therefore view RWA/A more as a measure of portfolio composition (regulatory risk) than of "true" credit risk (economic risk). The latter interpretation is independent of whether RWA/A is a correct measure of credit risk.

3. Data

The variables used in this study are obtained from Bankscope. The sample consists of an unbalanced panel containing yearly data on 576 G-10 commercial banks (but no holding companies) with assets of more than $100 million. Consistent with most studies on the impact of the 1988 capital standards, the sample is restricted to the 1988–95 period.[5]

The analysis is further restricted to six G-10 countries (Canada, France, Italy, Japan, the United Kingdom, and the United States) because capital adequacy data were not available for the other G-10 countries over the period of interest (although data were available for Sweden, this country was excluded from the sample because of the banking crisis it experienced in the early 1990s). In addition, banks with a total capital ratio above 50 percent or a credit-risk ratio above 200 percent were treated as outliers and excluded from the sample.

Table 1 shows the distribution of banks by country. Although the sample contains mostly banks located in the United States and Japan, it is also representative of the banking sector in the other four countries. Indeed, the sample always includes at least six of the ten biggest banks in terms of assets of each country, and the sample banks' assets always exceed half of the total banking assets of each country.

[5]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 guidelines focus on the first half of the 1990s. In the case of the United States, Flannery and Rangan (2002) show that none of the 100 largest banks appear to have been constrained by regulatory capital requirements since 1995.

Table 1. Representativeness of the Sample

Country	Number of Banks	Number of Banks from the National Top-Ten	Sample Bank Assets/Total National Banking Assets (%)
Canada	7	7	92.19
France	9	7	54.18
Italy	16	10	86.06
Japan	76	9	83.98
United Kingdom	9	6	69.66
United States	459	10	91.74

Note: The figures in the table are for year-end 1995. The whole sample consists of 576 commercial banks with assets of more than $100 million. The analysis is restricted to six G-10 countries because data on capital adequacy were not available for other G-10 countries over the period of interest. Sweden was excluded from the sample because of the banking crisis it experienced in the early 1990s.

Panels A–C of table 2 show the average total capital-to-assets ratio, tier 1 capital-to-assets ratio, and credit-risk ratio of banks in each country over the period surveyed. Figures are slightly difficult to compare, as the number of observations is increasing over time.[6] Nevertheless, some tentative remarks can be made. First, looking at panels A and B, the total capital-to-assets and tier 1 capital-to-assets ratios of banks are upward trending in each country over the period surveyed, except in Canada. Second, looking at panel C, some countries (Canada, France, the United Kingdom, and perhaps Italy) appear to have experienced a decrease in credit risk, whereas others (Japan and the United States) have seen credit risk remaining fairly constant.

The remainder of table 2 and table 3 report additional descriptive statistics on the relation between capital and credit risk. Panels D and E of table 2 show the total capital and tier 1 ratios of banks over the period surveyed. Both series are increasing in each country

[6]The Basel standards were implemented gradually, which explains the low number of observations in 1988 and 1989. Results of logit regressions (not reported here) indicate that banks with high capital-to-assets ratios were not more likely to join the sample between 1989 and 1995.

Table 2. Summary Statistics (Capital-to-Assets Ratios, Credit-Risk Ratio, and Capital Adequacy Ratios)

	1988		1989		1990		1991		1992		1993		1994		1995	
Country	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**
Panel A: Total Capital-to-Assets Ratio																
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	7.50	156	7.74	153	8.35	450	8.85	435	8.78	422	9.27	392
All Countries	6.85	8	6.48	19	7.33	184	7.46	193	8.18	495	8.62	484	8.56	472	8.97	440
Panel B: Tier 1 Capital-to-Assets Ratio																
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	6.33	153	7.15	450	7.58	435	7.41	422	7.82	392
All Countries	3.46	45	3.80	69	3.91	100	5.37	257	6.56	558	6.87	549	6.76	537	7.07	500
Panel C: Credit-Risk Ratio																
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	69.95	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	79.14	152	69.92	415	69.70	422	70.88	420	72.87	390
All Countries	71.19	45	70.86	69	69.39	100	74.71	256	69.61	524	68.97	536	69.70	535	71.21	498

(continued)

Table 2. (Continued)

Country	1988		1989		1990		1991		1992		1993		1994		1995	
	Avg.	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**	**Avg.**	**Obs.**
Panel D: Total Capital Ratio																
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	10.09	152	12.30	415	13.05	422	12.67	421	13.04	392
All Countries	8.99	47	8.49	75	8.88	106	9.55	258	11.68	527	12.36	537	12.09	538	12.39	505
Panel E: Tier 1 Ratio																
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	8.31	152	10.58	415	11.28	422	10.82	421	11.17	392
All Countries	5.00	47	5.36	73	5.69	103	7.32	257	9.64	524	10.24	536	9.97	537	10.20	502

Note: The whole sample consists of 576 commercial banks with assets of more than $100 million. The analysis is restricted to six G-10 countries because data on capital adequacy were not available for other G-10 countries over the period of interest. Sweden was excluded from the sample because of the banking crisis it experienced in the early 1990s. The Basel standards were implemented gradually, which explains the low number of observations in 1988 and 1989. Results of logit regressions (not reported here) indicate that banks with high capital-to-assets ratios were not more likely to join the sample between 1989 and 1995.

Table 3. Decomposition of the Average Annual Growth Rate of CAR (%), 1988–95

Country	$\frac{\dot{CAR}}{CAR}$	$\frac{\dot{K}}{K}$	$\frac{\dot{RISK}}{RISK}$	$\frac{\dot{A}}{A}$	Obs.
CAR = Total Capital Ratio					
Canada	4.56	8.66	−4.23	8.33	48
France	3.62	6.66	−2.08	5.12	44
Italy	−1.60	5.85	0.61	3.65	45
Japan	1.55	5.51	0.32	3.64	49
United Kingdom	3.16	5.09	−4.04	5.98	43
United States	3.33	11.43	0.83	7.27	1,348
All Countries	3.10	10.35	0.44	6.81	1,577
CAR = Tier 1 Capital Ratio					
Canada	4.56	8.66	−4.23	8.33	48
France	5.25	8.36	−2.31	5.42	39
Italy	−0.03	4.24	0.61	3.65	45
Japan	1.80	9.20	0.23	7.17	436
United Kingdom	3.98	5.98	−3.91	5.90	42
United States	2.96	11.06	0.83	7.27	1,348
All Countries	2.57	9.96	0.40	6.98	1,958

Note: This table decomposes the annual growth rate of the capital adequacy ratio (CAR) into three terms: the annual growth rate of capital (K), the annual growth rate of the credit-risk ratio (RISK), and the annual growth rate of total assets (A). The dots denote time derivatives. A proof is given in the appendix.

across the years 1988–93, with no significant increase afterward. On average, G-10 banks already met the minimum requirements of 8 percent for the total capital ratio and 4 percent for the tier 1 ratio as early as 1989, except in Canada and France.

Table 3 further decomposes the average annual growth rate of both capital adequacy ratios into three terms, as in equation (1). The growth rate of both ratios is roughly similar and is mainly driven by a rise in capital levels (Italy, Japan, and the United States) or by a rise in capital levels and a decrease in risk-weighted assets (Canada, France, and the United Kingdom), which offset the rise in total assets.

On the whole, however, tables 2 and 3 do not tell us whether changes in the capital-to-assets ratio and changes in the credit-risk ratio of banks were 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.[7] Determining whether the Basel standards caused changes in the capital-to-assets and credit-risk ratios of banks and whether these changes were related requires a more sophisticated analysis than just looking at descriptive statistics.

The following section presents a model that aims at assessing the empirical determinants of observed changes in the capital-to-assets and credit-risk ratios, with a particular emphasis on the role played by regulatory and market pressures.

4. Methodology

4.1 The Model

In order to acknowledge that capital and risk decisions are determined together, I use the simultaneous-equations model developed by Shrieves and Dahl (1992). In this model, observed changes in banks' capital and credit risk taking consist of two components—a discretionary adjustment and a change caused by factors exogenous to the bank:[8]

$$\Delta \mathrm{CAP}_{i,t} = \Delta^{\mathrm{d}} \mathrm{CAP}_{i,t} + E_{i,t}, \tag{2}$$

$$\Delta \mathrm{RISK}_{i,t} = \Delta^{\mathrm{d}} \mathrm{RISK}_{i,t} + S_{i,t}, \tag{3}$$

where $\Delta \mathrm{CAP}_{i,t}$ and $\Delta \mathrm{RISK}_{i,t}$ are the observed changes in capital and risk levels, respectively, for bank i in period t. The $\Delta^{\mathrm{d}} \mathrm{CAP}_{i,t}$ and

[7] For instance, in the case of the United States, an alternative explanation for the capital build-up observed in table 2 may be that banks were recapitalizing following the 1990–91 recession. The regression analysis in section 4 therefore controls for the state of the business cycle in each country via the lagged rate of GDP growth.

[8] The model analyzes the relation between changes in capital and changes in risk rather than the relation between capital and risk levels because the objective of this study is to understand how banks adjust their risk to changes in capital, and vice-versa.

$\Delta^{\mathrm{d}}\mathrm{RISK}_{i,t}$ variables represent discretionary adjustments in capital and risk, while $E_{i,t}$ and $S_{i,t}$ are random error terms.

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

$$\Delta^{\mathrm{d}}\mathrm{CAP}_{i,t} = \alpha\big(\mathrm{CAP}^{*}_{i,t} - \mathrm{CAP}_{i,t-1}\big), \tag{4}$$

$$\Delta^{\mathrm{d}}\mathrm{RISK}_{i,t} = \beta\big(\mathrm{RISK}^{*}_{i,t} - \mathrm{RISK}_{i,t-1}\big), \tag{5}$$

where $\mathrm{CAP}^{*}_{i,t}$ and $\mathrm{RISK}^{*}_{i,t}$ 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 (4) and (5) into equations (2) and (3), the changes in capital and risk can be written as

$$\Delta\mathrm{CAP}_{i,t} = \alpha\big(\mathrm{CAP}^{*}_{i,t} - \mathrm{CAP}_{i,t-1}\big) + E_{i,t}, \tag{6}$$

$$\Delta\mathrm{RISK}_{i,t} = \beta\big(\mathrm{RISK}^{*}_{i,t} - \mathrm{RISK}_{i,t-1}\big) + S_{i,t}. \tag{7}$$

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. As mentioned earlier, 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 risk (RISK) is defined as the credit-risk ratio (RWA/A).

4.2 Variables Affecting Changes in Banks' Capital and Risk

Although the target capital and risk levels of banks are not observable, they are assumed to depend on a set of observable variables describing the banks' financial condition and the state of the economy in each country. In this paper, the variables used 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), regulatory pressure interacted with market pressure (REG × MARKET), regulatory pressure interacted with the inverse of market pressure (REG × (1−MARKET)),

changes in the credit-risk ratio (ΔRISK), changes in the credit-risk ratio interacted with regulatory pressure (ΔRISK $\times$ REG), and year dummies (YEAR). The variables used to proxy the target credit-risk ratio (RISK*) are SIZE, LOANS, LLOSS, GROWTH, REG $\times$ MARKET, REG $\times$ (1$-$MARKET), changes in the capital-to-assets ratio (ΔCAP), changes in the capital-to-assets ratio interacted with regulatory pressure (ΔCAP $\times$ REG), and YEAR. Table 4 gives the definition of each variable and shows summary statistics for three subsamples: European and Canadian banks, U.S. banks, and Japanese banks.

4.2.1 Bank-Specific Variables

Bank size (SIZE) is measured as the natural log of total assets. It is included as a control variable because large banks have 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 and, hence, decrease their credit risk. The percentage of total assets tied up in loans (LOANS) is included both in the capital and in the risk equations because higher LOANS values correspond to higher investment in risk-weighted assets and should therefore lead to higher credit risk and a greater need for capital. Following Rime (2001), loan losses (LLOSS) are approximated with the ratio of provisions to total assets and are included in the system of equations with an expected negative effect on credit risk and capital. Indeed, loan losses affect risk, as they are deducted from outstanding loans and should therefore lead to a decrease in the ratio of risk-weighted assets to total assets. In addition, banks with higher loan losses are forced to make higher provisions, thereby reducing net earnings and, ultimately, capital. The return on assets (ROA) is included in the capital equation with an expected positive effect on capital, as banks may prefer to increase capital through retained earnings rather than through equity issues in the presence of asymmetric information in capital markets.

The regulatory pressure variable (REG) describes the behavior of banks close to or below the Basel minimum capital requirements. These banks are expected to have increased their regulatory

Table 4. Summary Statistics (All Variables)

Variable	European and Canadian Banks			U.S. Banks			Japanese Banks		
	Avg.	**SD**	**Obs.**	**Avg.**	**SD**	**Obs.**	**Avg.**	**SD**	**Obs.**
1990 Dummy	0.09	0.29	180	0.00	0.03	1,348	0.11	0.32	436
1991 Dummy	0.12	0.33	180	0.00	0.05	1,348	0.16	0.36	436
1992 Dummy	0.16	0.37	180	0.11	0.32	1,348	0.17	0.38	436
1993 Dummy	0.18	0.39	180	0.29	0.46	1,348	0.17	0.38	436
1994 Dummy	0.20	0.40	180	0.30	0.46	1,348	0.17	0.38	436
1995 Dummy	0.20	0.40	180	0.29	0.45	1,348	0.17	0.37	436
SIZE_{t-1}	10.63	1.34	180	8.09	1.15	1,348	10.38	1.07	436
LOANS_{t-1}	56.46	15.52	180	60.15	14.71	1,348	65.86	6.49	436
LLOSS_{t-1}	0.66	0.51	180	0.63	1.21	1,348	0.13	0.20	436
ROA_{t-1}	0.39	0.51	180	1.05	1.02	1,348	0.19	0.08	436
GROWTH_{t-1}	0.70	2.20	180	1.95	1.60	1,348	2.29	2.27	436
ΔRISK_t	−1.83	5.10	180	0.55	6.08	1,348	0.17	1.91	436
RISK_{t-1}	67.61	15.56	180	71.15	15.89	1,348	68.45	6.48	436
CAP = Total Capital-to-Assets Ratio									
$\text{REG}_{t-1} \times$ (1–MARKET)	0.26	0.44	180	0.07	0.26	1,348	0.10	0.31	49
$\text{REG}_{t-1} \times \text{MARKET}$	0.39	0.49	180	0.06	0.24	1,348	0.84	0.37	49
ΔCAP_t	0.00	0.90	180	0.38	1.40	1,348	0.06	0.94	49
CAP_{t-1}	6.55	2.07	180	8.58	2.11	1,348	6.69	0.92	49

(continued)

Table 4. (Continued)

Variable	European and Canadian Banks			U.S. Banks			Japanese Banks		
	Avg.	**SD**	**Obs.**	**Avg.**	**SD**	**Obs.**	**Avg.**	**SD**	**Obs.**
CAP = Tier 1 Capital-to-Assets Ratio									
$REG_{t-1} \times$ (1–MARKET)	0.18	0.38	174	0.03	0.16	1,348	0.14	0.35	436
$REG_{t-1} \times$ MARKET	0.28	0.45	174	0.02	0.13	1,348	0.50	0.50	436
ΔCAP_t	0.04	0.63	174	0.29	1.30	1,348	0.08	0.23	436
CAP_{t-1}	4.44	1.62	174	7.24	1.81	1,348	3.93	0.65	436

Note: The variables in the table are year dummy variables, SIZE (log of total assets in millions of dollars), LOANS (loans/total assets), LLOSS (loan loss provisions/total assets), ROA (net income/total assets), GROWTH (GDP growth rate), RISK (risk-weighted assets/total assets), CAP (total capital/total assets or tier 1 capital/total assets), REG (regulatory pressure), and MARKET (market pressure). REG is a dummy variable equal to one if the total capital adequacy ratio falls below 10 percent (regressions with CAP = total capital-to-assets ratio) or if the tier 1 capital adequacy ratio falls below 6 percent (regressions with CAP = tier 1 capital-to-assets ratio), and zero otherwise. MARKET is a dummy variable equal to one if banks had a credit rating from Moody's or S&P or were listed on a stock exchange between 1988 and 1995, and zero otherwise. All variables are in percent except year dummies, SIZE, REG, and MARKET. Statistics include average (Avg.), standard deviation (SD), and number of observations (Obs.) of each variable.

capital and/or decreased their risk-weighted assets more than well-capitalized banks because not meeting the Basel standards could trigger exclusion from international banking business.

The studies mentioned in section 1 generally measure regulatory pressure by a dummy variable equal to one if the capital adequacy ratio falls below the regulatory minimum (4 percent for tier 1 ratio and 8 percent for the total capital ratio) plus one standard deviation of the bank's capital adequacy ratio series, and zero otherwise. The rationale for this definition of regulatory pressure is that the regulatory minimum capital constraint was not binding for a majority of G-10 banks at the beginning of the 1990s (cf. table 2). At the same time, it seems reasonable to assume that the size of a bank's capital buffer partially depends on the volatility of its capital adequacy ratio.[9]

This definition of regulatory pressure is not used here because the data are unbalanced and, hence, computing the standard deviation of the capital adequacy ratio would require using a different number of observations for each bank, which does not make sense. In addition, this definition implies that regulatory pressure is influenced by bank behavior and, as a result, is endogenous.

For these reasons, I rely on a much simpler definition of regulatory pressure: banks are under regulatory pressure if their total capital ratio falls below 10 percent (regressions with CAP = total capital-to-assets ratio) or if their tier 1 ratio falls below 6 percent (regressions with CAP = tier 1 capital-to-assets ratio). These thresholds, which are similar to those imposed by FDICIA on U.S. banks to be recognized as well capitalized, produce sensible percentages of observations with REG equal to one in each subsample (see table 4).[10]

The regulatory pressure variable is nevertheless difficult to interpret, as the behavior of banks for which REG is equal to one is

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

[10]Robustness checks (not reported here) show that the results are not affected by the choice of alternative thresholds for the tier 1 ratio (5 percent or 7 percent) and for the total capital ratio (9 percent or 11 percent). In the case of U.S. banks, the regulatory pressure variable also includes the 4 percent tier 1 leverage requirement set by FDICIA for banks to be considered well capitalized.

likely to reflect not only regulatory pressure from prudential authorities but also pressure from market participants such as investors or credit-rating agencies (cf. section 1). In other words, it may be hard to disentangle the effects of regulatory pressure from increased market discipline when REG is used alone in the regressions.

For this reason, I introduce a market pressure variable (MARKET) in the analysis. This variable 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.[11] Since I am primarily interested in the impact of regulatory pressure, I interact REG with MARKET and with its inverse to create two new variables: REG $\times$ MARKET and REG $\times$ (1$-$MARKET). The former variable reflects the behavior of banks under both types of pressures, while the latter captures the behavior of banks under regulatory pressure but under no market pressure. Banks under no regulatory pressure act as a comparison group.

Finally, since previous sections indicate that banks' capital and credit-risk choices are interdependent, ΔCAP and ΔRISK are included on the right-hand side of equations (7) and (6), respectively. The sign of the relationship between both variables is not clear a priori. A positive and significant relation between ΔCAP and ΔRISK would be consistent with the unintended effects of more stringent bank capital requirements on credit risk (section 2.1) or with the fact that banks want to maintain their capital adequacy ratios (CAP/RISK) constant following a change in capital and credit risk. A negative and significant relation between ΔCAP and ΔRISK could indicate either an increase or a decrease in bank capital adequacy ratios, depending on which variable is increasing or decreasing and at what rate.

4.2.2 Country-Specific Variable

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

[11] Data on the ownership structure of banks could have been useful to refine the definition of market pressure but were not available for the period of interest. Note that market pressure does not show any significant correlation with bank size.

of loan demand—that may have affected banks' capital and credit-risk choices. There are reasons to believe that this variable may be significant, since several papers (e.g., Ayuso, Pérez, and Saurina 2004 and Jiménez and Saurina 2006) show that capital and credit risk tend to be driven by cyclical factors.

4.2.3 Year Dummy Variables

Year dummy variables (YEAR) are added to the specification in order to take account of common country shocks that may have affected banks' capital and credit-risk choices (e.g., end of the implementation period of the Basel Accord in 1992).

4.2.4 Specification and Estimation Technique

In order to avoid potential endogeneity problems, the variables selected to explain target capital and risk ratios are lagged once in the regressions. The model defined by equations (6) and (7) is thus written as follows:

$$\begin{aligned}\Delta\mathrm{CAP}_{i,t} = {} & a_0 + \sum_t a_{1t}\mathrm{YEAR}_t + a_2\mathrm{SIZE}_{i,t-1} + a_3\mathrm{LOANS}_{i,t-1} \\ & + a_4\mathrm{LLOSS}_{i,t-1} + a_5\mathrm{ROA}_{i,t-1} \\ & + a_6\mathrm{GROWTH}_{j,t-1} + a_7(\mathrm{REG}_{i,t-1} \times (1\text{–}\mathrm{MARKET}_i)) \\ & + a_8(\mathrm{REG}_{i,t-1} \times \mathrm{MARKET}_i) \\ & + a_9\mathrm{CAP}_{i,t-1} + a_{10}\Delta\mathrm{RISK}_{i,t} \\ & + a_{11}(\Delta\mathrm{RISK}_{i,t} \times \mathrm{REG}_{i,t-1}) + E_{i,t}, \qquad (8)\end{aligned}$$

$$\begin{aligned}\Delta\mathrm{RISK}_{i,t} = {} & b_0 + \sum_t b_{1t}\mathrm{YEAR}_t + b_2\mathrm{SIZE}_{i,t-1} + b_3\mathrm{LOANS}_{i,t-1} \\ & + b_4\mathrm{LLOSS}_{i,t-1} + b_5\mathrm{GROWTH}_{j,t-1} \\ & + b_6(\mathrm{REG}_{i,t-1} \times (1\text{–}\mathrm{MARKET}_i)) \\ & + b_7(\mathrm{REG}_{i,t-1} \times \mathrm{MARKET}_i) + b_8\mathrm{RISK}_{i,t-1} \\ & + b_9\Delta\mathrm{CAP}_{i,t} + b_{10}(\Delta\mathrm{CAP}_{i,t} \times \mathrm{REG}_{i,t-1}) + S_{i,t}, \qquad (9)\end{aligned}$$

where i is a bank index and t is a time index.

The system formed by equations (8) and (9) is estimated separately for three different subsamples of banks: European and Canadian banks, U.S. banks, and Japanese banks.[12] Regressions are run separately for the United States and Japan because these two countries have enough observations to allow estimation of the model at the country level. Canadian, French, Italian, and UK banks are included together in the estimated system of equations because table 2 shows that their capital-to-assets ratios and credit-risk ratio had relatively similar patterns (increasing for CAP and decreasing for RISK) between 1988 and 1995.[13]

For each subsample of banks, the system of equations is estimated by three-state least squares (3SLS) with bank fixed effects. The use of 3SLS is motivated by the fact that the right-hand side of each equation includes an endogenous variable that is the dependent variable from the other equation in the system. Bank fixed effects are added to the specification because Chow tests reject the null hypothesis of absence of bank fixed effects in each equation, while Hausman tests reject the null hypothesis of no correlation between the bank fixed effects and the explanatory variables.[14]

5. Results

5.1 Preliminary Results

Tables 5, 6, and 7 present the results for European and Canadian banks, U.S. banks, and Japanese banks, respectively. CAP is defined as the total capital-to-assets ratio in the first system of equations and as the tier 1 capital-to-assets ratio in the second system of equations of each table (in the case of Japanese banks, I only present results for the system of equations where CAP is equal to the tier 1

[12]Country dummies were also added in equations (8) and (9) in the European and Canadian subsample. Their coefficient is not reported due to the estimation procedure chosen (fixed effects).

[13]Since the capital-to-assets ratios of Canadian banks slightly decreased after 1991, I also estimated the system of equations for European banks only as a robustness check. The results found for European banks only are qualitatively similar to those that include Canadian banks and that are reported in table 5.

[14]The studies mentioned in section 1 do not test for the presence of fixed or random effects and systematically rely on pooled 3SLS for estimation purposes.

capital-to-assets ratio because too few banks report a total capital-to-assets ratio). Before analyzing the role played by regulatory and market pressures, as well as the relation between changes in capital and changes in credit risk, I briefly discuss the sign of the most important control variables.

Consistent with previous studies (e.g., Jacques and Nigro 1997 and Aggarwal and Jacques 2001), I find that bank size (SIZE) has a negative effect on ΔCAP in table 6, a result which suggests that large U.S. banks have easier access to capital markets and can therefore operate with lower amounts of capital. In addition, SIZE has a significant and highly positive impact on ΔRISK in table 7, reflecting large Japanese banks' disengagement from high-quality borrowers (risk weight equal to 0 or 20 percent) and increased exposure to the real-estate sector (risk weight equal to 100 percent) in the late 1980s and the early 1990s. The impact of loans as a percentage of total assets (LOANS) on changes in capital and credit risk, though often statistically significant, is not economically significant (less than 0.1 percentage point). Loan losses (LLOSS) exhibit little significance except in table 5, where they have a negative impact on ΔRISK, and in table 7, where they have a negative impact on ΔCAP, as expected. The return on assets (ROA) has a significantly positive effect on changes in capital in tables 5 and 7, a result consistent with the hypothesis that banks with higher earnings can improve more easily their capital position.

Interestingly, the rate of GDP growth (GROWTH) appears to have a somewhat negative and significant impact on the capital adequacy ratio of non-U.S. banks but no impact on the capital adequacy ratio of U.S. banks. Indeed, a 1-percentage-point change in GDP growth has a negative though very small (−0.09 percentage point) impact on capital changes in table 5 (CAP = total capital ratio), no impact on capital and risk changes in table 6, and a negative effect on both variables in table 7, with the overall effect on capital adequacy ratios (CAP/RISK) being slightly negative.[15]

The results for non-U.S. banks tend to confirm those of Ayuso, Pérez, and Saurina (2004), who find a negative relation between the

[15]The overall effect on capital adequacy ratios (−0.13) is obtained by applying the point estimates for ΔCAP and ΔRISK on Japanese banks' average tier 1 capital-to-assets and credit-risk ratios, respectively.

Table 5. Determinants of Changes in Capital and Credit-Risk Ratios (European and Canadian Banks)

Independent Variables	CAP = Total Capital-to-Assets Ratio		CAP = Tier 1 Capital-to-Assets Ratio	
	ΔCAP	**ΔRISK**	**ΔCAP**	**ΔRISK**
Intercept	−9.739	0.253	−8.113	4.352
	(1.00)	(0.01)	(1.27)	(0.11)
1990 Dummy	−0.496	−4.849***	0.032	−5.561***
	(1.39)	(3.07)	(0.14)	(3.69)
1991 Dummy	−0.768	−10.617***	−0.171	−10.379***
	(1.42)	(5.02)	(0.49)	(5.01)
1992 Dummy	−1.263**	−12.336***	−0.434	−12.473***
	(1.98)	(4.72)	(1.04)	(4.85)
1993 Dummy	−0.795	−13.519***	−0.150	−14.073***
	(1.39)	(5.77)	(0.39)	(6.05)
1994 Dummy	−0.904	−14.434***	−0.121	−14.741***
	(1.56)	(6.04)	(0.32)	(6.28)
1995 Dummy	−0.974*	−13.375***	−0.181	−13.588***
	(1.78)	(5.88)	(0.51)	(6.02)
$SIZE_{t-1}$	1.433	3.420	0.945	3.294
	(1.47)	(0.86)	(1.49)	(0.84)
$LOANS_{t-1}$	0.012	0.247***	0.014	0.103
	(0.66)	(2.81)	(1.15)	(1.17)
$LLOSS_{t-1}$	0.465*	−2.151***	0.065	−1.408**
	(1.83)	(3.25)	(0.40)	(2.05)
ROA_{t-1}	1.240***	—	0.634***	—
	(4.40)		(3.34)	
$GROWTH_{t-1}$	−0.091*	−0.112	−0.037	−0.205
	(1.92)	(0.51)	(1.18)	(0.99)
REG_{t-1} × (1–MARKET)	−0.085	−1.242	0.352	−2.008
	(0.31)	(1.06)	(1.50)	(1.27)
REG_{t-1} × MARKET	−0.386	−1.083	−0.065	−0.262
	(1.39)	(0.95)	(0.46)	(0.29)
CAP_{t-1}	−0.901***	—	−0.644***	—
	(6.69)		(5.98)	—
$\Delta RISK_t$	−0.015	—	0.024	—
	(0.54)		(1.31)	
$RISK_{t-1}$	—	−0.568***	—	−0.501***
		(8.36)		(6.99)
ΔCAP_t	—	2.416***	—	3.570***
		(5.17)		(4.74)
Observations	180	180	174	174
R-squared	0.41	0.59	0.47	0.61

Note: The dependent variables in the first system of equations are CAP (total capital/total assets) and RISK (risk-weighted assets/total assets). The dependent variables in the second system of equations are CAP (tier 1 capital/total assets) and RISK (risk-weighted assets/total assets). Each system of equations is estimated by 3SLS with bank fixed effects. Absolute *t*-statistics are in parentheses; *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 6. Determinants of Changes in Capital and Credit-Risk Ratios (U.S. Banks)

Independent Variables	CAP = Total Capital-to-Assets Ratio		CAP = Tier 1 Capital-to-Assets Ratio	
	ΔCAP	**ΔRISK**	**ΔCAP**	**ΔRISK**
Intercept	15.034***	48.922***	13.494***	51.342***
	(6.69)	(6.13)	(6.30)	(6.45)
1990 Dummy	—	—	—	—
1991 Dummy	—	—	—	—
1992 Dummy	2.025	10.974	0.871	8.773
	(0.98)	(1.41)	(0.45)	(1.13)
1993 Dummy	1.408	2.383	1.616*	6.227*
	(1.45)	(0.65)	(1.73)	(1.67)
1994 Dummy	1.494*	5.366*	1.402*	8.572***
	(1.95)	(1.87)	(1.90)	(2.95)
1995 Dummy	1.627	2.750	2.104	8.309
	(1.03)	(0.46)	(1.39)	(1.38)
$SIZE_{t-1}$	−1.095***	−0.769	−1.036***	−1.013
	(4.45)	(0.87)	(4.41)	(1.15)
$LOANS_{t-1}$	−0.022**	−0.075**	−0.019**	−0.086**
	(2.32)	(2.25)	(2.16)	(2.57)
$LLOSS_{t-1}$	−0.085	−0.077	−0.069	−0.050
	(1.46)	(0.46)	(1.23)	(0.30)
ROA_{t-1}	−0.085	—	−0.083	—
	(1.27)		(1.26)	
$GROWTH_{t-1}$	0.250	2.332	−0.108	0.970
	(0.41)	(1.00)	(0.18)	(0.42)
REG_{t-1} × (1–MARKET)	0.115	−0.621	0.134	−0.871
	(0.70)	(0.99)	(0.63)	(1.01)
REG_{t-1} × MARKET	0.486***	1.128	0.344	6.125***
	(2.80)	(1.63)	(1.33)	(5.99)
CAP_{t-1}	−0.750***	—	−0.684***	—
	(21.25)		(19.60)	
$\Delta RISK_t$	0.000	—	0.015	—
	(0.02)		(1.36)	
$RISK_{t-1}$	—	−0.654***	—	−0.663***
		(20.82)		(22.01)
ΔCAP_t	—	0.026	—	−0.059
		(0.15)		(0.30)
Observations	1,348	1,348	1,348	1,348
R-squared	0.36	0.47	0.33	0.48

Note: The dependent variables in the first system of equations are CAP (total capital/total assets) and RISK (risk-weighted assets/total assets). The dependent variables in the second system of equations are CAP (tier 1 capital/total assets) and RISK (risk-weighted assets/total assets). Each system of equations is estimated by 3SLS with bank fixed effects. Absolute t-statistics are in parentheses; *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 7. Determinants of Changes in Capital and Credit-Risk Ratios (Japanese Banks)

	CAP = Tier 1 Capital-to-Assets Ratio	
Independent Variables	**ΔCAP**	**ΔRISK**
Intercept	−6.331*	−54.581
	(1.90)	(1.44)
1990 Dummy	—	—
1991 Dummy	−0.063	−1.148*
	(1.02)	(1.78)
1992 Dummy	−0.204*	−1.656
	(1.74)	(1.26)
1993 Dummy	−0.676***	−7.117***
	(3.17)	(2.80)
1994 Dummy	−0.739***	−8.337***
	(2.94)	(2.76)
1995 Dummy	−0.907***	−9.595***
	(3.24)	(2.75)
$SIZE_{t-1}$	0.752**	8.823**
	(2.42)	(2.46)
$LOANS_{t-1}$	0.018**	0.064
	(2.47)	(0.77)
$LLOSS_{t-1}$	−0.280***	−0.206
	(4.14)	(0.28)
ROA_{t-1}	0.532**	—
	(2.47)	
$GROWTH_{t-1}$	−0.128***	−0.741**
	(4.01)	(2.26)
$REG_{t-1} \times$ (1–MARKET)	0.114*	−0.279
	(1.80)	(0.42)
$REG_{t-1} \times$ MARKET	−0.024	0.256
	(0.59)	(0.62)
CAP_{t-1}	−0.498***	—
	(7.92)	
$\Delta RISK_t$	0.016	—
	(1.02)	
$RISK_{t-1}$	—	−0.503***
		(6.29)
ΔCAP_t	—	−2.827**
		(2.15)
Observations	436	436
R-squared	0.51	0.34

Note: The dependent variables in the system of equations are CAP (tier 1 capital/total assets) and RISK (risk-weighted assets/total assets). The system of equations is estimated by 3SLS with bank fixed effects. Absolute t-statistics are in parentheses; *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

business cycle and the capital buffers of Spanish banks. The results for U.S. and non-U.S. banks do, however, contrast with those of Jiménez and Saurina (2006), who find a positive association between the business cycle and credit risk in Spain. A possible explanation, aside from the difference in sample, is that these authors use a different measure of credit risk (nonperforming loans) than the one employed in this paper (risk-weighted assets to total assets).

Finally, the parameter estimates on lagged capital and credit risk are negative and significant in each subsample, with values lying in the range $[-0.901, -0.501]$ in table 5, $[-0.750, -0.654]$ in table 6, and $[-0.503, -0.498]$ in table 7. These figures indicate that G-10 banks were adjusting their capital and credit-risk ratios very rapidly to desired levels in the first half of the 1990s.

5.2 Impact of Regulatory and Market Pressures on Changes in Capital and Credit Risk

Looking at banks under regulatory pressure, a distinction must again be made between U.S. and non-U.S. banks.

In the case of U.S. banks, regulatory pressure without market pressure (REG $\times$ (1$-$MARKET)) has no effect on capital-to-assets ratios, while the combination of both regulatory and market pressures (REG $\times$ MARKET) has a positive and significant impact on the total capital-to-assets ratio but no impact on the tier 1 capital-to-assets ratio. This result suggests that pressure from both regulators and market participants was effective in raising U.S. bank capital ratios in the early 1990s. This finding contrasts with existing studies on the impact of bank capital requirements in the United States (e.g., Aggarwal and Jacques 1997, 2001 and Jacques and Nigro 1997), which do not estimate the impact of market pressure and find that regulatory pressure alone had a positive and significant impact on U.S. bank capital ratios.[16] The results in table 6 suggest rather that it is the pressure exerted by both regulators and market participants which contributed to increasing the capital ratios of U.S. banks. The magnitude of the increase in banks' capital due

[16]Interestingly, and similar to these papers, I find that REG becomes significant in the capital equation when it is used alone, i.e., when it is not interacted with MARKET and with (1$-$MARKET).

to regulatory and market pressures (0.49 percentage points on an annual basis) is somewhat lower than the one attributed to regulatory pressure alone in the above-mentioned papers. The results for the system of equations where CAP is equal to the tier 1 capital-to-assets ratio further seem to suggest that U.S. banks under both regulatory and market pressures increased their credit risk taking in the early 1990s. However, the small percentage of observations for which REG and MARKET are both equal to one in this system of equations (2 percent, cf. table 4) more than probably reduces the reliability of this estimate.

In the case of non-U.S. banks (tables 5 and 7), regulatory pressure—either with or without market pressure—is insignificant at the 5 percent level both in the capital and in the risk equations. This result, which indicates that weakly capitalized banks located outside the United States did not significantly modify their capital-to-assets ratios and their ratio of risk-weighted assets to total assets more rapidly than well-capitalized banks, represents new evidence on the impact of the 1988 bank capital requirements.

The insignificance of regulatory pressure in the capital equations of table 5 is rather surprising given the widespread belief that weakly capitalized banks had a stronger capital response than well-capitalized banks in all countries following passage of the 1988 Basel standards (see, e.g., Basel Committee on Banking Supervision 1999). This result might be explained by the behavior of several Canadian and European banks that adjusted only slowly to the Basel standards and had their capital adequacy ratios on the edge or below the required minimum during most of the period studied.[17]

The results in table 7 are also interesting given 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 than their competitors (Wagster 1996). The fact that REG $\times$ (1$-$MARKET) has a small and only weakly significant impact and REG $\times$ MARKET has no impact in the capital equation suggests that the pressure

[17] Additional results (not reported here) show that when the sample is restricted to the 1988–93 or 1988–94 periods, regulatory pressure interacted with market pressure does have a negative and significant impact on ΔRISK when CAP is equal to the total capital-to-assets ratio.

exerted by regulators was not really effective in raising the tier 1 capital-to-assets ratio of weakly capitalized banks in Japan. This result is in line with Ito and Sasaki (1998) and Montgomery (2005), who show that undercapitalized Japanese banks tended to issue more subordinated debt (i.e., an increase in tier 2 capital but not in tier 1 capital) after the passage of the new capital adequacy rules. In addition, Montgomery (2005) also finds that banks with low 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 risk-weighted assets to total assets is a broader measure of credit risk than those used in that paper and, therefore, simultaneous changes may counterbalance one another.

The results so far indicate that U.S. banks experiencing both regulatory and market pressures increased their total capital-to-assets ratio faster than well-capitalized banks in the early 1990s. However, regulatory pressure—either with or without market pressure—was not effective in raising the capital-to-assets ratios of banks in the other G-10 countries analyzed here. Also, there is no strong evidence that weakly capitalized G-10 banks modified their credit risk taking over the period of interest.[18]

5.3 Relation between Changes in Capital and Credit Risk

The relation between changes in capital (ΔCAP) and changes in credit risk (ΔRISK) also appears to depend on the country or group of countries considered.

As shown in table 5 (European and Canadian banks), changes in capital and credit risk are positively and significantly related to each other in the ΔRISK equation of each system. Although this result

[18]The low within-variability of REG $\times$ MARKET and REG $\times$ (1$-$MARKET) suggests comparing the fixed effect estimates of both parameters with their pooled estimates. The latter show the same level of significance as the former, except for REG $\times$ (1$-$MARKET), which has a weakly positive impact on ΔCAP in the European and Canadian subsample when CAP is defined as the tier 1 capital-to-assets ratio.

is consistent with the unintended effects of higher capital requirements on credit risk mentioned in section 2.1, it does not imply a decrease in banks' capital adequacy ratios (CAP/RISK), as the response of ΔRISK to a 1-percentage-point increase in CAP (2.42 percentage points when CAP = total capital-to-assets ratio and 3.57 percentage points when CAP = tier 1 capital-to-assets ratio) is not large enough. The remainder of table 5 shows that changes in capital and credit risk are not significantly related to each other in the ΔCAP equation of each system, meaning that European and Canadian banks did not alter significantly their capital-to-assets ratios in reaction to changes in the composition of their ratio of risk-weighted assets to total assets.

In table 6 (U.S. banks), changes in capital and credit risk are not significantly related to each other, while in table 7 (Japanese banks), both changes are unrelated in the ΔCAP equation and are negatively and significantly related in the ΔRISK equation. In the latter case, an increase of 1 percentage point in the tier 1 capital-to-assets ratio of banks leads to a decrease of 2.83 percentage points in their credit-risk ratio, all other things being equal. This result indicates that Japanese banks improved their tier 1 ratio by simultaneously increasing their tier 1 capital-to-assets ratio and lowering their ratio of risk-weighted assets to total assets.

6. Conclusion

This paper analyzes adjustments in capital and risk-weighted assets at banks from six G-10 countries between 1988 and 1995 using the simultaneous-equations model developed by Shrieves and Dahl (1992). In particular, the paper tests whether weakly capitalized banks increased their capital or decreased their risk-weighted assets more rapidly than did well-capitalized banks.

The analysis distinguishes between changes in capital and credit risk brought about by regulatory and market pressures. This distinction is important, as little is known about the effectiveness of market pressure in complementing regulatory pressure in order to increase capital and/or decrease risk taking among weakly capitalized banks. It is also important in light of the fact that minimum capital requirements and market discipline constitute two of the three pillars of the New Basel Accord.

The results suggest that only in the United States did weakly capitalized banks increase their total capital ratio faster than well-capitalized banks; moreover, this increase appears to have been due to both regulatory and market pressures. In the other G-10 countries, little evidence is found that weakly capitalized banks increased their capital ratios at a faster rate than well-capitalized banks. Finally, no evidence is found that U.S. or non-U.S. weakly capitalized banks modified their ratio of risk-weighted assets to total assets differently from well-capitalized banks.

Taken as a whole, these results suggest that the effectiveness of the 1988 bank capital requirements to increase capital and/or reduce credit risk was rather limited outside the United States. The results also highlight the role of market discipline in influencing U.S. bank capital choices.

Appendix. Proof of Equation (1)

As $\mathrm{CAR} = \dfrac{\mathrm{K}}{\mathrm{RWA}}$ and $\mathrm{RISK} = \dfrac{\mathrm{RWA}}{\mathrm{A}}$, we have that $\mathrm{CAR} = \dfrac{\mathrm{K}}{\mathrm{RISK.A}}$.

Taking logs and differentiating with respect to time yields,

$$\frac{d\log \mathrm{CAR}}{dt} = \frac{d\log \mathrm{K}}{dt} - \left[\frac{d\log \mathrm{RISK}}{dt} + \frac{d\log \mathrm{A}}{dt}\right].$$

We obtain easily that $\dfrac{\dot{\mathrm{CAR}}}{\mathrm{CAR}} = \dfrac{\dot{\mathrm{K}}}{\mathrm{K}} - \dfrac{\dot{\mathrm{RISK}}}{\mathrm{RISK}} - \dfrac{\dot{\mathrm{A}}}{\mathrm{A}}$.

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