Capital requirements and bank behaviour: empirical evidence for Switzerland

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Abstract

In recent years, regulators have increased their focus on the capital adequacy of banking institutions to enhance the stability of the financial system. The purpose of the present paper is to shed some light on whether and how Swiss Banks react to constraints placed by the regulator on their capital. Building on previous work by Shrieves and Dahl (1992), we use a simultaneous equations model to analyse adjustments in capital and risk at Swiss banks, when those approach the minimum regulatory capital level. Our results indicate that regulatory pressure induce banks to increase their capital, but does not affect the level of risk.

Keywords: Risk-based capital; Capital ratios; Portfolio risk
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Capital requirements and bank behaviour: empirical evidence for Switzerland[*]

1. Introduction

In recent years, regulators have increased their focus on the capital adequacy of banking institutions in order to enhance the stability of the financial system. A major step in that direction was the 1988 agreement among G-10 countries on minimal risk-based capital requirements for banks, referred to as the Basle accord; very recently, the Basle Committee has launched a consultation for a fundamental revision of the Basle accord.[1] The increasing reliance of regulators on capital requirements raises several questions: Do banks respond to capital requirements, i. e. are the penalties for falling below the regulatory guidelines large enough to induce banks to raise their capital ratio? How do banks improve their capital ratio when they approach the regulatory minimum, i. e. do they increase their capital or do they reduce their higher-risk assets? Do increases in capital requirements induce banks to reduce or to increase the riskiness of their portfolio?

With economic theory split over these questions, many authors have tried to assess empirically the impact of capital requirements on banks' behaviour. Most studies concentrate on US banks, while empirical evidence has remained scarce for European banks, with the notable exception of the United Kingdom.[2] Therefore, an important

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[1] See Basle Committee (1999b).

[2] See Basle Committee (1999a) for a review of empirical literature on bank capital behaviour.

contribution of this paper is to provide further empirical evidence on bank capital behaviour outside the United States. The examination of Swiss banks capital behaviour is of interest in several respects. Firstly, Switzerland has much more experience with risk-based capital requirements than the United States; in that context, the results obtained for Swiss banks may better reflect the long-term effects of capital requirements. Secondly, the regulatory pressure implied by capital requirements may be stronger in Switzerland, where a breach of the guidelines rapidly leads to the closure or to the take-over of the bank; in the United States, by contrast, undercapitalised banks are not necessarily closed, but are subject to restrictions on their activities and to higher deposit insurance premiums. Thirdly, Swiss banks may differ from US banks in their ability to adjust capital and risk. This is due to the illiquidity of the Swiss market for small banks stocks and the absence of a market for asset-backed securities in Switzerland. Finally, Swiss capital requirements stipulate a larger number of risk-classes than the Basel accord, which may reduce the scope for regulatory arbitrage at Swiss banks. To our knowledge, only two studies provide empirical evidence on capital requirements for Switzerland. Sheldon (1996a) finds that Swiss banks are among the safest in terms of default probability as their higher capital ratios overcompensate the higher volatility of their ROA. Sheldon (1996b) observes that for the 1987-94 period, Swiss banks had a stable capital ratio and experienced a decrease in the volatility of their ROA, the net effect being a decrease in their default probability.

In the present paper, we use the simultaneous equations model developed by Shrieves and Dahl (1992) to analyse adjustments in capital and risk by Swiss banks as they approach the minimum regulatory capital level. An important aspect of this methodology is that it recognises that changes in both capital and risk have exogenous as well as endogenous character. The present study differs from Sheldon's work on Swiss banks in three main areas. First, bank capital and risk behaviour is modelled explicitly. Second, we take account of the regulatory pressure implied by the capital requirements. Finally, we examine a much larger number of banks.

The paper is organised as follows. Section 2 reviews the rationale for capital requirements and the theories related to banks' choices in respect of capital and risk. Section 3 summarises the recent developments of capital requirements in Switzerland and presents some data on Swiss banks' capital. In section 4, we introduce the model developed by Shrieves and Dahl (1992) with some modifications. Section 5 presents the data, the empirical methodology, and the results. Section 6 concludes the analysis.

2. Capital requirements and bank behaviour: review of theory[3]

2.1. Rationale for capital requirements

Capital regulation is motivated principally by the concern that a bank may hold less capital than is socially optimal relative to its riskiness as negative externalities resulting from bank default are not reflected in market capital requirements.

In theory, the stabilising effects of capital requirements are supported by models based on the option-pricing model. In this framework, an unregulated bank will take excessive

[3] See the surveys by Berger and al. (1995) and by Wall and Peterson (1996).

portfolio and leverage risks in order to maximise its shareholder value at the expense of the deposit insurance [See Benston et al. (1986), Furlong and Keeley (1989) and Keeley and Furlong (1990)]. Capital requirements can reduce these moral hazard incentives by forcing bank shareholders to absorb a larger part of the losses, thereby reducing the value of the deposit insurance put option. With more capital and less risk-taking, the effect is clearly a decrease in the bank's default probability. The ability of capital requirements to strengthen the stability of the banking system has been challenged in models based on the mean-variance framework. Koehn and Santomero (1980), Kim and Santomero (1988) and Rochet (1992) find that if capital is relatively expensive, the forced reduction in leverage diminishes the bank's expected returns. As a consequence, the bank's owners may choose a higher point on the efficiency frontier, with a higher return and a higher risk. In some cases, the increase in the bank's risk overcompensates the increase in capital and leads to a higher default probability.

The introduction of risk-based capital standards can be considered as an attempt to eliminate the possible perverse effects of capital requirements. Unfortunately, empirical evidence indicates that current capital requirements do not reflect banks' risk-taking accurately. Avery and Berger (1991), for example, find that the Basle risk-weighting framework explains only about 5% of banks' loan performance. If there are flaws in the risk-weightings, risk-based capital standards may have destabilising effects, as banks constrained by the capital requirements can improve their capital ratio by decreasing risk in terms of the official standards while business risk is actually increased.

2.2. Capital requirements, adjustment costs and capital buffer

In the absence of adjustment costs in the capital ratio, banks would never hold more capital than required by the regulators or by the market. In practice, however, adjusting the capital ratio may be costly. Equity issues may, in the case of information asymmetries, convey negative information to the market on the bank's economic value.[4] Moreover, shareholders may be reluctant to contribute new capital if the bank is severely undercapitalised, as most of the benefits would accrue to creditors. In the presence of these adjustments costs, banks falling under the legal capital requirements will not be able to react instantaneously. They may then be subject to repeated regulatory penalties, or even worse, closed down. As a consequence, banks may prefer to hold a "buffer" of excess capital to reduce the probability of falling under the legal capital requirements, especially if their capital ratio is very volatile.

As we will see in section 4, adjustments costs and the related capital buffer play a central role in the partial adjustment model developed by Shrieves and Dahl (1992) and in its extensions by Jacques and Nigro (1997), Aggarwal and Jacques (1998), and Ediz, Michael and Perraudin (1998).

[4] Myers and Majluf (1984)

3. Capital regulation and capital data for Swiss banks

Capital requirements constitute the main banking supervisory instrument in Switzerland. The Federal Banking Commission intervenes little in banks' activities and does not directly conduct on-site examinations, delegating this task to external auditors. By contrast, a breach of the capital requirements is considered a major infringement of banking legislation and is not tolerated by the Federal Banking Commission. Banks remaining undercapitalised for prolonged periods are closed. This drastic outcome is often avoided through a take-over of the undercapitalised institution by another bank.

3.1. Recent developments in the sphere of capital regulation at Swiss banks

As long ago as 1980, Switzerland introduced risk-based capital requirements for on-balance sheet positions and, to a lesser extent, for off-balance sheet positions. In 1989, the capital regulation was revised to take account of the development of off-balance sheet and securitisation activities. This reform, which constituted a partial harmonisation with the Basle accord, introduced heavier charges for off-balance sheet activities and allowed the banks to count more of their subordinated debt in tier 2. Capital charges for on-balance sheet activities and cross-border transactions were reduced. The 1995 revision involved a more systematic adaptation to the Basle accord and its subsequent amendment for off-balance sheet positions. The first change was to base the risk-weighting framework on the riskiness of the counterparty rather than the asset type. The revision also introduced a more accurate treatment of off-balance sheet positions. The last revision, dated 1997, introduced capital charges for market risk in accordance with the amended version of the Basle accord on market risk.

Overall, the refinement and the adaptation of the Swiss capital requirements to the Basle guidelines have lead to a small relief of the capital burden for Swiss banks, as indicated by the immediate drops of required capital following each revision. Nevertheless, Swiss capital requirements remain more detailed (15 asset categories instead of five) and more stringent than the Basle accord (Swiss risk-weightings are generally higher than the Basle ones, although both frameworks apply the 8% capital ratio on risk-weighted assets).

3.2. Data on the capital adequacy of Swiss banks

Swiss banks are well capitalised by international standards. According to the Banker (1998), the average BIS ratio of big Swiss banks represented 13.8% and exceeded the G-10 countries' average by more than 2.5 percentage points.

Table 1 shows the average level of excess capital as a percentage of required capital and its standard deviation for different categories of Swiss banks, based on the Swiss capital requirements for the period 1989-1996. At the four big banks, excess capital represents 8.1% of required capital. Big banks pursue all lines of banking business throughout Switzerland and abroad. Their relatively low capital buffer may be related to their easy access to capital markets, which allows them to raise capital quickly. Excess capital represents 21.0% of required capital at cantonal banks (25 institutions) and 25.2% at regional banks (125 institutions). Both cantonal and regional banks focus on the domestic market, and their activity is less diversified. A specificity of the cantonal banks is that their liabilities are guaranteed by the canton.[5] The difficulty for cantonal and regional banks to raise capital in a relatively illiquid market for small Swiss banks' stocks may explain their larger capital buffer. As predicted by the buffer theory, table 1 indicates a positive relationship between the level of excess capital and its volatility as measured by the standard deviation.

Table 1: Capital data for different categories of Swiss banks (average 1992-1996)

4. The model

4.1. Simultaneous model and partial adjustment framework for capital and risk

The theories discussed in section 2 presume that capital and risk decisions are determined simultaneously. To recognise this, we base our analysis of Swiss banks' capital behaviour on the simultaneous equations model developed by Shrieves and Dahl (1992). In their model, observed changes in banks' capital and risk levels consist of two components, a discretionary adjustment and a change caused by factors exogenous to the bank:

$$DCAP_{j,t} = D^d CAP_{j,t} + E_{j,t}; \qquad (1)$$

$$DRISK_{j,t} = D^d RISK_{j,t} + S_{j,t}, \qquad (2)$$

[5] A canton is a territorial subdivision in Switzerland. Cantons are financially independent from the central government and have their own administration and government.

where $DCAP_{j,t}$ and $DRISK_{j,t}$ are the observed changes in capital and risk levels, respectively, for bank j in period *t*.

The discretionary changes in capital and risk $D^dCAP_{j,t}$ and $D^dRISK_{j,t}$ are modelled using the partial adjustment framework, thereby recognising that banks may not be able to adjust their desired capital ratio and risk levels instantaneously. In this framework, the discretionary changes in capital and risk are proportional to the difference between the target levels and the levels existing in period *t*-1:

$$D^dCAP_{j,t} = a\,(CAP^*{}_{j,t} - CAP_{j,t-1}); \tag{3}$$

$$D^dRISK_{j,t} = b\,(RISK^*{}_{j,t} - RISK_{j,t-1}), \tag{4}$$

where $CAP^*{}_{j,t}$ and $RISK^*{}_{j,t}$ are bank j's target capital and risk levels, respectively.

Substituting equations (3) and (4) into equations (1) and (2), the observed changes in capital and risk can be written:

$$\Delta CAP_{j,t} = a\,(CAP^*{}_{j,t} - CAP_{j,t-1}) + E_{j,t}; \tag{5}$$

$$\Delta RISK_{j,t} = b(RISK^*{}_{j,t} - RISK_{j,t-1}) + S_{j,t}. \tag{6}$$

Thus, observed changes in capital and risk in period *t* are a function of the target capital and risk levels, the lagged capital and risk levels, and any exogenous factors.

4.2. Definitions of capital and risk

We use two definitions of banks' capital: the ratio of capital to total assets (RCTA) and the ratio of capital to risk-weighted assets (RCWA). Shrieves and Dahl (1992) used the first definition. The second definition has become more popular since the introduction of risk-weighted capital standards and has been used by Jacques and Nigro (1997), Aggarwal and Jacques (1998) and Ediz, Michael and Perraudin (1998).

Measurement and definition of banks' risk is quite problematic and the literature suggests a number of alternatives, all of which are subject to some criticism. In this study, we opt for the ratio of risk-weighted assets to total assets (RWA), as proposed by Shrieves and Dahl (1992) and used subsequently by Jacques and Nigro (1997) and Aggarwal and Jacques (1998). The rationale for using this measure is that portfolio risk is primarily determined by the allocation of assets across the different risk categories. A clear advantage of RWA is that it reflects banks' decisions on risk-taking with appropriate timeliness. The reliance on this indicator, however, supposes that the risk-weightings correctly reflect the economic risk of the different asset categories.

4.3. Variables affecting changes in banks' capital and risk

Equations (5) and (6) predict that changes in capital and risk in period *t* are a function of the target capital and risk levels, the lagged capital and risk levels and any exogenous factors or shocks. In the following, we present the explanatory variables and their expected impact on banks' capital and risk. All these variables have been used by Shrieves and Dahl (1992), with the exception of the current profits variable, emphasised by Aggarwal and Jacques (1998), and the regulatory pressure variables, proposed by Ediz et al. (1998) and Aggarwal and Jacques (1998).

4.3.1. Size

Size may influence target risk and capital levels due to its relationship with risk diversification, investment opportunities and access to equity capital. The natural log of total assets (SIZE) is included in the capital and in the risk equations to capture size effects.

4.3.2. Current profits

Current profits may have a positive effect on banks' capital if financial institutions prefer to increase capital through retained earnings than through equity issues, as the latter may convey negative information to the market about the bank's value in the presence of asymmetric information. The bank's return on assets (ROA) is included in the capital equation with an expected positive effect on capital.

4.3.3. Current loan losses

A bank's current loan losses affect the ratio of risk-weighted assets to total assets as they lead to a decrease in the nominal amount of the risk-weighted assets. These losses (LLOSS), approximated with the ratio of new provisions to total assets, are therefore included in the risk equation with an expected negative effect on risk.

4.3.4. Regulatory pressure

The buffer theory predicts that a bank approaching the regulatory minimum capital ratio may have an incentive to boost capital and reduce risk in order to avoid the regulatory costs triggered by a breach of the capital requirements. However, poorly capitalised banks may also be tempted to take more risk in the hope that higher expected returns will help them to increase their capital ("gambling for resurrection").[6] We expect regulatory pressure to have a substantial impact on Swiss banks' behaviour, given the tough attitude of the Federal Banking Commission towards banks that breach the capital guidelines. The Deposit insurance guarantee scheme, which is not compulsory in Switzerland, cannot exert regulatory pressure on banks. However, low capitalised banks may be subject to informal pressure by other members of this privately financed insurance scheme.

Regulatory pressure can be evaluated in several ways. Ediz et al. (1998) adopt a relatively refined approach of regulatory pressure that reflects the impact of the capital ratio's volatility on the probability of failing to meet the legal requirements. For Switzerland, this probabilistic approach is quite appealing, given the positive relationship between excess capital and its volatility observed in table 1. Aggarwal and Jacques (1998) measure regulatory pressure using the Prompt Corrective Action (PCA) classification between adequately capitalised and undercapitalised institutions. This approach is also of interest for our study, as both PCA and Swiss banking law consider banks with a capital to RCWA of less than 8% as undercapitalised. However, the very small number of officially undercapitalised Swiss institutions (3 banks per year compared to 36 in the US) may reduce the reliability of the estimates based on this approach.

We have estimated our model using both measures of regulatory pressure. Within the probabilistic approach, the regulatory pressure variable REG is unity if the bank's

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6 See Calem and Rob (1996).

capital ratio is within one standard deviation of the minimum capital requirement defined in the banking law and zero otherwise. Within the PCA based approach, we build a first regulatory variable PCAU, which is unity for banks with an RCWA of less than 8% and zero otherwise, and a second regulatory pressure variable PCAA, which is unity for banks with an RCWA comprised between 8 and 10%.

4.3.5. Simultaneous changes in risk and capital

The theoretical models mentioned in section 2 suggest that banks' capital and risk choices are interdependent, which requires the inclusion of both variables in the right part of the model. In a regime of risk-weighted capital requirements, we can assume that banks bounded by the regulatory capital requirements will compensate an increase (decrease) in RWA with an increase (decrease) in RCTA to keep their RCWA constant. A positive relationship between changes in RWA and RCTA would also be compatible with the assumption that banks not bounded by the capital requirements adjust risk and capital in the same direction to maintain their default probability at an acceptable level, thereby protecting their franchise value. For these reasons, we expect a positive relationship between changes in RWA and changes in RCTA; as a consequence, the relationship between changes in RWA and RCWA may be rather weak, or even not significant at all.

4.3.6. Regulatory shocks and macroeconomic shocks

Changes in the capital regime may directly affect capital and risk measures, as they modify the calculation method of these variables. Macroeconomic shocks such as a change in the volume or in the structure of loans demand can also affect banks’ capital ratios and risk. To take account of these changes in the macro-economic or regulatory environment which might systematically impact on observed risk and capital adjustments in any given year, dummy variables are added to the specification for each year of the reference period. As the dummies sum to unity, we omit the general intercept. Econometrically, this is equivalent to estimating an intercept plus a dummy for all but one year, as in Shrieves and Dahl (1992).

4.4 Specification

On the basis of the analysis in sub-section 4.3, the model defined by equations (5) and (6) is specified as follows:

$$\Delta CAP_{j,t} = a_0 + a_1 \cdot REG_{j,t-1} + a_2 \cdot ROA_{j,t} + a_3 \cdot SIZE_{j,t} + a_4 \cdot \Delta RISK_{j,t} - a_5 \cdot CAP_{j,t-1} + e_{j,t} \quad (7)$$

$$\Delta RISK_{j,t} = a_0 + a_1 \cdot REG_{j,t-1} + a_2 \cdot LLOSS_{j,t} + a_3 \cdot SIZE_{j,t} + a_4 \cdot \Delta CAP_{j,t} - a_5 \cdot RISK_{j,t-1} + n_{j,t} \quad (8)$$

where REG represents regulatory pressure defined under the probabilistic approach. Under the PCA approach, REG is replaced by the regulatory pressures variables PCAU and PCAA.

5. Data, empirical methodology and results

5.1. Data and empirical methodology

The sample includes 4 big banks, 25 cantonal banks and 125 regional banks in existence from 1989 to 1995 (a total of 924 observations spaced by bank and year), which represents 82% of total assets in the Swiss banking system. Foreign banks were excluded from the sample because of the very high frequency of entries and exits in this category.

Changes in capital and risk are measured on a yearly basis, which represents the highest periodicity for which data is systematically available.

Table 2 shows the mean values of the variables for each of the six sub-periods.

Table 2: Mean values of variables

Following Jacques and Nigro (1997) and Aggarwal and Jacques (1998), we estimate the system of equations defined by (7) and (8) using a three-stage least-squares procedure. This allows us to take account of the simultaneity of banks' adjustments in capital and risk and to get estimates that are asymptotically more efficient than under two-stage least squares.[7] The cross-sectional data are pooled over the six years of the reference period, as in Shrieves and Dahl (1992).

5.2. Results for the system based on the ratio of capital to risk-weighted assets

Table 3 presents the results for the system based on the ratio of capital to risk-weighted assets. To save space, we limit the extensive discussion to the results obtained using the probabilistic measure of regulatory pressure. The estimates obtained with the PCA measure of regulatory pressure are discussed succinctly for comparison purposes.

[7] We tested our model estimates using the two-part procedure proposed by Godfrey and Hutton (1994). The first test indicates that we cannot reject the hypothesis that error in variables/simultaneity is the only misspecification; this is important, since three stage least squares estimates are sensitive to specification errors. The second test indicates that the hypothesis that there is no simultaneity and all measurements errors equal zero can be rejected, which legitimates the use of instrumental variables.

Table 3: Results for the system based on the ratio of capital to risk-weighted assets

The system based on the probabilistic measure of regulatory pressure gives the following results (left part of table 3). In the capital equation, current earnings (ROA) have a significant and positive impact on capital, indicating that profitable banks can more easily improve their capitalisation through retained earnings. SIZE has a negative and significant impact on capital, indicating that large banks increased their ratio of capital to risk-weighted assets less than other banks; here, a possible explanation is that large Swiss banks have to compete on international markets with institutions that are, in general, less capitalised. Regulatory pressure (REG) has a positive and significant impact on the ratio of capital to risk-weighted assets. Ceteris paribus, banks within one standard deviation of the regulatory minimum increase their capital ratio by 0.46 percentage points more than other banks. In the risk equation, the regulatory pressure variable has no significant impact on banks' risk, which indicates that banks approaching the minimum capital requirements neither increased nor decreased the share of risk-weighted assets in their portfolio. SIZE has a positive impact on risk, reflecting big banks' disengagement from mortgage lending (preferential risk-weight of 50%) and their increased focus on corporate finance (100% risk-weight) during the nineties. In both equations, no significant relationship emerges between changes in capital and changes in risk.

The estimates obtained using the PCA measure of regulatory pressure (right part of table 3) indicate that the regulatory variable for undercapitalised banks (PCAU) has a positive and significant impact on capital but no significant impact on risk. Ceteris paribus, undercapitalised banks increase their capital by 2.4 percentage points more than other banks. This adjustment is larger in amplitude, although less significant, than that observed for the probabilistic measure of regulatory pressure. PCAA has no significant impact on capital and risk.

5.3. Results for the system based on the ratio of capital to total assets

Table 4 presents the results for the system based on the ratio of capital to total assets. Here again, we focus on the results obtained using the probabilistic measure of regulatory pressure REG. In the capital equation, current earnings (ROA) have a significant and positive impact on capital, indicating that profitable banks improve their capitalisation through retained earnings. SIZE has a negative and significant impact on capital, indicating that the big banks increased their capital less than other banks; here again, the competitive pressure from less capitalised international banks constitutes a plausible explanation. Finally, the regulatory pressure variable has a positive and significant effect on the ratio of capital to total assets. Ceteris paribus, banks close to the legal minimum requirements increase their capital by 0.28 percentage points more than other banks. In the risk equation, regulatory pressure has no significant impact on banks’ risk. For both equations, we observe a positive and significant relationship between changes in capital and changes in risk.

Table 4: Results for the system based on the ratio of capital to total assets

The estimates obtained using the PCA measure of regulatory pressure indicate that PCAU has a positive and significant impact on capital and no significant impact on risk.

Undercapitalised banks increase their capital by 1.8 percentage points more than other banks. This adjustment is larger in amplitude than that observed for the probabilistic measure of regulatory pressure.

5.4. Interpretation of the results and comparison with evidence on US and UK banks

The positive and significant impact of both regulatory pressure variables on RCWA indicates that Swiss banks approaching the minimum legal requirements tend to improve their capital adequacy in order to avoid the penalties implied by a breach of the guidelines. Regulatory pressure appears to be stronger for undercapitalised banks than for those within one standard deviation from the trigger, as indicated by the differences in the amplitude of the capital adjustment. Interestingly, the impact of regulatory pressure on RCWA is not larger in amplitude for Swiss banks (0.5% for REG and 2.4% for PCAU on an annual basis) than for UK banks (0.5% for REG on a quarterly basis in Ediz et al., 1998) and for US banks (5.6% for PCAU on an annual basis in Aggarwal and Jacques, 1998). This result may reflect Swiss banks' difficulties to adjust their capital in a relatively illiquid market for small banks' stocks. In any case, it contrasts with the traditional view that Swiss regulators have, in an international comparison, a stricter attitude towards undercapitalised or weakly capitalised banks.

The positive and significant impact of regulatory pressure on RCTA and its absence of influence on RWA indicates that Swiss banks improve their capital adequacy by increasing their capital (retained earnings, equity issues) and not by decreasing their risk-taking. Here, it is interesting to note that Aggarwal and Jacques (1998) find that undercapitalised banks reduced their risk-weighted assets more than adequately capitalised banks following the introduction of PCA. This contrast may be explained by the fact that the market for asset-backed securities, marginal in Switzerland, plays a central role in the US, where it offers banks a cost-effective way to adjust the risk of their portfolio.

The observation of a significant and positive relationship between changes in RWA and changes in RCTA is compatible with the assumption that in a regime of risk-weighted capital requirements, banks bounded by the capital standards have to adjust RWA and RCWA in the same direction to keep their RCWA constant. This interpretation is consistent with the observation of a non-significant relationship between changes in RCWA and in RWA. Comparison with empirical evidence on US banks indicates that Shrieves and Dahl (1992) and Aggarwal and Jacques (1998) also find a positive relationship between RCTA and RWA. The absence of a significant relationship between RCWA and RWA contrasts with the findings of Aggarwal and Jacques (1998), who observe a negative relationship between RWA and RCWA for the years 1991-1992, and a positive relationship for 1993.

6. Conclusions

In this study, we have examined the Swiss banks' capital and risk behaviour during the period 1989-1995 by estimating a modified version of the model developed by Shrieves and Dahl (1992). We find that Swiss banks close to the minimum regulatory capital requirements tend to increase their ratio of capital to risk-weighted assets. This indicates that regulatory pressure, i.e. the expected penalty implied by a breach of the capital requirements, has the desired impact on banks' behaviour.

Moreover, regulatory pressure has a positive and significant impact on the ratio of capital to total assets, but no significant impact on banks' risk-taking. This indicates that for Swiss banks, an increase in available capital through retained earnings or equity issues is less costly than a downward adjustment in the risk of the portfolio. The absence of a developed market for asset-backed securities in Switzerland constitutes a plausible explanation for the relative rigidity of Swiss banks' portfolios in comparison to what was observed in studies on US banks.

Interestingly, the impact of regulatory pressure on Swiss banks' capital is not larger in amplitude than that reported for comparable studies on UK and US banks. This result contrasts with the traditional view that Swiss regulators have a particularly strict attitude towards undercapitalised institutions, but it may also reflect Swiss banks' difficulties to adjust capital in a relatively illiquid market for small banks' stocks.

Finally, we observe a positive and significant relationship between changes in risk and changes in the ratio of capital to total assets but no significant relationship between changes in risk and changes in the ratio of capital to risk-weighted assets. These two findings are consistent in a regime of risk-based capital standards, as banks constrained by the capital requirements have to increase their ratio of capital to total assets following an increase in risk to keep their risk-adjusted capital ratio constant. The positive relationship between changes in risk and changes in the ratio of capital to total assets should not be interpreted as an unintended effect of higher capital requirements on banks' risk-taking, as the recent evolution of Swiss capital requirements has actually decreased the capital burden for Swiss banks.

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Table 1: Capital data for Swiss banks (1989-96)

	excess capital (percentage of required capital)	stand. deviation of excess capital
Cantonal banks	21.02	6.62
Big banks	8.06	2.15
Regional banks	25.16	7.60
All banks	26.72	3.52

Source: Les Banques suisses en 1996, Swiss National Bank (available in French and German)

Table 2: Mean of variables (in percent)

	1990	1991	1992	1993	1994	1995
REG_{t-1}	0.2288	0.2353	0.1765	0.1830	0.1176	0.0654
$REGU_{t-1}$	0.0183	0.0000	0.0137	0.0183	0.0228	0.0046
$REGA_{t-1}$	0.5525	0.5413	0.5342	0.4951	0.4032	0.3515
$CAP1_{t-1}$ (RCTA)	0.0623	0.0622	0.0620	0.0621	0.0642	0.0662
$CAP2_{t-1}$ (RCWA)	0.1085	0.1085	0.1085	0.1093	0.1145	0.1176
$RISK_{t-1}$ (RWA)	0.5815	0.5816	0.5782	0.5754	0.5689	0.5706
ROA_t	0.00273	0.00284	0.00258	0.00311	0.00287	0.00301
$SIZE_t$ (natural log)	12.68	12.76	12.80	12.88	12.99	13.05
$LLOSS_t$	0.00458	0.00622	0.00742	0.00718	0.00530	0.00530
$DCAP1_t$ (RCTA)	-0.00011	-0.00010	0.00025	0.00188	0.00153	0.00629
$DCAP2_t$ (RCWA)	-0.00002	0.00012	0.00089	0.00423	0.00248	0.00715
$DRISK_t$ (RWA)	-0.00038	-0.00339	-0.00155	-0.00465	0.00194	0.02038

Table 3: results for the systems based on the ratio of capital to risk-weighted assets

	Probabilistic measure of regulatory pressure						PCA measure of regulatory pressure					
	$DCAP2_t$			$DRISK_t$			$DCAP2_t$			$DRISK_t$		
	Coefficient		p-value	Coefficient		p-value	Coefficient		p-value	Coefficient		p-value
$Dum\ 90$	0,0207	*	0,000	0,0228	*	0,000	0,0272	*	0,000	0,0214	*	0,001
$Dum\ 91$	0,0222	*	0,000	0,0172	*	0,005	0,0290	*	0,000	0,0152	*	0,020
$Dum\ 92$	0,0230	*	0,000	0,0213	*	0,001	0,0295	*	0,000	0,0197	*	0,005
$Dum\ 93$	0,0260	*	0,000	0,0165	*	0,008	0,0322	*	0,000	0,0155	*	0,020
$Dum\ 94$	0,0247	*	0,000	0,0241	*	0,000	0,0308	*	0,000	0,0232	*	0,001
$Dum\ 95$	0,0290	*	0,000	0,0413	*	0,000	0,0353	*	0,000	0,0407	*	0,000
REG_{t-1}	0,0046	*	0,000	-0,0020		0,329						
$REGU_{t-1}$							0,0236	*	0,023	-0,0163		0,233
$REGA_{t-1}$							-0,0007		0,466	0,0008		0,662
ROA_t	1,7771	*	0,000				1,9834	*	0,000			
$LLOSS_t$				-0,0058		0,979				0,0771		0,742
$SIZE_t$	-0,0011	*	0,000	0,0012	*	0,005	-0,0013	*	0,000	0,0012	*	0,007
$DCAP2_t$				0,1301		0,292				0,0251		0,836
$DRISK_t$	0,0430		0,179				0,0306		0,353			
$CAP2_{t-1}$	-0,1233	*	0,000	-0,0645	*	0,000	-0,1498	*	0,000	-0,0644	*	0,000
Adj. R^2	0.088			0.064			0.081			0.057		

Note: * represent statistical significance at the 0.05 level

Table 4: results for the systems based on the ratio of capital to total assets

	Probabilistic measure of regulatory pressure $DCAP1_t$						PCA measure of regulatory pressure $DCAP1_t$					
				$DRISK_t$						$DRISK_t$		
	Coefficient		p-value	Coefficient		p-value	Coefficient		p-value	Coefficient		p-value
$Dum\ 90$	0,0072	*	0,000	0.0181	*	0.003	0,0086	*	0,000	0,0129	*	0,041
$Dum\ 91$	0,0082	*	0,000	0.0123	*	0.038	0,0094	*	0,000	0,0062		0,324
$Dum\ 92$	0,0082	*	0,000	0.0151	*	0.017	0,0096	*	0,000	0,0099		0,140
$Dum\ 93$	0,0093	*	0,000	0.0082		0.174	0,0110	*	0,000	0,0035		0,582
$Dum\ 94$	0,0094	*	0,000	0.0165	*	0.007	0,0104	*	0,000	0,0123		0,059
$Dum\ 95$	0,0143	*	0,000	0.0256	*	0.001	0,0136	*	0,000	0,0225	*	0,007
REG_{t-1}	0,0028	*	0,000	-0.0012		0.382						
$REGU_{t-1}$							0,0184	*	0,001	-0,0160		0,196
$REGA_{t-1}$							0,0009		0,079	-0,0006		0,737
ROA_t	1.0180	*	0.000				1,2376	*	0,000			
$LLOSS_t$				0.0795		0.697				0,2118		0,324
$SIZE_t$	-0.0003	*	0.009	0.0012	*	0.003	-0,0005	*	0,000	0,0015	*	0,001
$DCAP1_t$				1.7451	*	0.000				1,5182	*	0,000
$DRISK_t$	0.0964	*	0.000				0,0929	*	0,000			
$CAP1_{t-1}$	-0.0916	*	0.000	-0.0559	*	0.000	-0,1074	*	0,000	-0,0551	*	0,000
Adj. R^2	0.114			0.072			0.105			0.043		

Note: * represent statistical significance at the 0.05 level