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The effectiveness of bank capital adequacy regulation: A theoretical and empirical approach

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Abstract

The aim of this paper is to analyse how banking firms set their capital ratios, that is, the rate of equity capital over assets. In order to study this issue, two theoretical models are developed. Both models demonstrate the existence of an optimal capital ratio; the first one for firms not affected by capital adequacy regulation, the second one for firms which are. The models have been tested by estimating a disequilibrium model using data from Spanish commercial banks.

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1. Introduction

Although capital generally accounts for a small percentage of the financial resources of banking institutions, it plays a crucial role in their long-term financing and solvency position and therefore in their public credibility. In the event of a crisis, the lower the leverage ratio is, the lower the probability that a bank will fail to pay back its debts. This fact tends to justify the existence of capital adequacy regulation in order to avoid bankruptcies and their negative externalities on the financial system,

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although banks may respond to this regulation by increasing their risk exposure.¹ Other unintended negative effects associated to this regulatory mechanism or to the way it is implemented are also present in the literature. Santomero and Watson (1977) show that too tight a capital regulation lead banks to reduce their credit offer and, as a result, give rise to a fall in productive investment. Acharya (2001a,b) shows that capital adequacy regulation in some contexts could even accentuate systemic risk. So, under international financial integration, a simple coordination on some parts of banking regulation (uniform capital requirements) but not others (the forbearance in supervisor's closure policies) can give rise to international negative externalities that destabilize the global system. Furthermore, a design of capital adequacy requirements, based only on individual bank risk, as the actual proposed in the Basle Accord, is showed to be suboptimal in both papers. All the above arguments suggest the need for an analysis of how banks set their capital to assets ratio.

This topic is of special interest in Spain where from the late 1980s an important process of financial deregulation has coexisted with a supervisory re-regulation. The severe banking crisis suffered during 1978–1985 together with the international trend towards the application of risk-based capital rules seem to lie behind the 1985 risk-based capital legislation. The Spanish Capital Adequacy Regulation Act of 1985 imposed two simultaneous minimum capital ratios: A global or generic ratio and a selective or risk-based capital ratio. The former stipulated that capital had to be a minimum percentage of total investments. The latter stipulated a risk-weighted capital requirement, where capital had to exceed the sum of different assets or off-balance sheet exposures, weighted according to their relative risk. Accordingly, this last requirement was specific for each bank. The impact of this tighter capital adequacy regulation was apparently more pronounced in Spain than in most other EU countries. This can be corroborated by the fact that the average capital to assets ratio of Spanish banks rose substantially after 1985 reaching values above 3 percentage points with respect to the mean of EU countries.²

This legislation may have affected Spanish banking institutions (commercial banks, savings banks, credit co-operative banks) in different ways depending on their capital structure. This paper focuses only upon the analysis of the effectiveness of capital adequacy regulation on Spanish commercial banks, which account for over 50% and 50% of total loans and deposits, respectively, of the Spanish banking sector from 1985–1992. Nevertheless, this market quota has decreased over time as a result of the increasing competition in the financial sector.

Core capital (TIER 1) in Spanish commercial banks (share capital plus undivided profits plus reserves) accounts for over 80% of their total capital, accumulated re-

¹ See Koehn and Santomero (1980), Lam and Chen (1985), Lackman (1986), Kim and Santomero (1988) and Rochet (1992). In contrast with this idea, Furlong and Keeley (1989) and Keeley and Furlong (1991) state that capital adequacy requirements reduce incentives to increase risky assets, thus decreasing the probability of the bank's bankruptcy. Other works such as Kendall (1991) and Camel and Rob (1996) show an ambiguous impact on this incentive to take more risks, depending on a bank's capital adequacy and financial situation.

² See OCDE: Bank profitability.

serves representing the most important weight of this percentage. This implies that in a period of recession, too tight a regulation could reduce the assets growth of these institutions, especially when banks are constrained in capital markets when they try to issue new shares. The supplementary capital (TIER 2) includes essentially revaluation reserves and subordinated debt. The increasing importance of subordinated debt can be observed from its contribution to commercial banks capital which has grown from 0.9% of total capital in 1986 to 13.2% in 1992.

The purpose of this study is to explain whether regulatory capital requirements induce banks to hold higher capital ratios than would otherwise have been. Several studies on the effectiveness of capital requirements on US banks provide answers to this question by including a proxy for regulatory capital in empirical models.³ Variables such as the ABC ratio (ratio of actual bank capital to capital desired by the regulator) or binary variables (1 for banks with adequate capital and 0 otherwise) are examples of this regulatory pressure. This regulatory pressure was interpreted as being effective when the coefficients of these variables were found to be statistically significant with the predicted sign.⁴ One problem of these studies is that the factors used to evaluate capital adequacy were likely to be highly correlated with those used by the market. Conversely, Wall and Peterson (1987, 1995) speculate on whether the adoption of fixed minimum regulatory capital requirements led US bank holding companies (BHCs) to maintain higher capital ratios than those market forces would have led to.⁵ Both papers propose the classification of institutions into two regimes: A regulatory regime and a market regime. If regulatory guidelines exceed market requirements, then the regulation is binding and the bank is operating in the regulatory model, otherwise, the bank is operating in the market model. The disequilibrium estimation technique with cross section data is used in both works.

Regarding all those empirical studies concerning the effectiveness of capital adequacy regulation Jackson et al. (1999) conclude: “There is no provide evidence that capital adequacy regulation per se as opposed market discipline lead banks to hold higher capital ratios than they otherwise would, on the contrary, it seems that the two forces are likely to be closely interrelated”.

The immediate previous reference for this issue in the case of Spanish commercial banks can be found in Carbo (1993). In this paper the impact of capital adequacy regulation on capital augmentations of these institutions is analysed. The empirical model is built upon the Dietrich and James (1983) model after adapting this to reflect capital regulation and market developments for Spanish commercial banks. The model is tested using a cross-section analysis during 1987–1990. The differences between this work and our methodology will be presented throughout this paper.

³ See Peltzman (1970), Mingo (1975), Heggestad and Mingo (1975), Dietrich and James (1983), Marcus (1983), Shrieves and Dahl (1992), Jacques and Nigro (1997) and Aggarwal and Jacques (2001). In the context of EU countries, Carbo (1993), Ediz et al. (1998) and Rime (2001) study the effectiveness of bank capital adequacy regulation in the Spanish, English and Swiss banking systems, respectively.

⁴ These types of proxies introduce some problems in the estimation model. For a more detailed explanation see Jackson et al. (1999).

⁵ This central issue is also pursued in Dahl and Shrieves (1990), but employing a different methodology.

Our analysis build two models called the market and the regulatory regimes upon the Wall and Peterson (1987) approach but including important novelties with respect to this one. Both models explain the way banks set their capital to assets ratio in a context in which the authorities establish a (minimum) capital adequacy regulation and enforce the rule by means of sanctions. Both models demonstrate the existence of a desired capital to assets ratio and point out the variables determining it. The first one describes the behaviour of firms not affected by regulation as they have optimal market capital to assets ratios higher than the regulated one. This model synthesizes in a theoretical formulation the issues proposed in the banking literature to justify an optimal capital structure (liquidity premium, operating costs associated to deposits and deposit insurance). Although this framework was also present in Wall and Peterson (1987, 1995), they limited their analysis to build an empirical model based on factors discussed by their contemporaries. Our second model explains the behaviour of banks whose optimal capital ratio lies below the minimum one: Their decision will consist in maintaining not just the minimum regulated ratio but a slightly higher one (capital cushion). This idea of a capital cushion, established as a precaution against contingencies, was mentioned initially in Wall and Peterson (1987) although these authors provided only an intuitive explanation of this phenomenon. We show below that banks will set this cushion whenever the capital ratio is not totally controllable (or stochastic) and when important sanctions to enforce the capital rule exist. In this case, banks would maintain this cushion to prevent the stochastic capital ratio from reaching values below the permitted minimum in order to avoid being sanctioned. The market and the regulatory model are tested jointly using disequilibrium estimation techniques. The original sample contains 76 Spanish commercial banks during the period 1985–1991 (unbalanced panel data).

The paper is organized as follow. In Section 2, two theoretical models (the market and the regulatory regimes) analysing bank behaviour in setting capital ratios are developed. In Section 3 an econometric model for markets in disequilibrium is proposed to distinguish between these two regimes. The empirical results are also shown in this section. Finally, Section 4 presents a summary and conducting comments.

2. Theoretical background: The determinants of capital structure decisions

Does an optimal market capital ratio for banks exist?. There are two answers to this question from two alternative theoretical approaches. The Modigliani–Miller proposition ⁶ (henceforth M&M) has shown that, provided the existence of competitive capital markets and the absence of bankruptcy costs, corporate income taxation or other market imperfections, the value of a firm is independent of its financial structure. On the other hand, the classic thesis states that, restoring one or more of these excluded conditions, the value of the firm may reach an internal maximum with positive equity in its financial structure. In supporting the idea of an optimal

⁶ See Modigliani and Miller (1958).

capital ratio for banking institutions, some authors have contemplated several exceptions to the M&M proposition: Bankruptcy and agency costs, liquidity services and operating costs associated to deposits and deposit insurance.⁷ In these situations, they have shown that the market value of a bank is not independent of the way it is financed; in the absence of capital regulation an optimal capital ratio may exist. Nevertheless, even when accepting such optimal market capital ratios, banks are obliged by regulation to keep a minimum capital ratio to minimize the social cost derived from a banking crisis. This constraint is binding only for banks with an optimal market capital ratio lower than the minimum standard, this being irrelevant for banks with optimal capital positions above the regulatory minimum. These two situations allow us to classify banks into two different models or regimes: The market model and the regulatory model. In so far as there are banks operating with capital positions above the regulatory minimum (capital regulation is non-effective), one can suspect that market forces are at work resulting in banks maintaining capital in excess of regulatory requirements.

2.1. Market model

The model has the following simple time structure: There are two periods with two dates $t = 0, 1$ (see Fig. 1). At the beginning of time $t = 0$ a bank can invest its available funds. At the end of $t = 0$ returns are realized. If the bank does not go to bankrupt another investment can be undertaken at time $t = 1$. Again, at the end of $t = 1$ the final returns are realized and all parties are compensated.

Shareholders are risk neutral agents who can invest on personal account at the risk free interest rate (r_f), assumed constant over time.⁸ In the event of bankruptcy, their responsibility is limited to the value of their investment in the bank, which is protected by the standard limited liability provision of contracts. Due to limited liability, shareholders cannot be forced to pay any additional amount to cover unfulfilled claims. They seek to maximize the expected value of their investment in the bank.

The liability side is made up of deposits and capital. Since the initial stock of capital K_0 is exogenously given, the bank can choose the supply of deposits D_0 at $t = 0$. Denoting the value of assets at $t = 0$ by A_0 , the bank's balance sheet is $A_0 = K_0 + D_0$.

At the beginning of time $t = 0$, the bank invests A_0 in a portfolio of assets with a gross rate of return net of loan losses⁹ $(1 + \tilde{r}_{a0})$, which is a random variable independently and identically distributed over time. We assume that there exists a non-risky asset yielding a risk-free interest rate $(1 + r_f)$.

Deposits are fully insured (principal and interest promised to depositors) by a deposit insurance agency, so D_0 is raised from depositors at a face interest rate r_{d0}

⁷ See Berger et al. (1995) for examining other departures from the conditions under which M&M proposition holds.

⁸ We assume bank managers act in the interests of shareholders.

⁹ See Peek and Rosengren (1995).

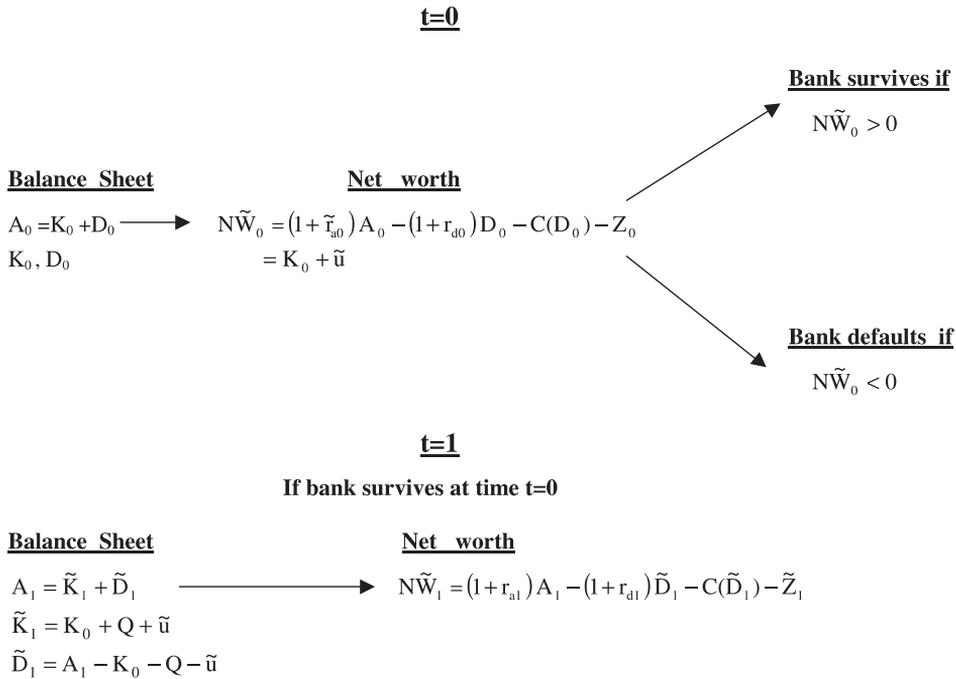


Fig. 1. The market model: Time line and investment choices of banks (note that the nature of randomness changes between two periods: Earnings are stochastic in the first period and non-stochastic in the second, while in the case of capital this assumption is the opposite).

which does not depend on default risk. The deposit interest rate is fixed at the beginning of each period by means of an agreement between the bank and the depositors. Deposit raising at $t = 0$ generate liabilities defined as: $(1 + r_{d0})D_0$.

In addition, deposits cause the bank to incur two other costs: The deposit insurance premium (Z_0) and operating costs¹⁰ $C(D_0)$. Both are paid at the end of each period. The deposit insurance premium is an under-priced proportion of the payments to depositors in the event of bankruptcy ($Z_0 = bD_0$), b being a variable rate premium that is a negative function of the expected capital ratio. On the other hand, operating costs depend on deposits such that $[C(D_0) = cD_0]$, c being a positive linear function of the mean of deposits:

$$c = c_x \bar{D}_t \quad t = 0, 1.$$

This assumption guarantees that cost function satisfies the following conditions: $C(0) = 0$, $C'(D) > 0$ and $C''(D) > 0 \forall D > 0$. The existence of these operating costs allows deposits to be raised in equilibrium at interest rates below (r_f), even if the

¹⁰ Intermediation costs due to the provision of transaction services attached to deposits.

market is perfectly competitive and agents are risk neutral. The difference between both rates ($r_f - r_{d0}$) consists in a liquidity premium paid for liquidity services provided by intermediaries. This premium represents what depositors are willing to renounce in terms of profitability in exchange for liquidity services.

At the end of period $t = 0$, once asset return has been observed, the bank's final net worth ($N\tilde{W}_0$) is computed as the difference between the value of assets and liabilities. If the available funds are not sufficient to cover the costs ($N\tilde{W}_0 < 0$), the bank defaults and all available funds (if any) are transferred to the deposit insurance agency. This agency will pay the contracted returns back to depositors and, in practice, will cover the rest of the losses of the bank.¹¹ Thereby, we are assuming that the deposit insurer takes control of the bank's assets in those states where the insurer pays the bank's debts. Alternatively, if ($N\tilde{W}_0 > 0$), the bank remains open and the bank's net worth will be determined by the initial capital plus the profits or losses of this period.¹²

$$\begin{aligned} N\tilde{W}_0 &= (1 + \tilde{r}_{a0})A_0 - (1 + r_{d0})D_0 - C(D_0) - Z_0 \\ &= K_0 + \tilde{r}_{a0}A_0 - r_{d0}D_0 - C(D_0) - Z_0. \end{aligned} \quad (1)$$

From Eq. (1) we can obtain a critical value

$$s = \{r_{d0}D_0 + C(D_0) + Z_0 - K_0\}/A_0,$$

such that $N\tilde{W}_0 \geq 0$ if and only if $\tilde{r}_{a0} \geq s$. Thereby, the bank's probability of failure at time $t = 0$ will be $F(s)$, where $F(\cdot)$ is the accumulated distribution function of \tilde{r}_{a0} .

By rewriting expression (1), we define

$$N\tilde{W}_0 = K_0 + \tilde{u}, \quad (2)$$

where, for analytical convenience, we assume that \tilde{u} is a stochastic disturbance term normally distributed $\tilde{u} \sim N(0, \sigma_u^2)$.

In the second period ($t = 1$), for simplicity, we abstract from the uncertainty of return of portfolio of assets ($1 + \tilde{r}_{a1}$) and assume this value is observed, its random value being replaced by a given value ($1 + r_{a1}$). Since we are interested in the choice of capital to assets ratio at $t = 1$, being so does not qualitatively affect the results of the paper.¹³ On the other hand, the bank can increase the capital ratio over period 1 by either reducing assets or increasing capital. However, since the aim pursued in this section is to obtain an optimal capital structure for each value of the bank, we will assume that the level of assets will be fixed at the amount A_1 at $t = 1$. Consequently, two propositions will be derived from this last assumption: (a) The bank will modify its capital ratio only by changing capital in period 1 and (b) the decision of the bank will entail choosing the capital to assets ratio that maximizes the expected value of shareholders' investment in the bank.

¹¹ The history of the Spanish Bank Deposit Insurance Corporation (SBDIC) is full of this type of intervention. Only recently, and in very few cases, did the SBDIC pay off the bank's insured depositors.

¹² See Rochet (1992).

¹³ See Blum (1999).

The amount of capital at the beginning of time $t = 1$ is determined by the initial amount K_0 at $t = 0$ plus the profits and losses of the first period \tilde{u} plus the amount of net capital issuance (Q). The variable Q can be interpreted as the option of the bank to be recapitalized with new funds ($Q > 0$) or the compromise to payoff dividends ($Q < 0$).

$$\tilde{K}_1 = K_0 + Q + \tilde{u} = \bar{K}_1 + \tilde{u}. \tag{3}$$

The randomness of net retained earnings at the beginning of time $t = 1$ is the source of randomization of \tilde{K}_1 . Although at that moment, an estimation of past accountant profits can be achieved, so being a value known, the uncertainty respect to the real economic profit generated in that period can persist. Not only certain loans, which had been classified initially as non-performing loans, could be recovered along $t = 1$, but also the magnitude of loan loss allowances should be increased with the new information obtained. In this context, at the beginning of time $t = 1$, bankers with the available information and being \tilde{u} stochastic, would select in equilibrium the optimal net capital issuance (Q).

Since \tilde{K}_1 is stochastic and the level of assets is given, deposits are stochastic too.

$$\tilde{D}_1 = A_1 - \tilde{K}_1 = A_1 - K_0 - Q - \tilde{u} = A_1 - \bar{K}_1 - \tilde{u}. \tag{4}$$

On the other hand, costs associated to deposits (the deposit insurance premium, operating costs, repayments of principal and interest rates) will be redefined as

$$\tilde{Z}_1 = b\tilde{D}_1,$$

$$[C(\tilde{D}_1) = c\tilde{D}_1],$$

$$(1 + r_{d1})\tilde{D}_1,$$

where $c = c_\alpha \bar{D}_1 = c_\alpha(A_1 - \bar{K}_1)$ and b is a negative function of (\bar{K}_1/A_1) .

Risk neutrality and the possibility of investing on personal account at the risk free interest rate allow shareholders to maximize the expected value of their investment in the bank. A bank in the market model should maximize expression (5) with respect to the net capital issues to assets ratio (Q/A_1). For analytical convenience, we define all variables as ratios per unit of assets.

$$\begin{aligned} \max_{Q/A_1} & \left\{ [1 - F(s)]E \left\{ \max \left[(1 + r_{a1}) - (1 + r_{d1}) \frac{\tilde{D}_1}{A_1} - \frac{C(\tilde{D}_1)}{A_1} - \frac{\tilde{Z}_1}{A_1}, 0 \right] \right\} \right. \\ & \left. + F(s) \max \left\{ 0, (1 + r_{a0}) - (1 + r_{d0}) \frac{\tilde{D}_0}{A_0} - \frac{C(\tilde{D}_0)}{A_0} - \frac{\tilde{Z}_0}{A_0} \right\} \right\}, \tag{5} \end{aligned}$$

where $E(\cdot)$ is the expectation operator.

The first term of expression (5) is the value of the bank for shareholders in the case of success at $t = 0$. Due to limited liability, the value of equity in case of failure at $t = 0$ is zero and the bank cannot continue operating. Hence, the second term is zero.

Redefining expression (5) in terms of the explanatory variables which can determine the bank’s capital structure decision, we can obtain

$$\begin{aligned} \max_{Q/A_1} &= \{1 - F(s)\} \{ (1 + r_{a1}) - (1 + r_{d1})(1 - (\bar{K}_1/A_1)) - c_\beta(1 - (\bar{K}_1/A_1))^2 \\ &\quad - E(\tilde{G}/A_1) \} \\ &= \max_{Q/A_1} \{ 1 - F(s) \} \{ E(X_u) - (1 + r_{d1})E(\tilde{D}_1/A_1) - E(C(\tilde{D}_1)/A_1) \\ &\quad - E(\tilde{G}/A_1) \}, \end{aligned} \tag{6}$$

where $c_\beta = c_\beta A_1$ is a constant parameter.

The expected value (per unit of assets) of a levered bank can be expressed as the sum of the expected value of an unlevered bank per unit of assets $E(X_u)$, minus the expected costs per unit of assets associated to deposits (repayment of principal and interest rates and operating costs) plus the expected value of the deposit insurance subsidy net of premium $[-E(\tilde{G}/A_1)]$.

After carrying out a number of algebraic manipulations, we can rewrite (6) as

$$\begin{aligned} \max_{Q/A_1} \{ 1 - F(s) \} \{ \rho + \mu(1 - \bar{K}_1/A_1) - c_\beta(1 - (\bar{K}_1/A_1))^2 + (1 + r_f)(\bar{K}_1/A_1) \\ - E(\tilde{G}/A_1) \}, \end{aligned} \tag{7}$$

where $\rho = r_{a1} - r_f$ denotes the excess return of the portfolio of assets in relation to the yield of non-risky assets (the risk free interest rate), and $\mu = r_f - r_{d1}$ the value that depositors assign to the liquidity premium. Depositors are disposed to receive a lesser profitability for their deposits in exchange for several liquidity services associated to them.¹⁴

The expected value (per unit of assets) of the deposit insurance subsidy net of premium $[-E(\tilde{G}/A_1)]$ depends on the quantity insured $\{(1 + r_{d1})\tilde{D}_1\}$, on other payment commitments $[C(\tilde{D}_1)]$ in the event of bankruptcy, on the probability of bankruptcy $F(p)$ in the second period ($t = 1$), on the insurance premium (\tilde{Z}_1) when the bank is solvent and on the expectancy of asset recovery after bankruptcy $(\int_{-\infty}^p (1 + r_{a1}) \times f(\tilde{u}_1) d\tilde{u}_1)$. Therefore,

$$\begin{aligned} -E(\tilde{G}/A) &= \int_{-\infty}^p \left[\{ (1 + r_{d1})\tilde{D}_1 + C(\tilde{D}_1) \} / A_1 - (1 + r_{a1}) \right] f(\tilde{u}_1) d\tilde{u}_1 \\ &\quad - \int_p^\infty (\tilde{Z}_1/A_1) f(\tilde{u}_1) d\tilde{u}_1 \\ &= \int_{-\infty}^p \left\{ [1 + r_{d1} + c_\beta \{ 1 - (\bar{K}_1/A_1) \}] (\tilde{D}_1/A_1) - (1 + r_{a1}) \right\} f(\tilde{u}_1) d\tilde{u}_1 \\ &\quad - b \int_p^\infty (\tilde{D}_1/A_1) f(\tilde{u}_1) d\tilde{u}_1, \end{aligned} \tag{8}$$

¹⁴ See Baltensperger (1973, 1980), Orgler and Taggart (1983) and Sealey (1983).

where $p = [1 - (\bar{K}_1/A_1)] - \{1 + r_{d1} + b + c_\beta[1 - (\bar{K}_1/A_1)]\}^{-1}(1 + r_{d1})$ defines a critical value such that the bank's net worth at time $t = 1$ is positive if and only if $\tilde{u}_1 = (\tilde{u}/A_1) \geq p$.

Rewriting Eq. (8), we can obtain expression (9):

$$-E(\tilde{G}/A) = \int_{-\infty}^p \left\{ [1 + r_{d1} + c_\beta\{1 - (\bar{K}_1/A_1)\}] (p - \tilde{u}_1) f(\tilde{u}_1) d\tilde{u}_1 \right\} - b\{1 - (\bar{K}_1/A_1)\}, \tag{9}$$

which is positive since we have assumed that the deposit insurance premium is underpriced.¹⁵ It can be shown that the value of (9) is equivalent to the value of a bank's limited liability per unit of assets (VLL) net of the expected deposit insurance premium $E(\tilde{Z}_1/A_1)$.

$$-E(\tilde{G}/A) = \text{VLL} - E(\tilde{Z}_1/A).$$

From expression (6), we can deduce that the value of a bank is not independent of its capital structure. However, this is not enough to demonstrate the existence of an optimal market capital ratio. The first order condition for a maximum establishes that the net capital issues to assets ratio (Q/A_1) will be increased until marginal revenue equals marginal cost (10). Consequently, the diminution in operating costs and the deposit insurance premium derived from greater solvency as a result of a smaller leverage is compensated by a lower deposit insurance subsidy and a liquidity premium net of capital opportunity cost, that is,¹⁶

$$\frac{\partial \left\{ -E\{\tilde{G}/A_1\} - E\{C(\tilde{D}_1)/A_1\} \right\}}{\partial(Q/A_1)} = \mu - (1 + r_f), \tag{10}$$

or equivalently,

$$\begin{aligned} \mu - (1 + r_f) + (1 + r_{d1})F(p) &= 2c_\beta\{1 - (\bar{K}_1/A_1)\}[1 - F(p)] - c_\beta\sigma_{u1}^2 f(p) \\ &+ \left(b - \frac{\partial b}{\partial(Q/A_1)} \{1 - (\bar{K}_1/A_1)\} \right) [1 - F(p)] \\ &+ \frac{\partial b}{\partial(Q/A_1)} \sigma_{u1}^2 f(p), \end{aligned} \tag{10'}$$

where $f(\cdot)$ and $F(\cdot)$ are the density and distribution functions and σ_{u1}^2 is the variance of \tilde{u}_1 .

By second order condition, marginal costs should increase faster than marginal revenues. In order to guarantee this result, the model should verify one of these con-

¹⁵ An actuarially fair premium will cancel out this expression.

¹⁶ This result is similar to this one obtained by Sealey (1983, p. 862) with the exception that his model did not include a deposit insurance agency. Sealey, assuming also that the level of assets was given $dA = 0$ and operating costs were a function of deposits, showed that "deposits should be substituted for equity as long as the marginal liquidity premium is greater than the marginal cost of servicing the additional deposits".

ditions or both jointly: First and second derivatives of operating costs (C' and C'') are positive¹⁷ and/or parameter b (the deposit insurance premium per unit of cover) is a decreasing and convex function of the expected capital ratio¹⁸ and consequently of (Q/A_1) . Therefore,

$$\left\{ -\frac{\partial^2 b}{\partial(Q/A_1)^2} \int_p^\infty \frac{\tilde{D}_1}{A_1} f(\tilde{u}_1) d\tilde{u}_1 - 2c_\beta[1 - F(p)] + 2\frac{\partial b}{\partial(Q/A_1)} [1 - F(p)] + [1 + r_{d1} + b + c_\beta\{1 - (\bar{K}_1/A_1)\}]^{-1} f(p) \left(\frac{\partial p}{\partial(Q/A_1)} \right)^2 \right\} < 0. \tag{11}$$

Even under the previous conditions, expression (11) fails to be negative for all parameter values. However, by carrying out a simulation exercise on first and second order conditions with quadratic operating costs, flat rate premium and parameter values similar to those of Spanish banks, we observe that expression (11) still can remain negative. Moreover this simulation allows us to approximate the first order condition to the following linear equation which can be estimated:

$$(Q/A_1) = -\gamma_0 + \gamma_1 b - \gamma_2\{\mu - (1 + r_f)\} + \gamma_3 c_\beta - \gamma_4(c_\beta)^2 + \gamma_5 \sigma_{u1}^2, \tag{12}$$

where γ_i are positive parameters.

The net capital issues to asset ratio increases with b , c_β and σ_{u1}^2 . It decreases with $\mu = (r_f - r_{d1})$. This fact reflects that a high level of banking demand for capital will be associated with high costs of deposits and a high variability of returns on assets. On the contrary, for a given risk-free interest rate, the higher the deposit interest rate is, the lower will be the liquidity premium depositors are willing to pay. This would reduce the bank's incentive to capture debt. Operating costs are a good indicator of efficiency and probability of bankruptcy (Berger, 1995). The sign of the variability of returns on assets indicates that the greater the dispersion of retained earnings of the company is, the greater the issues of new capital in order to avoid the firm going bankrupt.

Expression (12) shows the explanatory variables of capital variations. Since we are interested in obtaining the determinants of the capital to assets ratio, we will connect this expression with the definition of capital at time $t = 1$ in (3). Taking into account that the initial stock of capital K_0 is determined exogenously, we can define the expected optimal market capital to assets ratio under the control of the bank at time $t = 1$ $\{\bar{K}_1/A_1\}^*(m)$ as

$$\{\bar{K}_1/A_1\}^*(m) = +\varphi + \gamma_1 b - \gamma_2\{\mu - (1 + r_f)\} + \gamma_3 c_\beta - \gamma_4(c_\beta)^2 + \gamma_5 \sigma_{u1}^2, \tag{13}$$

where $\varphi = -\gamma_0 + (K_0/A_1)$.

¹⁷ This is one of the assumptions of the market model.

¹⁸ First and second derivatives of b with respect to (\bar{K}_1/A_1) are negative and positive respectively. It can be shown that if $\{C(\tilde{D}_1)/A_1\}$ is a constant proportion of deposits, that is, $\{C(\tilde{D}_1)/A_1\} = c_x(\tilde{D}_1/A_1)$, where c_x is a constant parameter and the deposit insurance premium is flat, the bank maximizes (6) by increasing its leverage to the limit.

2.2. Regulatory model

Bank capital adequacy requirements force banks to maintain at the end of each period ($t = 0, 1$) a level of capital above the mandatory (legal) regulatory minimum capital to assets ratio. The divergence between this last magnitude and the corresponding optimal market capital to assets ratio responds to a different conception between supervisor and bank with respect to the level of solvency that the bank should guarantee in order to safeguard the stability of the banking system. In particular, we assume in this model that the optimal market capital to assets ratio at time $t = 1$, $\{K_1/A_1\}^*$ is below the regulatory minimum capital R .

On the other hand, the actual (ex-post) capital ratio (K_1/A_1) at the end of time $t = 1$ is stochastic and can diverge from the regulatory minimum in a random way. The capital stock at the end of time $t = 1$ is determined by the initial amount at the beginning of time $t = 1$ plus the profits and losses generated along the period. Again, as in (3), the randomness of net retained earnings is the source of the randomization of capital at the end of $t = 1$.¹⁹

The supervisor, in order to enforce the capital adequacy rule, imposes two types of sanctions payments if $\{K_1/A_1\}^* < R$ (Fig. 2): A fixed one (J), if the bank operates below the regulation, and a variable one, which is proportional to the square of the difference between the regulated and the actual capital ratio.²⁰ As a result, the value of a bank per unit of assets (V/A_1) moves away from its pure unregulated value when the capital ratio moves away from the regulatory minimum to the left (V/A_1)_{*i*}. On the contrary, it remains unchanged when the capital ratio moves away to the right (V/A_1)_{*d*}.

Under these assumptions, the value of the bank per unit of assets will be:

$$V/A_1 = \begin{cases} (V/A_1)_d = \left\{ (V/A_1)_R - \delta[(K_1/A_1) - R]^2 \right\} & \text{if } (K_1/A_1)^* \geq R, \\ (V/A_1)_i = \left\{ (V/A_1)_R - J - \theta[(K_1/A_1) - R]^2 \right\} & \text{if } (K_1/A_1)^* < R, \end{cases} \quad (14)$$

where $(V/A_1)_R$ is the value of the bank per unit of assets when the capital ratio equals R . δ and θ are positive parameters and $\delta \leq \theta$.

The actual (ex-post) capital to assets ratio (K_1/A_1) will be the sum of the desired capital ratio $(K_1/A_1)^*(R)$ under regulation plus a stochastic disturbance term:

$$(K_1/A_1) = (K_1/A_1)^*(R) + \tilde{\varepsilon} \quad \text{where } \tilde{\varepsilon} \sim N(0, \sigma_{\tilde{\varepsilon}}^2). \quad (15)$$

The capital ratio target in the regulatory model is the amount of capital required to satisfy the capital guideline R plus a possible capital cushion as a caution against contingencies H .

¹⁹ For the sake of simplicity, we use in this section, as in Section 2.1, the subscript 1 to refer to the second period. However, we should take into account that here the subscript 1 refers to the end of time $t = 1$ while in Eq. (3) it is associated with the beginning of time $t = 1$.

²⁰ The pattern of penalties in Spain follows this principle: Fixed and variable sanctions.

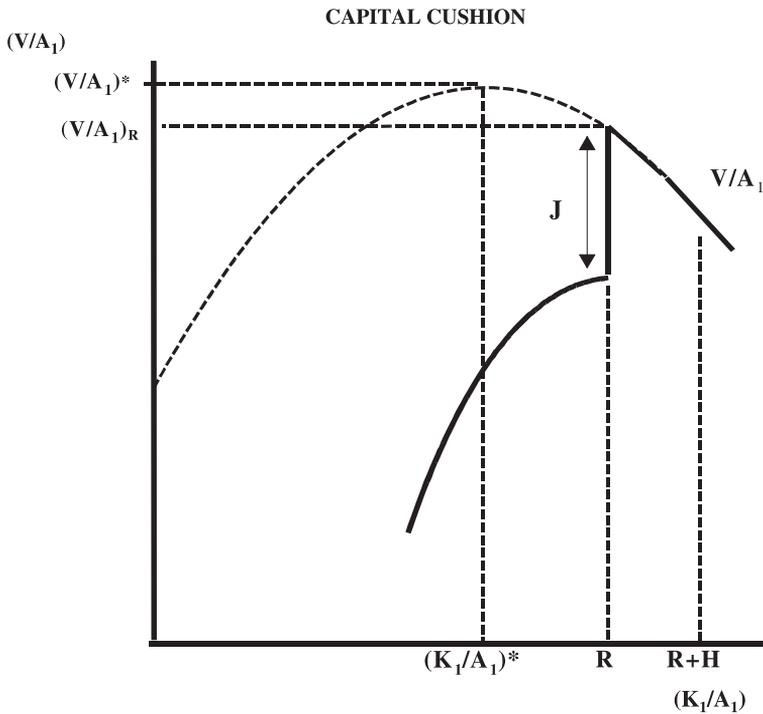


Fig. 2. Capital cushion.

$$(K_1/A_1)^*(R) = R + H. \tag{16}$$

Substituting Eqs. (15) and (16) into (14) the value per unit of assets of the bank (V/A_1) may be rewritten as:

$$V/A_1 = \begin{cases} (V/A_1)_d = \left\{ (V/A_1)_R - \delta H^2 - \delta \tilde{\varepsilon}^2 - 2\delta \tilde{\varepsilon}H \right\} & \text{if } \tilde{\varepsilon} \geq -H, \\ (V/A_1)_i = \left\{ (V/A_1)_R - J - \theta H^2 - \theta \tilde{\varepsilon}^2 - 2\theta \tilde{\varepsilon}H \right\} & \text{if } \tilde{\varepsilon} < -H, \end{cases} \tag{17}$$

and, taking expectations we obtain

$$E(V/A_1) = \left[(V/A_1)_R - \delta H^2 [1 - F(-H)] - \theta H^2 F(-H) - \delta E[\tilde{\varepsilon}^2]_{-H}^{+\infty} - \theta E[\tilde{\varepsilon}^2]_{-\infty}^{-H} - 2\delta HE(\tilde{\varepsilon})_{-H}^{+\infty} - 2\theta HE(\tilde{\varepsilon})_{-\infty}^{-H} - JF(-H) \right]. \tag{18}$$

The level of capital cushion per unit of assets which maximizes the expected market value will be ²¹

²¹ The second order condition is always met.

$$H = \frac{\sigma_\varepsilon \{ \phi [(-H)/\sigma_\varepsilon] [\theta - \delta] \}}{\delta + \Phi [(-H)/\sigma_\varepsilon] [\theta - \delta]} + \frac{J \{ \phi [(-H)/\sigma_\varepsilon] \}}{\{ 2\delta + 2\Phi [(-H)/\sigma_\varepsilon] [\theta - \delta] \} \sigma_\varepsilon}, \quad (19)$$

where ϕ and Φ are the distribution and density functions of a standard normal random variable. The optimal capital cushion will depend on J and on σ_ε (capital ratio volatility). Three special cases are worth pointing out: (i) If $\theta > \delta$, H is positive (even if $J = 0$), (ii) if $\theta = \delta$ and $J = 0$, H is zero and (iii) if $\theta = \delta$ and $J > 0$ expression (19) is reduced to

$$H = \frac{J \{ \phi [(-H)/\sigma_\varepsilon] \}}{2\delta\sigma_\varepsilon}. \quad (20)$$

Comparative static exercises show that H will be higher, the higher J , σ_ε and $\theta > \delta$ are. However, since the distribution function is normal and its integration limits depend on H , an explicit function of H cannot be obtained: It is necessary to use simulation techniques. We further assume (in order to simplify and without great loss of generality) that $\theta = \delta$ (expression (20)). This allows for a reduction in the number of parameters to 2 (σ_ε and J/δ). As a result of the simulation exercise, we obtain that the optimal capital cushion can be approximated to

$$H = -\alpha_1 + \alpha_2(J/\delta) - \alpha_3(J/\delta)^2 + \alpha_4\sigma_\varepsilon - \alpha_5\sigma_\varepsilon^2 + \alpha_6\sigma_\varepsilon^3, \quad (21)$$

where α_i are positive parameters. Therefore, the desired capital ratio can be estimated by using the following linear equation:

$$(K_1/A_1)^*(R) = R - \alpha_1 + \alpha_2(J/\delta) - \alpha_3(J/\delta)^2 + \alpha_4\sigma_\varepsilon - \alpha_5\sigma_\varepsilon^2 + \alpha_6\sigma_\varepsilon^3. \quad (22)$$

3. Empirical results

3.1. Specification

Accepting that changes in capital ratios involve some costs (transaction costs associated to the issue of capital instruments and the costs of adjusting the capital position to equilibrium level) and assuming these to be quadratic, the dynamic behaviour of banks in both regimes can be described by the following partial adjustment equations:²²

$$(K/A)_{i,t}(m) = \Phi_1(K/A)_{i,t}^* + (1 - \Phi_1)(K/A)_{i,t-1} + \tilde{\omega}_{i,t}, \quad \tilde{\omega}_{i,t} \rightarrow N(0, \sigma_w^2), \quad (23)$$

$$(K/A)_{i,t}(R) = \Phi_2[R_{i,t} + H_{i,t}] + (1 - \Phi_2)(K/A)_{i,t-1} + \tilde{e}_{i,t}, \quad \tilde{e}_{i,t} \rightarrow N(0, \sigma_e^2), \quad (24)$$

where the subscript “ i ” refers to firms while subscript “ t ” refers to time period and $0 < \Phi_i < 1$ ($i = 1, 2$) are the rate of adjustment coefficients to desired capital-to-assets ratios in both regimes. By assumption, we consider that the disturbance

²² The origin of this methodology can be found in the seminal paper of Peltzman (1970). This has been used in almost all of the studies on effectiveness of banking capital regulation.

terms are uncorrelated. Next, by plugging Eqs. (13) and (22) into (23) and (24) respectively and allowing for pure individual and pure time effects in the market model we obtain:

$$\begin{aligned} (K/A)_{i,t}(m) &= \Phi_1\varphi + (1 - \Phi_1)(K/A)_{i,t-1} - \gamma_2\Phi_1(\mu)_{i,t} + \gamma_1\Phi_1(b)_t \\ &\quad + \Phi_1\gamma_2[1 + (r_f)t] + \Phi_1\eta_t + \Phi_1\eta_i + \gamma_3\Phi_1(c_\beta)_{i,t} - \gamma_4\Phi_1(c_\beta^2)_{i,t} \\ &\quad + \gamma_5\Phi_1(\sigma_{u1}^2)_{i,t} + \gamma_6\Phi_1X_{i,t} + \tilde{\omega}_{i,t} \\ &\quad \text{(if bank } i \text{ belongs to the market model),} \end{aligned} \quad (25)$$

$$\begin{aligned} (K/A)_{i,t}(R) &= -\Phi_2\alpha_1 + (1 - \Phi_2)(K/A)_{i,t-1} + \Phi_2R_{i,t} + \Phi_2\alpha_2(J/\delta)_{i,t} \\ &\quad - \Phi_2\alpha_3(J/\delta)_{i,t}^2 + \Phi_2\alpha_4(\sigma_v)_{i,t} - \Phi_2\alpha_5(\sigma_v^2)_{i,t} + \Phi_2\alpha_6(\sigma_v^3)_{i,t} \\ &\quad + \Phi_2\alpha_7Z_{i,t} + \tilde{e}_{i,t} \\ &\quad \text{(if bank } i \text{ belongs to the regulatory model),} \end{aligned} \quad (26)$$

where γ_6 and α_7 are two vectors of parameters, $X_{i,t}$ and $Z_{i,t}$ two vectors of variables and η_i and η_t represent individual and time effects respectively.

Individual effects allow the control of some non-observable specific characteristics of each bank. These are assumed to be constant over time but variable across individuals. Time effects allow to control for macroeconomic variables such as the evolution of interest rates, output, employment and changes in banking legal regulations (apart from capital regulation). Although b and r_f (constant across banks) change over time, their variation will be included into time effects. We allow regulation ($R_{i,t}$) to show both cross-section and time series variability. The value of $R_{i,t}$ is approximated by the maximum between two minimum capital ratios imposed by the Spanish Capital Adequacy Regulation Act of 1985: The global or generic ratio and the selective or risk asset ratio. The former is defined as the minimum percentage (4% until 1987, 5% after that year) of capital to total assets. The second is calculated by first obtaining for each commercial bank the necessary minimum capital to cover the selective ratio (numerator) and afterwards dividing this quantity by total assets (denominator). This last requirement is specific for each commercial bank because the numerator is the regulatory minimum capital ratio times the different categories of assets or off-balance sheet exposures weighted according to their relative risk. The value of R presented in estimations will be the maximum between the generic ratio R_t (constant across individuals) and the selective ratio $R_{i,t}$ (variable across individuals and over time).²³ Thus, the risk-based requirement is the relevant constraint for banks with high risk ratios and the leverage requirement the relevant constrain for banks with low risk ratios. It is obvious that the risk strategy of the commercial bank

²³ The Spanish capital regulation, in contrast to US normatives, does not classify banks in different categories in terms of adequacy capital. A bank is well-capitalized or under-capitalized depending on whether it is above or below the regulatory minimum. Nevertheless, the sanctions system is escalated according capital deficiencies.

is present in the definition of $R_{i,t}$, which can change capital requirements by modifying its risky assets portfolio.²⁴

Vector $X_{i,t}$ includes some other variables used in previous research on effectiveness of capital adequacy regulation.²⁵ This allows us to reflect more accurately the Spanish reality and to relax some of the assumptions of the theoretical models, such as a constant level of assets and two-period economy. These variables are: Bank size (BS) (proxied by the natural log of total assets), the ratio of risky assets over non-risky and highly liquid assets RA, the ratio of provision for loan losses to total gross loans (LP) and, finally, the tax rate TR (proxied by lagged ratio of taxes over incomes).

BS is present in the market model in the parameter c_β of the operating costs function.²⁶ Furthermore, it may have a negative impact on capital levels due to the fact that a larger size can guarantee greater possibilities of diversification and of access to capital markets or because the “too big to fail” policy allow large banks that run into trouble can continue their lending activities.²⁷

RA is an available measure of a bank’s risk structure. High levels of credit and illiquidity risks are positively correlated with a high probability of failure, so the effect of this variable on the capital ratio should be positive. As Dahl and Shrieves (1990) claim, the higher the credit risk associated to loans is, the higher the capital ratio in order to avoid the bank going bankrupt. In accordance with this result, Crouhy and Galai (1986) state that liquidity, rather than the lack of capital per se, is a primary cause of banking crises, so we could say that a high liquidity could reduce the need for capital. On the other hand, the idea of market determination of capital seems to entail some form of market discipline in which default risk comes into play.

The ratio of provisions for loan losses to total gross loans (LP) is a measure of loan portfolio quality. The credit risk is positively correlated with the bankruptcy probability, so the effect of this variable on the capital should be positive. Nevertheless, if we interpret provisions as a positive indicator of the capacity of banks to generate incomes the sign of LP will be the opposite one. Finally, (TR) is a proxy for the tax shield. By allowing interests on debt to be tax-deductible, this tax shield provides an incentive for banks to substitute debt for equity in their financial structure. The expected sign of this variable is negative.

With regard vector $Z_{i,t}$ we have assumed firstly that capital adequacy does not operate in isolation from other important and related supervisory core prudential regulation practices, such as additional bank reporting, inspection and validation of banks’ internal control systems. In this respect, Spanish banking rules did not contemplate a CAMEL type regulatory approach (capital adequacy, asset quality, management skills, earnings and liquidity) during the period studied, when modern

²⁴ Wall and Peterson (1987, 1995) and Carbo (1993) include in their estimations only the generic or global ratio.

²⁵ See Peltzman (1970), Mingo (1975), Heggstad and Mingo (1975), Dietrich and James (1983), Marcus (1983), Dahl and Shrieves (1990), Shrieves and Dahl (1992), Carbo (1993) and Wall and Peterson (1987, 1995).

²⁶ Remember $c_\beta = c_2 A_1$.

²⁷ See Footnote 11.

supervision was implemented. Nevertheless, it is obvious that those variables were taken into account when the supervisor decided to intervene in bankruptcy procedures or simply to evaluate the effective solvency of a commercial bank. Following this reasoning, we have included two proxies of bank supervision in the regulatory empirical model: The ratio of provisions for loan losses to total gross loans (LP) and the ratio of cash accounts over total assets (CA). A higher loan loss provisioning reduces the need for capital augmentation. This implies that such loan loss provisions incorporate some downside (capital adequacy-related) provisioning within them, and that regulators and banks recognize this relationship. In the same way, the more liquid a bank is, the less it needs to augment capital. High levels of (CA) prevent banks from going bankrupt in the case of temporary unexpected deposit withdrawals.

On the other hand, we have included in the regulatory model a variable representative of the bank's deposits market share. In this way, we are assuming that the nature of regulatory interventions is not independent of the relative weight of the bank into difficulties in the financial system. The immediate closure of one large bank might entail systemic consequences, such that it might be optimal for the supervisor to bail out the depositors of the failed bank and allow the bankers to continue their lending activities. Since this policy induces moral hazard and accentuates the risk-shifting incentives, the supervisor could recommend bigger banks to hold greater capital cushion.²⁸ This variable (DQ) is defined as the ratio of deposits of an individual bank on the sum of market total deposits (deposits of commercial banks plus savings banks) The predicted sign of this variables is positive.

Other variables of Eqs. (25) and (26) are proxied as follows: σ_{u1}^2 by the variance of the return on assets over the previous five years, (μ) by the difference between the average yield of public assets for Spanish commercial banks²⁹ and their average financial costs, (c_β) by the ratio of operating costs over assets and (σ_ε^2) by the variance of the observed capital ratio over the previous five years. (J/δ) is proxied by two variables, the natural log of total deposits and the log of interbank liabilities, indicating that the sanctions and penalties to enforce the capital rule affect more to big banks and those banks with more interbank liabilities.³⁰ On the other hand, using the log of deposits as proxy of sanctions, the interest of deposit insurance agency is protected because the greater the volume of insured deposits is, the greater will be the capital required.

Traditional estimation techniques rely on single equation regressions (ordinary least squares, linear dynamic panel data). These methodologies assume implicitly that only one model describes all banking organizations' capital decisions, not allowing for regulation to be binding on some banks while the market determines the decisions of others. Disequilibrium estimation overcomes this problem since it allows

²⁸ This reasoning is in line with Acharya (2001b), who links the forbearance in supervisor's closure policy with capital adequacy requirements.

²⁹ See the Economic Bulletin of the Bank of Spain.

³⁰ The bigger a bank, the larger the systemic crisis in the banking system, if this bank were to go bankrupt. This result can be extended to medium-size banks with very large interbank liabilities.

each observation to come from one or the other of the two regimes (the regulatory or market model) without a priori classification. Moreover, the probability that an observation come from the first (or second) regime may be estimated.³¹ This disequilibrium framework implies that we can only observe the dependent variable (K/A) which is the greater (maximum) value of both the values obtained from each regime. This model's latent structure includes Eqs. (25) and (26) while the observation mechanism is

$$(K/A)_{i,t} = \max[(K/A)_{i,t}(m), (K/A)_{i,t}(R)]. \quad (27)$$

Thus, $(K/A)_{i,t}(m)$ and $(K/A)_{i,t}(R)$ are unobservable since we can only observe $(K/A)_{i,t}$. The crucial fact for this uncertainty is the existence of the above noted capital cushion since, otherwise, we would be able to identify all observations above the regulation minimum as coming from the market model.

3.2. Results

Table 1 shows the results of the disequilibrium estimation. Different specifications are considered in the analysis but similar results are obtained. Equations are estimated in a time series and cross section framework (unbalanced panel data). Seventy-six Spanish commercial banks were selected from 1985 through 1991 (annual data).³² The observable dependent variable in two models is the capital to real and financial investments (net of provisions and depreciation) ratio. It is calculated in book terms to correspond to regulatory measures. Bank capital is defined as the sum of share equity (capital stock) plus accumulated reserves plus subordinated debt (until the permitted maximum level) plus undivided profits minus past and current losses. The dependent variable and the proxy for regulatory guidelines are calculated using exactly the same accounts of balance sheet. Not only is the denominator of the capital ratio in both variables total assets but also the accounts of balance sheet used in the definition of capital are the same. However, they differ because observed and required capital cannot be the same. In this way, the model can fully capture commercial banks' capital adjustment towards their capital requirements.

The coefficients on the lagged capital ratio are found to be significantly positive and below unity (stationary conditions) in all cases and in both models (the regulatory and the market model). Furthermore, the speed of adjustment to desired capital levels is higher in the market regime (Φ_1 around 0.8) in comparison to the regulatory regime (Φ_2 around 0.4). This result can be explained by the fact that Spanish regulation allowed for a transitory period of adjustment to the regulatory minimum: Commercial banks were not forced to adjust their capital ratio immediately.

³¹ See Maddala and Nelson (1974), Maddala (1983) and Wall and Peterson (1987) for a more detailed explanation of this methodology.

³² The time period finishes in 1991 because: (i) Available accounting information (balance-sheets and profit and loss accounts) changed presentation in 1992 and (ii) a new capital adequacy regulation, that excludes the generic ratio, was introduced in 1993.

Table 1
Disequilibrium model estimation

	Estimation 1	Estimation 2	Estimation 3
<i>Market model (Eq. (25))</i>			
Dependent variable: $(K/A)_t$			
Constant = $\Phi_1\phi$	0.602(9)*	0.469(6)*	0.472(6)*
Lagged dependent variable $(K/A)_{t-1}$	0.216(8)*	0.227(6)*	0.227(6)*
Liquidity premium ($\mu = r_f - r_d$)	-0.135(-5)*	-0.313(-7)*	-0.313(-8)*
Operating costs (c_β)	1.593(5)*	1.717(3)*	1.730(4)*
Square of operating costs (c_β) ²	-21.4(-5)*	-17.88(-3)*	-18.01(-3)*
Variance of return on assets σ_{u1}^2	3.244(1.8)**	3.28(2)*	3.31(2)*
Log of total assets (BS)	-0.042(-3)*	-0.056(-5)*	-0.057(-5)*
Square of the log of total assets (BS) ²	0.00002(0.02)	0.0016(4)*	0.0016(4)*
Credit and illiquidity risk (RA)	0.0001(2.5)*	0.00016(4)*	0.00016(4)*
Provisions for loan losses to total gross loans (LP)	0.0304(5.5)*	0.0420(6)*	0.0425(6)*
Lagged tax rate (TR) _{t-1}	0.0061(1.6)	-0.0013(-0.3)	-0.0022(-0.5)
Time dummies: Year 1987	0.0071(6)*	0.006(5)*	0.006(5)*
Year 1988	0.015(12)*	0.015(10)*	0.015(11)*
Year 1989	0.019(11)*	0.016(7)*	0.0155(7)*
Year 1990	0.026(13)*	0.018(9)*	0.018(9)*
Year 1991	0.031(15)*	0.024(11)*	0.024(11)*
<i>Regulatory model (Eq. (26))</i>			
Dependent variable: $(K/A)_t$			
Constant = $-\Phi_2\alpha_1$	-0.066(-3)*	-0.078(-1)	-0.072(-1)
Lagged dependent variable $(K/A)_{t-1}$	0.600(10)*	0.673(10)*	0.666(10)*
Regulatory minimum capital ratio (R_{it})	0.732(4)*	0.753(3)*	0.786(3)*
Log of total deposits (first proxy for J/δ)	-0.0011(-1)	0.004(0.3)	0.003(0.3)
Square of log total deposits [proxy for $(J/\delta)^2$]		-0.0003(-0.5)	-0.0004(-0.5)
Log of interbank liabilities (second proxy for J/δ)	0.00009(0.8)	0.0005(0.8)	0.0003(0.2)
Standard error of observed capital ratio (σ_e)	2.572(3)*	2.618(5)*	2.526(4)*
Variance of observed capital ratio (σ_e^2)	-24.85(-1.2)	-24.62(-3)*	-23.83(-2)*
Cube standard error observed capital ratio (σ_e^3)	15.58(0.12)	18.18(0.42)	17.60(0.31)
Deposits market quota (DQ)	0.05(1.5)	0.023(1.4)	0.082(1.4)
Liquid assets proportion (CA)			0.024(0.8)
σ_u : Estimated standard error of the market model	0.044(14)*	0.004(16)*	0.004(16)*
σ_e : Estimated standard error of the regulatory model	0.029(21)*	0.031(18)*	0.031(17)*
P_m : Average estimated probability of belonging to market regime.	0.67	0.70	0.69
P_r : Average estimated probability of belonging to regulatory regime	0.33	0.30	0.31
N : Number of observations	435	435	435

Notes: (a) Dependent variable is $(K/A)_t$, (b) the market model has been estimated with firms and time dummies, (c) t -student in parenthesis, (d) * = significant to 5%, ** = significant to 10%.

In the market model, several variables are generally significant and present the expected signs. This is the case of operating costs (c_β), in its linear and quadratic form, the variance of return on assets (σ_{u1}^2), bank size (BS), the credit and liquidity risk (RA) and the liquidity premium (μ). On the contrary, the lagged tax rate (TR), does not achieve always its predicted sign and is not statistically significant. Finally, the

variable provisions for loan losses (LP) is significantly positive, a coherent result with the interpretation of provisions as a sign of bad management.

The time dummies are significantly positive and increasing over time. This result reflects the augmentation of capital demands during those years due to the increasing competition in the Spanish banking system which required a greater solvency of those organizations in order to prevent bankruptcies. The greater integration of international financial markets together with an important process of deregulation in those markets may have led to this result. On the other hand, with this strengthening of solvency conditions bank managers tried to avoid a situation of banking crisis similar to the one experimented in the previous years, which implied important bankruptcy costs for the entire banking system.

In the regulatory model, coefficients generally achieve their predicted signs, although they are not always significant. The regulatory equation meets the restriction predicted by the theoretical model in all the cases analysed: It cannot be rejected that the sum of the coefficient of variable $R_{i,t}$ and the coefficient of the lagged dependent variable is one.

The lagged dependent variable $(K/A)_{t-1}$ and the regulatory minimum capital ratio $(R_{i,t})$ are always significant and have the predicted sign. The standard error of the observed capital ratio (σ_e) is also generally significantly positive. The coefficient on deposits quota achieves its predicted sign, although is insignificant. The coefficient on liquid assets proportion (CA) is positive, contrary to expectations, although insignificant. Proxies variables of (J/δ) , achieve their predicted signs but are not significant. The imperfect choosing of these variables as proxies of regulatory pressure may explain these results. Finally, the empirical results do not show the variable (LP) because after including this variable in the process of estimation we cannot achieve convergence.

Regarding the complete empirical model we can conclude that market regime explains better the behaviour of Spanish commercial banks. This result is corroborated by the average probability of belonging to either regime, the market or the regulatory regime, which is close to 0.7 and 0.3 respectively. This classification scheme provides evidence of the dominance of the market model in our analysis. Table 2 shows the estimated probability of belonging to the market model according to the level of observed capital ratio. As proof of the model estimation adequacy, figures show that the probability of one observation coming from the market model is higher, the

Table 2

Estimated probabilities of belonging to a market model according to observed capital ratio level (P_m)

Capital to assets ratio	Average estimated probability of belonging to market model (P_m)			Number of observations
	Estimation 1	Estimation 2	Estimation 3	
$0\% \leq \text{capital ratio} < 4\%$	0.505	0.555	0.563	58
$4\% \leq \text{capital ratio} < 5\%$	0.646	0.676	0.661	42
$5\% \leq \text{capital ratio} < 6\%$	0.719	0.752	0.742	47
$6\% \leq \text{capital ratio} < 7\%$	0.774	0.793	0.785	57
$7\% \leq \text{capital ratio}$	0.675	0.717	0.709	115

higher the observed capital ratio. In fact for capital ratios below the minimum generic capital ratio (4% until 1987, 5% after that date), we obtain generally smaller estimated probabilities of belonging to the market model. This empirical result acts as a test to validate our theoretical model.

Our main conclusion could be summarized as follows: Although Spanish bank capital adequacy regulation can have had some incidence on bank capital decisions, market capital requirements are the best explanation why banks demand capital. Consequently, the capital adequacy is not so effective. This result does not coincide with this one of Wall and Peterson (1987, 1995) for US commercial banks and Carbo (1993) for Spanish commercial banks. While Wall and Peterson obtained that capital regulation was effective Carbo obtained inconclusive results in this respect. Nevertheless, the results here obtained are not exactly comparable with those of Carbo because differences in the process of testing of the model (OLS regression versus disequilibrium estimation techniques) and in the definition of regulatory capital requirements (generic versus selective plus generic capital ratio).

4. Conclusions

Above, we have developed and estimated two models to explain the behaviour of banks when they choose their capital to assets ratios. The first one – the market model – showed that there exists an optimal capital ratio which maximizes the market value of firms. Such a ratio depends on a set of variables (i.e. bank size, liquidity premium, operating costs variance of return on assets and credit and illiquidity risks). However, banks with an optimal market ratio below a legally required regulation cannot establish this optimal ratio. The second – the regulatory model – explains this behaviour. The optimal financial decision for these companies consists in setting a capital ratio that is the sum of the regulatory minimum plus a capital cushion. The aim of this cushion is to reduce the probability that a shock reduces the capital ratio to the extent that it drives it below the regulatory one. The amount of this cushion depends on sanction costs and on the current capital ratio volatility.

Both models are estimated using unbalanced panel data of Spanish commercial banks from 1985 to 1991. Since a priori we cannot distinguish between banks following a market behaviour (those whose optimal capital ratio is above the regulatory minimum) from those following a regulation rule (those whose optimal capital ratio is below the minimum), a disequilibrium technique is used to estimate both equations. This method allows us to estimate jointly both models without a priori information about which regime the observations belong to, but knowing that what can only be observed is the maximum value of the two.

The proposed partial adjustment model is validated by empirical results in both models. A higher adjustment speed to the desired capital ratio is observed in the market model than in the regulatory one. The determinants of the optimal market capital ratio (the market model) and the regulatory desired capital ratio (the regulatory model) have signs accorded with those predicted in the theoretical model and, in many cases, are significant. On the other hand, data show that banks affected

by regulation would set a capital cushion above the regulated minimum. It is worth mentioning that the calculated average probability of belonging to the market model (0.7) is higher than that of belonging to the regulatory model (0.3). Finally, a study of the estimated probabilities of belonging to the market regime according to the observed capital ratio allows us to validate the theoretical model proposed since the probability of coming from the market model turns out to be higher for banks with a higher observed capital ratio.

We can conclude that although the regulatory constraint is one of factors related to capital augmentations in Spanish commercial banks is not the most important. On the contrary, the pressure of market forces is the main determinant of banks capital requirements.

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