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Earnings quality and performance in the banking industry: A profit frontier approach

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Abstract

The analysis of efficiency and productivity in banking has received a great deal of attention for almost three decades now. However, most of the literature to date has not explicitly accounted for risk when measuring efficiency. We propose an analysis of profit efficiency taking into account how the inclusion of a variety of bank risk measures might bias efficiency scores. Our measures of risk are partly inspired by the literature on earnings management and earnings quality, keeping in mind that loan loss provisions, as a generally accepted proxy for risk, can be adjusted to manage earnings and regulatory capital. We also consider some variants of traditional models of profit efficiency where different regimes are stipulated so that financial institutions can be evaluated in different dimensions—i.e., prices, quantities, or prices and quantities simultaneously. We perform this analysis on the Spanish banking industry, whose institutions have been deeply affected by the current international financial crisis, and where re-regulation is taking place. Our results can be explored in multiple dimensions but, in general, they indicate that the impact of earnings management on profit efficiency is of less magnitude than what might a priori be expected, and that on the whole, savings banks have performed less well than commercial banks. However, savings banks are adapting to the new regulatory scenario and rapidly catching up with commercial banks, especially in some dimensions of performance.

Keywords: bank, efficiency, loan loss provision, profit, risk

JEL classification: C14, C61, G21, L50

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1. Introduction

Since the early eighties, the literature on bank efficiency and productivity has expanded dramatically, and the number of contributions continues to grow today. Indeed, the body of literature is large enough to have already warranted two surveys (Berger and Humphrey, 1997; Fethi and Pasiouras, 2010). Since the latter of these surveys was published, further empirical evidence has become available, partly because the banking industries in several Western economies have been substantially reshaped since the start of the international financial crisis in 2007. Under these renewed circumstances, one may naturally inquire how banks' efficiency is affected or, perhaps more interestingly, analyze the links between pre-crisis and crisis efficiency levels.

However, despite the large amount of relevant literature, some issues have not yet been fully addressed. For instance, some now *classic* studies in the field such as Hughes and Hughes and Mester (1993) or Mester (1996) and, more recently, Hughes and Mester (2009), have pointed out that bank efficiency studies generally disregard the impact of risk and, consequently, they miscalculate banks' levels of inefficiency. This is important for many reasons, one of them being that among the most fundamental causes of the international financial crisis lies the issue of bank risk mismanagement. During the last twenty years, due to the importance and growing relevance of this issue, although there was a notable increase in the number of bank efficiency analyses that disregard risk, some papers did actually take it into account, including Färe et al. (2004), Koetter (2008), Altunbaş et al. (2007) or, more recently, Fiordelisi et al. (2011) and Epure and Lafuente (2014), among others.

Many of the contributions in this particular field have considered different proxies for risk, among which the most extended approach has been to include loan loss provisions. Some authors such as Berger and DeYoung (1997) argue that, alternatively, non-performing loans might be a better option to measure bank risk, since loan loss provisions can be manipulated more easily. However, this decision largely hinges on the availability of data, and it is usually the case that data on non-performing loans are simply not available. In addition, since many non-performing loans are finally repaid, to write off the whole amount of non-performing loans as an expenditure might lead to overestimation of the effects of risk. However, as Ahmed et al. (1999) note, although the purpose of loan loss provisions is to adjust banks' loan loss reserves to reflect expected future losses on their portfolios, bank managers may also have incentives to use them to manage earnings and regulatory capital. Pérez et al. (2008) state that in the case of banks the accrual of loan loss provisions is left to bank managers' discretion (Beatty et al., 2002). The analysis of this industry becomes even more important due to inter-country differences in accounting and capital adequacy regulations (Laeven and Majnoni, 2003), or the regulatory changes within individual countries.

This and related issues have been considered by the earnings management and earnings quality literatures (Dechow et al., 2010; Louis et al., 2013) but, despite its magnitude and importance, it has received scant attention in studies into risk in bank efficiency. However, the literature on earnings management and earnings quality is not conclusive as to the links between loan loss provisions and earnings; for instance, while Collins et al. (1995) find evidence of a positive relationship between the two variables (which is consistent with smoothing earnings via loan loss provisions), Beatty et al. (2002) found no evidence of earnings smoothing (Ahmed et al., 1999).

Considering jointly the literature on bank efficiency (controlling for risk) and earnings management and earnings quality has additional implications. Whereas most contributions in the bank efficiency literature have been analyzing either cost or (input) technical efficiency, far fewer studies analyze either revenue (or output technical efficiency), or profit efficiency. However, the magnitude and heterogeneity of the differences among financial institutions when examining profit efficiency—which implies evaluating cost and revenue efficiency simultaneously—are much higher. In addition, in our particular case, which analyzes the links between earnings management and performance, it is clear we must adopt an approach which takes earnings (and, therefore, earnings *management* and earnings *quality*) into account—i.e., a profit efficiency approach.

Our analysis extends the existing literature in three main directions. First, we use several variables to measure credit risk. In this regard, despite the advantages of non-performing loans over loan loss provisions referred to by Berger and DeYoung (1997), the frequent unavailability of the former measure, along with the ease with which loan loss provisions can be manipulated, led us to consider an alternative strategy. Specifically, we consider some accounting modifications to control provisions which add a discretional component to the use of loan loss provisions—i.e., we will consider two additional proxies for credit risk that give us an intuition about whether banks actually did manipulate this information during the analyzed period. Therefore, our profit frontier approach explicitly takes into account the quality of those variables which affect the measurement of bank profits. This approach, as far as we know, has never been used in the literature measuring bank efficiency—regardless of whether risk is controlled for or not. However, an accurate profit frontier evaluation will hinge on the quality of the components of profits. The literature on earnings quality and earnings management (Roychowdhury, 2006; Dechow et al., 2010), as indicated, deals precisely with this. In our setting, both the choices regarding when transactions occur (timeliness and timely loss recognition) and other choices made to *manipulate* the profits to be disclosed (Beaver and Engel, 1996) are particularly relevant due to their impact on profits. This has been widely recognized in the literature, since the expected future losses cannot be estimated with certainty and, therefore, bank managers have relatively substantial discretion when setting loan loss provisions (LLP).

Although, in theory, discretion is exercised to provide best estimates of their portfolios' expected losses, in practice, managers might have great incentives to manipulate LLP. These incentives include, for instance, helping to reduce earnings volatility, enhancing managers' compensation, or avoiding capital adequacy regulation. Several contributions have acknowledged this reality (see, for instance Ahmed et al., 1999; Kim and Kross, 1998; Collins et al., 1995), and much of the literature, especially studies focusing on the US, has extensively analyzed the determinants of the LLP decision. Our model controls for this decision by including loan loss provisions (LLP) as an expenditure in the profit function and, in a subsequent step, in order to offset the effects of their manipulation, we will consider *expected* as opposed to *realized* LLP, for which we follow the recent proposals by Nichols et al. (2009). Specifically, as opposed to other contributions adopting a static approach, Nichols et al. (2009) suggest estimating LLP by taking into account not only present but also past and future non-performing loans. We will therefore estimate three earnings management models, depending on whether we *allow* bank managers to "manipulate" the LLP, or whether we estimate these provisions considering both a time series and a cross-sectional approach.

Our second contribution consists of proposing three variants of our profit frontier model. We estimate a non-convex short-run profit frontier model in the spirit of Prior (2003), taking as a starting point the contributions of Färe et al. (1994) and Primont (1993). However, in contrast to previous studies, we go beyond a model in which output and input prices are kept constant—implying that market power might not exist, an assumption that recent literature suggests might be implausible (Salas and Saurina, 2003; Maudos and Fernández de Guevara, 2007). We extend this basic model in two main directions. In the first one banks are allowed to influence quantities only, i.e., they are price-acceptant, whereas in the second one banks are able to influence prices. We refer to these three models as the unconstrained profit model, the price-constrained profit model and the quantity-constrained profit model, respectively. For all three profit frontier models we will consider three variants depending on the degree to which LLP are manipulable—i.e., one model subject to manipulation, and two models in which the estimation of LLP are plugged in.

Finally, we apply the analysis to the Spanish banking system, for which there is compelling evidence available on its performance (see, for instance Grifell-Tatjé and Lovell, 1999). However, contributions with an explicit concern about risk are almost non-existent. In addition, very few contributions have adopted a *profit* frontier approach. We consider this to be a relevant context, especially in light of the difficulties facing many Spanish commercial and savings banks following the crash of the housing market, and the threat that this represents for the entire European banking industry. In addition, the Spanish banking system is going through a deep re-regulatory change whose impact on the industry has not yet been examined. Our strategy to estimate LLP also fits the Spanish banking system particularly well, due to the dynamic LLP scheme introduced by the Bank of Spain in 2000.

Results can be summarized from multiple angles. Our combination of profit frontier models (unconstrained, price-constrained, and quantity-constrained) and proxies for risk gives us a total of nine models. Whereas there are several differences depending on the profit frontier model considered, little heterogeneity is found when comparing results yielded by models with varying degrees of LLP discretion, suggesting that the likely impact of LLP manipulation on profit efficiency is limited. This result is robust across profit frontier models, time (pre-crisis or crisis years) and types of firms (commercial or savings banks). The differences, however, are quite large, and significant, when considering the context—time or type of firm. During the pre-crisis years, commercial banks performed better than savings banks, regardless of the model considered. In the 2008-2010 period, savings banks caught up with banks and, for some particular models, their efficiency is higher, suggesting that they are adapting rapidly to the new regulatory scenario.

The article is organized as follows. After this introduction, section 2 presents the model considered to measure profit efficiency taking into account risk preferences, and the data is described in section 3. The results from the working of our analytical proposal are interpreted in section 4 and, finally, some concluding remarks are outlined in section 5.

2. The analytical framework

Some banks perform better than others. This is an indisputable fact, but how do we actually recognize a high performing bank? Is a very profitable bank a high performer? Before providing the answer to this question, we have to consider the degree of reliability we should accord to the variables needed to define banking industry profits. In order to do this, we first need to define the synthetic components that make up the **profits** of a banking firm:

$$\Pi = \text{Revenues} - \text{Operating costs} - \text{Loan loss provisions} = \\ = \sum_{m=1}^{M} r_m u_m - \sum_{n=1}^{N} p_n x_n - \sum_{o=1}^{O} p_o npl_o \quad (1)$$

where Π are the profits, r_m and u_m are the price and quantity for output m ($m = 1, \ldots, M$), respectively, p_n and x_n are the price and quantity for input n ($n = 1, \ldots, N$), respectively, p_o is the *estimated price* (say, the percentage of write-offs) for non-performing asset o, and npl_o refers to its monetary value (quantity).

Clearly, the degree of accuracy of Π depends on the *quality* of each of its basic elements. In this regard, in the framework of agency theory, a well developed stream in the accounting literature addresses the assessment of the quality of the variables that have an impact on periodic profits, namely, the literature on **earnings quality** (see, for instance Dechow et al., 2010, for a review of some of the variables employed by this literature). On the one hand, under some specific circumstances there are several choices to consider at the moment when transactions occur—or incentives exist to manipulate real operations (Roychowdhury, 2006)—and this can affect the amount of flow of real variables to consider (u_m, x_n, npl_o). This is what the literature on earnings quality refers to as timeliness and timely loss recognition (Dechow et al., 2010). On the other hand, when prices are determined internally (a situation that could affect both p_n and p_o), subjective and opportunistic choices could be considered in order to "embellish" (or "manipulate") the profits to be disclosed. In this respect, in the particular case of the banking industry, the manipulation of profits is commonly oriented to deal with the problems caused by credit risk—bad loans, problem loans or provisions for loans losses (see, for instance Beaver and Engel, 1996).

Dechow and Dichev (2002) define higher profit quality as existing when earnings and cash flows follow the same pace. They document that earnings quality is poorer for smaller firms, which experience losses and greater volatility in sales and cash flows. Some of these characteristics are present in the Spanish banking industry, which provides the rationale for our research objectives.

Another perspective on earnings quality is that some banks also have incentives to reduce volatility by decreasing earnings in years with unexpectedly strong performance, and increasing earnings in years with weak performance. A smoother stream of earnings might help to reduce the information asymmetry between managers and outside investors (Beatty and Harris, 1999; Beatty et al., 2002; Liu and Ryan, 2006). The majority of previous studies find evidence that managers smooth earnings via loan loss provision and recognize security gains and losses. Accordingly, these are the variables to be accounted for when the quality of the earnings is under scrutiny.

Different approaches can be considered to incorporate the risk-taking behavior of banks in estimating efficiency indicators. Following previous literature, non-performing loans can be incorporated into the production function of banks as a bad output (or, in terms of the profit function, an expense that decreases total profits). Under Spanish accounting standards, banks must classify a loan as non-performing when either interest or principal payments are more than 90 days overdue. In addition, all loans granted to borrowers in default are also considered as non-performing, irrespective of whether or not they are overdue.

Because many of these loans are finally repaid, to write off the whole amount of non-performing loans *(npl)* as an expenditure would lead us to overestimate the effects of risk on profit efficiency scores. Hence, we undertake an alternative approach which consists of including loan loss provisions (LLP, defining $LLP = \sum_{o=1}^{O} p_o npl_o$) as an expenditure in the profit function. Under Spanish banking regulations, bank managers estimate LLP following a strict set of rules devised by the Bank of Spain, which depend heavily on the time overdue. However, Bank of Spain rules determine the *minimum* losses a bank must recognize once a loan has been defined as non-performing, leaving the banks with considerable room for discretion.[1] To mitigate the effects of the *potential manipulation of LLP*, our approach consists of using *expected* loan loss provisions as an expenditure, instead of *realized* loan loss provisions. This would reveal whether banks' loan loss provision decisions to manage earnings or capital (and, therefore, circumvent strict accounting rules by over- or under-provisioning assets, or misclassifying them) are successful or not. As indicated by Pérez et al. (2008), if they were successful, having painstaking regulations on LLP might be irrelevant, and that "there is merit in having more principles-oriented accounting standards" (Pérez et al., 2008, p.424).

Expected, or "non-manipulated" loan loss provisions are estimated at the bank level, following the proposals by Nichols et al. (2009). In particular, we regress LLP on the increase in npl in npl in $t-2$, $t-1$ (backward looking component) and t. Furthermore, in order to control for accounting conservatism, the increase in npl in $t+1$ is also incorporated in our regression model as an independent variable (forward looking component):

$$LLP_t^{\text{not manipulated}} = \beta_0 + \beta_1 \triangle npl_{t-2} + \beta_2 \triangle npl_{t-1} + \beta_3 \triangle npl_t + \beta_4 \triangle npl_{t+1} + \varepsilon_t \qquad (2)$$

We run a regression for each bank for the sample period. To carry out the estimation, two different specifications are considered. We first include total loan loss provisions as the dependent variable, considering not only the specific component of loan losses, but also the *dynamic* loan loss provisions, which were introduced by the Bank of Spain in 2000. Since the dynamic provisioning system had a deep impact on the relationship between npl and LLP, we run a second set of regressions excluding the dynamic, or time series, loan loss provisions from

[1] However, some authors such as Pérez et al. (2008) consider the Bank of Spain enforces strict regulations on the accrual of loan loss provisions which would impose, *a priori*, considerable restrictions on banks' ability to use managerial discretion.

the dependent variable.[2] This gives us two sets of "non-manipulated" loan loss provisions, i.e. static (cross-section) and dynamic (time series), for which we consider this counter-cyclical loan loss provision.[3]

Having estimated the degree of earnings manipulation present in the Spanish banking system, we estimate a non-convex short-run profit frontier model. This model basically follows Färe et al. (1994), taking the original variables (in the case of the bad output, considering the realized loan loss provisions only) and classifying the inputs into variable (x_v) and fixed (x_f) inputs (see also Primont, 1993, for a short-run cost frontier definition). Therefore, we will be modeling **variable profit maximization**:

$$
\begin{array}{ll}
\Pi^{\text{manip}}\left(r_{jm}, p_{jv}, p_{jo}\right) & \\
= \max_{(z,u_m,x_v,npl_o)}\left(\sum_{m=1}^{M} r_{jm}u_m - \sum_{v=1}^{V} p_{jv}x_v - \sum_{o=1}^{O} p_{jo}npl_o\right) & \\
\text{s.t.} & \\
\sum_{j=1}^{J} z_j u_{jm} \geq u_m, & m=1,\ldots,M, \\
\sum_{j=1}^{J} z_j x_{jv} \leq x_v, & v=1,\ldots,V, \\
\sum_{j=1}^{J} z_j x_{jf} \leq x_{jf}, & f=1,\ldots,F, \\
\sum_{j=1}^{J} z_j npl_{jo} \leq npl_o, & o=1,\ldots,O, \\
\sum_{j=1}^{J} z_j = 1, & \\
z_j = [0,1]. &
\end{array}
\tag{3}
$$

where $r_{jm} \in \mathbb{R}_+^M$ is the vector of output prices for bank j, $r_{jm} \geq 0$, and we also have variable inputs (netputs) with prices $p_{jv} \in \mathbb{R}_+^V$, $v = 1,\ldots,V$. Analogously, $u_j \in \mathbb{R}_+^M$ is the vector of output quantities for j, $x_{jv} \in \mathbb{R}_+^V$ are the variable netputs for bank j and $x_{jf} \in \mathbb{R}_+^F$ are the fixed netputs for the same bank. However, with respect to the contributions of Färe et al. (1994) and Primont (1993) we are considering here the role of risk via loan loss provisions. Therefore, we have that $npl_j \in \mathbb{R}_+^O$ is the amount of non-performing loans for bank j, $o = 1,\ldots,O$, and $p_{jo} \in \mathbb{R}_+^O$ will be their prices.

As a second step, we will re-run the previous variable profit maximization model (3), but

[2] In 2000 the Bank of Spain promulgated the so-called "statistical provision", according to which banks had to use their own reserves to cover realized losses, making it easier for banks to maintain provisions for incurred losses embedded in the credit portfolios created in expansion years. This rule ultimately enforced a counter-cyclical LLP that resulted in income smoothing practices by banks (Pérez et al., 2008, p.425).

[3] Considering cross section and time series estimations is also relevant because of their economic implications since the former would be adopting an industry perspective (i.e., each bank is compared with the rest of the banks in the sample), whereas the latter implies being compared only with the bank itself and therefore would be focusing on income smoothing.

replacing the variables subject to manipulation with their estimated values:

$$
\begin{array}{ll}
\Pi^{\text{not manip}}\left(r_{jm}, p_{jn}, \tilde{p}_{jo}\right) & \\
= \max_{(z,u_m,x_v,npl_o)} \left(\sum_{m=1}^{M} r_{jm}u_m - \sum_{v=1}^{V} p_{jv}x_v - \sum_{o=1}^{O} \tilde{p}_{jo}\widetilde{npl}_o\right) & \\
\text{s.t.} & \\
\sum_{j=1}^{J} z_j u_{jm} \geq u_m, & m = 1, \ldots, M, \\
\sum_{j=1}^{J} z_j x_{jv} \leq x_v, & v = 1, \ldots, V, \\
\sum_{j=1}^{J} z_j x_{jf} \leq x_{jf}, & f = 1, \ldots, F, \\
\sum_{j=1}^{J} z_j \widetilde{npl}_{j,o} \leq \widetilde{npl}_o, & o = 1, \ldots, O, \\
\sum_{j=1}^{J} z_j = 1, & \\
z_j = [0,1]. &
\end{array}
\tag{4}
$$

Obviously, $\Pi^{\text{not manip}}\left(r_j m, p_{jv}, \tilde{p}_{jo}\right)$ will provide a more objective profit target for each bank, as profits generated by **earnings manipulation** are controlled for in this second program.

The problem of programs (3) and (4) is that potential *outputs* and *inputs* are estimated in order to maximize profits for the unit under analysis, keeping constant the corresponding output and input prices. This assumption is equivalent to considering that prices are determined in competitive markets, so that firms cannot implement any strategy to influence market prices, or that local markets can absorb any level of output without any change in output prices. This assumption can be strong in the Spanish banking industry, where recent studies have been analyzing whether market power exists (see, for instance Maudos and Pérez, 2003; Maudos and Fernández de Guevara, 2007; Salas and Saurina, 2003). From the theoretical point of view, in the efficiency literature there are also contributions indicating the problems caused by setting prices in non-fully competitive settings (Camanho and Dyson, 2006; Portela and Thanassoulis, 2014; Portela, 2014; Tone, 2002; Tone and Tsutsui, 2007).

To confirm with our data the extent to which banks are oriented towards the maximization of profits in an imperfect competition setting, we followed the Monopolist Axiom of Profits Maximization (proposed by Varian, 1984) and, more specifically, the condition of downward sloping demand function:

$$(r_i - r_j).(u_i - u_j) \leq 0 \tag{5}$$

After estimating expression (5) for all possible combinations of output quantities and prices for each unit/year, the results indicated that for more than 89% of the possible comparisons, the condition was not met—i.e., the sign was negative. This might constitute evidence supporting the existence of market power, as previously found by Maudos and Pérez (2003). This would imply that we cannot artificially deal with quantities and prices separately, meaning that the two previous programs oriented towards the estimation of the profit frontier are not applicable.

One way to overcome this limitation can be to make the profit function to be dependent on the total revenues minus costs as in the following expression:

$$
\begin{aligned}
\Pi &= \text{Revenues} - \text{Operating costs} - \text{Loan loss provisions} \\
&= \sum_{m=1}^{M} R_m - \sum_{v=1}^{V} VC_v - \sum_{o=1}^{O} LLP_o
\end{aligned}
\tag{6}
$$

where $R_m = r_m u_m$, $VC_v = p_v x_v$ and $LLP_o = p_o npl_o$.

This serves to define a profit frontier program depending on the revenues and the costs by combining feasible amounts of quantities and prices.

First we consider **model 0**, also referred to as the **unconstrained variable profit model**, which is defined as follows:

$$
\begin{aligned}
&\Pi^0\left(FC_{jf}\right) = \max_{(z,R_m,VC_v,LLP_o)} \textstyle\sum_{m=1}^{M} R_m - \sum_{v=1}^{V} VC_v - \sum_{o=1}^{O} LLP_o \\
&\text{s.t.} \\
&\textstyle\sum_{j=1}^{J} z_j R_{jm} \geq R_m, \quad m = 1, \ldots, M, \\
&\textstyle\sum_{j=1}^{J} z_j VC_{jv} \leq VC_v, \quad v = 1, \ldots, V, \\
&\textstyle\sum_{j=1}^{J} z_j FC_{jf} \leq FC_{jf}, \quad f = 1, \ldots, F, \\
&\textstyle\sum_{j=1}^{J} z_j LLP_{jo} \leq LLP_o, \quad o = 1, \ldots, O, \\
&\textstyle\sum_{j=1}^{J} z_j = 1, \\
&z_j = [0,1].
\end{aligned}
\tag{7}
$$

From the optimal solution of this program, we can obtain the optimal revenues (R_m^* and, subsequently, the optimal values of output prices $r_m^* = \sum_{j=1}^{J} z_j^* r_{jm}$ and physical outputs $u_m^* = \sum_{j=1}^{J} z_j^* u_{jm}$), the optimal values of variable costs (VC_v^* and, subsequently, the optimal values of variable input prices $p_v^* = \sum_{j=1}^{J} z_j^* p_{jv}$ and physical variable inputs $x_v^* = \sum_{j=1}^{J} z_j^* x_{jv}$), the optimal values for the loan loss provisions (LLP_o^* and, subsequently, the optimal values of loss recognition $p_o^* = \sum_{j=1}^{J} z_j^* p_{jo}$).

In the second stage, we consider the **constrained model 1**. Compared with the **unconstrained model 0**, in model 1 banking firms are price-acceptant and can influence quantities only. We will refer to this as the **price-constrained variable profit model**, according to which we will have that:

$$\begin{array}{ll}
\Pi^1\left(r_{jm}, p_{jv}, p_{jf}, p_{jo}, x_{jf}\right) & \\
= \max_{(z,u_m,x_v)}\ \left(\sum_{m=1}^{M} r_{jm}u_m - \sum_{v=1}^{V} p_{jv}x_v - \ \sum_{o=1}^{O} p_{jo}npl_o\right) & \\
\text{s.t.} & \\
\sum_{j=1}^{J} z_j u_{jm} \geq u_m, & m= 1, \ldots, M, \\
\sum_{j=1}^{J} z_j r_{jm} = r_{jm}, & m= 1, \ldots, M, \\
\sum_{j=1}^{J} z_j x_{jv} \leq x_v, & v= 1, \ldots, V, \\
\sum_{j=1}^{J} z_j p_{jv} = p_{jv}, & v= 1, \ldots, V, \\
\sum_{j=1}^{J} z_j x_{jf} \leq x_{jf}, & f= 1, \ldots, F, \\
\sum_{j=1}^{J} z_j npl_{jo} \leq npl_o, & o = 1, \ldots, O, \\
\sum_{j=1}^{J} z_j p_{jo} = p_{jo}, & o = 1, \ldots, O, \\
\sum_{j=1}^{J} z_j = 1, & \\
z_j = [0,1]. &
\end{array} \tag{8}$$

Finally, we can also have **model 2**, which we refer to as the **quantity-constrained variable profit model**, which assumes that banks can influence output and input prices but not quantities, according to which:

$$\begin{array}{ll}
\Pi^2\left(u_{jm}, x_{jv}, x_{jf}, npl_{jo}\right) = & \\
= \max_{(z,r_m,p_v,p_o,)}\ \left(\sum_{m=1}^{M} r_m u_{jm} - \sum_{v=1}^{V} p_v x_{jv} - \ \sum_{o=1}^{O} p_o npl_{jo}\right) & \\
\text{s.t.} & \\
\sum_{j=1}^{J} z_j u_{jm} = u_{jm}, & m= 1, \ldots, M, \\
\sum_{j=1}^{J} z_j r_{jm} \geq r_m, & m= 1, \ldots, M, \\
\sum_{j=1}^{J} z_j x_{jv} = x_{jv}, & v= 1, \ldots, V, \\
\sum_{j=1}^{J} z_j p_{jv} \leq p_v, & v= 1, \ldots, V, \\
\sum_{j=1}^{J} z_j x_{jf} \leq x_{jf}, & f= 1, \ldots, F, \\
\sum_{j=1}^{J} z_j npl_{jo} = npl_o, & o = 1, \ldots, O, \\
\sum_{j=1}^{J} z_j p_{jo} \leq p_o, & o = 1, \ldots, O, \\
\sum_{j=1}^{J} z_j = 1, & \\
z_j = [0,1]. &
\end{array} \tag{9}$$

Figure 1 illustrates the three models defined above to synthesize the characteristics of the proposed evaluation process. As can be seen, model 0 (unconstrained profit model) tries to maximize profits by estimating of the optimal level of revenues and operating costs, constrained not to have more fixed inputs than the observed values. This means that to remedy the inefficiencies found, inefficient banks should try to introduce modifications both to the outputs and operating inputs side as well as to the output and to the operating input prices. Reducing the options available, assuming that output and input prices are negotiated on competitive markets, model 1 estimates the profit inefficiency due to suboptimal levels in the outputs and the operating inputs, keeping the respective prices constant.

By definition, this will produce a smaller level of inefficiency than model 0 or, put the other way round, the differences between models 0 and 1 are due to rigidity on the prices side. One can compare model 1 (price-constrained profit model) with the standard programs of technical efficiency because, at the end of the day, both programs orient their assessment to the consideration of quantities. If this is true, model 1 will always have a better impact on profits than DEA models, as the radial increase (decrease) in outputs (inputs) does not signify that their movement should mechanically improve the level of potential profits. In contrast, our proposed model 1 allows to change the output and input mixes in order to improve profits.

From another perspective, model 2 (quantity-constrained profit model) estimates the profit frontier trying to optimize the corresponding output and operating input prices, given the observed levels of outputs and operating inputs. This is the case when, for instance, local markets restrict levels of activity once a certain limit is reached. In these circumstances, managers should orient their strategy to find the optimal levels of output and input prices (and the optimal level of financial risk) that allow the bank to improve its net profits. As a result of this, the differences between model 0 and model 2 are due to rigidity in the level of activity; in these circumstances, when the activity level is not a controlled variable, the consideration of prices and the risk assumed can drive increases in the level of profitability.

3. Data and variables

Our decomposition of banks' profits requires detailed information on revenues, costs and loan loss provisions. All three magnitudes have associated both quantities and their corresponding prices. In the particular case of loan loss provisions these associated quantities correspond to the non-performing loans. In the case of costs, the three specified categories correspond to the cost of funds (total interest expenses), the cost of labor (personnel expenses), and other operating expenses. We will refer to these three magnitudes as VC_1, VC_2 and FC_1, respectively—the two former variables reflect variable costs, whereas the latter refers to the costs generated by fixed assets and consequently represents a fixed cost. These three cost categories are generated by their corresponding input categories, i.e. loanable funds (or financial capital, xv_1), number of employees (xv_2), and fixed assets (or physical capital, xf_1).

Defining bank outputs is a more difficult task. These difficulties have been an enduring concern (some initial and relevant contributions were Fixler and Zieschang (1992) and, in the context of efficiency in banking, Berger and Humphrey (1992). As indicated by Tortosa-Ausina (2002), there are three approaches to define banks' output, i.e., the asset approach, the value added approach and the user cost approach. All these three approaches correspond to the intermediation approach (as opposed to the *production* approach), which has been the most extended way of defining bank activities. The definition of bank outputs it has generally been conditioned by the available statistical information, which in most cases is rather poor. This has meant that most studies have disregarded the user cost approach and often also the value added approach, for similar reasons.

However, as indicated by Colangelo and Inklaar (2012), statistical agencies have usually considered the user cost approach, according to which banks do not charge explicit fees for many of the services they provide but bundle the payment for services with the interest rates charged on loans and paid for deposits. This approach has recently received a new twist thanks to recent contributions by Colangelo and Inklaar (2012), Basu et al. (2011) and Diewert et al. (2012), since the latest international financial crisis suggests there could be some mis-measurements in the banking sector.[4] Yet most of these proposals are based on information that is only available at the country level. Therefore, extending these revamped contributions to the bank level is just not possible because, in general, the information they use is not available at this individual level of disaggregation.

In this study we have the added difficulty that since we are focusing on the detailed decomposition of bank profits we must be able to attach each particular revenue to each output category. This implies that our approach to define output is not strictly the asset approach because we are considering other output categories apart from assets. Specifically, we consider two outputs, namely: (i) loans, which represent traditional lending activity; and (ii) other operating income, which refers to non-lending activities.

An added difficulty relates to the incorporation of the risk-taking behavior of banks in the estimation of efficiency scores, for which three different approaches are considered. Following previous literature, we first incorporate non-performing loans (NPL) into the production function of banks as a bad output. Under Spanish accounting standards, Spanish banks have to classify a loan as non-performing when either interest or principal payments are more than 90 days overdue. In addition, all loans granted to the borrowers in default are also considered as non-performing, irrespective of whether or not they are overdue. As for the inputs,

[4]Specifically, Colangelo and Inklaar (2012) argue that the methodology currently used in the euro area (and in many other economies) is flawed because it does not take into account the risk characteristics of loans and deposits. We also account for risk, although in a different fashion.

they consist of: (i) total interest expenses; (ii) personnel expenses; and (iii) other operating expenses. Table 1 provides detailed definitions of inputs, outputs, and their correspondence prices. Analogously, Table 2 provides definitions for the loan loss provisions, non-performing loans and their associated prices.

We selected Spanish banking firms for the 1997–2003 period. Our sample includes both commercial and savings banks. Inputs and outputs data to estimate efficiency were provided by Fitch-IBCA Bankscope database and come from each firms' balance sheets and profit and loss account except for data on number of employees, which was obtained from Spanish Banking Association (AEB, "Asociación Española de Banca") for commercial banks and the Spanish Confederation of Savings Banks (CECA, "Confederación Española de Cajas de Ahorro") for savings banks; data on credit risk variables was taken from each institution's annual report. All monetary variables are expressed in thousands of euros. After removing some unreliable data and excluding all non-consistent values (such as zero total assets or zero employees) we have a total of 352 observations for all the sample years.

4. Results

The results can be explored from multiple perspectives. Taking into account the rationale presented in the preceding sections, we consider five of them: (i) results for the unconstrained, price-constrained and quantity-constrained model; (ii) results for the manipulated and non-manipulated model (either static or dynamic); (iii) results for the different types of banks considered (commercial banks, savings banks, or all banks); (iv) results for all years, pre-crisis and crisis years; (v) and results for efficient vs. inefficient banks.

All these results are reported in Tables 3, 4, and 5. Each table refers to the three periods and sub-periods considered (all, pre-crisis, and crisis years). Tables are divided into three panels referring to the type of constraint considered (unconstrained profit model in the upper panel, price-constrained profit model in the central panel, and quantity-constrained profit model in the lower panel). The different rows in each panel report results according to either manipulated or non-manipulated models, and also considering the different types of firms—all banks, commercial banks, and savings banks. Finally, the columns in each table report results for both efficient and inefficient units, as well as the percentage of efficient firms.

4.1. Unconstrained vs. price-constrained vs. quantity-constrained models

We provide summary statistics (mean and standard deviation) in each of the tables considered (Tables 3, 4, and 5). Comparing the three panels displayed in each of the tables, it is apparent that the quantity-constrained profit model (according to which banks can only optimize prices, with quantities fixed) yields more favorable results—i.e., the ROA lost due to inefficiencies is *lower* than both the unconstrained and the price-constrained models. This is a general result, robust to the different periods considered, types of firms, or either manipulated or non-manipulated models, implying that when banks are able to adjust their prices—on both on the costs and revenues sides—the amount of inefficiency decreases sharply.

According to the market prices, we are trying to improve profits through the changes in the quantities of inputs and outputs. The difference from the existent standard models (Färe et al., 1994) is that in our case prices appear in the restrictions while prices are not considered in the alternative definition and, therefore, the efforts are directed towards the physical quantities in order to maximize profits. In other words, the standard proposal (Färe et al., 1994) is appropriate when competitive markets exist, driving banking firms to be price-acceptant. However, when imperfect markets exist (as in the case of the Spanish banking sector), our proposed models (unconstrained, price-constrained, and quantity-constrained) contribute to disentangle the extent to which profit inefficiencies are caused by imperfect amounts of quantities or by sub-optimal output and input prices.

If we consider the decomposition by type of bank (commercial or savings), whose behavior is reported in the different rows in each table, the differences observed are indeed considerable. This is a robust result across the different models and sub-periods considered, although in some cases the differences are especially remarkable. For instance, for the price-constrained profit model (central panel in each table), the magnitude of the inefficiencies for savings banks is almost ten times that for commercial banks (see the central panel in Table 4). In contrast, in the case of the quantity-constrained profit model, the differences between the two types of bank are much less obvious—although they are still notable.

Although there could be multiple explanations for this difference, the specific literature on bank ownership and efficiency (Altunbaş et al., 2001), as well as the broader literature on ownership of banks (La Porta et al., 2002) have forcefully made the point that it could be relevant to banks' performance. In the case of Spanish banking, and in the particular case of savings banks, (Illueca et al., 2014) argue that the political ties of some board members might have affected the decision-making process in those firms. More specifically, the likely sources for initially inquiry into whether savings banks do actually maximize profits or not include the political causes resulting from boards with strong political ties, the inefficiencies deriving from an absence of market for corporate control, social corporate responsibility issues, or the cost of the geographic expansions carried out by these firms over more than fifteen years. These issues have been analyzed in detail by Crespí et al. (2004), García-Cestona and Surroca

(2008), Prior and Surroca (2006), Surroca and García-Cestona (2006), Illueca et al. (2009) and, more recently, Illueca et al. (2014).

Tables 4 and 5 extend the analysis in Table 3 to the two sub-periods considered, i.e., pre-crisis (1997–2007) and crisis years (2008–2010), respectively. It is apparent that the differences between commercial banks and savings banks were especially large during the pre-crisis (or expansion) years, especially in the case of the price-constrained profit model. However, during the crisis years, the differences have shrunk substantially, especially considering the quantity-constrained profit model, as shown by the lower panel in Table 5. There may be multiple reasons for this behavior, but they could be largely related to the recent restructuring which is markedly reshaping the Spanish banking industry, since most savings banks will ultimately be recast as full commercial banks—including in terms of type of ownership. In this regard, the geographic contraction policies (especially for those banks involved in mergers) and the greater difficulties facing members of savings banks' boards of directors who have specific political affiliations during the crisis years may be contributing to boost convergence between commercial banks and savings banks (Illueca et al., 2014).

4.2. Manipulated vs. non-manipulated models

As indicated above, Tables 3, 4, and 5 also provide also information split according to the way we controlled for risk, i.e., the manipulated earnings model, the non-manipulated short-run model, and the non-manipulated long-run model. Several features emerge, some of which are worth mentioning. First, the differences among the three models are modest. Despite specific statistical tests to analyze whether these differences are significant or not, the magnitude of the differences across the three types of models according to the way risk enters the models is rather limited compared with the differences found across the unconstrained, price-constrained and quantity-constrained profit models.

The magnitude of these differences is, on average, particularly low when considering the entire period (Table 3) and the pre-crisis years (Table 4). For instance, in the case of the price-constrained profit model for all years (Table 3), on average, the results are quite similar for all banks, commercial banks or savings banks; for example, in the case of savings banks the means are 1.3861, 1.3618 and 1.3697 for the manipulated earnings, non-manipulated short-run, and non-manipulated long-run model, respectively. In the case of commercial banks, and considering all banking firms jointly, the magnitude of the discrepancies is also very low.

However, there are slight differences for both the unconstrained and the quantity-constrained profit models (upper and lower panels in Tables 3 and 4). In the case of the unconstrained profit model, these differences are basically driven by savings banks' behavior which, contrary to what one might expect, is actually *more* inefficient in the case of the manipulated earnings model. This result is shown in the upper panels of Tables 3 and 4. It is also extended to the crisis years (Table 5), although for this particular period the magnitude of the differences is much lower compared to the previous period.

Yet for the quantity-constrained profit model (lower panel in Tables 3 and 4), the inefficiencies found are lower for the manipulated earnings model, and this behavior can also be extended to the crisis years (Table 5). Of particular note is the fact that whereas commercial banks' behavior for this quantity-constrained profit model is similar for both the pre-crisis and crisis years, in the case of savings banks the differences are remarkable, suggesting that the restructuring of the Spanish banking system is having a marked effect on the behavior of these financial institutions.

In these estimations, the manipulation of the accounting variables (both short-run and long-run models) does not change the overall picture. This situation can be illustrative of two very different situations. First, on average, the manipulation of the accounting variables has a reduced impact on the levels of profit efficiency. This does not imply that the worst performers would probably have incentives to manipulate their accounts, but this behavior does not have significant results on the averages corresponding to the sector. Second, it may well be that as the manipulation of the accounting information is important, we do not perceive any bias on the potential manipulators, as similar procedures are followed by both efficient and inefficient banks. Further research is needed to disentangle this in the near future.

4.3. Analyzing the significance of the differences found

We can also formally test for the statistical significance of differences between the results reported in Tables 3, 4 and 5. The results in these tables provide summary statistics of the results for the different profit models under consideration. In some cases (especially when comparing commercial banks with savings banks, or results for different time periods) the differences were notable. In others (especially when comparing the different ways to control for risk) the differences were negligible. In neither case, however, did we formally test for those differences.

We can follow some proposals such as Li (1996, 1999) or Fan and Ullah (1999), who proposed nonparametric tests to compare two unknown distributions that we may refer to as $f(x)$ and $g(x)$. Thus, we would be testing the null hypothesis that $H_0 : f(\cdot) = g(\cdot)$ against the alternative $H_1 : f(x) \neq g(x)$. In our particular case, these $f(x)$ vs. $g(x)$ comparisons would refer to the variety of models and contexts present inin Tables 3, 4 and 5.

Specifically, we consider two types of comparisons of distributions, namely, *contextual* and *across models*. In the former we refer to $f(x)$ and $g(x)$ distinguishing between commercial banks and savings banks, or between pre-crisis and crisis years. In the latter, we refer to $f(x)$ and $g(x)$ distinguishing between the variety of models considered.

Results are shown in Tables 6 and 7 for the contextual and across models comparisons, respectively. One of the main advantages of the proposals by Li (1996, 1999), or Fan and Ullah (1999), is that they do not actually test for differences between some summary statistics of the distributions of interest but for the entire distributions themselves, using kernel methods. The aspect, or shape, of these distribution is depicted in Figures 2 and 3. The results on the differences observed among the different densities depicted in the two figures are reported in Tables 6 and 7.

The results in Tables 6 and 7 generally corroborate the results presented in the preceding subsections. When comparing results for commercial banks vs. savings banks (upper panel in Table 6) the differences are statistically significant when the entire period or the pre-crisis years are considered. However, the differences are not significant during the crisis years, with the exception of the price-constrained profit model, for which the differences are significant, although only at the 10% significance level. In the lower panel of Table 6, results indicate whether the differences are significant when comparing the results for the pre-crisis and crisis years, and they turn out to be strongly significant, but for savings banks only. This result is robust across the range of models considered.

Table 7 provides results on formal testing for the differences across models. Results indicate that the differences are mostly non-significant when comparing the different ways to control or, more accurately, when comparing the manipulated earnings model with the non-manipulated earnings model—either short- or long-run. The bivariate kernel density functions, in which the different variables considered are the results for the different models, strongly corroborate this finding, as the probability mass is tightly concentrated along the 45-degree main diagonal (see Figures 4, 5 and 6). In contrast, when comparing the results for the market power models (Figures 7, 8 and 9), results differ sharply, as shown by the probability mass shifting clockwise, indicating marked differences in the results for the unconstrained, price-constrained and quantity-constrained profit models.

5. Conclusions

For more than two decades now the analysis of the efficiency and productivity of financial institutions has received a great deal of attention. The magnitude and length of the international financial crisis has afforded a new perspective on the available evidence, shifting the relevance of the aspects dealt with by this literature.

Some recent contributions have shown great interest in carefully defining banks' inputs and, more importantly (due to the difficulties in measuring them), outputs, among which we may highlight those by Basu et al. (2011), Colangelo and Inklaar (2012) or Diewert et al. (2012). In this article, we extend this relevant literature, although with more modest aims due to data limitations, to the specific analysis of how controlling for risk may influence the analysis of financial institutions' performance.

Controlling for risk is actually a major limitation in most studies of financial institutions' performance, mostly due to lack of data; however we try to fill this gap in the literature by providing a painstaking comparison of the results yielded by different earnings management models, namely, a naive model in which bank managers can "manipulate" the results compared with those provided by two accounting models in which loan loss provisions are estimated in the first stage and then plugged into the profit model in the second stage.

In this respect, another contribution of the paper is its presentation of a profit model in which banks can set prices non-competitively. This modeling is consistent with recent contributions that have found the existence of market power in some European banking industries such as the Spanish banking industry, on which we focus.

Results are explored from several perspectives. In general, they indicate that results for the manipulated and non-manipulated earnings model do not show marked differences—following some nonparametric tests, the differences found were not statistically significant. In contrast, these differences were notable for the different competitive models considered, when comparing commercial banks and savings banks, or when comparing results for either the pre-crisis or crisis years.

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Table 1: Definition of costs, revenues, inputs, outputs, and the associated prices

Revenues and costs		Outputs and inputs		Output and input prices	
Revenues, R	Definition	Output (quantity), y	Definition	Output price, r	Definition
R_1	Interest income (interest income on loans + other interest income)	y_1	Customer loans	r_1	Price corresponding to y_1
R_2	Other operating income	y_2	Other operating income	r_2	Price corresponding to y_2
Operating costs, VC, FC	Definition	Input (quantity), xv, xf	Definition	Input price, wv, wf	Definition
VC_1	Total interest expenses	xv_1	Loanable funds (=financial capital)	wv_1	$wv_1 = VC_1/xv_1$
VC_2	Personnel expenses	xv_2	Number of employees	wv_2	$wv_2 = VC_2/xv_2$
FC_1	Other operating expenses	xf_1	Fixed assets (=physical capital)	wf_1	$wf_1 = FC_1/xf_1$

Table 2: Definition of loan loss provisions, non-performing loans and the associated prices

Loan loss provisions, LLP	Definition	Non-performing loan (quantity), npl	Definition	Non-performing loan price, r	Definition
LLP	Loan loss provisions	npl	Loan loss provisions	wl_1	Price corresponding to loan loss provisions npl
$LLP + llp_1$	LLP+increase corresponding to the specific and generic provision	npl	Non-performing loans	wl_2	Price corresponding to loan loss provisions npl
$LLP + llp_2$	LLP+increase which also includes the counter-cyclical provision	npl	Non-performing loans	wl_2'	Price corresponding to loan loss provisions npl
$LLP + llp_1$ (predicted)	Predicted value for $LLP + llp_1$	npl	Non-performing loans	wl_3	Price corresponding to loan loss provisions npl
$LLP + llp_2$ (predicted)	Predicted value for $LLP + llp_2$	npl	Non-performing loans	wl_3'	Price corresponding to loan loss provisions npl

Table 3: Evaluation of profit efficiency, all years (1997–2010)

		All banks		Inefficient banks		% efficient
Unconstrained profit model						
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.7037	1.2621	1.8098	1.4476	61.1157
	Commercial banks	0.2300	0.7143	1.5142	1.1940	84.8123
	Savings banks	1.1423	1.4821	1.8781	1.4932	39.1785
Non-manipulated short-run model	All banks	0.6561	1.1441	1.6390	1.2882	59.9672
	Commercial banks	0.2245	0.6883	1.3425	1.1579	83.2765
	Savings banks	1.0557	1.3234	1.7135	1.3097	38.3886
Non-manipulated long-run model	All banks	0.6583	1.1616	1.6410	1.3235	59.8852
	Commercial banks	0.2304	0.6925	1.2985	1.1505	82.2526
	Savings banks	1.0544	1.3526	1.7336	1.3530	39.1785
Price-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.7993	1.5082	2.0909	1.8033	61.7719
	Commercial banks	0.1654	0.6098	1.1969	1.2123	86.1775
	Savings banks	1.3861	1.8227	2.2789	1.8514	39.1785
Non-manipulated short-run model	All banks	0.7838	1.4648	2.0372	1.7394	61.5258
	Commercial banks	0.1594	0.6044	1.1827	1.2305	86.5188
	Savings banks	1.3618	1.7610	2.2103	1.7771	38.3886
Non-manipulated long-run model	All banks	0.7890	1.4721	2.0334	1.7483	61.1977
	Commercial banks	0.1618	0.6068	1.1850	1.2242	86.3481
	Savings banks	1.3697	1.7701	2.2061	1.7893	37.9147
Quantity-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.4831	0.6292	1.0033	0.5479	51.8458
	Commercial banks	0.3482	0.6435	1.1728	0.6539	70.3072
	Savings banks	0.6080	0.5893	0.9319	0.4798	34.7551
Non-manipulated short-run model	All banks	0.5430	0.6918	1.1049	0.5940	50.8614
	Commercial banks	0.3930	0.7172	1.2867	0.7308	69.4539
	Savings banks	0.6817	0.6373	1.0275	0.5065	33.6493
Non-manipulated long-run model	All banks	0.5538	0.7019	1.1233	0.5994	50.6973
	Commercial banks	0.4060	0.7291	1.2931	0.7388	68.6007
	Savings banks	0.6906	0.6468	1.0484	0.5095	34.1232

Table 4: Evaluation of profit efficiency, pre-crisis years (1997–2007)

		All banks		Inefficient banks		% efficient
Unconstrained profit model						
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.7445	1.2444	1.7607	1.3688	57.7148
	Commercial banks	0.2367	0.7187	1.5090	1.1762	84.3137
	Savings banks	1.2484	1.4370	1.8178	1.4040	31.3230
Non-manipulated short-run model	All banks	0.7000	1.1360	1.6001	1.2289	56.2500
	Commercial banks	0.2321	0.6937	1.3154	1.1452	82.3529
	Savings banks	1.1643	1.2893	1.6717	1.2403	30.3502
Non-manipulated long-run model	All banks	0.6976	1.1424	1.5945	1.2463	56.2500
	Commercial banks	0.2366	0.6951	1.2835	1.1340	81.5686
	Savings banks	1.1551	1.3047	1.6771	1.2632	31.1284
Price-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.8299	1.4702	1.9948	1.6952	58.3984
	Commercial banks	0.1677	0.5925	1.1561	1.1355	85.4902
	Savings banks	1.4868	1.7589	2.1711	1.7413	31.5175
Non-manipulated short-run model	All banks	0.8202	1.4424	1.9533	1.6561	58.0078
	Commercial banks	0.1603	0.5810	1.1198	1.1389	85.6863
	Savings banks	1.4750	1.7179	2.1237	1.6944	30.5447
Non-manipulated long-run model	All banks	0.8260	1.4493	1.9444	1.6648	57.5195
	Commercial banks	0.1631	0.5865	1.1241	1.1417	85.4902
	Savings banks	1.4837	1.7254	2.1125	1.7060	29.7665
Quantity-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.5109	0.6356	1.0004	0.5489	48.9258
	Commercial banks	0.3485	0.6459	1.1693	0.6635	70.1961
	Savings banks	0.6721	0.5827	0.9312	0.4784	27.821
Non-manipulated short-run model	All banks	0.5678	0.6876	1.0908	0.5810	47.9492
	Commercial banks	0.3864	0.7043	1.2553	0.7216	69.2157
	Savings banks	0.7477	0.6210	1.0221	0.4963	26.8482
Non-manipulated long-run model	All banks	0.5775	0.6909	1.1012	0.5772	47.5586
	Commercial banks	0.3999	0.7154	1.2589	0.7278	68.2353
	Savings banks	0.7537	0.6177	1.0331	0.4837	27.0428

Table 5: Evaluation of profit efficiency, crisis years (2008–2010)

		All banks		Inefficient banks		% efficient
Unconstrained profit model						
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.4894	1.3339	2.3275	2.0602	78.9744
	Commercial banks	0.1848	0.6876	1.5601	1.4207	88.1579
	Savings banks	0.6839	1.5896	2.5433	2.1764	73.1092
Non-manipulated short-run model	All banks	0.4256	1.1613	2.0747	1.7888	79.4872
	Commercial banks	0.1734	0.6526	1.6478	1.3366	89.4737
	Savings banks	0.5866	1.3710	2.1814	1.8877	73.1092
Non-manipulated long-run model	All banks	0.4518	1.2403	2.1488	1.9296	78.9744
	Commercial banks	0.1894	0.6785	1.4393	1.3557	86.8421
	Savings banks	0.6194	1.4710	2.3776	2.0473	73.9496
Price-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.6388	1.6889	3.1142	2.5064	79.4872
	Commercial banks	0.1500	0.7199	1.6281	1.9161	90.7895
	Savings banks	0.9510	2.0268	3.4294	2.5263	72.2689
Non-manipulated short-run model	All banks	0.5924	1.5676	2.9620	2.3115	80.0000
	Commercial banks	0.1538	0.7473	1.9475	2.0455	92.1053
	Savings banks	0.8725	1.8661	3.1464	2.3373	72.2689
Non-manipulated long-run model	All banks	0.5949	1.5762	3.0527	2.3066	80.5128
	Commercial banks	0.1529	0.7330	1.9362	1.9789	92.1053
	Savings banks	0.8772	1.8806	3.2621	2.3307	73.1092
Quantity-constrained profit model						
		All banks		Inefficient banks		% efficient
		Mean	Std.dev.	Mean	Std.dev.	
Manipulated earnings model	All banks	0.3371	0.5742	1.0270	0.5435	67.1795
	Commercial banks	0.3466	0.6312	1.1974	0.5965	71.0526
	Savings banks	0.3310	0.5373	0.9378	0.4979	64.7059
Non-manipulated short-run model	All banks	0.4127	0.7009	1.2192	0.6841	66.1538
	Commercial banks	0.4373	0.8021	1.5107	0.7739	71.0526
	Savings banks	0.3969	0.6311	1.0735	0.5913	63.0252
Non-manipulated long-run model	All banks	0.4294	0.7466	1.3084	0.7402	67.1795
	Commercial banks	0.4473	0.8192	1.5452	0.7870	71.0526
	Savings banks	0.4180	0.6996	1.1844	0.6920	64.7059

Table 6: Distribution hypothesis tests (Li, 1996), context

			Unconstrained profit model			Price-constrained profit model			Quantity-constrained profit model		
			Manipulated earnings model	Non-manipulated short-run model	Non-manipulated long-run model	Manipulated earnings model	Non-manipulated short-run model	Non-manipulated long-run model	Manipulated earnings model	Non-manipulated short-run model	Non-manipulated long-run model
f(Commercial banks) = g(Savings banks)	All years	T-statistic	79.8544	82.5449	78.8027	92.5202	95.5660	95.7494	61.2968	62.7876	60.8816
		p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Pre-crisis	T-statistic	97.6865	102.2428	100.7372	110.0211	113.5227	115.1802	79.4832	80.2015	78.9394
		p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Crisis	T-statistic	0.7665	1.0095	0.5387	1.3674	1.4602	1.3141	-0.2343	0.1059	-0.0890
		p-value	0.2217	0.1564	0.2951	0.0858	0.0721	0.0944	0.5926	0.4578	0.5355
f(Pre-crisis) = g(Crisis years)	All banks	T-statistic	7.8143	10.0694	10.2150	7.6519	8.4404	9.2960	6.9663	7.0359	7.8898
		p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Commercial banks	T-statistic	-0.5793	-0.3413	-0.5143	-0.5230	-0.4726	-0.4223	-0.7068	-0.6655	-0.5287
		p-value	0.7188	0.6336	0.6965	0.6995	0.6818	0.6636	0.7602	0.7471	0.7015
	Savings banks	T-statistic	21.2829	22.3786	22.1329	20.5584	22.2176	23.3355	19.9471	20.1588	20.4850
		p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: the functions $f(\cdot)$ and $g(\cdot)$ are (kernel) distribution functions for each model being compared.

Table 7: Distribution hypothesis tests (Li, 1996), model

			All years			Pre-crisis years			Crisis years		
			All banks	Commercial banks	Savings banks	All banks	Commercial banks	Savings banks	All banks	Commercial banks	Savings banks
Unconstrained profit model	f(Manipulated earnings model) =	T-statistic	0.2417	0.0412	0.0548	0.2290	0.0564	0.0545	-0.0060	0.0018	-0.0427
	g(Non-manipulated short-run model)	p-value	0.4045	0.4836	0.4781	0.4094	0.4775	0.4783	0.5024	0.4993	0.5170
	f(Manipulated earnings model) =	T-statistic	0.1803	0.1960	0.1229	0.2939	0.2031	0.3513	-0.0074	-0.0087	-0.0194
	g(Non-manipulated long-run model)	p-value	0.4284	0.4223	0.4511	0.3844	0.4195	0.3627	0.5030	0.5035	0.5077
	f(Manipulated short-run model) =	T-statistic	0.0098	0.0311	0.2045	-0.0088	0.0029	0.1803	-0.0219	0.0127	-0.0290
	g(Non-manipulated long-run model)	p-value	0.4961	0.4876	0.4190	0.5035	0.4989	0.4285	0.5087	0.4949	0.5116
Price-constrained profit model	f(Manipulated earnings model) =	T-statistic	0.1011	-0.0353	0.1356	0.1268	-0.0446	0.1496	-0.0847	-0.0336	-0.0257
	g(Non-manipulated short-run model)	p-value	0.4597	0.5141	0.4461	0.4495	0.5178	0.4405	0.5337	0.5134	0.5102
	f(Manipulated earnings model) =	T-statistic	0.1464	-0.0287	0.1726	0.2128	-0.0291	0.2066	-0.0282	-0.0265	0.0296
	g(Non-manipulated long-run model)	p-value	0.4418	0.5114	0.4315	0.4157	0.5116	0.4182	0.5112	0.5106	0.4882
	f(Manipulated short-run model) =	T-statistic	0.0537	0.0130	-0.0240	0.0888	0.0190	-0.0092	0.0255	0.0000	0.0369
	g(Non-manipulated long-run model)	p-value	0.4786	0.4948	0.5096	0.4646	0.4924	0.5037	0.4898	0.5000	0.4853
Quantity-constrained profit model	f(Manipulated earnings model) =	T-statistic	0.5596	0.0203	1.1959	0.4995	0.0177	1.2681	0.1658	0.0116	0.1730
	g(Non-manipulated short-run model)	p-value	0.2879	0.4919	0.1159	0.3087	0.4929	0.1024	0.4341	0.4954	0.4313
	f(Manipulated earnings model) =	T-statistic	0.5248	0.0336	1.5420	0.5721	0.0780	1.8972	0.0151	-0.0111	0.0634
	g(Non-manipulated long-run model)	p-value	0.2998	0.4866	0.0615	0.2836	0.4689	0.0289	0.4940	0.5044	0.4747
	f(Manipulated short-run model) =	T-statistic	-0.2405	0.0573	-0.3249	-0.1672	0.0769	-0.2042	0.1489	0.1266	0.0350
	g(Non-manipulated long-run model)	p-value	0.5950	0.4771	0.6274	0.5664	0.4693	0.5809	0.4408	0.4496	0.4860

Notes: the functions $f(\cdot)$ and $g(\cdot)$ are (kernel) distribution functions for each model being compared.

Figure 1: Synthesis of the proposed evaluation models

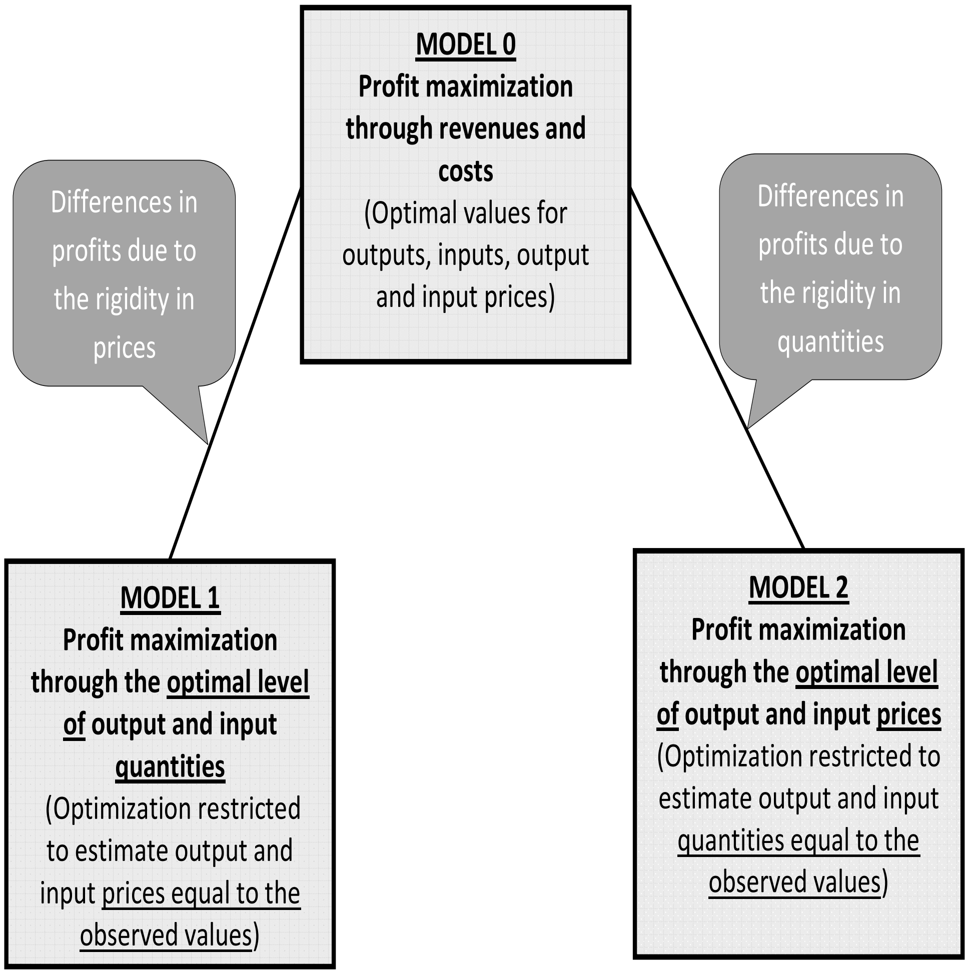
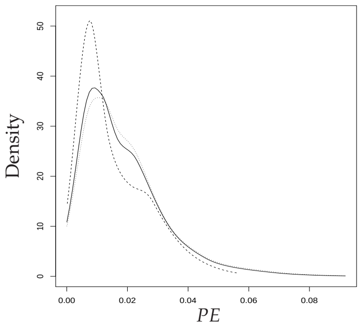
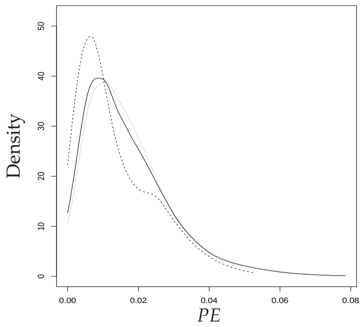


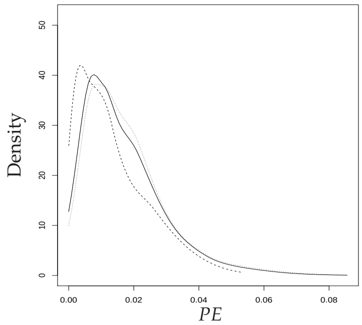
Figure 2: Kernel density plots, unconstrained, price-constrained and quantity-constrained profit models, by risk model



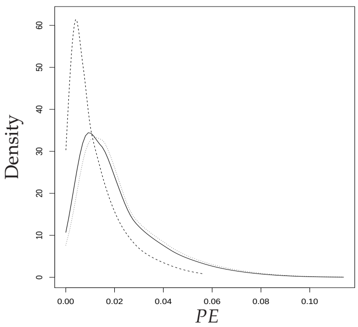
a) Unconstrained profit model/manipulated earnings model



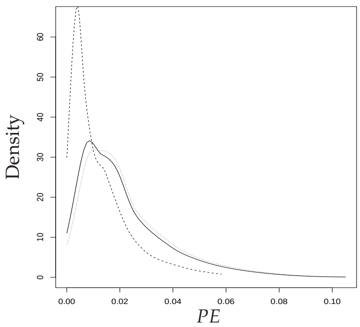
b) Unconstrained profit model/Non-manipulated short-run model



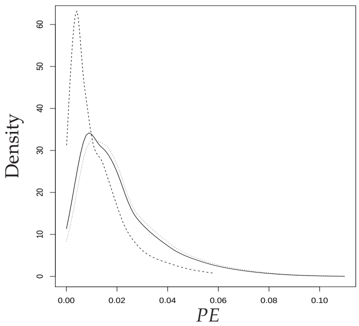
c) Unconstrained profit model/Non-manipulated long-run model



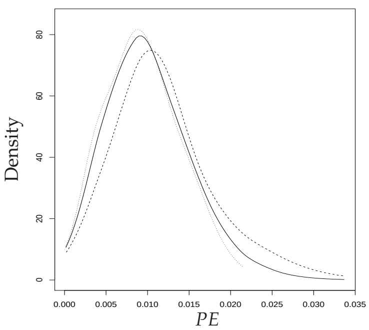
d) Price-constrained profit model/Manipulated earnings model



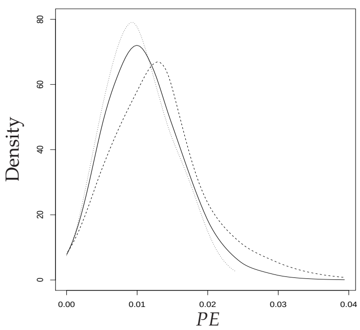
e) Price-constrained profit model/Non-manipulated short-run model



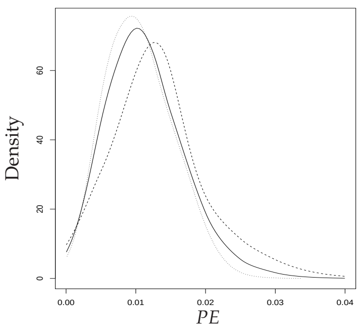
f) Price-constrained profit model/Non-manipulated long-run model



g) Quantity-constrained profit model/Manipulated earnings model



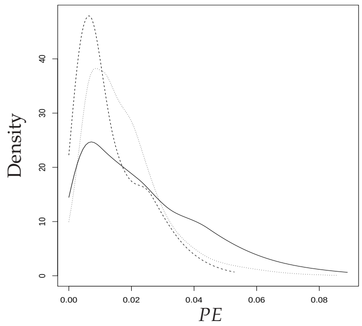
h) Quantity-constrained profit model/Non-manipulated short-run model



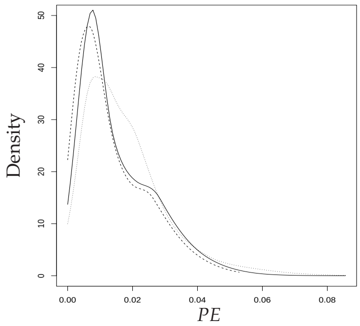
i) Quantity-constrained profit model/Non-manipulated long-run model

All banks ——— Commercial banks ------- Savings banks · · · · · ·

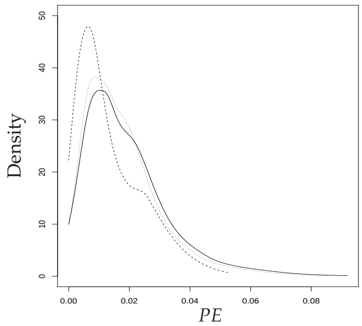
Figure 3: Kernel density plots, unconstrained, price-constrained and quantity-constrained profit models, by type of bank



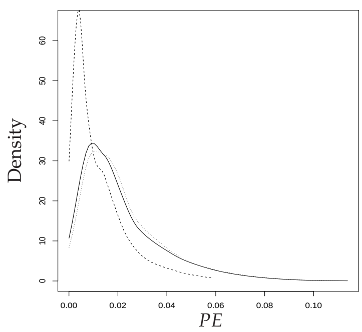
a) Unconstrained profit model, all banks



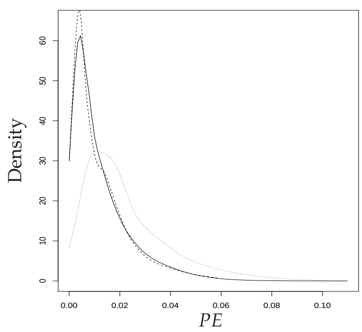
b) Unconstrained profit model, commercial banks



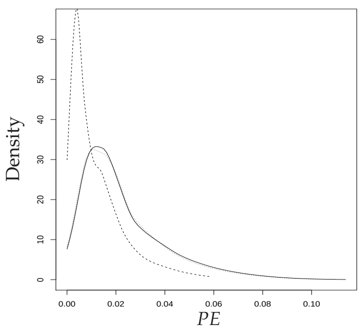
c) Unconstrained profit model, savings banks



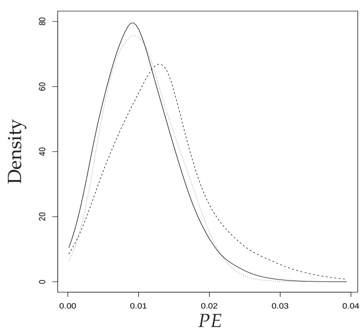
d) Price-constrained profit model, all banks



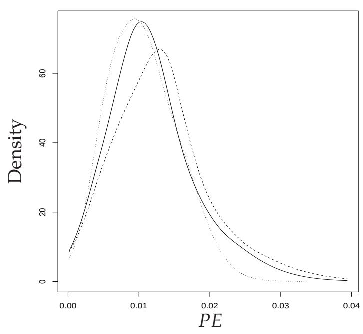
e) Price-constrained profit model, commercial banks



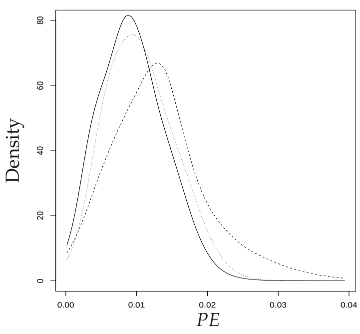
f) Price-constrained profit model, savings banks



g) Quantity-constrained profit model, all banks



h) Quantity-constrained profit model, commercial banks

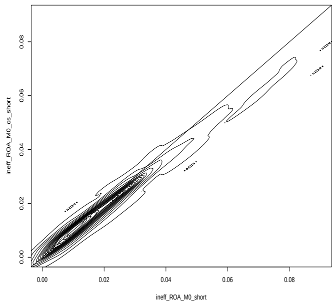


i) Quantity-constrained profit model, savings banks

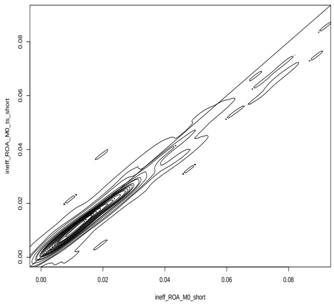
——— Manipulated earnings model
-------- Non-manipulated short-run model
· · · · · · · Non-manipulated long-run model

Figure 4: Transitions for the unconstrained profit model, manipulated earnings vs. non-manipulated (short- and long-run), contour plots

All banks

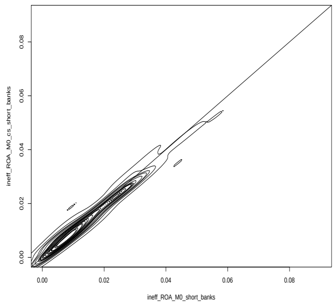


a) Manipulated earnings model vs. non-manipulated short-run model

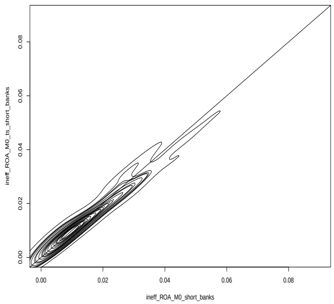


b) Manipulated earnings model vs. non-manipulated long-run model

Commercial banks

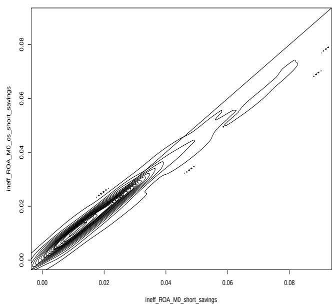


c) Manipulated earnings model vs. non-manipulated short-run model

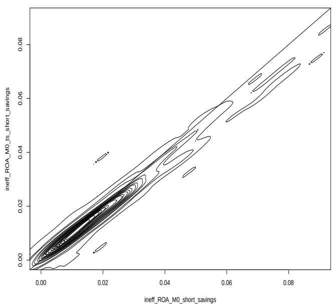


d) Manipulated earnings model vs. non-manipulated long-run model

Savings banks



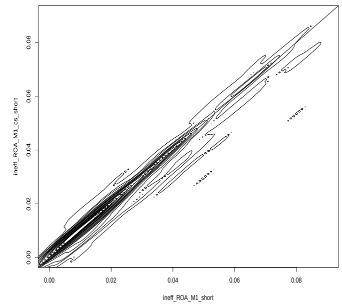
e) Manipulated earnings model vs. non-manipulated short-run model



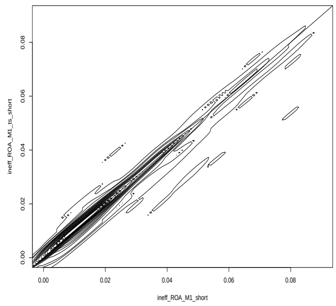
f) Manipulated earnings model vs. non-manipulated long-run model

Figure 5: Transitions for the price-constrained profit model, manipulated earnings vs. non-manipulated (short- and long-run), contour plots

All banks

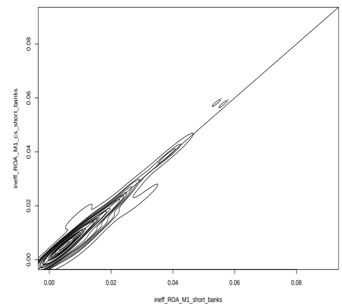


a) Manipulated earnings model vs. non-manipulated short-run model

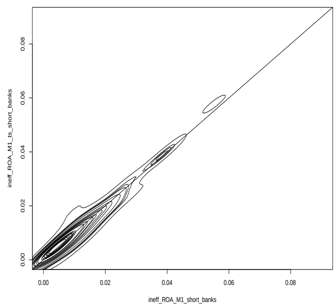


b) Manipulated earnings model vs. non-manipulated long-run model

Commercial banks

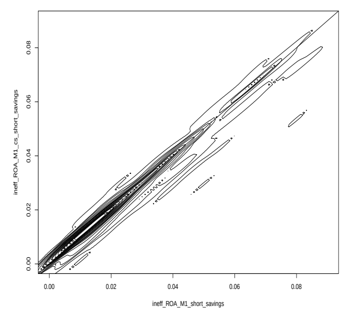


c) Manipulated earnings model vs. non-manipulated short-run model

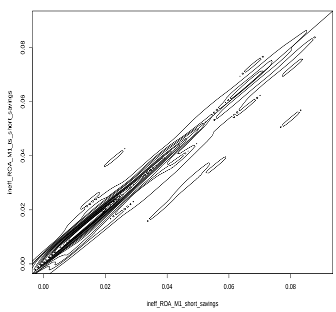


d) Manipulated earnings model vs. non-manipulated long-run model

Savings banks



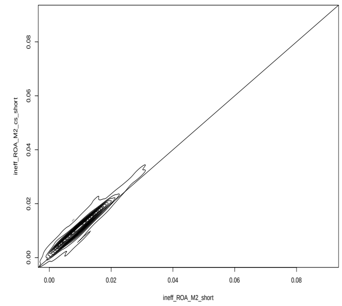
e) Manipulated earnings model vs. non-manipulated long-run model



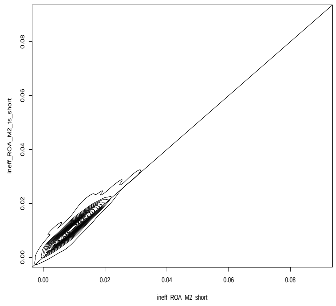
f) Manipulated earnings model vs. non-manipulated short-run model

Figure 6: Transitions for the quantity-constrained profit model, manipulated earnings vs. non-manipulated (short- and long-run), contour plots

All banks

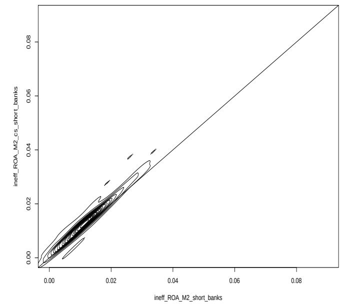


a) Manipulated earnings model vs. non-manipulated short-run model

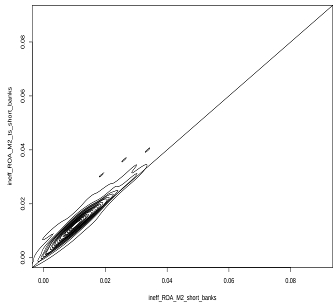


b) Manipulated earnings model vs. non-manipulated long-run model

Commercial banks

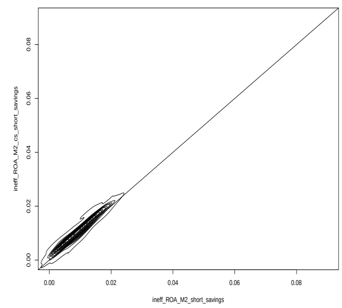


c) Manipulated earnings model vs. non-manipulated short-run model

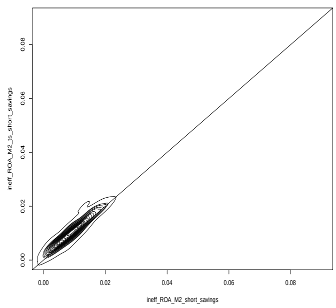


d) Manipulated earnings model vs. non-manipulated long-run model

Savings banks



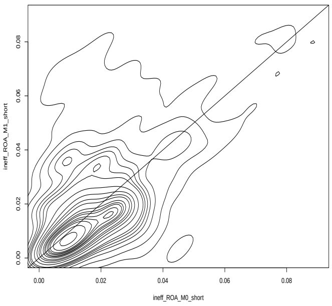
e) Manipulated earnings model vs. non-manipulated short-run model



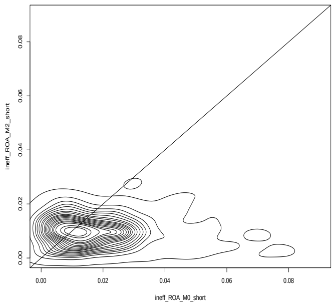
f) Manipulated earnings model vs. non-manipulated long-run model

Figure 7: Transitions across unconstrained/price-constrained/quantity-constrained profit model (manipulated earnings model), contour plots

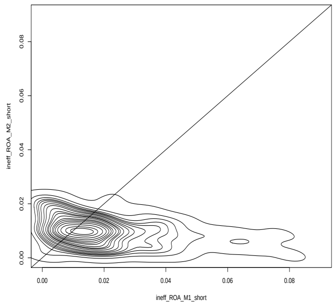
All banks



a) Unconstrained profit model vs. price-constrained profit model

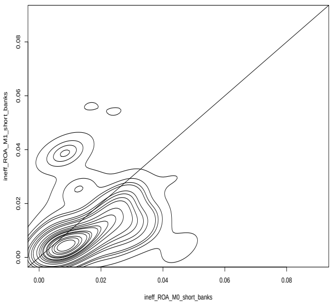


b) Unconstrained profit model vs. quantity-constrained profit model

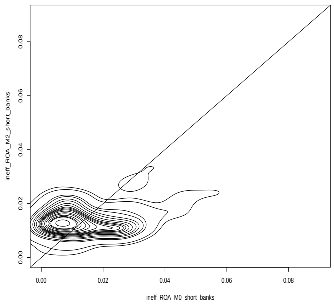


c) Price-constrained profit model vs. quantity-constrained profit model

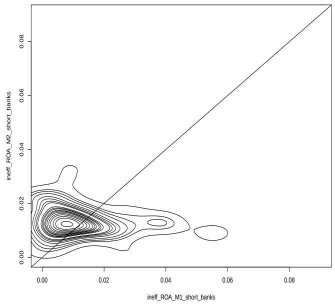
Commercial banks



d) Unconstrained profit model vs. price-constrained profit model

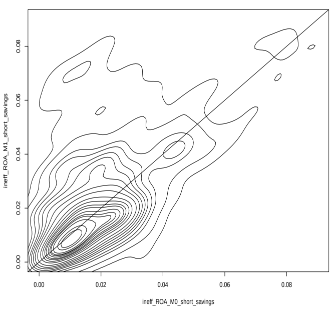


e) Unconstrained profit model vs. quantity-constrained profit model

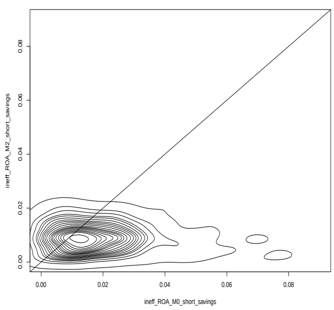


f) Price-constrained profit model vs. quantity-constrained profit model

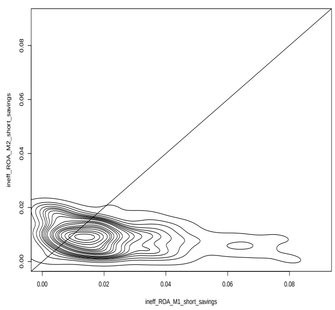
Savings banks



g) Unconstrained profit model vs. price-constrained profit model



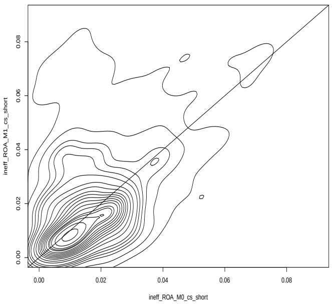
h) Unconstrained profit model vs. quantity-constrained profit model



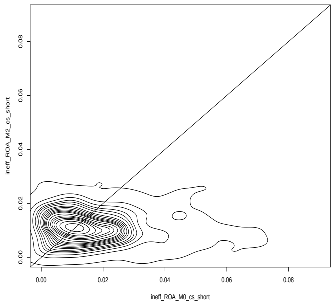
i) Price-constrained profit model vs. quantity-constrained profit model

Figure 8: Transitions across unconstrained/price-constrained/quantity-constrained profit model (non-manipulated short-run model), contour plots

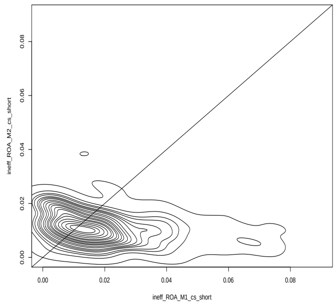
All banks



a) Unconstrained profit model vs. price-constrained profit model

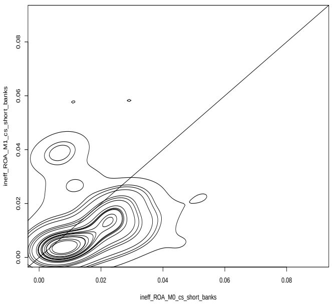


b) Unconstrained profit model vs. quantity-constrained profit model

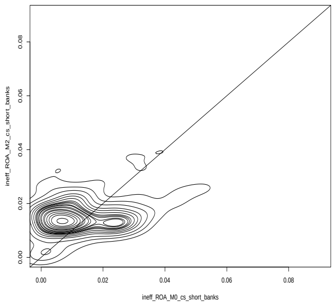


c) Price-constrained profit model vs. quantity-constrained profit model

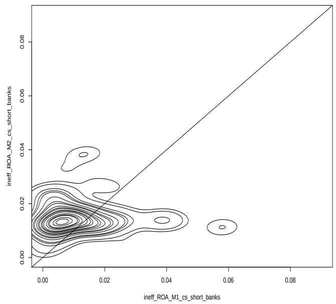
Commercial banks



d) Unconstrained profit model vs. price-constrained profit model

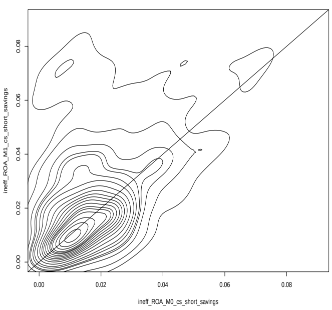


e) Unconstrained profit model vs. quantity-constrained profit model

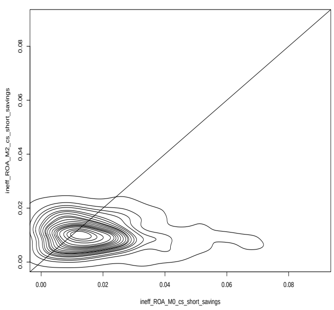


f) Price-constrained profit model vs. quantity-constrained profit model

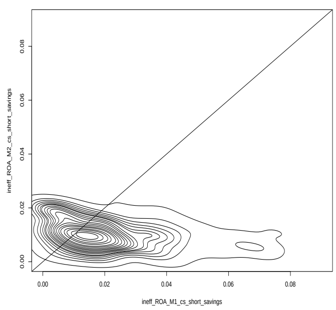
Savings banks



g) Unconstrained profit model vs. price-constrained profit model



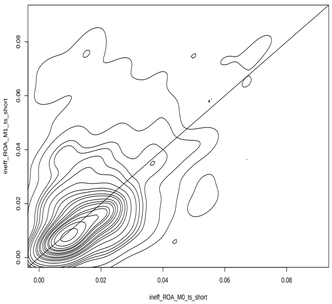
h) Unconstrained profit model vs. quantity-constrained profit model



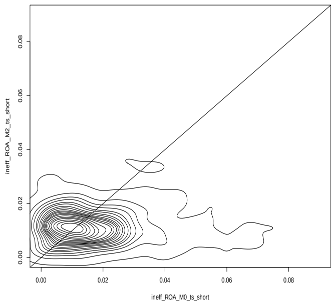
i) Price-constrained profit model vs. quantity-constrained profit model

Figure 9: Transitions across unconstrained/price-constrained/quantity-constrained profit model (non-manipulated long-run model), contour plots

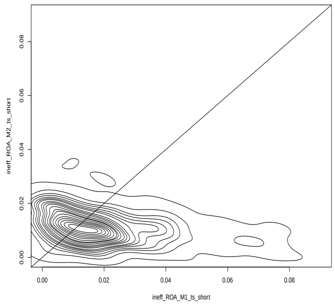
All banks



a) Unconstrained profit model vs. price-constrained profit model

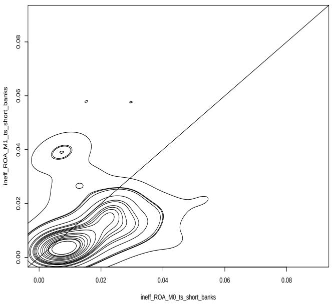


b) Unconstrained profit model vs. quantity-constrained profit model

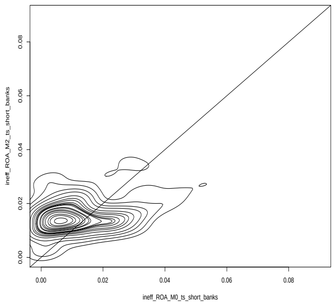


c) Price-constrained profit model vs. quantity-constrained profit model

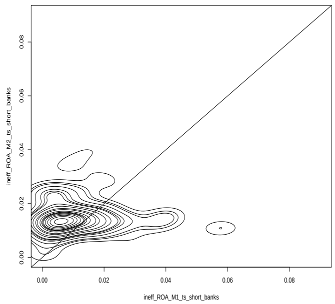
Commercial banks



d) Unconstrained profit model vs. price-constrained profit model

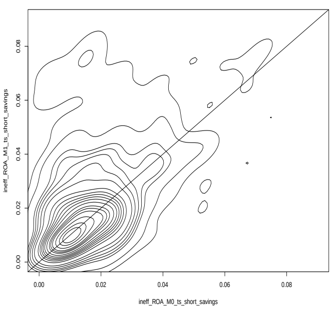


e) Unconstrained profit model vs. quantity-constrained profit model

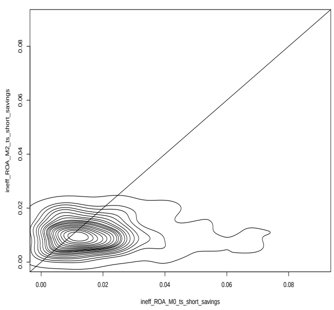


f) Price-constrained profit model vs. quantity-constrained profit model

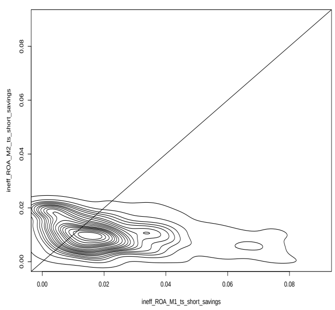
Savings banks



g) Unconstrained profit model vs. price-constrained profit model



h) Unconstrained profit model vs. quantity-constrained profit model



i) Price-constrained profit model vs. quantity-constrained profit model

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