EFFICIENCY AND RISK MANAGEMENT IN BANKING FIRMS: A METHOD TO DECOMPOSE RISK*

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WP-EC 98-10

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Editor: Instituto Valenciano de Investigaciones Económicas, S.A.
First Edition May 1998.
ISBN: 84-482-1761-6
Depósito Legal: V-1176-1998

* The author wishes to thank Professor David Humphrey for his comments and suggestions. This paper was written while the author was a visiting researcher at Florida State University. The author also wishes to thank Fundación F.I.E.S and CICYT PB94-1523 for financial support as well as IVIE for data support.

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Abstract

Traditional efficiency measures neglect bank risk and, even when risk is accounted for, do not differentiate between the portion subject to managerial control ("internal") versus the portion that is exogenous and is part of a changing environment ("external"). This paper proposes a new sequential DEA procedure which decomposes a major indicator of bank risk --provision for loan losses (PLL)-- into internal and external components. Our decomposition methodology is contrasted with three alternatives to judge how different approaches to this problem may affect the results. The analysis is illustrated by application to the Spanish banking system where deregulation, imposed by the Single Market Program of the European Community, has affected banks' conduct in terms of efficiency and risk.

Key words: Risk, environment, DEA.

Resumen

Las medidas tradicionales de eficiencia no consideran el riesgo y aquellas que pretenden incluir riesgo no distinguen la parte que sí es debida a la gestión empresarial ("interna") de la parte que es exógena a las empresas y que depende del ambiente económico ("externa"). En este trabajo se propone un nuevo procedimiento DEA secuencial que descompone uno de los principales indicadores de riesgo –las provisiones por prestamos de dudoso cobro (PLL)—en sus dos componentes interno y externo. La metodología propuesta se contrasta con tres alternativas diferentes para valorar si diferentes enfoques a la medición de este problema pueden afectar a los resultados. El método se ilustra con una aplicación para el sistema bancario español, donde la desregulación, impulsada por el Mercado Unico ha afectado a la conducta de los bancos en términos de la eficiencia y riesgo.

Palabras clave: Riesgo, entorno, DEA.

1. Introduction

Banking efficiency studies have proliferated over the last few years. The high quantitative importance of the financial sector and its close interrelationship with the real sector of the economy appears be the cause. Numerous advances have been realized, not only regarding improvement in the techniques, but also in relation to the wide variety of aspects analyzed. Though all the studies analyzed different aspects of banking sector and used different techniques[1], all share a common interest: to judge the performance of financial institutions' intermediation process by some indicator, generally efficiency.

While the traditional efficiency measures are usually considered good indicators of banks' performance, other factors related to the assessment of financial institutions should be considered. One of the most important is risk[2].

Thus, not only it is desirable that financial institutions be efficient, but also that they be secure. While important in any sector of the economy, this is crucial to financial institutions, given the high economic repercussions the collapse of a large bank could have on other banks. However, the interrelationship between risk and efficiency for banking firms has received little attention in the banking literature. Only Berger and De Young (1995) (B&D), Hughes et al. (1993, 1996) and Mester (1994a, 1994b) have examined this issue in any depth, and them usually by adding some indicator of risk to the estimating process.

There are many aspects in which risk, usually measured thorough loan losses or problem loans[3], are related to efficiency. All of them are comprehensively analyzed by B&D, who find a

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[1] An excellent survey on efficiency of financial institutions can be found in Berger and Humphrey (1997).

[2] Toevs et al. (1994) also advise that standard ratios, often used by analysts as an efficiency indicator, do not consider risk. Moreover, they assert that trying to improve efficiency can be counterproductive since banks can get it by moving into higher-risk activities, with low functional costs and high yields.

[3] Loan losses are those loans written off, meanwhile problem loans are those loans placed in a provisional status as a result of reasonable doubts of repayment.

negative relation between cost efficiency and loan losses in bankrupt banks[4]. B&D offer several reasons for this result. First, inefficient banks, besides having poor internal cost control, may not effectively screen loan applications. B&D call this (internal) negative relationship between cost efficiency and loan losses as the "bad management" hypothesis. Secondly, loan losses can arise from adverse economic circumstances, causing banks to spend more to recover the loans. This external source of inefficiency B&D call the "bad luck" hypothesis. Alternatively, a positive relationship between loan losses and efficiency could exist if some banks prefer not to spend sufficient resources to review better loan applications so these banks would appear as efficient, at least in the short term, and a positive relationship between loan losses and efficiency, called "skimping" by B&D, would occur.

Despite B&D's extensive analysis of this issue, their procedure, based on Granger-causality analysis, does not allow the causes of loan losses to be assigned at the individual bank level but rather only draws broad-based conclusions for the industry's performance as a whole. Besides, the general conclusions drawn will depend on the proportion of banks' performance falling into each hypothesis category and, because of this, all the hypotheses will be under-evaluated, since banks do not perform homogeneously[5]. Moreover, as B&D asserted, Granger-causality methodology measures statistical associations that, while strongly implying economic causation, do not necessarily prove it.

Current banking literature provides no work which decomposes loan losses or even analyzes the origin of loan losses and, though some studies have tried to obtain efficiency risk-adjusted efficiency measures specifying loan losses or problem loans directly within the estimation structure[6], the method used to do so is inappropriate for two reasons. First, these

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[4] For example, failed banks tend to be cost inefficient (Berger et al., 1992; Barr et al., 1994; Wheelock et al., 1995 and Becher, et al., 1995) or an increase of loan losses tends to be preceded by a decrease in cost efficiency (De Young et al., 1994)).

[5] B&D find that some hypothesis are only consistent with subsets of the data, since when the whole data set is considered there are a mixture of the effects of each hypothesis.

[6] The first study was Berg et al. (1992) using DEA technique. Afterwards Hughes et al. (1993), Mester (1994a, 1994b, 1996) and using parametric techniques.

papers try to adjust the effect of loan losses (problem loans or provisions for loan losses) on efficiency by including them directly in the model as an additional input. This procedure properly characterizes those institutions which have poor quality assets and high loan loss ratios, exclusively, due to poor risk management. However, those banks that assess risk correctly, but which are influenced by adverse economic conditions, will be incorrectly shown as very inefficient. If we wish to consider banks' efficiency controlling by risk, only those loan losses arising from internal factors, such as risk management inefficiency or "bad management", should be considered while risk generated by adverse local business conditions ("bad luck") should be excluded.

Second, the risk-adjusted efficiency literature relies on stock measures, usually in a cost function context[7]. This approach cannot capture the effect of asset quality on liabilities and asset prices and therefore on efficiency. Risky borrowers typically pay a higher interest rate (asset price effect) and, as noted by Hughes and Mester (1993), depositors wish to have a risk premium when they put their money into a risky bank (liability price effect). These price effects only can be captured by flow measures or by stock measures in a profit function context.

With the aim of addressing these problems this paper proposes a new sequential DEA method to identify the internal and external sources of bank credit risk –measured by provision for loan losses (*PLL)*-- from which we obtain appropriate risk-adjusted efficiency measures. This procedure allows us to calculate, for each bank, the proportion of *PLL* due to poor risk management and the proportion of *PLL* due economic/environmental factors[8]. The second phase, using the total amount of *PLL* exclusively due to internal factors, together with estimation of the efficiency purged of environmental variables from a perspective of profits, allows us obtain efficiency measures adjusted by risk and by environment factors, as well as to determine the

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[7] Berger and De Young (1997), Hughes et al. (1993) and Mester (1994a, 1994b). On the other hand Berg et al. (1992) uses a production function approach. Only Hughes et al. (1996) uses a profit function approach.

[8] *PLL* due to bad risk management includes those *PLL* originated exclusively by internal and discretional factors of each bank (i.e. risk policy, risk aversion, specialization, bad risk control, etc.). For the contrary, *PLL* due to external factors includes those *PLL* originated exclusively by economic or environmental circumstances (external and non discretionary factors) out of banks control.

influence on efficiency of adverse economic environment ("bad luck") and the influence of risk management efficiency (“bad management”).

So, unlike B&D, instead of trying to obtain general conclusions, this paper tries to find the causes of loan losses at the bank level (economic cycle or "bad luck" and risk management inefficiency or “bad management”) and, unlike Hughes et al. (1993) and Mester (1994a, 1994b) we obtain risk-adjusted efficiency measures by using a profit function approach, using flow measures, and consider only that proportion of *PLL* associated with internal factors. Our analysis is applied to the Spanish banking system in order to test whether the deregulation process imposed by the European Community has affected banks’ conduct in terms of efficiency and risk.

The paper is organized as follows. Section 2 discusses some features of the Spanish banking system while section 3 presents a review of the different methodologies used to incorporate environmental variables in a DEA context. Additionally, section 3 describes the procedure to calculate our risk management efficiency measures and decomposition of *PLL*. Section 4 presents the data set as well as the model specification, which includes the influential environmental while section 5 presents our results. Section 6 concludes.

2. The Spanish banking system: some features

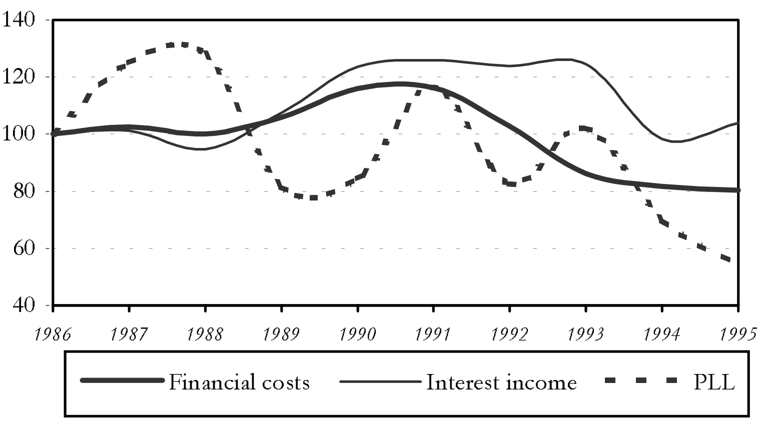
The analysis and decomposition of loan losses and efficiency of Spanish banks is a relevant question that, in spite of the important changes in terms of competition and deregulation that have occurred during the past decade as a consequence of the European directives has not been previously analyzed (see table 1).

Table 1 : Implementation of the EU deregulation process in the SBS

EU Directive	*Focus*	*Year*	*Implementation into Spanish law*
INTEREST RATE DE-REGULATION	Conduct		1986-92
73/183 Freedom of establishment	Structure	1973	1987
77/780 + 85/354 + 86/137 + 86/524 First Banking Directive	Structure	1977	1987
1988-Article 67 of the EEC Treaty Liberalisation of capital movements	Structure	1988	1992
89/117 Branch establishment & head offices outside EU	Structure	1989	1993
89/299 + 92/16 Own funds directive	Prudential	1989	1993
89/646 Second Banking Directive	Conduct	1989	1994
89/647 +91/31 Solvency Ratio directives	Prudential	1991	1993
91/308 Money Laundering directive	Conduct	1991	1993

Though the structural liberalization of the Spanish banking system (SBS) was almost complete in 1987 and the interest rates for most common banking products were deregulated, competition between banks was, until the end of the decade, more "potential" than "real". Deposit and loan interest rates were negligible and very few European banks began to do business in Spain. However, in the last trimester of 1989 an extraordinarily competitive environment began to develop. That year, Banco de Santander, one of the Spain's largest banks, began to offer a "new" product : a demand deposit account with a high interest rate. Other banks reacted quickly to meet this product and, as a consequence, interest rates paid on deposits rose markedly (see graph 1).

Graph 1: Interest income, financial cost and PLL over total assets (1986=100)



After pursuing deposits for a number of years, banks reduced their competition for deposits and interest rates on deposits began to decrease (see graph 1). But competition did not entirely cease : banks merely switched their focus to the asset side of the general ledger. It was Banco de Santander again which, at the beginning of 1992, offered a new asset product, this time a mortgage loan with a variable interest rate that led to an overall decrease in interest rates on loans. As before, other banks quickly reacted to this offensive, offering similar products. All these actions produced a substantial decrease in interest income.

The consequence of this competitive environment was a decrease in financial margins. However, some important questions rise: How did the competitive environment affect *PLL*? Did it encourage banks to engage in riskier activities?. As seen in table 1, some of the EU directives have been prudential and have been focus in risk control. The answer to these questions seems to be negative if we observe the evolution of *PLL* in graph 1. Nevertheless, a deeper analysis is necessary, since *PLL* are also affected by external factors that should be removed to obtain accurate conclusions. The next sections show that different conclusions can be drawn when external factors are considered.

3. Methodology

3.1. Incorporation of environmental variables

There are several procedures for including environmental variables in DEA (Rouse, 1996 and Fried and Lovell, 1996). These procedures can be classified into one-step, two-step and three-step procedures. The one-step procedure is the most direct and easy method and consists in jointly considering outputs, inputs and environmental variables and restricting the optimization only to outputs and/or inputs in the analysis of units' performance. The purpose is to restrict the comparison set to those units subject to the same or worse environmental conditions. This procedure has an easy and direct interpretation. However, it has the drawback that the direction of the influence of each variable must be known a priori[9].

The most common two-step method tries to explain traditional efficiency scores obtained in a first-step by means of an ex post regression in terms of the set of environmental variables[10]. This method fails to generate adjusted efficiency measures on the (0,1] interval. However Pastor (1995a) proposed an alternative two-step method based on the use of DEA on inputs (or outputs) and environmental variables in the first-step. He proposes using the radial expanded inputs (or radial expanded outputs) to remove the effect of environmental variables. This procedure does generate efficiency measures on the (0,1] interval.

Finally Fried and Lovell (1996) propose a three-step procedure. In the first stage, they use a traditional DEA model including only output and input variables. In the second-step, they use either a DEA or a parametric stochastic frontier model to attribute the units' performance to environmental effects (external factors) and managerial efficiency (internal factors). To do this, they apply a parametric stochastic frontier (PSF) or DEA analysis, with the aim of obtaining slacks purged of environmental effects. These purged slacks are used to adjust the current inputs (or outputs). Finally, in the third step they use the adjusted inputs (or adjusted outputs) to obtain an efficiency measure purged of environmental effects.

In this paper, as in Lozano, Pastor and Pastor (1996), a one-step method is used. While we must know in advance the influence of each environmental factor, this is not a serious problem since the direction of the influence of each variable on the *PLL* is well known a priori[11].

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[9]This procedure were developed by Banker et al. (1986a, 1986b). Some modifications are proposed in Lozano et al. (1996).

[10] The first paper on this procedure was Timmer (1971). Afterwards limited dependent variable regression has been commonly applied. Others use residuals or slacks to adjust the efficiency scores (McCarty et al., 1993 and Fried et al., 1993).

[11] Pastor (1997) explains *PLL* using several statistical procedures. We use his results to obtain information about the influence of each environmental variable.

3.2. Risk management efficiency and PLL decomposition: Phase 1

As described in section 1, the provisions for bank loan losses *(PLL)* arise from two main causes: internal and external factors. The first is associated with poor risk management, risk aversion, risk policy, etc. The second is associated with the general economic circumstances of the region where banks do their business. The principal difference between these two causes resides in their discretionality. While banks can reduce *PLL* by improving their management or modifying their risk policy, they are not able to reduce *PLL* due to external factors. So the proper risk management efficiency measure should be calculated by removing the effect of external factors so they are not attributed to managerial inefficiency.

This section describes the method, based on DEA technique, we use to estimate risk management efficiency and to decompose total *PLL* into internal and external components. The procedure consists of comparing each bank with a linear combination of banks that, with an equal (or larger) amount of loans and being subject to equal (or worse) environmental conditions (economic cycle), have less (or an equal) amount of *PLL*. Since we control for external factors, the quotient of each bank's *PLL* to the *PLL* of the reference bank give us the potential reduction of *PLL* that could be done without reducing the amount of loans, given the environmental factors. We call this measure "risk management efficiency" and it can be obtained by solving the following linear programming problem for each bank *j*, under variable returns to scale (VRS):

$$
\begin{aligned}
&Min_{\gamma,\lambda} \quad \gamma_j \\
&\textstyle\sum_{i=1}^{N} \lambda_i PLL_i \le \gamma_j PLL_j \\
&\textstyle\sum_{i=1}^{N} \lambda_i L_i \ge L_j \\
&\textstyle\sum_{i=1}^{N} \lambda_j Z_{pi}^{+} \le Z_{pj}^{+}; \quad p = 1,..,P \\
&\textstyle\sum_{i=1}^{N} \lambda_j Z_{qi}^{-} \ge Z_{qj}^{-}; \quad q = 1,\ldots,Q \\
&\textstyle\sum_{i=1}^{N} \lambda_i = 1; \lambda_i \ge 0; \quad \forall i
\end{aligned} \tag{1}
$$

where N is the number of banks *(i=1,..,N)*, λ_i is a vector containing the non-negative weights, PLL_i is the amount of provision for loan losses, L_i is the amount of loans, and $Z_i^{+} = \left(Z_{1i}^{+}, Z_{2i}^{+}, \ldots, Z_{Pi}^{+}\right)$ and $Z_i^{-} = \left(Z_{1i}^{-}, Z_{2i}^{-}, \ldots, Z_{Qi}^{-}\right)$ are the vectors of environmental conditions (business cycle) with a positive or negative influence, respectively[12]. The optimum solution, γ_j^*, gives us the proportion of *PLL* that bank *j* could reduce without altering its amount of loans. If, $\gamma_j = 1$, this means that it is not possible to find a bank or a linear combination of banks, that with equal (or greater) volume of loans and equal (or worse) external economic conditions, has a lower value of *PLL* than bank *j*. In this case, all *PLL* would then be due to external factors and bank *j* would be risk management efficient. In general, $\gamma_j \leq 1$, and smaller values of γ_j means larger proportions of *PLL* are attributed to internal factors. Thus γ_j offers us a measure of the proportion of *PLL* for bank *j* that is due to external factors and $1-\gamma_j$ a measure of the proportion of *PLL* due to internal factors or risk management inefficiency.

3.3. Efficiency measurement and decomposition : Phase 2

The efficiency measures, as in problem (1), are obtained by comparing each bank with a linear combination of efficient banks. The efficiency measures under constant returns to scale (CRS) are obtained by solving *N* linear programming problems such as:

$$
\begin{aligned}
&Min_{\psi,\lambda} \quad \psi_j \\
&\textstyle\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots,R \\
&\textstyle\sum_{i=1}^{N} \lambda_i x_{si} \leq \psi_j x_j; \quad s = 1,\ldots,S \\
&\lambda_i \geq 0; \quad \forall i
\end{aligned}
\qquad (2)
$$

where $y_i = (y_{1i}, y_{2i}, \ldots, y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, \ldots, x_{Si})$ is the input vector. Solving (2) for each one of the *N* banks of the sample, *N* weighs and *N* optimum solutions are found. Each optimum solution, ψ_j^* is the efficiency indicator of bank *j* and, by construction,

---

12 The treatment of the environmental variables as outputs or inputs in the model is realized inverting their influence. Thus, for example, if a given environmental variable has a positive influence (more means better) it is considered as input in the model (See Cooper et al., 1996). Note that all the environmental variables are treated as non-discretionary variables (See Banker et al., 1986a).

satisfies $\psi^*_j \leq 1$. Those banks with $\psi^*_j < 1$ are considered inefficient, while those with $\psi^*_j = 1$ are catalogued as efficient.

The assumption of constant returns to scale (CRS) can be easily removed by adding the restriction $\sum_{i=1}^{N} \lambda_i = 1$ on the problem (2). This model, proposed by Banker, et al. (1984), permits generalizing the model to variable returns to scale (VRS). The model is the following,

$$
(3) \qquad \begin{aligned}
& Min_{\vartheta,\lambda} \quad \vartheta_j \\
& \textstyle\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots,R \\
& \textstyle\sum_{i=1}^{N} \lambda_i x_{si} \leq \vartheta_j x_j; \quad s = 1,\ldots,S \\
& \textstyle\sum_{i=1}^{N} \lambda_i = 1; \lambda_i \geq 0; \quad \forall i
\end{aligned}
$$

The comparison of efficiency measures of problems (2) and (3) provide us information about scale efficiency. Thus, the ratio between ψ_j and ϑ_j is a measure of the scale efficiency (*SE_j*) of bank *j* that is the result of deducting from total technical efficiency (ψ_j) the pure technical efficiency (ϑ_j):

$$
(4) \qquad SE_j = \frac{\psi_j}{\vartheta_j}
$$

This part of inefficiency is due to the fact that banks perform with a non-optimum size. When $SE_j=1$, the efficiency measure under CRS is equal to the one obtained under the assumption of VRS, implying that bank *j* performs under constant returns to scale, so there are no scale inefficiencies. In the other cases ($SE_j<1$), bank *j* performs under non constant returns to scale (i.e. increasing or decreasing).

Nevertheless, these traditional efficiency measures under VRS (ϑ_j) do not consider risk. If we want to consider risk as a undesirable quality we must <u>reward</u> (increasing their efficiency) those banks that are good risk managers. To do so, we must take into account differences in the provision for loan losses (*PLL)*, but only that portion of the *PLL* due to risk management efficiency. We call this efficiency measure the "risk-adjusted efficiency measure" and it is obtained by solving the following problem:

$$(5) \qquad \begin{aligned} & Min_{\rho,\lambda} \quad \rho_j \\ & \textstyle\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots,R \\ & \textstyle\sum_{i=1}^{N} \lambda_i x_{si} \leq \rho_j x_j; \quad s = 1,\ldots,S \\ & \textstyle\sum_{i=1}^{N} \lambda_i (1-\gamma_i) PLL_i \leq (1-\gamma_j) PLL_j \rho_j \\ & \textstyle\sum_{i=1}^{N} \lambda_i = 1; \lambda_i \geq 0; \quad \forall i \end{aligned}$$

in which only *PLL* of the bank due to internal factors, $(1-\gamma_j)PLL_j$ are included. This risk adjusted efficiency measure ρ_j provides us a more suitable appraisal of the performance of banks than occurs in Berg et al (1992), Hughes et al. (1993) or Mester (1994a, 1994b) since our risk-adjusted efficiency measure penalizes only those banks that incur *PLL* due exclusively to poor risk management policies (risk management inefficiency), rather than total *PLL*..

Comparing the non risk-adjusted efficiency measure (ϑ_j) obtained in problem (3), to the risk-adjusted efficiency measure (ρ_j) obtained in problem (5), allows us to measure the impact of risk management efficiency on the bank's *j* global efficiency (a measure of the premium). Thus, we designate this impact as the "risk effect" and we obtain it through the ratio between both measures.

$$(6) \qquad RE_j = \frac{\vartheta_j}{\rho_j}$$

Those banks with *RE<1* are risk management efficient $(\gamma = 1)$ or, even if they are risk management inefficient $(\gamma < 1)$, they manage risk better than their other costs (inputs) and are seen as less risky. If, on the contrary, *RE=1*, it means the *PLL* restriction in the model has no effect, indicating that banks manage risk badly and manage it even worse that their other costs and they are seen as more risky. For the banks with *RE=1,* including risk has no influence on their efficiency. When *RE<1,* it means that including risk improves efficiency.

However, even if the efficiency measures obtained in (5) ρ_i are risk-adjusted, we still do not have a truly adequate measure of efficiency. We need to further refine the measure by adding the effect of external factors since structural and economic factors of the region where the banks do business influence efficiency. A risk-adjusted efficiency measure purified by these external factors is obtained by adding these environmental variables in problem (5) so the problem would be,

(7)

$$
\begin{aligned}
& Min_{\Omega,\lambda} \quad \Omega_j \\
& \textstyle\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots,R \\
& \textstyle\sum_{i=1}^{N} \lambda_i x_{si} \leq \Omega_j x_j; \quad s = 1,\ldots,S \\
& \textstyle\sum_{i=1}^{N} \lambda_i (1-\gamma_i) PLL_i \leq (1-\gamma_j) PLL_j \Omega_j \\
& \textstyle\sum_{i=1}^{N} \lambda_j Q_{pi}^{+} \leq Q_{pj}^{+}; \quad p = 1,..,P \\
& \textstyle\sum_{i=1}^{N} \lambda_j Q_{qi}^{-} \geq Q_{qj}^{-}; \quad q = 1,\ldots,Q \\
& \textstyle\sum_{i=1}^{N} \lambda_i = 1; \lambda_i \geq 0; \quad \forall i
\end{aligned}
$$

in which $Q_i^{+} = \left(Q_{1i}^{+}, Q_{2i}^{+}, \ldots, Q_{Pi}^{+}\right)$ and $Q_i^{-} = \left(Q_{1i}^{-}, Q_{2i}^{-}, \ldots, Q_{Qi}^{-}\right)$ are the vectors of environmental conditions with positive or negative efficiency influence respectively[13]. The optimal solution of the problem $\left(\Omega_j^{*}\right)$ is the efficiency measure adjusted by risk and by the environmental factors, since the comparison set of each bank is restricted to those banks subject to the same (or worse) environment conditions.

As before, comparing risk-adjusted efficiency measures (ρ) (problem (5)) to those measures adjusted for risk <u>and</u> economic environment (Ω) (problem (7)) provides information about the degree of influence of the environment on banks' efficiency or what we call "environment effect" (*EE*).

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[13] Note that this set of environmental variables Q_i is not the same to the set considered in *PLL* decomposition (Z_i).

(8) $$EE_j = \frac{\rho_j}{\Omega_j}$$

However, the interpretation is different, since *PLL* due to internal factors have been treated as a discretionary variable, while environmental variables have been treated as non-discretionary variables. If $EE_j=1$, it means that the environment is not unfavorable for bank *j*. On the contrary, if $EE_j<1$ this means that the environment is unfavorable since when it is compared with other banks subject to the same environmental conditions, the efficiency measure improves.

Based on prior equations it is possible to decompose the efficiency measure under CRS as follows:

(9) $$\psi_j = \Omega_j \frac{\rho_j}{\Omega_j} \frac{\vartheta_j}{\rho_j} \frac{\psi_j}{\vartheta_j} \qquad \psi_j = \Omega_j EE_j RE_j SE_j$$

Expression (9) offers us information about the origins of the CRS efficiency measures. So the changes of CRS efficiency measures (ψ_j) can be explained by changes in efficiency measures adjusted by risk and environment (Ω_j), changes of environmental effect (EE_j), changes of risk effect (RE_j), and changes of scale effect (SE_j).

3.4. Selection of external factors (environmental variables)

In problems (1) and (7) economic environment variables are used, only business cycle variables in the first case and business cycle (Z_i) and business cycle and structural economic variables in the second (Q_i). Since there are, a wide variety of variables that could influence *PLL* and efficiency we attempt to determine the influence of each one thorough use of a stepwise testing procedure proposed by Pastor et al. (1995a) and applied by Lozano et al. (1996).

Basically the procedure consists of introducing, one by one, each environmental variable and determining the degree of influence of each by comparing the model with and without particular environmental variables. Each step calculates the ratio *r* is adopted and a given number of firms have to have *r* less than the tolerance limit to conclude than the variable is influential. Pastor et al. (1995a) define a non-parametric statistical test based on the binomial distribution to determine if a variable is influential or not. If *T* is the number of units with *r* less than the tolerance level, the corresponding probability level is *[1-F(T-1)]*, with *F* being the corresponding binomial distribution function to *B(N,p)*. If the p-value is zero, or close to zero, the null hypothesis is rejected and the added variable is determined to be influential. Once the influential variable is determined, we include it in the model and repeat the above-noted procedure to see if other influential variables can be found[14].

4. Data and variables

Previous Spanish banking studies indicate that a great similarity between banks and saving banks exists, not only regarding efficiency, but also in terms of specialization[15]. Because of this, and to obtain a large sample of institutions, this paper considers banks and savings banks jointly. All national banks and saving banks existing in the SBS were included[16]. The number of

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[14] For more details about this method see Pastor et al. (1995a) and Lozano et al. (1996).

[15] See Doménech (1992), Doménech et al. (1992), Grifell et al. (1993), Lozano (1993), Pastor (1995b & 1996) and Pérez et al. (1990 & 1994). Pastor et al. (1997) show a convergence in terms of specialization. Moreover, in those cases in which this difference has been tested (Pastor, 1996), it has not been found to be statistically significant. There are, however, some differences between banks and saving banks due to past regulations. For example, past regulations only allowed savings banks to operate with specified regions, thus producing a high concentration of branches in this regions,. Commercial banks, on the other hand, used to operate nationally. In this sense, it is possible to consider saving banks as regional banks. Since the economic circumstances of the regions have greater influence on those banks that are highly concentrated (i.e. saving banks) in particular regions, efficiency measures could be biased by the economic environment. However, this problem can be overcome by taking into account, as is done in this paper, the environment variables.

[16] After checking for outliers, only Banesto, because it failed in 1992 was excluded in 1992 and 1993. Similarly Banco de Depósitos and Banco de Sevilla were excluded because they are in a liquidation period. Foreign banking was excluded because of a lack of information since 1992.

banks has fallen considerably over time as a consequence of numerous mergers, mainly in the case of saving banks (see table A.1.).

There is considerable disagreement in the current banking literature relative to the proper definition of outputs and inputs. In this paper, in order to capture the impact of higher or smaller risk on output and input prices, flow measures are used[17]. Consequently, we have selected two outputs: y_1 = financial revenues (interest), and collected fees, y_2 = stock and bond portfolio returns; and two inputs: x_1 = financial costs, and x_2 = operating expenses (see table A.1).

A set of environmental variables has been initially considered to capture the business cycle influence that can influence *PLL* as well as efficiency. Other economic aspects related to bank services' demand and the degree of accessibility to bank services that can influence banks' efficiency but are not directly related to the business cycle are specified (see table A.2.).

Since banks operate simultaneously in several regions, and since the economic circumstances of the Spanish regions are very different, the influence of the economic circumstances of a given region on each bank will be proportional to the banks' activity in this region. Although there is not much information about banks' activity by region we can use regional branch distribution as a proxy of banks' activity in each region. The set of environmental variables by regions has been weighted in order to obtain specific environmental variables per each bank[18].

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17 Charnes, Cooper, Huan and Sun (1990), Kuussaari and Vesala (1995) and Doménech (1992) also use flow measures.

18 AEBP for banks and CSB for saving banks provide information about the banks' distribution of branches for each one of the 53 provinces of Spain. The weighted environmental variables per banks were built as follows:

$$VARIABLE_i = \Sigma_{p=1}^{P} VARIABLE_p \left(BRANCHES_{ip} \Big/ \Sigma_{p=1}^{P} BRANCHES_{ip} \right)$$

where p corresponds to province p ($p=1,...,P$) and i corresponds to bank i.

Note that it is assumed that banks activity in each region is narrowly correlated with the percentage of branches placed in each region.

Table A. 1 : Summary data

	y1=Interest income		y2=Stock&portof. ret.		x1=Finnacial costs		x2=Oper. Expenses		PLL		*Number of firms*		
	Sum	*Std*	*Sum*	*std*	*um*	*std*	*Sum*	*std*	*Sum*	*std*	*S. banks*	*Banks*	*Total*
1985	4,697,825.0	104,709.5	317,142.2	8,017.6	2,882,810.4	63,454.6	1,177,088.4	26,847.8	233,542.2	6,167.4	-	89	-
1986	5,666,512.2	70,487.1	703,795.3	8,866.4	3,563,692.3	43,305.9	1,748,016.8	21,292.4	233,051.4	2,805.4	77	88	165
1987	6,167,921.2	75,545.1	716,123.0	11,591.9	3,827,189.9	46,632.3	1,823,325.1	22,331.0	260,227.3	2,582.5	77	82	159
1988	6,454,844.8	89,957.5	698,353.8	13,378.2	3,841,057.2	51,845.7	1,891,908.4	25,924.9	316,000.5	5,515.0	77	80	157
1989	7,457,294.7	102,797.8	700,305.4	12,644.3	4,751,001.3	65,810.5	2,036,723.9	26,897.5	191,012.0	3,009.0	76	82	158
1990	8,342,425.7	123,920.2	689,349.6	13,421.1	5,586,051.9	88,546.2	2,162,525.2	31,025.2	182,179.6	2,560.2	65	73	138
1991	8,774,999.8	140,341.6	753,184.5	12,693.4	5,982,172.2	99,504.8	2,241,969.9	34,570.2	220,188.1	3,847.7	56	88	144
1992	7,878,000.9	129,135.6	1,434,350.0	24,133.8	5,977,452.6	102,017.9	2,346,629.4	36,429.6	151,465.5	2,056.6	53	88	141
1993	7,641,486.5	136,715.7	1,342,754.4	23,304.3	6,949,915.0	117,442.2	2,346,264.5	34,929.1	350,660.6	5,356.3	51	88	139
1994	7,778,313.3	121,494.1	1,555,026.5	26,571.2	5,886,548.0	98,116.0	2,466,816.6	36,688.3	257,874.9	2,763.3	51	84	135
1995	7,976,483.0	123,111.7	1,811,207.0	31,567.8	6,478,817.0	108,243.6	2,428,224.0	36,130.5	178,258.9	2,297.3	50	82	132

Table A. 2 : Selected variables and description.

	Disag.	Description		Observations
		Bussines cycle variables		
RGGNP	Community	Rate of growth of GNP in t-1	FIES-BBV	
RGGNP5	Community	Average rate of growth of GNP in last 5 years.	Contabilidad Regional de España (Base 1986)	(2)
RGINV	Community	Average rate of growth of private investment in last 5 years.	Contabilidad Regional de España (Base 1986)	(1)
RGPINV	Community	Average rate of growth of public investment in last 5 years.	Contabilidad Regional de España (Base 1986)	(1)
UNEMP	Province	Rate of unemployment	Capital humano, Series Históricas, 1964-91 (BANCAJA) and INE	(3)
UNEMP1	Province	Rate of unemployment in t-1	Capital humano, Series Históricas, 1964-91 (BANCAJA) and INE	(3)
RGUNEMP	Province	Rate of growth of unemployment	Capital humano, Series Históricas, 1964-91 (BANCAJA) and INE	(3)
RGUNEMP5	Province	Average rate of growth of unemployement in last 5 years.	Capital humano, Series Históricas, 1964-91 (BANCAJA) and INE	(3)
VUNEMP	Community	Variance of the rate of unemployment within year.	Banco de España	
VUNEMP1	Community	Variance of the rate of unemployment within t-1 year.	Banco de España	
		Other economic environmental variables		
INV/INH	Community	Private investment per person	Contabilidad Regional de España (Base 1986) and INE	(1)
INV/KM2	Community	Private investment per square kilometer	Contabilidad Regional de España (Base 1986) and An. Est. de Esp.(1994)	(1)
PINV/INH	Community	Public investment per person	Contabilidad Regional de España (Base 1986) and INE.	(1)
PINV/KM2	Community	Public investment per square kilometer	Contabilidad Regional de España (Base 1986) and An. Est. de Esp. (1994)	(1)
GNPP/INH	Province	GNP per person	Contabilidad Regional de España (Base 1986) and An. Est. de Esp. (1994)	(2)
GNPP/KM2	Province	GNP per square kilometer.	Contabilidad Regional de España (Base 1986) and INE	(2)
GNP/INH	Community	GNP per person	Contabilidad Regional de España (Base 1986) and INE.	(2)
GNP/KM2	Community	GNP per square kilometer.	FIES-BBV and Anuario Estadístico de España (1994).	
BRA/INH	Province	Branches per person	Banco de España and INE.	
BRA/KM2	Province	Branches per square kilometer	Banco de España and Anuario Estadístico de España (1994)	
RGGNPP5	Province	Average rate of growth of GNP in last 5 years.	Contabilidad Regional de España (Base 1986).	(2)
ENTROPY	Community	Diversification index of bank branches	CSB and CECA	(1)
OJIVE	Province	Diversification index of bank branches	CSB and CECA	
SENTROPY	Province	Sector diversification index by sectors (4 sectors)	Contabilidad Regional de España (Base 1986) and own preparation	(2)
SOJIVE	Province	Sector diversification index by sectors (4 sectors)	Contabilidad Regional de España (Base 1986) and own preparation	(2)

(1) 1993-95 values are projections

(2) 1994-95 values are projections

(3) 1993-95 community level

Initially, rate of growth of GNP (RGGNP), average rate of growth of GNP in last five years (RGGNP5) and private and public investment rate of growth (RGINV and RGPINV) were considered. These variables negatively impact loan losses and positively effect efficiency, since those banks placed in regions with a favorable economic cycle have lower delinquency rates and greater bank services demand. Greater unemployment rates (UNEMP) or lagged unemployment rates (UNEMP1), greater unemployment rate of growth (RGUNEMP) or the average rate growth in last five years (RGUNEMP5), and the variance of the unemployment rate within that year (VUNEMP) or of the prior period (VUNEMP1), positively influence delinquency rates and have a negative impact on efficiency.

Similarly, higher private investment levels per person (INV/INH) or per squared kilometer (INV/KM2), higher public investment per person (PINV/INH) or per squared kilometer (PINV/KM2), higher GNP per person (GNP/INH) or per squared kilometer (GNP/KM2), are thought to have a positive influence on the efficiency, given the greater banking services demand. On the other hand, banks in regions with a larger number of branches per person (BRA/INH) or per squared kilometer (BRA/KM2) are faced with increased competition and offer more accessibility of services, causing efficiency to fall due to higher operating costs[19].

5. Empirical results

5.1. Risk management efficiency and PLL decomposition

Results of the stepwise procedure explained in section 3 are shown in table 2. Ten influential business cycle variables were initially considered as influencing *PLL* (problem (1)). After five steps, only four were found to be statistically significant. These were: the volatility of

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[19] Note, that more accessibility in terms of these variables means more operating cost, but it may reduce financial cost when the customers prefer to receive less interest in order to obtain more services. This posibility has been considered in other papers however, they did not find this parallel effect (i.e. Pérez et al, 1994 and Pastor 1995b).

the unemployment (VUNEMP), the average rate of growth over the last five years of unemployment (RGUNEMP5), the GNP rate of growth (RGGNP), and the unemployment rate (UNEMP).

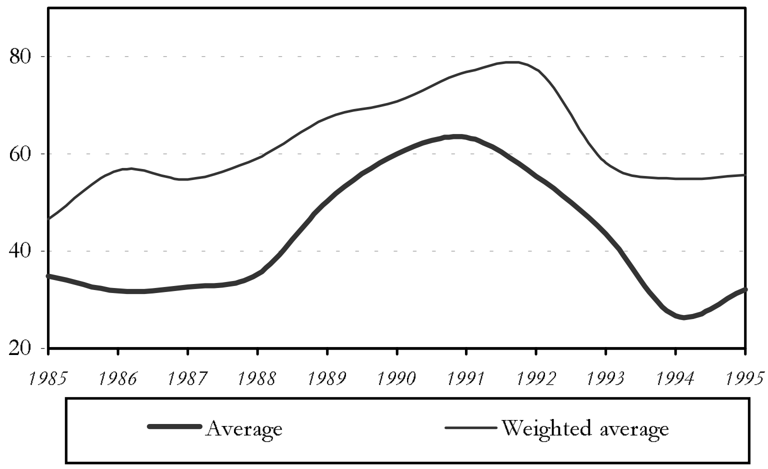
Table 2 : P-values stepwise procedure (*)

	Step 1		***Step 2***		***Step 3***		***Step 4***		***Step 5***	
	No.	***P-value***	***No.***	***P-value***	***No.***	***P-value***	***No.***	***P-value***	***No.***	***P-value***
RGGNP	49	1.000	59	0.978	177	9.91E-25	-	-	-	-
RGGNP5	19	1.000	65	0.897	91	0.046	145	3.77E-14	80	0.237
RGINV	114	2.03E-05	160	9.28E-19	174	1.55E-23	188	1.31E-30	93	0.017
RGPINV	9	1.000	45	1.000	133	6.51E-10	131	5.02E-10	75	0.476
UNEMP	24	1.000	79	0.338	152	1.41E-15	206	5.33E-39	-	-
UNEMP1	8	1.000	64	0.918	129	7.09E-09	98	3.72E-03	52	0.998
RGUNEMP	96	0.014	98	0.005	139	1.42E-11	118	8.16E-07	71	0.663
RGUNEMP5	111	7.46E-05	201	8.16E-36	-	-	-	-	-	-
VUNEMP	115	1.29E-05	-	1.000	-	-	-	-	-	-
VUNEMP1	111	7.46E-05	127	1.18E-08	155	1.41E-16	102	9.34E-04	43	1.000

(*) Most significant influence underlined. T is the number of firms with "r" less than the tolerance level used to obtain the p-value of the binomial distribution.

Simple and weighted average measures of risk management efficiency in terms of problem (1) including these four significant business cycle variables (Z_i) for each one of the eleven years are shown in graph 2. Banks' risk management efficiency significantly improved between 1985-92. In 1992 risk management efficiency begins to fall, indicating that competition for loans between banks from 1992 appears to have had a negative impact. This feature contrasts with the evolution of loan losses ratio (graph 1).

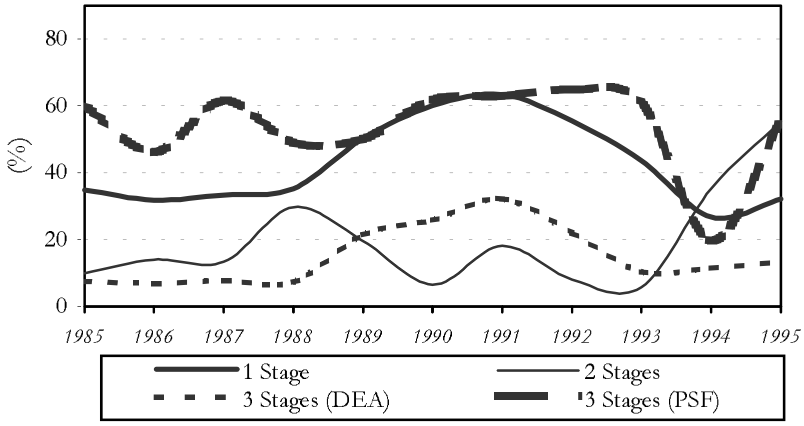
Graph 2: Risk management efficiency



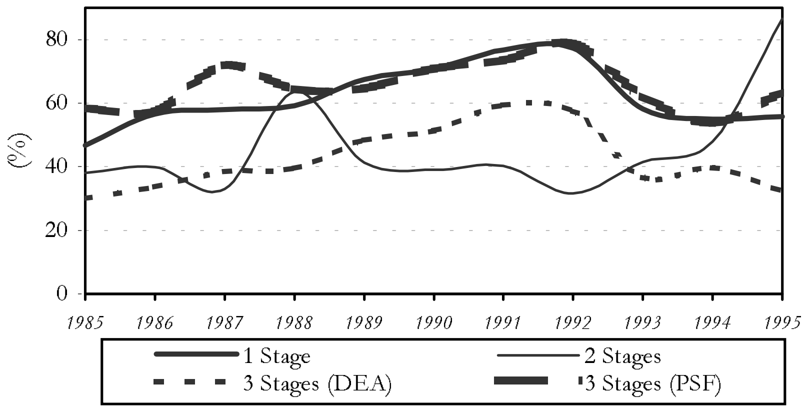
Graphs 3 (i) and 3 (ii) show the evolution of risk management efficiency using a number of alternative approaches: the one-stage procedure used in this paper, Pastor's two-stage procedure and two versions of the three-stage procedure of Fried and Lovell (1996) which use a DEA or a parametric stochastic frontier (PSF). The one-stage and three-stage procedures generate a very similar fluctuation in results over time and differ only in their level. The PSF three-stage procedure also produces very similar levels of efficiency compared with the one-stage procedure we use in this paper. However Pastor's (1995a) two-stage procedure produces very different results[20].

[20] Rouse (1996) obtained similar results. He found very low, and even negative, correlation between Pastor (1995a) and the alternative procedures. In these papers, even the average risk management efficiency is very similar in the case of one-stage and three-stage procedure, the correlation between methods is only around 70%.

Graph 3 (i): Risk management efficiency: Comparison
(Simple average)



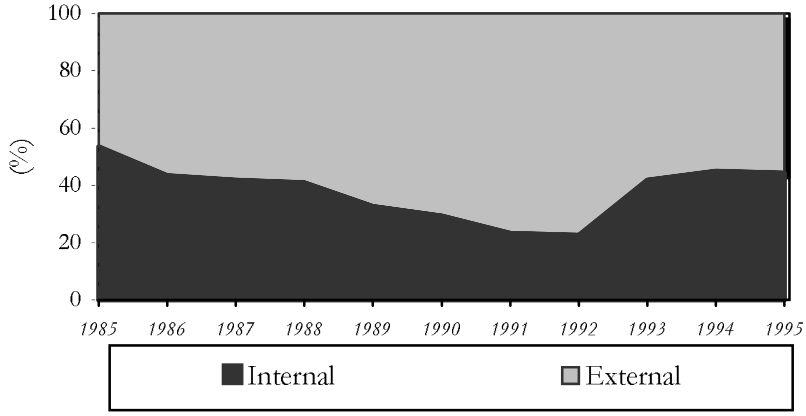
Graph 3 (ii): Risk management efficiency: Comparison
(Weighted average)



Simple average risk management efficiency is lower than weighted average measures in all the procedures. This is expected and means that the greater a bank's size, the higher the risk management efficiency. Several reasons may explain the higher efficiency of large banks. First, large banks located nation-wide have more opportunities to diversify by economic sector and geographical region. In addition, large banks are likely to have greater access to information than smaller ones and they have internal departments specifically dedicated to appraising the risk associated with loan applications.

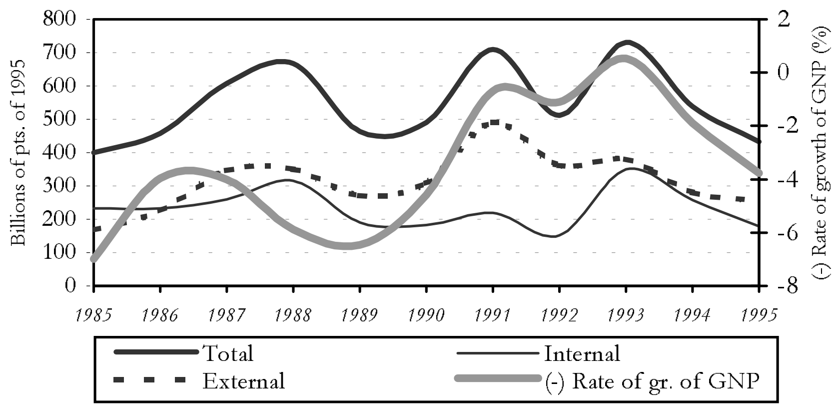
If we interpret risk management efficiency as the proportion of *PLL* that could be reduced, given external factors, this measure offers us the proportion of *PLL* exclusively due to internal factors. So, large banks have a lower proportion of *PLL* due to internal factors than smaller ones. Graph 4 shows the break-down of *PLL* of the weighted average. In general, around 40% of *PLL* is attributable to internal factors. However, the results are quite different if we look at *PLL* by period. In this case, we find that from 1985-92 the proportion of *PLL* due to internal factors is continuously decreasing due to the improvement in risk management efficiency. In 1992, however, this proportion began to increase as competition for loans caused banks to lower their risk management standards.

Graph 4: PLL decomposition



Graph 5 presents the growth and decomposition of total *PLL*. Although a clear trend does not exist, *PLL* seems particularly high in 1988, 1991 and 1993, when economic conditions were less favorable than in other years. Thus, if we compare the evolution of the rate of growth of GNP in real terms (with the sign changed), a close correlation between economic cycle and loan delinquency can be seen. Moreover, the "erratic" fluctuation of total and external *PLL* during this period, can be almost completely explained by economic circumstances beyond banks' control.

Graph 5: Evolution of PLL and rate of growth of GNP



Graph 6 shows the proportion of *PLL* due to external factors by bank asset size. As shown graph 2, there is a positive relationship between size and risk management efficiency. Specifically, of the four bank sizes, the largest banks (with volume of assets above 2,000 billion pesetas or $15 billion) are the best risk managers, since the majority of *PLL* are due to external factors (in 1992 only 8% of the *PLL* were due to risk management efficiency for these banks).

Graph 6: Proportion of PLL due to exernal factors by sizes.
Sizes in billions of pts. of 1995

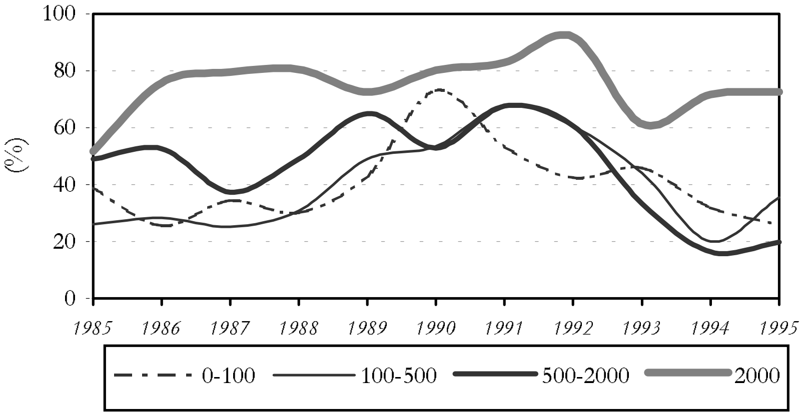


Table 3 : P-values stepwise procedure (*)

	Step 1		*Step 2*		*Step 3*	
	No.	***P-value***	***No.***	***P-value***	***No.***	***P-value***
RGINV	434	0.000	219	1.77E-44	-	-
RGPINV	429	0.000	110	6.81E-05	55	0.952
RGGNP	582	0.000	38	1.000	15	1.000
RGGNP5	631	0.000	59	0.980	18	1.000
INV/INH	649	0.000	49	1.000	34	1.000
INV/KM2	774	0.000	14	1.000	9	1.000
PINV/INH	649	0.000	61	0.963	25	1.000
PINV/KM2	741	0.000	27	1.000	10	1.000
VUNEMP	434	0.000	56	0.992	24	1.000
VUNEMP1	426	0.000	56	0.992	27	1.000
GNP/KM2	835	0.000	-	-	-	-
GNPP/KM2	662	0.000	41	1.000	30	1.000
BRA/INH	424	0.000	42	1.000	27	1.000
BRA/KM2	417	0.000	1	1.000	0	1.000
UNEMP	422	0.000	36	1.000	14	1.000
UNEMP1	419	0.000	31	1.000	12	1.000
RGUNEMP	430	0.000	55	0.995	15	1.000
RGUNEMP5	417	0.000	102	1.51E-03	50	0.990

(*) Most significant influence underlined. T is the number of banks with "r" less than the tolerance level used to obtain the p-value of the binomial distribution.

5.2. Selection of environmental variables and adjusted efficiency measures

The results of the forward stepwise procedure regarding the environmental variables included in problem (7) are shown in table 3. A set of eighteen variables were initially considered. After three steps, only two variables were statistically significant for efficiency: the GNP per square kilometer (GNP/KM2) and private investment rate of growth (RGINV).

The efficiency measures under CRS (problem (2), VRS (problem (3)), adjusted by risk (problem (5)) and adjusted by risk and environmental factors (problem (7)) are shown in table 4 and graph 7.Unlike the CRS efficiency measure, VRS efficiency measure does not change significantly, indicating that changes in regulation and increases in competition have had a little impact on efficiency. Average risk adjusted efficiency measures (column 3) are similar to unadjusted ones (column 2) indicating that the risk effect does not significantly affect to the average level of the efficiency.. Average risk and environment adjusted efficiency measures are much more stable. The results reflect that when risk and environment effects are purged, both competition and deregulation do not seem to have any important impact on banks' efficiency.

Graph 7: CRS, VRS and adjusted efficiency measures

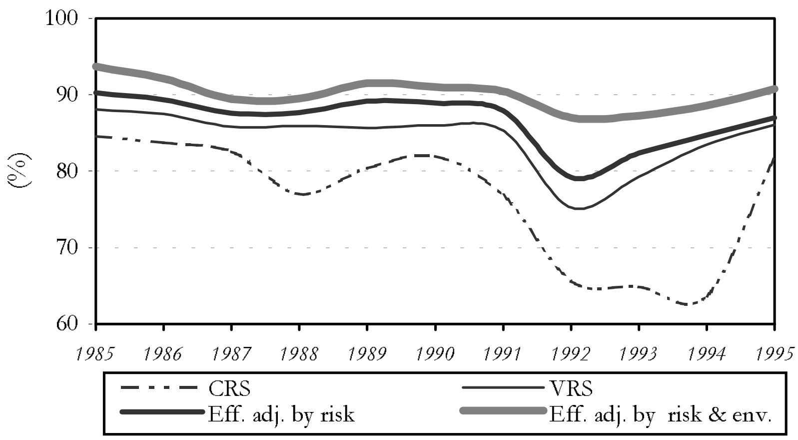


Table 4 : Technical, pure technical and adjusted efficiency measures

	(1) Efficiency (CRS) (Ψ)	*(2) Efficiency (VRS) (ϑ)*	*(3) Efficiency adj. by risk (ρ)*	*(4) Eff. adj. by risk and env. (Ω)*
1985	84.574	88.033	90.240	93.670
1986	83.683	87.472	89.367	92.108
1987	82.549	85.782	87.592	89.415
1988	76.991	85.925	87.679	89.475
1989	80.378	85.671	89.160	91.492
1990	81.930	85.941	88.873	90.971
1991	76.838	85.275	87.882	90.429
1992	65.620	75.230	79.171	87.002
1993	64.859	79.241	82.367	87.237
1994	63.631	83.461	84.689	88.573
1995	81.925	86.052	87.000	90.717

The efficiency decomposition in terms of expression (9) is shown in table 5. Basically, since 1989 the increase loan competition caused efficiency (CRS) to fall as a consequence of an increase in financial costs (1989-93) and a decrease in revenues (1992-95). This fact can be explained almost completely by a decrease in scale efficiency (*SE*). This means that larger banks have been more affected by competition for deposits (1989-92) and for loans (1993-95) than small banks. The environmental effect (*EE*) is very stable and close to one. But in 1992-1994 environmental variables appear to have had more impact on efficiency due to adverse economic circumstances. The risk effect (*RE*) is also very stable. The portion of *PLL* due to internal factors does not have a high impact on average efficiency, since *RE* is very close to one. The average of *RE* all over the period is 97%. This means that banks seem to manage risk worse than other types of costs. This is especially significant in 1992, when the loan market competition began[21].

[21] However, this feautre does not mean that including the risk has a little effect in efficiency at firm level. On the contrary, the ranking correlations between VRS efficiency measures and risk -adjusted efficiency measures is only 0.67.

Table 5 : Efficiency decomposition

	(1) Efficiency (CRS) (ψ)	*(2) Efficiency adj. By risk and env. (Ω)*	*(3)/(4) Env.. Effect (EE)*	*(2)/(3) Risk Effect (RE)*	*(1)/(2) Scale effect (SE)*
1985	84.574	93.670	96.423	97.636	96.196
1986	83.683	92.108	97.178	97.892	95.807
1987	82.549	89.415	98.037	97.991	96.347
1988	76.991	89.475	98.029	97.947	89.995
1989	80.378	91.492	97.523	96.203	94.212
1990	81.930	90.971	97.818	96.786	95.314
1991	76.838	90.429	97.266	96.885	90.378
1992	65.620	87.002	91.587	94.728	87.144
1993	64.859	87.237	94.811	96.068	82.033
1994	63.631	88.573	95.921	98.546	76.045
1995	81.925	90.717	96.169	98.877	95.496

6. Conclusions

The current banking literature has made only a few attempts to analyze how risk can affect measured and how it can affect bank efficiency. Attempts made to date have two main drawbacks. First, they do not distinguish between risk that arises from environmental factors that are essentially beyond the control of ban management versus risk factors associated with internal management actions. As a result, current measures of efficiency can be misstated and will penalize improperly those banks subject to adverse economic conditions by attributing it to poor management rather than external conditions. Second, they typically use stock measures, usually in a cost function context. This approach cannot capture the effect of asset quality on liabilities and asset prices. These price effects only can be captured by flow measures or by stock measures in a profit function context.

To address this problem a new sequential DEA procedure is proposed using flow measures of outputs and inputs in a profit function framework. In addition, we use provision for loan losses (*PLL*) as a comprehensive measure of risk. The first phase estimates the risk management efficiency of each bank. Using this indicator, total *PLL* are broken down into those due to internal factors and those due to the external environment. In the second phase, risk-adjusted efficiency measures and risk and environmental adjusted efficiency measure are obtained including only that portion of *PLL* due to internal factors and *PLL* due to internal factors and environmental influence respectively. This procedure is illustrated by application to the Spanish banking system (SBS) to see if the banking deregulation process there has affected banks' risk behavior.

A large set of business cycle variables were initially considered as risk influential, but only four were found to be statistically significant using Pastor's (1995a) procedure. Including these four variables in the first phase, risk management efficiency was calculated using three alternative approaches. The results show that these approaches produce similar results to the one used in this paper. Risk management efficiency in the SBS has improved significantly over the period 1985-92, consequently the proportion of *PLL* due to internal factors has decreased. So it seems that credit restrictions imposed by the *Banco de España* with the aim to discourage private consumption, encouraged banks to be more careful in making loans, accepting less risky customers (credit rationing). However, from 1992, risk management efficiency began to decrease as a consequence of the increase in competition in loan markets, leading to an increase in the proportion of *PLL* due to internal factors. In this instance, deregulation has negatively affected bank risk.

In the second phase, eighteen environmental variables were examined as influential to the efficiency, from which only two were found to be statistically significant. The efficiency measures under CRS, CRS, adjusted by risk and adjusted by risk and environmental factors were calculated. Except for the CRS efficiency measures, the remaining efficiency indicators have not changed significantly. Moreover, the decomposition of the efficiency measures under CRS provides information about the sources of efficiency.

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