HOW DO INTANGIBLE ASSETS CREATE ECONOMIC VALUE? AN APPLICATION TO BANKS

2007

Alfredo Martín-Oliver and Vicente Salas-Fumás

Documentos de Trabajo
N.º 0730

BANCO DE ESPAÑA
Eurosistema

HOW DO INTANGIBLE ASSETS CREATE ECONOMIC VALUE? AN APPLICATION TO BANKS

HOW DO INTANGIBLE ASSETS CREATE ECONOMIC VALUE? AN APPLICATION TO BANKS (*)

Alfredo Martín-Oliver

BANCO DE ESPAÑA

Vicente Salas-Fumás

UNIVERSIDAD DE ZARAGOZA

(*) This paper is the sole responsibility of its authors and the views represented here do not necessarily reflect those of the Banco de España. Any remaining errors are entirely the authors' own responsibility.

Documentos de Trabajo. N.º 0730
2007

The Working Paper Series seeks to disseminate original research in economics and finance. All papers have been anonymously refereed. By publishing these papers, the Banco de España aims to contribute to economic analysis and, in particular, to knowledge of the Spanish economy and its international environment.

The opinions and analyses in the Working Paper Series are the responsibility of the authors and, therefore, do not necessarily coincide with those of the Banco de España or the Eurosystem.

The Banco de España disseminates its main reports and most of its publications via the INTERNET at the following website: http://www.bde.es.

ISSN: 0213-2710 (print)
ISSN: 1579-8666 (on line)
Depósito legal: M.45377-2007
Unidad de Publicaciones, Banco de España

Abstract

This paper examines the determinants of economic value and investment behavior of Spanish banks under the theory of investment for a multi-asset firm, focusing on three key issues: i) the distinction between immaterial and intangible assets and how each of them is related to the economic value of the firm; ii) the test of whether the accumulation of intangibles is a consequence of incurring adjustment costs or, on the contrary, intangibles are accumulated at no cost, and iii) how to account for market power in the valuation of the multi-assets firm. The empirical results quantify the contribution of material, immaterial (information technology and advertising) and intangible (organization capital) assets to economic value of Spanish banks, separated from the contribution of market power. We find that intangible assets build up from adjustment costs of investments in IT and rents from market power split evenly the economic value of the bank above the replacement cost of material and immaterial assets.

JEL Classification: G21, D21.

Keywords: Intangibles, IT capital, adjustment costs, valuation of banks, investment of banks.

1 Introduction

What underlies the stock-market value of a firm? This is a widely-posed research question in economics and management. At the turn of the 21st century, stock markets around the world routinely valued listed firms above their book values and investors inferred from this the end of the Old Economy (where tangible assets reported in balance sheets were the main productive resource) and the onset of a New Economy (where intangible assets, not reported in the balance sheets, will dominate the business landscape)[1]. At the micro level, differences in the market value of firms not explained by their respective book values have been attributed to intangibles (R&D, advertising, information technology), to market competition and to the firm's competitive strategies[2]. The hope of the New Economy faded away with the bursting of the Internet bubble, but the interest in measuring intangibles and in determining how they contribute to the economic value of the firm continues to be high[3].

The theory of investment for multi-asset firms [Wildasin (1984), Hayashi and Inoue (1991), Bond and Cummins (2000)] provides a unified conceptual framework to investigate the determinants of the economic value of the firm, as well as the process of asset accumulation over time. Intangibles are one of the multiple assets of the firm, but the definition of what is an intangible asset is not unique. Most often, intangibles refer to immaterial assets such as those resulting from R&D, advertising and information technology (IT) expenditures. However, intangible assets can also be defined in a more restrictive way as the assets that firms build up internally as a sub-product of their regular activities such as production or investment in market-purchased assets. Examples of intangibles defined thus would be the "organization capital" of Prescott and Vischer (1980) and the new forms of organization and management of firms implemented to maximize the productivity of investments in IT (also referred to as organizational capital [Brynjolfsson, Hitt and Yang (2002)]). Within the narrower definition of intangibles there remain differences between those who consider that intangibles are costly [Cummins (2004)] and those who believe that they are free [Brynjolfsson, Hitt and Yang (2002)]. This paper will use the term *immaterial* to refer to assets resulting from R&D, advertising or IT, and will reserve the word *intangibles* for assets built as sub-products of the regular production and investment activities of firms.

1. Bond and Cummins (2000) present an excellent analysis of the debate around intangibles and the stock market valuation of firms. See also Nakamura (1999) and Lev (2001).

2. Griliches (1981) is considered the pioneering work in evaluating the economic return from intangibles around R&D expenditures and patents. The work continued with Hirschey (1982) who evaluated the return of R&D and advertising; Jaffe (1986), who added measurement of spill over effects; and Hall (1993), who examined the change of return on investment in R&D over time. Later, interest shifted to the evaluation of returns from investment in Information Technologies (IT), Hitt and Brynjolfsson (1996) and Bharadwaj et al. (1999) among others. Papers that use market value data to investigate the effect of market structure, and the competitive decisions of firms on economic profits are Lindenberg and Ross (1981), Salinger (1984), with special attention to the effect of unionization, Smirlock et al. (1984), and Montgomery and Wernerfelt (1988), on diversification. Within the management literature, much of the empirical research since the early nineties under the Research Based View (RBV) of the firm has followed these early approaches to the determinants of economic value with little variation. [See Newbert (2007) for a complete list of papers on empirical research.]

3. More recent papers on this topic are Bond and Cummins (2000), Brynjolfsson, Hitt and Yang (2002), Cummins (2004), on IT capital and market value of firms; Toivanen et al. (2002) and Hall and Oriani (2006) apply the early research methodology to evaluate the return from R&D investment to countries outside the US; Villalonga (2004) explicitly links intangibles measured using the Griliches' framework with the sustainability of competitive advantage and the literature on RBV of the firm. A distinctive feature of more recent research is that the definition of intangible assets is not the same for all authors, as is indicated later in this paper.

All approaches to intangibles recognize the complexity of measuring them, either because accounting practices do not capitalize immaterial assets built from expenditures in R&D, advertising and IT as capital, or because firms do not provide separate estimates of costs originated in organizational changes, or estimates of the adjustment costs of investment and growth. Since efficient capital markets will provide an estimate of the stock market value of listed firms, including the value attributed to all kind of assets normally invisible in accounting statements, one approach to valuing the intangible assets of a particular firm has been to observe the difference between its market value and its book value [Hall (2001)]. This approach has three clear limitations: first, it does not distinguish between immaterial and intangible assets; second, it makes no distinction between economic value and cost of the assets of the firm; and third, it assumes without proof that the rents from the market power of the firm, if any, are all part of the value attributed to intangibles[4].

Using the market value of a listed firm to value hidden intangibles presumes that investors can observe the internal decisions of firms, or they can use indirect information to estimate the quantity and quality of expenditures in intangibles made by firms, as well as the expected return from such investments. This is a strong assumption, since firms only publicly report, in an item-by-item form, a small fraction of the expenditures on immaterial assets, and none of the expenditures on intangibles. Under current accounting practices, firms often report expenditures on R&D as a separate line of the income statement, but expenditures on advertising, IT, process and organizational innovation, are all aggregated into operating expenses. A more realistic assumption is that the stock market value of the firm does not properly reflect the true economic value of those firms with high investments in immaterial and intangible assets. One way to improve market efficiency would be to change the current reporting practices, and ask firms to explicitly inform investors about stocks and flows of intangibles [Lev and Zarowin (1999), Healy et al. (2002)]. However, Kanodia et al. (2004) question the "value-relevance approach" of accounting policy and propose instead the "real-relevance approach", that is, to make recommendations about external reporting practices that induce efficient investment decisions.

The paper approaches the valuation and investment of immaterial and intangible assets using only accounting-related data, since very few of the firms in the data base are listed in the stock market. The paper does not focus on the value relevance of accounting data, but rather on whether we can explain the estimated present value of future profits and also explain the investment behavior of banks. Our accounting-related data come from different sources, the public accounting statements of banks and confidential reports sent by banks to the Banco de España. Next, the data is adjusted to obtain economically relevant measures of profits and costs of the assets. For example advertising expenditures are taken away from the income statement, capitalized and depreciated over time; additionally all assets are valued at replacement cost. The paper then allows us to calibrate the information content of economically adjusted accounting data, compared with that of raw accounting data, and also to asses the convenience of asking firms to disclose complementary data on immaterial assets so that external analysts can use them to explain the behavior of firms (banks in our case). It can be reasonably expected from the outset that banks and firms in general will make decisions, such as the amount invested in a particular asset, using internal

4. This method also presumes perfect capital markets. When stock prices declined after the Internet crisis, most residual intangibles faded away. This appears implausible. One can raise the concern of using highly volatile, noisy and perhaps erroneous stock price data to estimate the economic value of the firm [Bond and Cummins (2000)]. Most banks in our sample data are not listed on the stock market, so their economic value is estimated using econometric techniques to forecast future earnings.

data that will be different from the data reported in external accounting statements, but the expectation should be empirically confirmed, as we do in the paper.

The paper begins with a brief overview of the dynamic model for the value-maximizing, multi-asset firm that incurs adjustment costs for investing in market-purchased assets, and at the same time faces an inelastic demand for the product sold in the market (market power). Adjustment costs play a key role in explaining why existing assets can be more valuable than those sold in the market [Abel (1990)]. The difference in values provides an estimate for the intangible assets acquired in the process of adjustments needed to make the new investments fully productive. This value of intangibles does not correspond to the economic rents or extraordinary profits of the firm, but to the costs incurred in producing them, so intangibles can also be valued at their production cost. Of course, intangibles may contribute to the market power and economic rents of the firm, but they do so jointly with the other assets of the firm.

The solution to the model provides two main equations, empirically tested using data on Spanish banks in the period 1984 to 2003. One of the equations determines the economic value of the firm (present value of expected future cash flows) as a function of the replacement cost of the assets and of the discounted economic rents from market power. The other equation determines the investment rate in material assets as a function of the economic value of the firm, of the investment rate of non-material assets and, when the firm has market power, of the opportunity loss of expanding capacity. The two equations allow us to formulate empirically testable propositions around the hypothesis that intangible assets are costly to produce, and around the hypothesis that the economic value of the firm incorporates rents from market power that are differentiated from returns that just compensate for the replacement cost of existing assets. The fact that the propositions can be tested twice, from the valuation and from the investment equations, provides robustness to our conclusions. Moreover, the empirical analysis of the valuation and investment of the multi-asset banking firm, and in particular the study of the economic effects of large investments in IT made by banks, is new in the banking literature.

The paper is related to Lindenberg and Ross (1981) on economic valuation of the firm with market power, although our analysis extends the model to account for multiple assets and for non-zero adjustment costs. Other related studies are Bond and Cummins (2000), who model and estimate the investment equation of the multi-asset firm, and Brynjolfsson, Hitt and Yang (2002) and Cummins (2004), who model and empirically test the determinants of the economic value of the multi-asset firm. Our contribution here is the extension of these models to include a more detailed explanation of the relationship between adjustment costs and intangibles, and to allow for the market power of banks. In the empirical part of the analysis, we take advantage of the available data on training expenditures by banks to provide a direct test of the adjustment cost incurred in investing in IT capital. As indicated, the paper is also related to the literature on the accounting policy of intangibles. The contribution here is, on the one hand, methodological (for example, in terms of identifying the correct valuation and investment model in testing the value-relevance of reporting intangibles) and, on the other hand, conceptual, since it raises the issue of whether the observed behavior of unlisted firms is better explained by conventional accounting variables than by economically adjusted ones.

Our evidence documents the growing importance of IT and, to a lesser extent, advertising capital, among Spanish banks in the past twenty years. Second, the results support the hypothesis that intangibles are costly: those banks that are able to grow faster in the accumulation of IT capital, are the same banks that incur higher training costs for their workers. Third, banks have market power, which implies that the economic value of the bank is above the replacement cost of all the invested assets, including immaterial and intangible assets. The paper provides estimates of this market power, separate from estimates of the replacement costs of immaterial and intangible assets not reported in the balance sheet of banks. Fourth, advertising capital appears as the asset most highly correlated with the economic rents of the banks, together with intangibles from training expenditures. When the contribution of market power to the economic value of the banks is isolated then advertising only contributes to economic value in an amount equal to the replacement cost of the investment. Finally, raw accounting data does not explain the investment behavior of banks, while economically adjusted data does.

Section 2 presents the basic model of the multi-asset firm that maximizes economic value. It also examines alternative hypotheses for the contribution of market-purchased and internally-generated assets to the economic value of the firm, and derives the investment equations implied by the value-maximization model. In section 3, we provide empirical estimates of the valuation and investment equations, using data for Spanish banks, and test the main implications of the theoretical models. The conclusions summarize the main results of the paper.

2 Economic value maximization with multiple assets[5]

Consider a firm that, in each time period, decides how much to invest in each type of N different market purchased capital goods, $I_t = (I_{1t}, I_{2t},\dots,I_{Nt})$. The firm holds a stock of capital services at the beginning of the period t, $K_{t-1} = (K_{1t-1},\dots,K_{Nt-1})$ that changes over time as the result of new investments and of the depreciation of old ones,

$$K_{j,t+s} = (1-\delta)K_{j,t+s-1} + I_{j,t+s} \quad for\ j = 1,\dots, M\ and \quad s > 0 \tag{1}$$

where δ_φ is the depreciation rate of capital asset j.

Let $\Pi(K_s, I_s, e_s)$ be the net cash flow of the firm in period s as a function of the stock and the investment flow of the assets in the period, and of the random productivity shock e_s, once the variable inputs are already optimized. The cash flow function has three separate components: gross profits from operations, adjustment costs, and the outlay from the current market purchased assets:

$$\Pi(K_s, I_s, e_s) = R(K_s, e_s) - C(K_s, I_s) - \sum_j p_{js} I_{js}$$

Gross revenue $R(.)$ is in turn equal to price, $p\ (QP\ (K_s))$, times quantity of product sold $QP(K_s)$, $R(.) = p\ (QP\ (K_s))\ QP(K_s)$ where price is non increasing with quantity sold (i.e. firms can have market power); p_{js} is the current market purchase price of one unit of capital asset j. And $C(.)$ is the adjustment cost function which is assumed separable in the adjustment costs of each of the assets in which the firm invests,

$$C(K_s, I_s) = \sum_j C_j(K_j, I_j) = \sum_j p_j \frac{b_j}{2}\left(\frac{I_j}{K_j} - a_j\right)^2 K_j \tag{2}$$

where b_j is a positive (cost) parameter and a_j is the stationary investment rate for which adjustment costs are zero (in general equal to δ_φ, the depreciation rate). The economic value of the firm in period t, V_t, will be equal to the present value of expected future cash flows[6],

$$V_t = E_t\left\{\sum_{s=t}^{\infty} \beta_s^t \cdot \Pi(K_s, I_s, e_s)\right\}$$

where E_t is the expectations operator, conditional on the information available at the beginning of period t, and β^t_s is the discount factor.

The firm chooses I and K to maximize V_t subject to (1). If $\lambda_{j,t+s}$ is the multiplier of the respective constraint in (1) the first order conditions of the maximization problem are as follows [see Bond and Cummins (2000) appendix A],

5. This section is based on Lindenberg and Ross (1981), Wildasin (1984) Hayashi and Inoue (1991) Bond and Cummins (2000).

6. The paper uses "value" as synonymous of willingness to pay. The value of the firm means the willingness to pay for the stream of cash flow expected over time.

$$-\Pi'_{Ijt}\left(K_t, I_t, e_t\right) = \lambda_{jt} \quad (3)$$

$$\lambda_{jt} = \left(\frac{\partial \Pi_t}{\partial K_{jt}}\right) + \left(1-\delta_j\right)\beta^t_{t+1}E_t\left[\lambda_{j,t+1}\right] \quad (4)$$

$$= E_t\left[\sum_{s=0}^{\infty}\beta^t_s\left((1-\delta_j\right)^s\left(\frac{\partial \Pi_{t+s}}{\partial K_{j,t+s}}\right)\right] \qquad \forall j = 1,\ldots,N$$

Equation (3) gives the first order optimal condition for investment flow in each period *t,* and it establishes that the value-maximizing investment is that for which the marginal cost of the investment *(-Π'I)* equals the marginal return from the last unit of invested capital, given by the shadow price of capital asset *j*,, λ_{jt}. On the other hand, equation (4) is the first order condition for the stock of capital asset *j* and it states that the marginal return from asset *j* is equal to the present value of the future expected returns derived from a marginal increase in the stock of asset *j.* Combing (3) and (4) this marginal return in terms of discounted cash flows is also equal to the marginal cost of investment in asset *j.*

The dynamic optimization problem has been applied to the study of the investment behaviour of firms [Wildasin (1984), Hayashi and Inoue (1991), Hayashi (1992), Bond and Cummins (2000)][7]; to study the valuation of the stock of invested assets [Brynjolfsson, Hitt and Yang (2002), Cummins (2004)]; and to investigate the market power of firms [Lindenberg and Ross (1981) and references listed in note 2]. Papers on investment and valuation often assume that firms do not have market power, while Lindenberg and Ross (and the large number of papers inspired by their model) ignore adjustment costs. Next we provide an integrated view of this literature, with special attention to the relationship between intangibles and adjustment costs of growth.

2.1 General valuation

Assuming that cash flows are linear and homogeneous in *K* and *I*, and that firms face an inelastic demand for the product they sell (market power), in the optimal solution the economic value of the firm satisfies the condition [Bond and Cummins (2000), Lindenberg and Ross (1981)].

$$V_t = \sum_j^M \lambda_{jt}\left(K_{jt} - I_{jt}\right) + \sum_{s=t}^{\infty}\beta^t_s\frac{1}{\varepsilon}p\left(QP(K_s)\right)\cdot QP\left(K_s\right) \quad (5)$$

Where all variables are evaluated at the optimal values and *Σ* is the absolute value of the price-elasticity of demand.

If the firm **does not have market power,** the price elasticity is infinite and the last term of equation (5) will be zero. Given the adjustment cost function in (2), equation (3) implies $\lambda_{jt} = p_{jt} + C'_{Ij}$. Substituting in (5),

7. The paper focuses only on investment equations based on Tobin's q, equation (3), and will not consider investment models based on Euler conditions, equation (4).

$$V_t = \sum_j^{\infty} \lambda_{jt} \left(K_{jt} - I_{jt} \right) = \sum_j^{N} p_{jt} \left(K_{jt} - I_{jt} \right) + \sum_j^{N} C'_{Ij} \left(K_{jt} - I_{jt} \right) + e_t \quad (5.1)$$

The first term in (5.1) establishes that the economic value of the firm in the optimal solution is equal to the sum of the contributions to economic value of each market-purchased asset. The contribution of asset *j* is equal to marginal return λ_{jt} times the stock of asset *j* at the end of the period. The second term is the consequence of substituting the value-maximizing condition of marginal return equal to marginal cost of the asset [equation (3)]. Therefore, in the value-maximizing solution, the contribution of each asset to the value of the firm is just equal to the opportunity cost of the asset, and the economic value of the firm is just equal to the replacement cost of all its invested assets. The replacement cost has two components, the outlays needed to purchase the services of capital from the market at current prices, plus the outlays needed to install the market-purchased assets to make them fully productive. In the stationary solution, where adjustment costs are zero (firms only invest the amount needed to replace depreciated assets, and $C_{Ij}'=0$), equation (5.1) implies that the economic value of the firm in the competitive market will be equal to the current purchase cost of the invested assets. This is the long-term zero profit condition, similar to the period-by-period condition that firms earn accounting profits equal to those needed to compensate for the opportunity cost of capital invested[8].

If **the firm has market power,** but adjustment costs are zero, and there is only one capital asset, equation (5) transforms into the valuation equation derived by Lindenberg and Ross (1981),

$$V_t = p_{K_t} \left(K_t - I_t \right) + \sum_{s=t}^{\infty} \beta_s^t \frac{1}{\varepsilon} p\left(QP\right) \cdot QP\left(K_t\right) \quad (5.2)$$

Now, the economic value of the firm in the optimal solution is equal to the market purchase cost of the asset, plus the present value of economic rents from market power[9].

2.2 Investment

Assume first that the firm has no market power. Substituting C'_{Ij} from (2) in (3) and re-arranging the terms, it gives the optimal investment path of the firm as a function of the ratio $\lambda_{jt} / p_{jt} = q_{jt}$,

$$\frac{I_{jt}}{K_{jt}} = a_j + \frac{1}{b_j} \left(q_{jt} - 1 \right) + e_t$$

8. Equation (5) can also be related to the methodology often used to estimate the return from intangible assets, inspired by Griliches (1981). Assuming only two assets, tangible A and intangible KI, equation (5) is written as V = λ1A+λ2KI = λ1A(1+λ2KI/λ1A).

9. These economic profits can be interpreted as follows. Let ct be the user cost of capital. Profits in period t are given by Rt - ctKt. The profit maximizing price of the period implies that (p-mc)/p=1/ε, where mc is the marginal cost, equal to average cost under constant returns to scale, mc=ctKt/QPt. Therefore $\frac{1}{\varepsilon} p(QP) \cdot QP(K_t) = \left(p - mc \right) \cdot QP\left(K_t \right)$ is the economic profit, after the imputed user cost of capital, of the firm in period t. This result also implies that if the firm earns a return on assets, at replacement cost, equal to the user cost of capital, its economic value will be equal to the replacement cost of market-purchased assets. On the other hand, with market power, the economic value of the firm is equal to the replacement cost of assets plus the present value of expected future economic profits. Lindenberg and Ross (1981) also show that, from Tobin's q, it is possible to obtain upper limits on the measure of market power in terms of the Lerner index, (Q-1)/Q ≥(p-mc)/p.

This equation is the basis of the "q theory of investment" [Hayashi (1982)]. The optimal (value-maximizing) investment rate decreases with the slope parameter of the adjustment cost function, *b,* and increases with the value of marginal q_j: the ratio between the increase in economic value *V* from one additional unit of capital asset *j* (economic value of the last unit invested), and the purchase price of one unit of capital asset *j*. In the stationary equilibrium solution, the marginal value equals the marginal cost of the asset; thus,

$$q_{jt} = 1, \quad \frac{I_{jt}}{K_{jt}} = a_j$$

When there is only one asset, under certain regularity conditions, the unobservable marginal *q* can be replaced by the average *q* [Hayashi (1982)] and the value of *q* is estimated as the ratio between the total economic value of the firm (equal to market value of equity plus debt if the firm is listed on the stock market) divided by the purchase cost of the asset already invested. With multiple assets, the investment function is less straightforward [Wildasin (1984), Hayashi and Inoue (1991), Bond and Cummins (2000)]. Divide both sides of (5) by p_1K_{1t-1}, that is the replacement cost of asset 1 at the beginning of the year; after some re-arrangement, the new equation is,

$$\frac{V_t}{p_1K_{1t-1}} = \frac{\lambda_1}{p_1} + \sum_{j=2}^{M} \frac{\lambda_j K_{j,t-1}}{p_1 K_{1t-1}} + e_t = b_1\left(\frac{I_1}{K_{1t-1}} - a_1\right) + \sum_{j=2}^{M} \frac{\lambda_j p_j K_{j,t-1}}{p_j p_1 K_{1t-1}} + e_t \tag{6}$$

Since the investment in asset *j* can be assumed to be proportional to the marginal *q* of the asset, the unobservable marginal *q* of asset *j* can be substituted by its investment rate, that is $\frac{\lambda_j}{p_j} \cong b_j \frac{(1-\delta_j)I_j}{K_{jt-1}}$. Substituting in (6), and again after some re-arrangement,

$$\frac{I_1}{K_{1t-1}} = a_1 + \frac{1}{b_1}\left(\frac{V_t}{p_1K_{1t-1}} - 1\right) - \sum_{j=2}^{M} \frac{b_j}{b_1} \frac{(1-\delta_j)p_jI_j}{(1-\delta_1)p_1K_{1t-1}} + e_t \tag{7}$$

If asset 1 includes all tangible assets, and the non-tangible assets fully depreciate during the period when expenditures are made (δ_j=0 for *j>1),* equation (7) will give the investment rate of tangible assets as a function of average *q*, V_t / p_1K_{1t-1} of the asset (the terms on the right-hand side after the negative sign will all be zero). When immaterial assets do not depreciate instantly, and adjustment costs are positive, the investment model of tangible assets as a function only of average *q* of tangible assets will be mis-specified, unless the investments in immaterial assets are uncorrelated with the economic value of the firm. In general, immaterial assets are part of the investment equation and should not be omitted in the specification of the model. The negative association between investment in tangible assets and investment in immaterial assets, from (7), can be interpreted as showing that average *q* for tangible assets V_t / p_1K_{1t-1} will over-estimate the marginal return from investment in these assets, since a substantial part of market value *V* will reflect the economic value of immaterial assets. When modelling the investment in tangible assets, one must correct for the excess value of ratio q for only tangible assets; the negative coefficients of the investment rates in intangibles provide this correction[10].

The investment equation can be generalized in the case where firms have market power and the term $\sum_{s=t}^{\infty}\beta_s^t \frac{1}{\varepsilon} p(QP)\cdot QP(K_t)$ is positive. Equation (7) is now written as

$$\frac{I_1}{K_{1t-1}} = a_1 + \frac{1}{b_1}\left(\frac{V_t}{p_1 K_{1t-1}} - 1\right) - \sum_{j=2}^{M}\frac{b_j}{b_1}\frac{(1-\delta_j)p_j I_j}{(1-\delta_1)p_1 K_{1t-1}} - \phi\frac{p(QP)QP_t}{p_1 K_{1,t-1}} + e_t \qquad (8)$$

where the parameter ϕ is inversely related to the elasticity of demand and to the expectations about growth of sales and sustainability of economic rents from market power over time. The last negative term of the investment equation accounts for the opportunity loss that new investment produces in rents from existing assets, due to the lower selling price after increasing production capacity and demand.

2.3 Intangible assets

This paper uses the word *intangibles* in a restrictive way, referring only to those assets that the firm generates internally as an outcome of the adjustment costs incurred in production, and in making new investments fully productive.

In Prescott and Vischer (1980), intangibles take the form of what the authors call “organization capital” (the information accumulated by the firm jointly with producing output, for example information about the match between workers and the task, the match between employees working in teams, and enhancing the human capital stock by on the job training). The cost of accumulating organizational capital has to do with the restrictions on output that firms trade off with having additional capital. Brynjolfsson, Hitt and Yang (2002) refer to the costs of implementing new processes, the costs of training, and design of incentive systems to make computer technology fully productive. These costs must have a counterpart in terms of benefits for the firm, so Brynjolfsson et al. (2002) argue that, while incurring such costs, “managers must believe that they are investing in an economic asset”.

Intangibles can be made explicit in the model above, as follows. Let M_j be the stock of intangible and let $\Pi(K, M, I)$ be the extended profit function of the firm. The stock M_j will vary over time as the net result of depreciation, and the flow of new intangibles from current expenses in adjustment costs, C_j

$$M_{jt} = (1-x_j)\cdot M_{j,t-1} + f(C_{j_t}) \qquad j = 1,\ldots,M \qquad (9)$$

where x is the depreciation rate of the intangible assets and $m= f(C)$ is the flow of intangibles produced with the adjustment costs incurred in period t, which in turn depend on I and K [from equation (2)]. This is a new constraint to be added to the value maximization problem.

---

10. Hayashi and Inoue (1991) propose an alternative approach to model investment in firms with multiple assets. The approach is based on the idea that firms optimally aggregate all assets into a single measure of capital services, ϕ(Kt+1). The aggregation method consists of constructing a Divisia index of capital so that ϕ(Kt+1)=ΣcjtKjt+1 where cj is the user cost of capital.

Maintaining our other assumptions, if z_j is the Lagrange multiplier (shadow price) of (9), equation (3.1) is now formulated as[11],

$$\lambda_{jt} = p_{jt} + C'_{Ij} - z_j f'_{C_j} C'_{Ij} \tag{3.2}$$

The marginal cost of investment in asset *j* [the right-hand side of (3.2)] is now lower, since investment produces an externality in the form of valuable intangible assets. The externality is equal to the shadow price of one unit of intangible (marginal return, *z*) times the intangibles produced per unit of investment, $f_{Ij}'(C_j) = f'_{Cj}\, C'_{Ij}$. This benefit is directly subtracted from the replacement cost of asset *j*. The marginal cost of intangibles produced by investing in asset *j* is $C'_m = C'_{Ij}/m'_{Ij} = C'_{Ij}/(C'_{Ij}\, f'_{Cj}) = 1/f'_{Cj}$. If the marginal return must be equal to the marginal cost in the optimal solution, then $z_j = 1/f'_{Cj}$. Substituting in (3.2), we have $\lambda_{jt} = p_{jt}$. In the optimal production of intangibles the marginal return of the market purchased asset is just equal to the purchase price of the asset, and the marginal adjustment cost of the market-purchased asset is driven to zero. This result would be modified if one realistically assumes that the accumulation of intangible assets has its own adjustment costs so, as in Prescott and Vischer (1980), it would be the cost of accumulating intangibles that limits the growth of the firm.

Assuming no market power, and that adjustment costs endow firms with valuable intangible assets, the economic value of the firm in the optimal solution [equation (5)] will be given by

$$V_t = \sum_j^N p_j \left(K_{jt} - I_{jt}\right) + \sum_j^N z_j \left(M_{jt} - f(C_j)\right) + e_{jt} \tag{5.2}$$

where $z = 1/f'_C$. Equation (5.2) is a special case of (5.1) where $\lambda_{jt} = p_{jt}$ [from (3.2)] and the value-maximization problem has the additional constraint (9) that describes the process of accumulation of intangible assets over time. Since M_j is the intangible generated from the investment in asset *j*, it can be expected that this stock of intangibles will co-vary with the stock of asset *j*. Assuming that *M* is proportional to *K*, and that the proportion is in turn equal to the marginal change of *m* with respect to *I*, then $M = sK = f'_I\, K = f'_C C'_I\, K$. Substituting in (5.2), the economic value of the firm is given by,

$$V_t = \sum_j^N p_j \left(K_{jt} - I_{jt}\right) + \sum_j^N \frac{1}{f'_{Cj}} \left(f'_{Cj} C'_{Ij} \left(K_{jt} - I_{jt}\right)\right) = \sum_j^N \left(p_j + C'_{Ij}\right)\left(K_{jt} - I_{jt}\right) + e_t \tag{5.1}$$

Under the above assumptions, the contribution of intangibles to the value of the firm is just equal to the adjustment costs incurred in the investment process.

To illustrate the former results consider a firm that trains workers in the use of computers. Training costs are part of the adjustment costs of investing in computers, so from (9) one can estimate the replacement cost in human capital through training activities. Such costs will also be part of the optimal economic value of the firm, just as are the replacement costs of machinery or other physical capital. The return for the firm is in the form

11. This result follows from the new first order condition with respect to I, -Π'I (K, M, I) = λjt + zj f'Ij(C) and therefore λjt = - Π'I (K, M, I) - zj f'Ij(C). It is assumed that adjustment costs C always originate as a consequence of investment in market purchased assets.

of lower marginal adjustment costs and higher investment rates in computers, according to (3.2). Computers are more valuable, when used by trained workers, than they would be without training (the difference between installed and uninstalled market purchased asset), but firms incur a cost to achieve such increase of value. In a competitive market, where firms are price takers, cost and value are expected to be equal and, consequently, long term profits will be equal to zero.

3 Application to the Spanish banking industry

3.1 Data

The framework of the measurement and determinants of economic value and the investment rate of firms, presented in section 2, is now applied to data on Spanish commercial and savings banks from 1984 to 2003. Credit cooperatives and branches of foreign banks are excluded, because of the lack of relevant data, in the case of cooperatives, and because most foreign banks are not active in retail banking. The banks in the sample represent 89.25% of total banking assets in Spain in the year 2003. The primary data come from confidential reports submitted to Banco de España by Spanish banks (balance sheets, income statements and complementary notes) at the non consolidated level. These data allow us to obtain estimates of the investment flow and capital stock of four main types of assets: Physical (K^{Ph}), Information Technology (K^{IT}), Advertising (K^{Ad}) and Financial (K^{FE}) assets. Physical operating capital includes buildings (mainly branches) and long-lived assets excluding those having to do with computer hardware or software. IT capital is set equal to the sum of the assets reported in the balance sheet under the label of information technology, plus the capitalization of annual expenditures in IT reported in the income statement using the perpetual inventory method [equation (1)]. The stock of Advertising capital is obtained applying the perpetual inventory method to the annual flow (investment) of advertising expenditures, as reported in the income statement of banks. Finally, Financial assets is the counterpart, on the asset side of the balance sheet, of bank equity remaining after financing the assets used in production and sales [Equity-(Physical + IT + Advertising)]. Regulatory requirements on the minimum capital ratio for banks explain that this difference is positive for banks under normal conditions. The stocks of each of the assets are valued at current estimated purchase cost in the market, calculated using the official price index of capital goods and services, and an estimate of economic depreciation[12].

For banks with market power, the valuation and investment equations depend, among other variables, on revenues from sales. Banks can have market power on both loan and deposit markets, so for each bank, data are collected on interest paid on deposits *ID*, and on gross profit margins in loans (interest on loans minus opportunity cost of loans at the interbank interest rate), *GLP;* the gross margin of loans is used, rather than total revenue, in order to avoid double-counting, since compensation to deposits is one component of the cost of loans.

For certain years during the time period, banks also report individual data on training expenditures, which will be used to obtain a proxy for adjustment costs. Since a year-by-year variable of training expenditures is not available, the proxy is constructed using a dummy variable that takes the value of 1 for a bank that expends in training per worker an amount which is above the median of the distribution of training expenditures per worker across banks $(KH^{high} = 1)$, and 0 for the remaining banks $(KH^{high} = 0)$.

Only a few of the banks in the sample are listed on the stock market. Since the market value of the bank based on the market price of issued shares is not available, the fundamental economic value of the bank, equal to the discounted present value of future expected cash flows, must be estimated using earnings forecasts and discount

12. For a full description of the data see Martín-Oliver, Salas-Fumás and Saurina (2007). See also the Appendix of this paper for a summary of the method followed to obtain the adjusted economic data on banks.

factors for each bank in the sample. Other studies [Abel and Blanchard (1986), Bond and Cummins (2000)] have questioned the use of share price to obtain estimates of the economic value of the firm, even when they are available arguing that share price only reflects the fundamental value of the firm under perfect financial market conditions. In this paper, we do not have that option, but the method used to calculate economic value is validated through its use in previous studies.

The economic value of the bank will be set equal to the present value of the predicted future profits, discounted at the cost of capital of the bank. In this paper, we follow the approach of Abel and Blanchard and forecast the future earnings of each bank using an *ARIMA* econometric model. The economic value of a bank *i* in year *t* is then calculated as follows,

$$\hat{V}_{it} = \hat{P}_{it}^{t} + \xi_{i,t}\,\hat{P}_{i,t+1}^{t} + \xi_{i,t}^{2}\,\hat{P}_{i,t+2}^{t} + \xi_{i,t}^{3}\,\overline{P}_{i}^{t}\,\frac{1+\overline{\rho}_{it}}{\overline{\xi}_{it}-\overline{\rho}_{it}} \qquad (10)$$

where $\hat{P}_{i,t+s}^{t}$ are the predicted adjusted profits of bank *i* at time *t+s*, given the information available at time *t* using an *AR*(*2*) model; $\xi_{i,t}$ is the discount factor of each bank, inversely related to the opportunity cost of capital of that bank at time *t*. The opportunity cost of capital of the bank is equal to the risk-free interest rate plus a risk premium that takes into account the risk of loans plus the risk from debt leverage. Adjusted profits are obtained from accounting profits reported by banks modified as follows: adjusted profits = accounting profits + expenditures on advertising and IT + amortization – estimated economic depreciation of material and immaterial assets at current purchased cost.

From *t+3* onwards, the level of profit of banks is calculated applying a constant expected growth rate ρ_i to the average of the predictions for *t*, *t+1* and *t+2*, $\overline{P}_i^t$. It is assumed that this rate of growth of profit is equal to the profit retention rate times the long-run Return Over Equity (*ROE*). The proxy value of the long-term growth rate $\overline{\rho}_{it}$ is obtained assuming that banks retain one half of their earnings, and further assuming that the long-term *ROE* is equal to the average of the *ROE* of the last three years. The long-term discount factor $\overline{\xi}_{it}$ has been approximated to the average of the opportunity cost of capital of the bank in the previous three-year period[13].

Table 1 provides year-by-year statistics of the estimated economic value, *V*, and of the market purchased assets at their estimated current purchase costs, for each year from 1984 to 2003 (in thousands of euros). All values are at current prices. Roughly, in the twenty-year period, the median-estimated economic value per bank, and the median-estimated replacement cost of each asset, are multiplied by a factor of ten or more, except Financial assets, which have grown at a much faster rate, and Commercial capital, which has multiplied its median by a factor of 8.3. The relative importance of immaterial assets (IT and Advertising Capital) has grown with respect to Physical capital, though the

13. In order to test for possible biases in our measure of the economic value of banks, for those banks listed on the market, we estimate the actual market value of the bank as the product of share price and number of issued shares at the end of each year. Then we postulate and estimate a linear equation model, where the dependent variable is the actual market price, Market, and the explanatory variable is our estimated economic value of the bank, Econvalue. The results of the estimation are $Market = 846.9 + 1.07 \cdot Econvalue$ (87 observations). The null hypothesis of intercept equal to zero and slope equal to one are not rejected at the 5% level of significance or less. Therefore, we have no evidence that our estimate of the economic value of banks is a biased estimate of their market value if they were listed on the stock market.

latter remained the principal asset component in 2003[14]. Table 2 has a similar structure, but for investment rates. These rates differ across assets, low for physical and financial assets, high for IT and advertising; these differences in investment rates reflect differences in depreciation rates and cross-substitution among assets. The descriptive data are completed with Table 3, which provides information on the ratio between the economic value of the bank and the current purchase costs of all assets listed in Table 1 (average Tobin *q* for the aggregation of all assets). Since *q* equal to one is the benchmark for zero economic profits (assuming no adjustment costs), the median Spanish bank earns extraordinary profits in almost all the years of the period. Extraordinary profits start high *(q* ratio close to 3) and disappear in the middle period (the value falls to 0.94 in 1994), when the country was starting to come out of a serious economic recession. Finally, they rise again at the end of the sample period, but remain at values lower than 2. Increasing competition in the last part of the period (coinciding with the full liberalization of the banking sector) compressed economic profits, but not to the point of falling to zero. The coefficient of variation, standard deviation over mean, and the percentile range, also decrease over time, indicating convergence in economic profits across banks.

Table 3 also shows, for comparison, the mean and standard deviation of the Tobin's *q* if it was computed using the accounting net profit (without adjustments) to estimate the economic value of the bank (present value), and using book value of equity in the denominator. We observe the same trend in both variables, but the Tobin's *q* at book value for the median bank is always substantially higher than that calculated with assets at replacement-cost. Accounting profits are lower than adjusted profits, since, in the former, advertising and IT expenditures are considered costs of the period and, in the latter, they are investments to be capitalized. Therefore, economic value is lower with accounting profits than with adjusted profit. On the other hand, equity at book value is much lower than assets at replacement costs.

3.2 Empirical model and econometric issues

There are two equations to be estimated, equation (5), with variations on intangibles, (5.2), that corresponds to the economic value of the bank, and the investment equation (8).

3.2.1 VALUATION

The standard approach in the literature has been to estimate the economic value of the firm as a function of the assets in the balance sheet at book value, or at replacement cost. Using our notation the equation to be fitted to the firm level data is written as

$$V_t = \sum_{j}^{N} \alpha_j \left(p_j \left(K_{jt} - I_{jt} \right) \right) + e_t \tag{5.3}$$

where α_j are the parameters to be estimated. According to the results in the theory section, this empirical model ignores two sets of additional explanatory variables, intangibles and revenues. To simplify the exposition, assume first that banks do not have market power so the true model is (5.2),

$$V_t = \sum_{j}^{N} \alpha_j \left(p_j \left(K_{jt} - I_{jt} \right) \right) + \sum \left(M_j - f(C_j) \right) + e_t \tag{5.2}$$

---

14. For a detailed analysis of the composition of banks' assets and their evolution over time, see Martín-Oliver, Salas-Fumás and Saurina (2007).

Brynjolfsson, Hitt and Yang (2002) estimate equation (5.3) with two additional assumptions, zero adjustment costs and that the unobservable stock of intangibles is linearly correlated with observed capital stock *j* in the form $M_j - f(C_j) = a_j + v_j(K_j - I_j)$, where *a* and *v* are non-negative parameters. Zero-adjustment cost implies that the estimated coefficient in model (5.3) will be $\alpha_j = 1 + v_j$. Consequently, $v_j = \alpha_j - 1$ gives the monetary units of intangible assets generated by measurable asset *j*.

When the realistic assumption of adjustment cost is restored, from (5.1), the estimated coefficient in (5.3) would be $\alpha_j = (1 + C'_{Ij})$. Consequently $\alpha_j - 1 = C'_{Ij}$ provides an estimate of the marginal adjustment cost of investment in asset *j*. Cummins (2004) assumes that intangible assets are unobservable and independent of the stock of asset *j*. However, the value-maximizing condition requires that the marginal cost-adjustment of investment C'_{Ij} be equal to the marginal return from intangibles built around asset *j*. Therefore, according to Cummins, $\alpha_j - 1$ provides an estimate of the marginal return from intangibles, as opposed to Brynjolfsson, Hitt and Yang (2002). Now, the total replacement cost of intangibles accumulated through the investment process in asset *j* would be equal to $(\alpha_j - 1)p_j K_{t-1} = C'_{Ij} p_j K_{t-1}$.

The approach of Brynjolfsson, Hitt and Yang (2002) to the measurement of intangibles is not empirically distinguishable from the method proposed in this paper, but it has different implications when a proxy of adjustment costs is included to explain the economic value of the firm. One of the adjustment costs faced by firms is the expenditure to train workers when a new technology is adopted. Our data base provides partial information on the training expenditures of banks that can be used to construct the dummy variable KH^{high} as a proxy of intangibles built from training expenditures.

Equation (3.2) predicts that banks with higher training expenditures (higher intangibles) will have lower marginal adjustment costs than banks with low training expenditures. Therefore, if intangibles built up through training activities are valuable for the firm, then $C'_I(KH^{high}) < C'_I(KH^{low})$. If training expenditures are adjustment costs resulting from investments in IT capital, then it is expected that the estimated coefficient of the IT capital variable in the valuation and investment equations will be lower in banks with high training expenditures. On the other hand, if there were no adjustment costs, as Brynjolfsson, Hitt and Yang (2002) assume, then intangibles built through training expenditures will be directly incorporated into the economic value of the bank. To discriminate between the two hypotheses, the explanatory variables KH^{high} and $KH^{high} \times K_j^{IT}$ are added to the basic model. If intangibles resulting from training really do lower the adjustment costs of investing in *IT* capital, then the estimated coefficient of $KH^{high} \times K_j^{IT}$ is expected to be negative, and the estimated coefficient of KH^{high} positive (model 5.2). If intangibles are free, and grow in parallel with the investment in *IT*, then the coefficient of *KH* is expected to be positive and the coefficient of $KH^{high} \times K_j^{IT}$ is expected to be non-negative.

If banks have market power, the omission of revenues from loans and deposits in the empirical equation (5.3) will be another source of miss-specification. Revenues are expected to be correlated with the other assets if they contribute to increase demand and/or make it less price elastic (for example, through advertising) and, consequently, the estimated coefficients of the explanatory variables in (5.3) will over-estimate the marginal adjustment costs of intangibles.

The actual model to be estimated is formulated as follows,

$$lnV_{it} = \mu_0 + \sum_{j \in J} \mu_j \, ln\, p_{jt} K_{it}^{j} + d_1 ln\ ID_{it} + d_2\ ln\ GLP_{it} + c_1 KH_i^{high} + c_2 KH_i^{high} \cdot ln\, p_{jt} K_{it}^{IT} + \eta_i + m_{it} + \varepsilon_i$$

$$J=\{Ph, IT, Ad, FE\}; \quad \eta_\iota, m_{it}, \varepsilon_{it} \sim iid(0, \sigma_k); k=\{\eta, m, \varepsilon\} \qquad (11)$$

where sub-index *i* refers to the bank and *t* to the time period. The equation is formulated in logs, since the estimated value of the elasticity μ_j will provide a direct estimate of the relative contribution of asset *j* to the economic value of the bank, $\mu_j = V'_{K_j}(K_j / V) = \lambda_j (K_j / V)$[15]. Super-indices *Ph*, *IT*, *Ad* and *FE* are the identifying labels of Physical, IT, Advertising and Financial types of capital, and *ID* and *GLP* stand for deposit interest and gross loan profits, respectively. The error term is made up of three components: η_ι or bank-specific effects that control for unobserved heterogeneity across banks; m_{it}, that accounts for the measurement error in the calculation of the value of the capital stocks and, finally, $\varepsilon_{\iota\tau}$, a random term that captures productivity shocks, measurement errors of the dependent variable, and other disturbances not explained by the model.

The elasticity μ_j is expected to be non-negative. It is assumed that the elasticity of the economic value to the stock of asset *j* is constant over time and equal across banks. Time-dummy variables and firm-specific fixed effects capture time-varying factors common to all banks, and bank-specific effects constant over time. Market power of banks in the deposit and loan markets imply d_1, $d_2>0$. Finally we have $c_1>0$ and $c_2<0$ from the assumptions of training expenditures as a source of adjustment costs.

The estimation of (11) with the *OLS* techniques, and the like, will produce biased estimates of the parameters, since the explanatory variables are correlated with the error term (productivity shocks, in ε_{it}, affect both the value of the firm and the investment policy and, consequently, the value of the capital stock). In addition, measurement errors *(m_{it})* are correlated by definition with the explanatory variables. Finally, another source of potential correlation arises due to the existence of bank-specific effects in the error term that control for unobservable heterogeneity and can be correlated to the explanatory variables, leading to inconsistent estimates of the parameters[16]. The standard econometric solution to these potential estimation problems is to take first differences, to eliminate unobservable firm-specific effects, and use lagged values of the variables as instruments. However, it has been shown that if the persistence[17] of the variables that enter into the regression is high, then the lagged values are no longer good instruments for the first differentiated variables, and this gives inconsistent estimates of the parameters. Blundell and Bond (1998) propose additional orthogonal conditions that are instrumented through the so-called *System-GMM estimator,* and assure consistent parameter estimates in the presence of a high degree of persistence of the variables. Model (12) is then estimated using the *GMM* system.

---

15. The marginal return = marginal cost condition as a function of μj is $MR_j = \left(1 + \frac{C'_{Ij}}{p_j}\right)$ = βj·(V/Kj).

16. Brynjolfsson, Hitt and Yang (2002) argue that firms' fixed effects should not be eliminated from the regression since part of the intangible assets of the firm may be part of the idiosyncratic component of the valuation model. However, if omitted variables are correlated with the explanatory variables included in the regression, the estimated coefficients of the latter will be biased. Since bank fixed effects can always be recovered from the residuals of the regression, if needed, we opt for an estimation procedure that eliminates the fixed bank effects from the estimation (first differences in the variables) in order to minimize estimation bias in the parameters.

17. The degree of persistence of a variable refers to the dependence of the new values on its past history. Suppose that the variable x_t is explained by an autoregressive stochastic process; persistence is higher as the coefficient of the lagged variable is closer to one.

3.2.2 INVESTMENT EQUATION

The empirical specification of (8) is formulated as

$$\frac{I_{it}^{Ph}}{K_{it-1}^{Ph}} = \varphi_0 + \varphi_1 \ln q_{it}^{Ph} + \sum_{j \in J} \left(\varsigma_j \frac{p_j I_{it}^{j}}{p_{Ph} K_{it-1}^{Ph}} \right) + \gamma_1 \frac{ID_{it}}{p_{Ph} K_{it-1}^{Ph}} + \gamma_2 \frac{GLP}{p_{Ph} K_{it-1}^{Ph}} + \chi_1 KH^{high} + \chi_2 KH^{high} \times \frac{p_{IT} I_{it}^{IT}}{p_{Ph} K_{it-1}^{Ph}} + \eta_i + u_{it}$$

J={IT, Ad , FE}; η_i ,u_{it} ~ iid(0, σ_k); k={η, u} (12)

The dependent variable is the investment rate of Physical assets. The *q* ratio of economic value over physical assets of the bank is expressed in logs[18]; the coefficient φ_1 (equal to the inverse of the slope parameter of the adjustment cost function for physical assets) is expected to be non-negative. The coefficients of the normalized investment flow of the remaining assets, ζ_j, are expected to be non-positive. We expect χ_1 <0 and χ_2 >0 from the contribution of intangible assets. Finally γ_1 >0 and γ_2 <0 if banks have market power. The sign of the coefficients of the explanatory variables in the investment equation correspond to the signs of the explanatory variables of the valuation equation, which provides a robustness test for the multi- assets model of the banking firm.

As investment rates present a large cross-section and time-series variation, the System *GMM* estimation technique is not required here, and the investment equation will be estimated with the first-differenced *GMM* estimator using as instruments the lags *t-2* and *t-3* of the explanatory variables.

3.3 Results

The results of the estimation of the valuation equation are presented in Table 4. Column 1 shows the estimated elasticity when the economic value is explained only as a function of the stocks of market- purchased assets. The estimated elasticity is statistically significant for the four assets, and the estimated values are in a range between 0.18 and 0.27. Therefore, according to this estimation, the relative contribution of each market-purchased asset to the economic value of the bank is similar for all, and in a range between 18.3% and 26.6% of the total economic value (the equal elasticity and sum of elasticity for all assets equal to 1 hypotheses cannot be rejected, *p* values of 0.95 and 0.27, respectively).

Column 2 adds KH^{high} and $KH^{high} \times K_j^{IT}$ to the list of explanatory variables; the estimated coefficient of KH^{high} is positive, and that of $KH^{high} \times K_j^{IT}$ negative, both being statistically significant. The estimated elasticity of economic value with respect to IT capital rises to 35% for banks with low training expenditures, and decreases to 7% (35%-28%), not significantly different from zero, for banks with high training expenditures. On the other hand, since the mean value of log of economic value in the sample is 12.11, the relative contribution of intangibles from training to economic value is 19.6% (2.33/12.11).The empirical evidence is consistent with the hypothesis that training expenditures contribute to economic value, providing intangible assets which facilitate the adoption of IT investments by banks, but at the same time part of the economic value of the bank has to compensate for the cost of intangibles. In fact, when the model is estimated with only KH^{high} (i.e. excluding the cross effect) the estimated coefficient of KH^{high} is not statistically different from zero, suggesting that benefits from intangibles originated in training activities just compensate for the costs of training. One indirect way to capture the benefits from training expenditures

18. Bond and Cummins (2001) provide an econometric justification for the semi-log approximation to the q model of investment, based on a possible multiplicative structure of the measurement error in the variables.

is to compare the stock of IT capital of banks with high and low training expenditures. The difference between log of the stock of IT per worker of banks with high and banks with low training expenditures (controlling for time effects) is statistically significant; the estimated mean value of the difference implies that the stock of IT per worker in banks with high training expenditures is, on average, 50% higher than in the other banks.

Finally, the empirical valuation model is modified, introducing as explanatory variables the interest from deposits *ID* and the gross profits from loans *GPL* (column 3). The respective estimated coefficients are 0.22 and 0.02. This implies that rents from market power contribute 24% to the economic value of the bank, and that most of the contribution appears to come from market power in deposit markets[19]. Once the contribution of market power is isolated, the relative contribution of the assets is reduced in a significant way, with the exception of the contribution of Financial assets. The highest reduction is for Advertising, with an estimated elasticity 50% lower and no longer statistically different from zero, and for intangible assets built from training expenditures; the estimated coefficient of KH^{high} in column 3 is only half of what it was in column 2. For IT and Physical capital, their respective estimated contributions are 30% and 20% lower.

Summarizing the results from column 3 of Table 4, the economic value of banks in the sample is distributed in value attributed to assets used in production and sales, and value attributed to market power as follows: in banks with low training expenditures, 18% to Physical assets; 27% to IT; 24% to Financial assets (residual equity); and 24% to market power. The estimated contribution of advertising is 8%, but the value is not significantly different from zero. In banks with high training expenditures, the contribution of IT is 12% (not statistically significant), but their economic value is 10% higher than banks with low training expenditures, a difference in value that can be attributed to the cost of the increase in human capital that results from the higher training intensity.

3.3.1 INVESTMENT

We now turn to the investment equation, Table 5. The sequence of estimated empirical models parallels that of Table 4 and, over all, the results of the valuation and investment equations are mutually consistent and consistent also with the theoretical analysis. The estimated coefficient of Inq^{Ph} is positive and statistically significant, and the estimated coefficients of investment flows in IT and Advertising capital are negative and statistically significant, exactly as the model predicts. The estimated coefficient of Financial assets is not rejected to be equal to zero, suggesting that banks have generally been operating with non-binding regulatory capital constraint. When the variable of training expenditures is added as an explanatory variable of investment (column 2), the coefficient of KH^{high} is negative, which confirms that investment in intangibles behaves similarly to investment in other assets. On the other hand, for those banks with $KH^{high} = 1$, the adjustment cost of investment in IT is not significantly different from zero (-0.677+ 0.793 = 0.116), consistent with the prediction from equation (3.2), which determines the optimal investment path for the firm with valuable intangibles: higher intangible capital, in the form of human capital accumulated through training, implies a lower adjustment cost of investing in IT capital. The coefficient of investment in IT for banks with low training expenditures is higher than the average for all banks in column 1 (-0.677 compared with -0.276).

19. Martín-Oliver, Salas-Fumás and Saurina (2006) report the Lerner index for loans by Spanish banks as being much lower than the Lerner index for deposits, not counting the unremunerated deposits, which are consistent with the finding of this paper of a higher contribution to economic value for rents from deposits than for rents from loans.

Column 3 of Table 5 shows the results of the estimation equation when the variables that control for market power are added to the empirical model. The coefficient of *ID*, interest on deposits, is negative as expected, while the coefficient of gross profits in loans is now non-significant. The results are consistent with the market power of banks in deposit markets. Adding the market power variables increases the estimated coefficient of the $ln q^{Ph}$ variable (which captures the marginal return (cost) from Physical capital in an inverse way) and lowers the absolute value of the coefficient of Advertising, again consistent with the pattern of results observed in Table 4 and with the theoretical predictions[20].

Comparing the theoretical investment equation (12) with the empirical one [equation (8)], it is possible to recover the parameters of the original adjustment cost functions for the respective assets. The slope of the adjustment cost function of investment in physical assets, b_1, is equal to 20 (1/0.05). To calibrate the importance of adjustment costs for investment in physical assets, notice that if the rate of investment differs from the stationary rate by, for example, 5 percentage points, the adjustment cost will represent 2.5% of the stock of invested physical capital [substituting these values in the adjustment cost function (2) we have 20/2 $(0.05)^2$ *pK* = 2.5% of *pK*]. For IT, the calculations give an adjustment cost parameter for banks with low training expenditures equal to $b_2 = 0.65 \cdot b_1 \cdot 0.97/0.65 = 19.4$ (the calculation takes into account the different depreciation rates; 0.35 for IT and 0.03 for Physical capital). In the case of advertising, the estimated coefficient in the investment equation is only marginally statistically significant.

3.3.2 MEASUREMENT OF INTANGIBLES

Section 2 shows that, under certain assumptions of proportionality between the stock of unobservable intangibles and the stock of observable market purchased assets, it is possible to obtain the estimates of the hidden intangibles from the estimated marginal return of measurable assets. It is clear that the relative contribution of asset *j* to the economic value of the bank μ_j includes the purchase cost of the asset and the adjustment cost of intangibles built in the process of investing in asset *j*: $\mu_j = V'_{K_j}(K_j/V) = \lambda_j(K_j/V) = (p_j + C'_{I_j})K_j/V$. Therefore, the relative importance of intangibles, at production cost, in the economic value of the bank, is given by $C'_{I_j}(K_j/V) = \mu_j - p_j K_j/V$. That is, the intangibles from the market-purchased asset *j,* relative to the economic value of the bank, are equal to the difference between the elasticity of economic value of the stock of asset *j,* minus the ratio of the stock of asset *j* at market purchase price over the economic value of the bank.

The calculations of the difference between elasticity of economic value to the stock of asset *j,* and the average ratio of purchase cost of the asset to economic value, give the following results (the p value of the test of the null hypothesis that the difference is equal to zero): -0.036 (0.84) for Physical assets; -0.09 (0.13) for Financial assets; 0.25 (0.01) for IT in banks with low training expenditures; 0.10 (0.32) for IT in banks with high training expenditures; and 0.083 (0.35) for Advertising. The difference in economic value between banks of high and low training expenditures (controlling for the other variables) represents 9% of the value of the bank with high training. Therefore, the differential cost of intangibles built through training expenditures in banks with high expenditures is 9% of the economic value of the bank.

In banks with low training expenditures, the estimated cost of intangibles represents 24% of the value of the bank. Low training expenditures forces banks to slow

20. The estimated coefficient of $ln\ q^{Ph}$ goes up from 0.03 in the first estimation to 0.05 in the last; this estimation can be compared with the 0.082 value of the coefficient obtained by Bond and Cummins (2001), for firms from all industries.

down the investment process in IT (the stock of IT capital per worker in these banks is one half of the stock in banks with high training expenditures, on average) and this has a net negative effect on the overall size of the bank: for the full sample, the average economic value of banks with high training expenditures is 80% larger than the average economic value of banks with low training. In banks with high training expenditures, intangibles around IT (not counting those directly measured through the training variable) are 10% of the value of the bank, although this estimate is not statistically different from zero (p value of 0.32) [21]. The non-rejection of the null hypothesis of zero intangibles is repeated in all assets, except IT in banks with low training expenditures[22].

3.3.3 ACCOUNTING OR ECONOMIC DATA

The economic valuation and the investment behaviour of banks could also be examined using raw accounting data publicized in the externally reported balance sheet and income statements. It might happen that expenditures in IT and advertising create assets that depreciate within the year, so the two are properly reported as costs of the period. And that the book value of the reported assets was the right measure of their replacement cost. In fact, those that value intangible assets as the difference between market value and book value of the firm implicitly assume that all market purchased assets are reported at current or replacement costs. One way to investigate the relevance of the adjustments made in accounting data to measure material and immaterial assets and value them at their replacement costs, as it is done in this paper, is to see whether or not the value and investment behaviour of banks are explained by raw accounting data, and compare the results with those obtained using economically adjusted data.

In the asset side of the balance sheet we can identify two types of resources, physical assets different from IT and IT related assets. Therefore, when restricted to raw accounting data the valuation equation will explain the present value of future profits of the bank as a function of the physical, IT and Financial assets at book values. In the same vein, the investment equation will explain the investment flow in physical capital as a function of Tobin's q and the flows of IT and of Financial assets. The unadjusted economic value of the bank will be obtained from equation (10), taking as profits those reported by banks in their income statement (unadjusted). The Tobin's q is obtained dividing the unadjusted estimated economic value by the book value of the equity of the bank (the same as reported in Table 3).

Table 6 shows the results of the estimations. If one uses raw accounting data in explaining the economic value of banks the conclusion will be that the only resource that significantly contributes to the economic value of banks is the physical capital with 25% of the total value. Market power on the other hand appears to contribute as much as 50% to the economic value, a clearly unreasonable result. Most likely this variable is also capturing the contribution of the rest of immaterial assets not fully captured by the observable book valued physical and financial assets. In the investment equation estimation using raw accounting data none of the explanatory variables is statistically significant at the 5% level or less, so the raw accounting data can not explain the flow of investments.

---

21. Brynjolfsson, Hitt and Yang (2002) find that one dollar of stock of IT capital generates almost 12 dollars of intangibles in their sample of US firms, not controlling for market power. Our estimate of this measure of intangibles (weighted for banks with high and low training expenditures) is 9 euros of intangibles per euro of IT capital, after controlling for market power.

22. Notice that the net marginal contribution of Financial assets to economic value is -9%, statistically significant at 13%. Apparently banks are unable to obtain a return above the opportunity cost for the financial assets where they invest the regulatory capital in excess of that used to finance directly productive assets (i.e. in excess of that invested in branches, IT, advertising).

On the other hand, the investment equation using economically adjusted data behaves as expected according to the theoretical model. It is clear then that economically adjusted and, extended, data on material and immaterial assets are relevant to explain the investment behaviour of banks.

4 Conclusion

The importance attributed to intangibles in the modern firm is as great as the lack of knowledge of the nature, origin and valuation method of this type of assets. This paper makes a distinction between material, immaterial and intangible assets, in the process of explaining the economic value of Spanish banks during the period 1984-2003, and provides a conceptual framework to disaggregate the economic value of banks into the current purchase cost of market-supplied assets (physical, IT and advertising), the cost of internally-produced intangibles, and the value attributed to rents from market power. The framework draws on the theory of investment for the multi-asset bank with adjustment costs and market power, and the empirical analysis of the determinants of banks' economic value is complemented with the empirical estimation of the investment model resulting from the value-maximizing problem. Overall, the results support the hypothesis that the investment behaviour of Spanish banks in the sample is well described by the posed value maximization problem, in such a way that banks set a value-maximizing investment rate that equals marginal benefits and marginal adjustment costs of growth.

The optimal value-maximizing behaviour of banks implies optimal decisions, over time, on the capital stock of the market-purchased and internally-produced (intangible) assets. The theoretical results empirically tested here are on the determinants of the economic value of the bank. Such determinants are the purchase cost at current market prices of material and immaterial assets, the production cost of immaterial assets (costsof training workers in the use of IT in our illustration) and the capitalized rents from market power. We only find evidence of internally-produced intangibles from the adjustment costs incurred in IT investment, and more particularly, from the costs of training workers to use these investments more effectively. Such intangibles represent up to 20% of the economic value of the bank for those banks with low training expenditures, that is, 20% of their economic value represents the anticipated cost of expenditures not yet made, in adjusting the internal conditions to allow IT investments to become fully productive. Banks with high training expenditures are 10% more valuable than banks with low expenditures, which is interpreted as an estimate of the cost of efforts in training workers in computers and IT. In compensation for this cost, banks with high training expenditures invest at a higher rate and accumulate, on average for the whole period, a stock of IT per worker 50% higher than that of banks with low training expenditures.

Another component of value is the rents from market power, which represent, on average, up to 24% of the economic value of the banks. The average Tobin's *q* exceeds the competitive value of 1 by 47% [average value of 1.9 and (1.9-1)/1.9 =0.47]. Therefore, rents from market power represent almost one half of this excess in economic value. The rest would be attributed to intangibles. The separation between the contribution to economic value attributed to intangibles, and the contribution due to market power (which, a priori, cannot be attributed to any particular asset) is one of the main results of the paper, compared with previous work on valuation. Ex-post, the empirical results show that advertising and training are the assets which contribute the most to the rents from market power of banks (but not the only ones).

The empirical evidence also indicates that information about expenditures on immaterial and intangible assets is valuable in explaining the real decisions of firms. The banks of the sample are not affected by strategic behaviour in response to certain reporting practices since information on immaterial and intangible assets used in the analysis is private (it is not even published in indirect sources, such as industry reports of firms' expenditures on IT or advertising). Moreover, these banks are unlisted and the only public information available to externally evaluate their performance is that provided by accounting statements. Our results suggest that the real decisions of banks are dictated by internal measures of performance, not by external, accounting-based measures. However, we do not know if changes in disclosure regulation concerning intangibles would induce some strategic behaviour by banks that would be anticipated by external observers and, in turn, would affect the real decisions in line with the results of Kanodia et al. (2004). Since managers do not have to communicate with distant shareholders (only reporting to the board of directors), the incentives to produce information might be different and, by expanding the information about expenditures on intangibles, there would be a net social gain, in terms of a better empirical ex-post explanation of the real behaviour of firms.

One important limitation of the paper is that these banks are not listed on the stock market and, therefore, the market value of equity as an external estimate of the economic value is not available. The application of the framework to listed firms would allow extending the empirical analysis to issues such as the value-relevance of intangibles. A second limitation of the paper is that training expenditures are only partially approximated. Such expenditures prove to be a good proxy for the adjustment costs of growth, and it would be quite important —in terms of refining the results— to have more detailed year- and bank-level data on the total training expenditures of banks.

REFERENCES

ABEL, A. (1990). "Consumption and Investment", in *Handbook of Monetary Economics,* Vol. 2, B. Friedman and F. Hahn (Eds.), North-Holland.

ABEL, A. B., and O. BLANCHARD (1986). "The Present Value of Profits and Cyclical Movements in Investment", *Econometrica,* 54, 2, pp. 249-273.

BHARADWAJ, A., S. BHARADWAJ and B. KONSYNSKI (1999). "Information technology effects on firm performance as measured by Tobin´s q", *Management Science,* 45, pp. 1008-1024.

BOND, S., and J. CUMMINS (2000b). "The stock market and investment in the new economy: Some tangible facts and intangible fictions", *Brookings Papers on Economic Activity,* pp. 61-124.

— (2001). *Noisy share prices and the Q model of Investment,* IFS, Working Paper 01/22.

BLUNDELL, R., and S. BOND (1998). "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics,* 87, 1, pp. 115-143.

BRYNJOLFSSON, E., and L. HITT (1996). "Paradox lost? Firm level evidence on the returns to information systems expending", *Management Science,* 42, pp. 541-558.

Brynjolfsson, E., L. Hitt, and S. Yang (2002). "Intangible assets: Computers and organization capital", *Brookings Papers on Economic Activity,* pp. 137-181.

CUMMINS, J. (2004). *"A new approach to the valuation of intangible capital,* NBER Working Papers, No. 9924.

GRILICHES, Z. (1981). "Market value, R&D and patents", *Economic Letters,* 7, pp. 183-187.

GRILICHES, Z., and J. MAIRESSE (1999). "Production functions: the search for identification", in S. Strom (Ed.), *Econometrics and Economic theory in the 20th century: The Ragnar Frisch Centennial Symposium,* Cambridge Uni. Press.

HALL, B. (1993). "The Stock market valuation of R&D investment during the 1980s", *American Economic Review,* 83, pp. 259-264.

HALL, B., and R. ORIANI (2006). "Does the market value R&D investment by European firms? Evidence from panel data of manufacturing firms in France, Germany and Italy", *International Journal of Industrial Organization,* 24, pp. 971-993.

HALL, R. (2001). "The stock market and capital accumulation", *American Economic Review,* 91, 6, pp. 1185-1202.

HAYASHI, F. (1992). "Tobin's marginal q and average q: A neoclassical interpretation", *Econometrica,* 50, pp. 213-224.

HAYASHI, F., and T. INOUE (1991). "The relation between firm growth and Q with multiple capital goods: Theory and evidence from panel data on Japanese firms", *Econometrica,* Vol. 59, 3, pp. 731-753.

HEALY, P., S. MYERS and C. HOWE (2002). "R&D accounting and the trade-off between relevance and objectivity", *Journal of Accounting Research,* 40, pp. 677-710.

HIRSCHEY, M. (1982). "Intangible capital aspects of advertising and R&D expenditures", *Journal of Industrial Economics,* 30, pp. 375-390.

JAFFE, A. (1986). "Technological opportunity and spill over of R&D: evidence from firms' patents, profits and market value", *American Economic Review,* 76, pp. 984-1001.

KANODIA, CH., H. SAPRA and R. VENUGOPALAN (2004). "Should intangibles be measured: What are the economic trade-offs?", *Journal of Accounting Research,* 42, 1, pp. 89-120.

LEV, B. (2001). *Intangibles: Management, measurement, and reporting,* Brookings Institution Press, Washington, DC.

LEV, B., and P. ZAROWIN (1999). "Boundaries of Financial Reporting", *Journal of Accounting Research,* 37, pp. 353-385.

LINDENBERG, E. B., and S. A. ROSS (1981). "Tobin's q ratio and industrial organization", *Journal of Business,* 54, pp. 1-32.

MARTÍN-OLIVER, A., V. SALAS-FUMÁS and J. SAURINA (2006). "Risk premium and market power in credit markets", *Economic Letters,* 93, 3, pp. 450-456.

— (2007). *Measurement of Capital Stock and Input Services of Spanish Banks,* Working Paper No. 0711, Banco de España.

MONTGOMERY, C., and B. WERNERFELT (1988). "Diversification, Ricardian rents, and Tobin's q", *Rand Journal of Economics,* 19, 4, pp. 623-632.

NAKAMURA, L. (1999). "Intangibles: What put the new in the New Economy?", *Business Review,* Federal Reserve Bank of Philadelphia, pp. 3-16.

NEWBERT, S. (2007). "Empirical research on the Resource Based View of the firm: An assessment and suggestions for future research", *Strategic Management Journal,* 28, pp. 121-146.

PRESCOTT, E., and M. VISSCHER (1980). "Organization capital", *Journal of Political Economy,* 88, 3, pp. 446-461.

SALINGER, M. (1984). "Tobin's q, unionization, and the concentration-profits relationship", *Rand Journal of Economics,* 15, pp. 159-170.

SMIRLOCK, M., T. GILLIGAN and W. MASHALL (1984). "Tobin's q and the structure-performance relationship", *American Economic Review,* 74, pp. 1051-1060.

TOIVANEN, O., P. STONEMAN and D. BOSWORTH (2002). "Innovation and market value of UK firms, 1989-1995", *Oxford Bulletin of Economics and Statistics,* 64, pp. 39-61.

VILLALONGA, B. (2004). "Intangible resources, Tobin's q and sustainability of performance differences". *Journal of Economic Behaviour and Organization,* Vol. 54, pp. 205-230.

TABLE 1. MARKET VALUE OF SPANISH BANKS (V_t) AND VALUE AT REPLACEMENT COST OF THEIR CAPITAL STOCKS. DESCRIPTIVE STATISTICS. Millions of euros 1984-2003

Year	V_{it}			Physical Capital			IT Capital			Advertisement Capital			Financial Assets		
	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.
1984	187	76	311	45	16	87	3.0	1.0	5.3	1.6	0.7	2.5	38	9	104
1985	207	80	349	49	19	91	3.3	1.2	5.4	1.8	0.7	2.8	48	12	129
1986	266	93	483	53	19	101	4.3	1.8	6.3	1.9	0.9	2.8	59	14	156
1987	293	120	543	51	21	89	4.4	2.2	6.2	2.0	1.0	2.8	75	22	186
1988	333	135	608	63	25	117	5.0	2.8	6.3	2.2	1.1	3.1	76	23	188
1989	648	161	1394	115	40	277	6.4	3.7	7.3	2.6	1.3	3.4	102	28	228
1990	779	171	1829	126	42	315	6.7	4.0	7.5	2.9	1.6	3.6	107	28	245
1991	756	196	1532	194	53	435	7.7	4.1	8.4	3.4	1.7	4.2	133	37	291
1992	581	180	1166	163	55	352	7.8	4.9	8.1	3.8	1.9	4.3	144	52	286
1993	501	145	1048	165	55	350	7.9	5.0	8.1	4.0	2.1	4.4	206	70	438
1994	532	170	1089	153	59	281	7.7	5.1	7.6	4.0	2.3	4.4	210	77	391
1995	923	159	3992	155	61	327	7.7	5.1	7.6	4.4	2.8	4.5	233	91	450
1996	742	174	2196	189	67	424	8.6	6.4	8.2	4.6	3.1	4.5	282	114	532
1997	673	246	1072	208	75	412	9.5	7.1	8.3	4.9	3.6	4.6	297	128	534
1998	859	316	1345	242	80	505	10.3	8.7	8.5	5.3	4.0	4.6	329	152	568
1999	1152	435	1892	238	93	480	10.3	8.5	8.5	5.2	3.9	4.6	316	165	470
2000	1637	584	3753	278	107	615	10.8	9.0	8.7	5.3	3.9	4.7	369	192	593
2001	2179	674	4854	365	130	754	11.9	9.9	8.7	5.8	4.9	4.8	629	245	1622
2002	2248	839	4968	403	145	802	12.4	10.5	8.8	6.1	5.3	4.9	703	267	1779
2003	2254	930	4455	422	187	725	12.8	11.5	8.8	6.4	5.8	4.9	637	304	1120

TABLE 2. INVESTMENT RATES IN MATERIAL AND IMMATERIAL ASSETS

DESCRIPTIVE STATISTICS 1984-2003

Year	Physical Capital			IT Capital			Advertising Capital			Financial Assets		
	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.	Mean	Median	Std.Dev.
1984	5.85	3.94	10.54	43.71	44.10	17.55	38.60	37.22	11.25	25.14	26.33	49.02
1985	2.33	2.63	10.35	50.71	49.56	18.47	38.38	36.49	12.35	38.16	26.88	32.80
1986	3.06	1.77	9.58	39.81	38.78	16.47	36.46	35.05	11.60	44.82	39.05	43.99
1987	1.75	1.17	9.11	43.57	43.37	15.14	36.78	37.85	10.17	30.91	22.80	35.75
1988	4.73	2.60	8.95	42.46	43.50	14.86	41.50	39.77	15.11	19.93	15.55	42.71
1989	5.86	3.28	8.79	42.25	41.89	14.50	41.62	39.47	15.39	5.99	8.59	43.37
1990	5.84	3.54	8.09	40.63	38.89	15.03	43.43	42.30	15.31	14.81	13.33	33.23
1991	4.96	2.55	8.72	41.82	40.99	14.01	41.44	37.35	16.17	9.31	12.02	40.22
1992	3.78	2.88	7.82	38.86	36.89	16.19	36.75	34.96	12.27	27.02	24.16	34.67
1993	3.31	2.01	6.81	39.41	38.41	13.75	33.92	33.11	12.23	22.65	20.23	34.75
1994	1.92	0.53	5.74	41.43	40.12	14.48	34.05	33.43	13.45	20.95	18.48	31.51
1995	1.11	0.77	5.42	40.59	40.81	14.66	35.61	33.93	15.68	18.87	16.18	26.29
1996	6.32	5.17	8.98	40.96	42.04	14.19	35.20	34.68	13.42	11.45	11.14	28.73
1997	0.99	0.27	4.53	42.11	43.26	14.03	37.20	36.26	13.91	13.61	12.17	26.13
1998	0.91	0.31	5.50	42.08	41.90	11.97	35.14	35.40	9.27	11.19	9.06	31.02
1999	0.48	0.34	5.01	43.60	42.35	12.04	32.99	33.49	11.94	2.95	8.78	28.61
2000	0.59	1.02	5.31	42.43	41.17	10.76	34.66	34.36	11.50	4.61	9.58	32.03
2001	2.58	1.54	6.09	43.26	43.68	10.44	36.11	35.22	11.23	5.84	6.75	24.70
2002	1.04	0.50	4.72	39.58	38.80	9.99	34.59	35.05	8.44	8.10	7.15	22.58
2003	1.79	0.76	5.40	38.91	39.90	10.18	33.00	33.29	6.27	2.90	5.04	26.02

TABLE 3. TOBIN'S *Q* COMPUTED AT REPLACEMENT COST AND BOOK VALUE

DESCRIPTIVE STATISTICS 1984-2003

	Replacement Cost				Book value			
Year	Median	Std.Dev.	10th perc	90th perc	Median	Std.Dev.	10th perc	90th perc
1984	2.98	2.72	0.66	7.28	3.10	3.08	0.65	8.10
1985	2.67	2.67	0.59	7.05	3.07	3.17	0.73	8.60
1986	2.85	2.70	0.61	6.80	3.86	4.49	0.78	8.63
1987	2.95	1.98	0.76	5.78	3.32	2.80	0.81	7.39
1988	2.58	2.26	0.61	5.54	3.46	3.91	0.86	8.86
1989	2.03	3.24	0.46	5.97	2.80	3.56	0.43	7.81
1990	2.18	4.13	0.59	6.17	2.59	5.97	0.64	6.98
1991	1.75	3.45	0.55	5.08	2.49	5.42	0.65	6.77
1992	1.31	2.08	0.42	3.93	1.95	2.86	0.53	5.41
1993	1.12	0.99	0.45	3.07	1.53	1.52	0.51	4.20
1994	0.94	0.79	0.39	2.31	1.33	1.08	0.50	3.05
1995	0.99	1.04	0.25	2.63	1.07	1.05	0.39	2.97
1996	1.09	1.09	0.37	2.64	1.33	1.08	0.46	3.15
1997	1.03	0.96	0.41	2.49	1.42	1.13	0.54	3.32
1998	1.17	1.21	0.45	2.76	1.87	1.45	0.61	3.70
1999	1.67	1.33	0.57	3.08	2.45	1.85	0.79	4.03
2000	1.91	1.71	0.54	3.50	2.75	2.20	0.93	4.12
2001	1.91	1.65	0.74	3.19	2.58	2.33	1.30	3.98
2002	1.70	1.70	0.69	2.69	2.44	2.13	1.17	3.73
2003	1.66	0.94	0.66	2.64	2.25	1.05	1.09	3.58

TABLE 4. ESTIMATION OF THE VALUATION EQUATION FOR SPANISH BANKS

Estimation of $lnV_{it} = \alpha + \sum_{j \in J} \beta_j \, ln\,K_{it}^{j} + \gamma \, ln\,HK_i^{high} + b_1 ln\; ID_{it} + b_2 \, ln\,GLP + \eta_i + m_{it} + \varepsilon_{it}$; *J={Ph, IT, AD, FE}*. V_{it} is the market value of the bank computed according to (11). $K_{it}^{Ph}, K_{it}^{IT}, K_{it}^{AD}, K_{it}^{FE}$ stand for the value of the stock of Physical, IT, Advertisement and Financial assets held by bank *i* at the beginning of period *t,* valued at replacement cost. HK_i^{high} is a dummy variable that takes the value of 1 for bank *i* if the average value of the stock of human capital held by the bank over the period is above the median of the distribution, and ID_{it}, GLP_{it} are, respectively, the value of the deposit interests and gross loan profits of bank *i* at time *t.* Finally, η_i captures the fixed effects of bank *i*, m_{it} the measurement errors of the stocks of capital and ε_{it} is the error term. All the variables are expressed in logs. The model has been estimated with the *System-GMM* technique, which estimates the valuation equation in first-differences jointly with the valuation equation in levels. The instrumental variables for the first-differenced equation are the levels of the explanatory variables in period *t-3* and *t-4.* The instrumental variables for the levels equation are the first-differences of the explanatory variables in period *t-2.* All estimations contain time-dummy variables. *P-values* of the tests of Sargan and lack of first and second-order autocorrelation are presented at the bottom of the table.

K^{Ph}	**0.232** ***	**0.256** ***	**0.179** **
	(0.082)	(0.081)	(0.085)
K^{IT}	**0.266** ***	**0.353** ***	**0.275** ***
	(0.094)	(0.115)	(0.089)
K^{AD}	**0.183** **	**0.193** **	**0.090**
	(0.087)	(0.082)	(0.077)
K^{FE}	**0.244** ***	**0.241** ***	**0.241** ***
	(0.078)	(0.076)	(0.063)
HK^{high}		**2.328** *	**1.467** **
		(1.205)	(0.736)
$HK^{high} \cdot K^{IT}$		**-0.277** *	**-0.182** *
		(0.151)	(0.094)
ID			**0.215** ***
			(0.075)
GLP			**0.019** *
			(0.011)
Sargan	1.000	1.000	1.000
1 st order	0.187	0.193	0.107
2 nd order	0.800	0.872	0.930
N.Obs	1847	1847	1847

Notes. (*) = Significant at 10% (**) = Significant at 5% (***) = Significant at 1%.
Standard errors in parentheses.

TABLE 5. ESTIMATION OF THE INVESTMENT EQUATION FOR SPANISH BANKS

Estimation of $\frac{I_{it}^{Ph}}{K_{it-1}^{Ph}} = \beta_0 + \beta_1 \ln q_{it}^{Ph} + \sum_{j\in J}\left(\beta_j \frac{I_{it}^{j}}{K_{it-1}^{Ph}}\right) + \gamma_1 \frac{ID_{it}}{K_{it-1}^{Ph}} + \gamma_2 \frac{GLP}{K_{it-1}^{Ph}} + \delta_1 KH^{high} + \delta_2 KH^{high} \times \frac{I_{it}^{IT}}{K_{it-1}^{Ph}} + \eta_i + u_{it}$; *J={IT, Ad, FE}*. q_{it}^{Ph} is the ratio between V_{it} and K_{it}^{Ph} . $I_{it-1}^{IT} / K_{it-1}^{Ph}, I_{it-1}^{Ad} / K_{it-1}^{Ph}, I_{it-1}^{FE} / K_{it-1}^{Ph}$ stand for the investment of IT, Advertising and Financial assets with respect to the stock of physical capital at the beginning of the period held by bank *i*. HK_i^{high} is a dummy variable that takes the value of 1 for bank *i* if the average value of the stock of human capital held by the bank over the period is above the median of the distribution, and ID_{it}, GLP_{it} are, respectively, the value of the deposit interests and gross loan profits of bank *i* at time *t*. Finally, η_i captures the fixed effect of bank *i*, and ε_{it} is the error term. The model has been estimated with the *First-Difference GMM* technique. The instrumental variables for the first-differenced equation are the levels of the explanatory variables in period *t-2* and *t-3*. All estimations contain time-dummy variables. *P-values* of the tests of Sargan and lack of first and second-order autocorrelation are presented at the bottom of the table.

q^{Ph}	**0.026** ***	**0.036** ***	**0.047** ***
	(0.008)	(0.012)	(0.011)
I^{IT} / K^{Ph}	**-0.276** ***	**-0.677** ***	**-0.655** ***
	(0.099)	(0.158)	(0.162)
I^{Ad} / K^{Ph}	**-0.942** **	**-1.465** *	**-1.102**
	(0.381)	(0.878)	(0.851)
I^{FE} / K^{Ph}	**-0.010**	**-0.002**	**-0.001**
	(0.007)	(0.006)	(0.007)
HK^{high}		**-0.052** ***	**-0.067** ***
		(0.005)	(0.006)
$HK^{high} \cdot K^{IT}$		**0.793** ***	**0.920** ***
		(0.231)	(0.286)
ID / K^{Ph}			**-0.046** **
			(0.019)
GLP / K^{Ph}			**0.005**
			(0.027)
Sargan	0.995	0.443	0.737
1 st order	0.000	0.000	0.000
2 nd order	0.667	0.726	0.941
N.Obs	1667	1667	1667

Notes. (*) = Significant at 10% (**) = Significant at 5% (***) = Significant at 1%. Standard errors in parentheses.

TABLE 6. VALUATION AND INVESTMENT EQUATIONS WITH RAW AND WITH ECONOMICALLY ADJUSTED ACCOUNTING DATA

The left half of the table shows the estimation of

$lnV_{it} = \alpha + \sum_{j \in J} \beta_j \ ln K_{it}^{j} + b_1 ln \ ID_{it} + b_2 \ ln GLP + \eta_i + m_{it} + \varepsilon_{it}$, *J={Ph, IT, AD, FE}* and the right half the estimation of $\frac{I_{it}^{Ph}}{K_{it-1}^{Ph}} = \beta_0 + \beta_1 \ln q_{it}^{Ph} + \sum_{j \in J} \left(\beta_j \frac{I_{it}^{j}}{K_{it-1}^{Ph}} \right) + \gamma_1 \frac{ID_{it}}{K_{it-1}^{Ph}} + \gamma_2 \frac{GLP}{K_{it-1}^{Ph}} + \eta_i + u_{it}$, *J={IT, AD, FE}* V_{it} is the market value of the bank, $K_{it}^{Ph}, K_{it}^{IT}, K_{it}^{AD}, K_{it}^{FE}$ stand for the value of the stock of Physical, IT, Advertisement and Financial assets held by bank *i* at the beginning of period *t*, q_{it}^{Ph} is the ratio between V_{it} and K_{it}^{Ph}; $I_{it-1}^{IT} / K_{it-1}^{Ph}, I_{it-1}^{Ad} / K_{it-1}^{Ph}, I_{it-1}^{FE} / K_{it-1}^{Ph}$ stand for the investment of IT, Advertising and Financial assets with respect to the stock of physical capital at the beginning of the period.and ID_{it}, GLP_{it} are, respectively, the value of the deposit interests and gross loan profits of bank *i* at time *t*. We present the estimations of the valuation and investment equations using raw accounting data (*Book version*) and using data at replacement cost (*Econ version*). The econometric procedure followed to estimate the valuation and investment equations are explained in Table 4 and 5, respectively. *P-values* of the tests of Sargan and lack of second-order autocorrelation are presented at the bottom of the table.

VALUATION EQUATION	Book version	Econ version	INVESTMENT EQUATION	Book version	Econ version
K^{Ph}	0.253 **	0.171 **	q^{Ph}	0.027	0.048 ***
	(0.120)	(0.071)		(0.036)	(0.011)
K^{IT}	0.099	0.216 **	I^{IT} / K^{Ph}	0.072	-0.341 **
	(0.066)	(0.099)		(0.342)	(0.151)
K^{AD}		0.114	I^{Ad} / K^{Ph}		-1.518 *
		(0.086)			(0.805)
K^{FE}	0.097	0.260 ***	I^{FE} / K^{Ph}	0.005	-0.001
	(0.076)	(0.065)		(0.009)	(0.006)
ID	0.482 ***	0.183 **	ID / K^{Ph}	-0.002 *	-0.032 **
	(0.127)	(0.075)		(0.001)	(0.016)
GLP	0.055	0.023 **	GLP / K^{Ph}	-0.001	0.003
	(0.034)	(0.011)		(0.006)	(0.024)
2nd Autocorr	0.678	0.953	2nd Autocorr	0.248	0.543
Sargan	0.285	1.000	Sargan	0.038	0.953

Notes. (*) = Significant at 10% (**) = Significant at 5% (***) = Significant at 1%. Standard errors in parentheses.

APPENDIX 1: Summary of methodology used to estimate the stock of assets for Spanish banks

A detailed explanation of the calculations and complementary data needed to obtain the replacement cost of assets and user cost of capital is contained in Martín-Oliver, Salas-Fumás and Saurina (2007). The replacement cost of an asset is obtained applying the permanent inventory method, as follows.

Let I_t be the gross investment flow of new capital services in year t; K_t the stock of homogeneous capital services at the end of year t; ϕ the depreciation rate of the asset used in production activities during a one-year period; μ the rate of technological progress incorporated into capital services invested during one year, with respect to those invested one year before. And let q_t be the price of one unit of services in period t. The permanent inventory model implies,

$$p_t K_t = p_t I_t + \frac{1-\phi}{1+\mu} \cdot \frac{p_t}{p_{t-1}} \cdot \left(p_{t-1} \cdot K_{t-1} \right) \qquad (1)$$

The formulation takes into account the fact that, to replace in t one unit of capital service in place at the end of the previous year, *t-1*, with the technical progress in capital goods of the period, only *1/(1+μ)* units are needed. Depreciation implies that for each unit of capital in place in *t-1*, there is only *(1-ϕ)* units remaining at the end of the year. This computation of the net capital services is exact when the depreciation of the asset is exponential at rate ϕ. The actual application of the formula requires finding data on investment flows, prices, depreciation and technological progress rates.

In the case of physical capital (buildings plus non-IT fixed assets) investment flows of period *t* are set equal to amortization of physical capital in period *t*, as reported by the bank in the income statement, plus the difference between net book value of physical assets in year *t* and year *t-1.* For IT capital, a distinction is made between booked IT assets and IT expenditures expensed in the income statement. For booked IT assets, we assume that book value is equal to replacement value, while IT expenditures are capitalized using the permanent inventory method. Total IT capital of year *t* is the sum of the two stocks. Finally, the flow of advertising capital is the year expenditure in advertising as reported in the income statement of the bank.

The term (1-ϕ)/(1+μ) is substituted by (1-δ) where δ is the overall economic depreciation rate. The value of δ is 0.03 for buildings, 0.15 for fixed assets different from IT, 0.35 for IT capital, 0.35 for advertising capital. These values are in line with others used in the literature. The price index of buildings is taken from the Ministerio de Fomento and the price index of other non-IT fixed capital is set equal to the price deflator of gross capital formation. We assume that the price index of quality-adjusted IT capital is zero, and the price index of advertising capital is the price of market services published by the Spanish Institute of Statistics. The zero inflation rate of the price of IT capital services departs from the 15% to 20% decline assumed in other studies with US data, Litchenberg (1995), since, in Spain, general inflation is much higher than in the US and technological innovations are usually introduced at a later time.

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS[1]

0626 CRISTINA BARCELÓ: A Q-model of labour demand.
0627 JOSEP M. VILARRUBIA: Neighborhood effects in economic growth.
0628 NUNO MARTINS AND ERNESTO VILLANUEVA: Does limited access to mortgage debt explain why young adults live with their parents?
0629 LUIS J. ÁLVAREZ AND IGNACIO HERNANDO: Competition and price adjustment in the euro area.
0630 FRANCISCO ALONSO, ROBERTO BLANCO AND GONZALO RUBIO: Option-implied preferences adjustments, density forecasts, and the equity risk premium.
0631 JAVIER ANDRÉS, PABLO BURRIEL AND ÁNGEL ESTRADA: BEMOD: A dsge model for the Spanish economy and the rest of the Euro area.
0632 JAMES COSTAIN AND MARCEL JANSEN: Employment fluctuations with downward wage rigidity: The role of moral hazard.
0633 RUBÉN SEGURA-CAYUELA: Inefficient policies, inefficient institutions and trade.
0634 RICARDO GIMENO AND JUAN M. NAVE: Genetic algorithm estimation of interest rate term structure.
0635 JOSÉ MANUEL CAMPA, JOSÉ M. GONZÁLEZ-MÍNGUEZ AND MARÍA SEBASTIÁ-BARRIEL: Non-linear adjustment of import prices in the European Union.
0636 AITOR ERCE-DOMÍNGUEZ: Using standstills to manage sovereign debt crises.
0637 ANTON NAKOV: Optimal and simple monetary policy rules with zero floor on the nominal interest rate.
0638 JOSÉ MANUEL CAMPA AND ÁNGEL GAVILÁN: Current accounts in the euro area: An intertemporal approach.
0639 FRANCISCO ALONSO, SANTIAGO FORTE AND JOSÉ MANUEL MARQUÉS: Implied default barrier in credit default swap premia. (The Spanish original of this publication has the same number.)
0701 PRAVEEN KUJAL AND JUAN RUIZ: Cost effectiveness of R&D and strategic trade policy.
0702 MARÍA J. NIETO AND LARRY D. WALL: Preconditions for a successful implementation of supervisors' prompt corrective action: Is there a case for a banking standard in the EU?
0703 PHILIP VERMEULEN, DANIEL DIAS, MAARTEN DOSSCHE, ERWAN GAUTIER, IGNACIO HERNANDO, ROBERTO SABBATINI AND HARALD STAHL: Price setting in the euro area: Some stylised facts from individual producer price data.
0704 ROBERTO BLANCO AND FERNANDO RESTOY: Have real interest rates really fallen that much in Spain?
0705 OLYMPIA BOVER AND JUAN F. JIMENO: House prices and employment reallocation: International evidence.
0706 ENRIQUE ALBEROLA AND JOSÉ M.ª SERENA: Global financial integration, monetary policy and reserve accumulation. Assessing the limits in emerging economies.
0707 ÁNGEL LEÓN, JAVIER MENCÍA AND ENRIQUE SENTANA: Parametric properties of semi-nonparametric distributions, with applications to option valuation.
0708 ENRIQUE ALBEROLA AND DANIEL NAVIA: Equilibrium exchange rates in the new EU members: external imbalances vs. real convergence.
0709 GABRIEL JIMÉNEZ AND JAVIER MENCÍA: Modelling the distribution of credit losses with observable and latent factors.
0710 JAVIER ANDRÉS, RAFAEL DOMÉNECH AND ANTONIO FATÁS: The stabilizing role of government size.
0711 ALFREDO MARTÍN-OLIVER, VICENTE SALAS-FUMÁS AND JESÚS SAURINA: Measurement of capital stock and input services of Spanish banks.
0712 JESÚS SAURINA AND CARLOS TRUCHARTE: An assessment of Basel II procyclicality in mortgage portfolios.
0713 JOSÉ MANUEL CAMPA AND IGNACIO HERNANDO: The reaction by industry insiders to M&As in the European financial industry.
0714 MARIO IZQUIERDO, JUAN F. JIMENO AND JUAN A. ROJAS: On the aggregate effects of immigration in Spain.
0715 FABIO CANOVA AND LUCA SALA: Back to square one: identification issues in DSGE models.
0716 FERNANDO NIETO: The determinants of household credit in Spain.
0717 EVA ORTEGA, PABLO BURRIEL, JOSÉ LUIS FERNÁNDEZ, EVA FERRAZ AND SAMUEL HURTADO: Actualización del modelo trimestral del Banco de España.
0718 JAVIER ANDRÉS AND FERNANDO RESTOY: Macroeconomic modelling in EMU: how relevant is the change in regime?

1. Previously published Working Papers are listed in the Banco de España publications catalogue.

BANCO DE **ESPAÑA**
Eurosistema

Unidad de Publicaciones
Alcalá, 522; 28027 Madrid
Telephone +34 91 338 6363. Fax +34 91 338 6488
e-mail: publicaciones@bde.es
www.bde.es