J Regul Econ (2008) 33:253–282
DOI 10.1007/s11149-007-9041-0

ORIGINAL ARTICLE

Regulation and efficiency in transition: the case of Romanian banks

Gabriel Asaftei · Subal C. Kumbhakar

Published online: 30 October 2007

Abstract Using disaggregated panel data for the period 1996–2002, this paper estimates the cost efficiency of Romanian banks and relates it to regulation implemented by the National Bank of Romania. We estimate efficiency using a model that combines the frameworks of both stochastic frontier analysis and shadow cost functions. Our results indicate that, for all types of banks, the cost of technical inefficiency decreases in the years following tightening of regulation. A significant part of this decrease can be attributed to the policy change. Overall, the short-run increase in cost due to additional regulation exceeds the benefits from reduced technical inefficiency. However, our model does not account for other benefits, besides changes in X-inefficiency, such as stability of the banking system, which may be significant.

Keywords Allocative distortions · Technical efficiency · Stochastic frontier · Shadow cost function · Regulation · Transitional economies

JEL Classifications G21 · G28 · P34

1 Introduction

Transition economies offer a unique opportunity to study the impact of various policy changes on efficiency. When an economy changes its course from a planned economy and moves towards a market economy, allocation of resources is greatly affected by

G. Asaftei
Department of Economics, University of Richmond, Richmond, VA 23179, USA
e-mail: gasaftei@richmond.edu

S. C. Kumbhakar (✉)
Department of Economics, State University of New York, Binghamton, NY 13902, USA
e-mail: kkar@binghamton.edu

frequent changes in regulation, competition from abroad, foreign direct investment, restructuring and privatizations, etc. If the economy quickly develops institutions that are conducive to proper functioning of the market economy, the path towards the market economy is likely to be smooth and fast converging. An important aspect of resource allocation that is not addressed in the efficiency literature is whether regulatory changes affect both technical and allocative efficiency of producers. Regulations that help create a better business environment often decrease transaction costs and help managers to become more efficient technically. On the other hand, regulations impose constraints that are likely to lead to inefficiency in the allocation of resources. Thus, from a policy point of view it is important to examine both technical and allocative inefficiencies and their behavior after regulatory changes.

Banking is undoubtedly one of the most regulated industries in the world. Because governments provide some sort of safety net for the banking system, whether is implicit or explicit, they need to limit the moral hazard and the adverse selection this safety net creates. To a large degree, the role played by bank regulators is analogous to that of writing and monitoring debt covenants for depositors, whose debt is not protected by standard covenants (DeYoung et al. 2001). Safety and soundness covenants, such as minimum capital ratios and loan concentration limits, constrain banks' portfolios. When these safety and soundness covenants become binding, regulators can enforce remedial covenants, such as restricting asset growth (output mix) or raising additional equity capital (input mix), that constrain production of bank output further. Because regulatory covenant enforcement generate benefits but also impose substantial costs on banks, the regulation burden must be carefully administered. Prudential regulation is even more critical in emerging economies. Inadequate prudential regulation has led to severe problems in these countries, leading to severe currency and financial crises (Mishkin 1999; Corsetti et al. 1998).

In this paper, we study the effect of regulatory changes on X-efficiency for a transitional economy. In particular, we estimate the effects of regulation initiated by the National Bank of Romania on efficiency of individual banks for the period 1996–2002. Motivated by concerns over the solvency of the banking industry in 1998–1999, the central bank drastically tightened regulation (e.g., increased required reserves for demand deposits, capital adequacy ratios, the frequency of reporting and on-site auditing, introduced a deposit insurance fee for the newly established Deposit Guarantee Fund) and initiated new bank legislation regarding risk management. Some of these policies were beneficial for individual banks' management and the banking industry as a whole. For example, restricting banks to engage in certain businesses reduces banks' overexposure to risky assets, which may have improved the risk-adjusted allocation of resources. Similarly, the policy of restructuring insolvent banks and enforcement of some prudential regulation increased the stability of the banking system. These policies may have also made banks more efficient indirectly by imposing a set of best practices for all banks in the system. However, as Hughes and Mester (1993) point out, it is also possible that new regulations such as raising capital adequacy are likely to force a bank to use more financial capital than it would use in an unregulated environment. Similarly, an increase of required reserves raises the opportunity cost of deposits and acts as a tax on the price of deposits. As a result, the cost of producing a given level of output will be higher.

A large number of X-efficiency studies for transition economies focus on the relationship between ownership and bank efficiency in a series of single-country and of multi-country studies.[1] While previous studies of bank efficiency examine factors that are associated with higher X-efficiency across banks and across countries, few of them study the impact of government policy on efficiency. Some of the previous banking efficiency studies for developed and developing economies focus on the effects of deregulation (e.g., Kumbhakar and Sarkar 2003; Kumbhakar and Lozano-Vivas 2005; Berger and Mester 2003; Humphrey and Pulley 1997; Bauer et al. 1993). Barth et al. (2004) examine the relationship between bank regulation and banking industry development. For transitional economies, Grigorian and Manole (2006) use Data Envelopment Analysis to estimate bank efficiency and its relationship to policy changes in seventeen Eastern European countries from 1995 to 1998. These authors find some weak evidence that improving prudential rules is associated with greater efficiency. Our methodology is somewhat similar to Granderson and Linvill (2002), who studied the relationship between regulation and efficiency for a panel of natural gas pipeline companies.

Our paper differs from the previous studies on transition economies in several ways. First, our sample covers approximately 70% of total banking assets, which makes it the most comprehensive database on the Romanian banking system so far. It also covers a longer period, which allows us to study the effects of policy change. Second, the focus of abovementioned studies was either technical or allocative inefficiency, not both. Kumbhakar and Wang (2006) show that ignoring allocative distortions and use of a single equation cost function results in inconsistent parameter estimates, and biased estimates of the cost of inefficiency. We use a system approach that allows us to disentangle the costs of technical and allocative inefficiencies. The modeling approach combines the stochastic cost frontier and the shadow cost function techniques. The novelty of this approach is that we incorporate correlation between technical and allocative inefficiencies through some common variables that explain both, thereby allowing them to be correlated. The Romanian banking sector and the econometric technique employed gives us a unique opportunity to examine the positive and negative

[1] Kraft and Tirtiroglu (1998) studied Croatian banks in 1994 and 1995 and found that new banks are less efficient but more profitable than both old privatized banks and state banks. Jemric and Vujcic (2002) used data for Croatia from 1995 to 2000 and found that foreign banks and new banks are more efficient. Nikiel and Opiela (2002) studied Polish banks from 1997 to 2000 and found that foreign banks servicing foreigners and business customers are more cost-efficient but less profit-efficient than other banks. Havrylchyk (2006) found that foreign banks servicing foreigners and business customers are more cost-efficient but less profit-efficient than other banks in Poland. Weill (2003) covered both the Czech Republic and Poland. Hasan and Marton (2003) found that for Hungary during 1993 to 1998 relatively more efficient foreign banks created an environment that forced the entire banking system to become more efficient. Matousek and Taci (2002) studied the Czech Republic. Yildirim and Philippatos (2002, unpublished paper) used data from 12 transition countries from 1993 to 2000 found that foreign majority owned banks are more cost efficient but less profit efficient than other banks in these transition countries. Fries and Taci (2005) used data for 11 countries and found that costs are lower in countries where foreign owned banks have a large share of assets. Bonin et al. (2005) did a comparison analysis of 11 transition economies and found that foreign-owned banks are more cost-efficient than other banks and that they also provide better service, in particular if they have a strategic foreign owner. Fries and Taci (2005) studied fifteen Eastern European countries and found that banking systems with a large foreign presence have higher cost efficiency.

effects of regulations on X-efficiency, which to our knowledge has not been addressed in the literature in this fashion.[2]

Overall, our results of the cost of technical inefficiency are similar in magnitude with those reported in the previous literature for transitional economies (e.g., Grigorian and Manole 2006; Fries and Taci 2005; Bonin et al. 2005). Moreover, we find that across all banks, the mean cost of technical inefficiency decreased from 41% in pre-regulation period to 21% in the post-regulation period. This decrease (20 basis points) is the result of policy change (15 basis points), managerial improvements (2 basis points) and changes in ownership and other factors. Since the total cost increase due to allocative distortions is 19% for the period 2000–2002, we could say that while the policy change was successful at reducing the cost of technical inefficiency, this benefit was exceeded by the short run cost induced by the distortionary policy. However, our study does not account for other benefits, besides changes in X-inefficiency, such as stability of the banking system, which might be significant.

The rest of the paper is organized as follows. In Sect. 2 we illustrate the relationship between regulation and X-inefficiency. Section 3 describes the development of the Romanian banking sector. The econometric model is discussed in Sect. 4, followed by a description of the data in Sect. 5. Section. 6 reports the results and Sect. 7 concludes the paper.

2 Regulation and X-inefficiency

Leibenstein (1966) introduces the concept of X-inefficiency and points out that, for various reasons, firms do not operate on the outer-boundary of their production possibility frontier. Commonly identified with X-inefficiency, Farrell (1957) measure of total economic inefficiency consists of two components: technical inefficiency and allocative inefficiency. The technical inefficiency can be further decomposed into a pure technical and a scale inefficiency component (Fare et al. 1985). Formally, technical inefficiency can be defined either as the percentage by which all inputs are overused (cost is increased) to produce a given level of outputs (input-oriented approach) or the percentage by which output is reduced (compared to the maximum possible output) given a vector of inputs (output-oriented approach). Allocative inefficiency reflects the bank's inability to use inputs in optimal proportions (consistent with cost minimization or profit maximization) given their respective prices. Allocative distortions arise when observed input price ratios differ from their effective/shadow price ratios due to the presence of external constraints (e.g., new regulations). These price distortions result in misallocation of resources, which in turn leads to an increase in cost. Since both allocative inefficiency (inability on the part of the producers to use inputs optimally given input prices) and allocative distortions (misallocation due to divergence of actual and effective prices) lead to non-optimal use of inputs and therefore increase cost, we are not separating

[2] Given the substantial regulatory and structural changes during the sample period, it is very likely that the credit markets in Romania were in a state of disequilibrium. However, the methodology employed in this paper does not require the assumption of equilibrium. Our findings and conclusion are therefore not affected by the lack of equilibrium.

these two. Thus, cost can be higher due to technical as well as allocative inefficiency/distortions, and it is desirable to estimate both of these components.

The departure of firms from the optimal production point could be the result of agency issues, managerial slack, technical incompetence, market structure, distortionary government policies, etc., which will be reflected in the measures of economic efficiency discussed above. While factors explaining X-inefficiency have been discussed in the literature (e.g., Hughes et al. 2003), the relationship between bank regulation and X-efficiency, to our knowledge, has not been summarized in one place. X-efficiency may be affected by regulation since prudential regulation aimed at preventing excessive risk taking behavior involves placing constraining limits on bank activity. This in turn affects bank production and resource allocation, and therefore impacts the measures of firm's efficiency mentioned above.

Due to the central role of the banking system in the economy, most governments set up some form of safety net (e.g., deposit insurance) to prevent systemic crises. However, governments also take some steps to limit the moral hazard and adverse selection that the safety net creates. Regulators monitor and constrain bank risk-taking, place limits on banks' investment activities and production plans, and have the power to remove bank officers and revoke bank charters. The regulatory process is analogous to writing debt covenants on behalf of demandable debt holders and to enforcing these covenants when they become binding. Mishkin (2000) groups prudential regulation into: (i) restrictions on asset holding and activities, (ii) separation of banking and other financial industries like securities, insurance or real estate, (iii) regulation of competition, (iv) capital requirements, (v) risk-based deposits insurance premiums, (vi) disclosure requirements, (vii) bank chartering, (viii) bank examinations, and (ix) a supervisory versus a regulatory approach.

Some of these prudential regulation instruments can have a positive effect on X-efficiency. Regulation could generate a diffusion of the best practices among all banks in the system. Management practices or characteristics that are found to be relatively common among best managed financial institutions may be identified as 'best practices' and could be adopted as a set of prudential regulation. Some of the prudential regulations such as restrictions on asset holding and activities, maximum exposure to a single borrower or separation of banking from other financial industries may affect output-oriented technical efficiency by limiting the amount of loans a bank can produce. By promoting regulations, which reduces banks' overexposure to risky assets, regulators may improve the risk-adjusted output portfolio and therefore enhance allocative efficiency.

Cost X-efficiency may also be improved if regulation reduces the perceived risk profile of banks. Banks with large amounts of nonperforming loans incur higher labor expenses (to negotiate terms of refinancing, manage repossessed physical assets, etc.) and higher funding costs (premiums to offset higher default risk). When nonperforming loans result from lax underwriting or monitoring, these expenses are clearly examples of X-inefficiency. However, when nonperforming loans are caused by an economic downturn, these expenses are beyond the control of management and should not be included as X-inefficiency (DeYoung 1998). Capital regulations may affect output-oriented efficiency by preventing some banks from achieving their highest potential value through increased leverage. Regulatory restrictions on capital adequacy may

also affect allocative efficiency of the banking system by preventing high-leverage banks from fully exploiting the potentially mispriced insured deposits safety net.

Other prudential regulation such as regulation of competition may increase managerial effort (e.g., Schmidt 1997). Bank management seeking a quiet life may choose to adopt lower risk projects (Berger and Hannan 1998), or operate at lower levels of cost efficiency. Some studies (e.g., DeYoung et al. 1998; Hughes et al. 1999) suggest that the competition induced by deregulation has provided banks with an incentive to operate more efficiently. Other studies (Keeley 1990; Kwan and Eisenbeis 1996) however, point out that increased competition can also increase banks' incentives to take risk, which can potentially threaten the safety of banks and the payments system. Related to managerial discipline implied by competition, prudential regulation on bank chartering may affect X-efficiency as well. Typically, a bank's charter value is proxied by its franchise value (the value produced by its current owners and managers). High standards for maintaining a bank's charter may encourage bank's managers to reduce X-inefficiency. Branching regulatory restrictions may prevent banks from operating as efficiently as possible. Evanoff and Israilevich (1991) found for the US that X-inefficiency in large banks is greater in regions characterized by more restrictive state level regulation and also that X-inefficiency in these banks decreased after the financial deregulation of the early 1980s.

Prudential regulation enforcement and bank examinations are an integral part of monitoring and enforcing regulatory covenants. When supervisors can gauge the efficiency of banks' risk-taking and impose higher expected distress costs on inefficient risk-takers, they give ineffective banks an incentive to become more efficient by constraining their risk-adjusted portfolios. Supervisors will respond to poor performance by enforcing remedial covenants.

On the other hand, some regulation may distort output/input prices and therefore have negative effects on technical and allocative efficiency. Over-restrictive capital requirements may reduce the volume of financial intermediation (Berger et al. 1995). Chiuri et al. (2002) examine the effects of capital asset requirements (CARs) enforcement in emerging economies. They obtain three major results (1) CARs enforcements significantly trimmed credit supply, particularly at less-well capitalized banks; (2) the negative impact has been larger for countries enforcing CARs in the aftermath of a currency/financial crisis; (3) the adverse impact of CARs has been somewhat smaller for foreign-owned banks, suggesting that opening up to foreign investors may have partly shielded the domestic banking sector from negative shocks. Moreover, higher CARs may result in a perverse risk-shifting pattern, by which banks may move along the efficiency frontier towards more profitable but riskier loans in order to finance new and higher capital requirements. Other types of regulation such as increases in required reserve ratios and deposit insurance premiums raise the effective price of deposits and determine a reallocation in the resource mix of banks. Moreover, insurance premiums that are not risk-adjusted may enhance the moral hazard problem generated by the safety net, affecting the allocative efficiency of the entire banking system.

3 Banking in Romania

Romania started its transition towards market economy much later than other Eastern European countries. Unlike the other countries in the region there had been practically no attempts to reform the Romanian economy before 1990. The state of the Romanian economy in 1990 spoke of its arrested development during the most restrictive regime in the communist block. The structure of the industry was skewed towards energy-intensive heavy industry such as machine building, metallurgy and chemicals at the expense of consumer goods industries. In the beginning of the transition toward a market-based economy, the government eliminated all the rules and constraints of the old system and gradually started to develop the institutional framework needed for a functioning market economy. In the absence of private sector monitoring of banks, the National Bank of Romania (NBR) assumed the role of establishing the regulatory framework and supervision need for the stability of the banking sector.

Table 1 reports the composition and the evolution of the Romanian banking system for the period 1996–2002. Until 1999 a small number of state-owned banks dominated the banking industry, holding 75% of total industry assets. The sharp deterioration of the financial situation of two state-owned banks and two banks with domestic private capital in 1998–1999 prompted a tightening of regulation and bank restructuring. Despite these restructuring measures, several banks with fragile financial standing generally caused by mismanagement and risky practices still existed.[3] For these banks, the NBR undertook a series of measures such as limitation of bank operations, interdiction or limitation to collect new household deposits and required these banks to submit recovery plans and report on the progress of their implementation.

Appendix 1 reports a summary of regulatory development in Romania for the period 1990–2002. The year 1999 marks a major policy shift. The NBR was granted independence a year before and was given more supervision and regulatory powers. As a result, the NBR was engaged in a comprehensive enhancement of the regulatory process and restructuring of the banking industry. New prudential regulations have been introduced, and provisioning regulations have been strengthened. For example, required reserves for demand deposits were increases from an average of 13% in 1998 to 19% in 1999 and to 30% in 2000; banks were required to increase their minimum registered capital and the capital adequacy ratio was raised from 8% to 12% in 1998; all banks were required to pay deposit insurance fees for the newly established Deposit Guarantee Fund; new prudential rules regarding provisioning and limits on lending to a single borrower were designed and implemented; new legislation gave NBR the enhanced powers to conduct a more effective banking supervision and initiate prompt corrective measures which was materialized in increased frequency of reporting and on-site auditing. An examination manual consistent with international best practices was completed, and inspections were being conducted using Capital Asset Management Profitability and Liquidity (*CAMPL*) ratings.

As a result of the regulatory and restructuring efforts of the NBR, the health of the banking system started to improve after 1999. The industry share of loans and interest

[3] Annual Report of the National Bank of Romania, 1999 p. 358.

Table 1 Composition of sample of Romanian banks

Variable	Units	1996	1997	1998	1999	2000	2001	2002
Number of banks	#	22	27	26	28	29	29	25
State-owned	#	6	6	6	3	2	2	2
Private	#	6	8	8	6	6	4	2
Foreign	#	7	9	9	14	14	17	17
Representative offices	#	3	4	3	5	7	6	4
Total assets	billion USD	8.9	10.1	10.3	8.3	6.9	9.0	11.4
State-owned	%	83.9	78.9	74.8	47.4	42.2	40.2	40.4
Private	%	7.0	4.8	6.0	4.5	3.7	3.2	2.6
Foreign	%	7.4	11.0	15.3	41.6	44.0	47.9	50.2
Representative offices	%	1.8	5.4	3.9	6.5	10.1	8.8	6.8

Note: State-owned includes banks with state participation more than 50%. Private includes banks that were in private hands at a given time period. They include de novo and privatized enterprises. Foreign includes branches of foreign banks in which the foreign investor holds at least 50%. The representative offices are banks operating in Romania and serving as a liaison and marketing function for the parent bank. From a legal perspective, a representative office cannot commit to any contractual engagements in its own name but acts as a loan production office, generating loan business for its parent bank at home. From a loan production perspective, however, they act as any other commercial bank

listed as "doubtful" and "loss" in total loan portfolios decreased from 35.4% in 1999 to 2.5% in 2001 and 1.1% in 2002. The industry "doubtful" and "overdue" claims (net value) to equity decreased from 253.6% in 1998 to 2.66% in 2001 and 1.97% in 2002. Moreover, looking at the consolidated balance sheet of the banking system we see a gradual improvement in the quality of the loan portfolio starting with 2000. With the privatization of two large state-owned banks (BRD and Banc Post) in 1999 as well as with the liquidation and transfer of the viable assets from the largest state-owned bank (Bancorex) to another large state-owned bank (BCR), the share of total assets held by state-owned banks fell from 75% in 1998 to 47% in 1999 while the share of assets held by foreign banks increased from 15% in 1998 to 42% in 1999. This year also marks the entry of large multinational banks. The entry increased competition in banking business and decreased the share (and influence) of domestic banks in their lending and borrowing activities. Although the composition of the banking industry changed, the banking industry in 2002 was still dominated by a small number of large banks. For example, the top five banks in terms of total assets controlled 63% of total deposits at the end of 2002.

While these restructuring and regulatory measures helped to improve the stability of the banking industry, it was not without costly side effects. Increase in required reserve ratios raised the effective price of deposits, while higher capital requirements may have reduced the volume of financial intermediation (Berger et al. 1995). The new capital requirements were imposed at a time when the typical bank experienced a decrease in the internal capital generation rate and an increase in the growth rate of assets. Since the capital market in Romania is still in its infancy, most domestic banks had to rely on their internal sources to generate new capital. While the state-owned banks were periodically recapitalized by the central bank and the large foreign banks used their parent company

to meet the capital requirements, most of the domestic private banks had to restrict the growth of their assets to meet the new capital requirements set by the NBR. Some of these measures may have restricted the quantity of credit. At the beginning of the transition period, Romania had a ratio of lending to GDP of 67%, comparable with other transitional economies. In 2002 this ratio was the lowest among Eastern-European economies standing at 14%, well below the average of 45% for its peers.

In summary, the evolution of the Romanian economy and banking system until 1999 is characterized by the following: (1) inadequate restructuring and weak corporate governance in both enterprises and banks, missing and incomplete markets and institutions that contributed to a perpetuation of inefficiencies in both the corporate and banking sector; (2) mismanagement and "improper credit policy led by some bank managers, ranging from incompetence to fraud";[4] (3) state-owned banks captivity to lending to some loss-making state-owned enterprises; (4) lack of judicial tools to implement the liquidation procedures and execution of bank's guarantees; (5) legislation favoring debtors and (6) lack of liquid market for the sale of assets backing the loans granted by banks. After 1999, although some of the problems mentioned above still persisted, there were several improvements in the Romanian economy and banking industry: (a) increased pace of privatization and restructuring of state-owned companies as well as banks, (b) increased competition among banks; (c) improvement in the general state of the economy and (d) increased regulatory and supervisory powers of the NBR.

4 Econometric model

To estimate the cost of technical inefficiency, we use a cost minimization framework with multiple-output and multiple-input technology (Kumbhakar 1996). We assume that the inputs are *nonallocable,* meaning that one observes the quantities of inputs used in the production process instead of quantities of each input allocated to a particular output. We use a radial measure of technical inefficiency, which is defined as the maximum rate ($\lambda \geq 0$) at which all the inputs can be reduced without reducing the output vector.[5] However, if input markets are competitive but firms face constraints due to government regulations then they must include these additional constraints in their optimization decisions:

$$\begin{aligned} &\text{minimize } C{=}W'X \\ &\text{s.t.} F(Y, X \cdot e^{-\lambda}, Z, t) = 0 \\ &\text{and} \quad R_s(Y, X \cdot e^{-\lambda}, W, Z, t) = 0, \quad s = 1, \ldots, S \end{aligned}$$

[4] Annual Reports of the National Bank of Romania, 1999, p. 357.

[5] This is referred to as the input-oriented (IO) measure. The IO measure is almost universally used to study technical inefficiency in banking as well as other service oriented industries. In using the IO measure one assumes that outputs are demand determined and therefore exogenously given (which is the case for the services provided by the banks). Unlike manufacturing firms excess outputs for banks cannot be stored. Like electricity, telephone and other services, the objective of the bank is to meet the externally (demand) determined outputs at the lowest possible cost.

where, $W = (w_1, \ldots\ldots, w_J)' \in R^J_{++}$ is a $(J \times 1)$ vector of positive observed input prices, $X = (x_1, \ldots, x_J)' \in R^J_+$ is a $(J \times 1)$ vector of nonnegative variable inputs, $Y = (y_1, \ldots, y_M)' \in R^M_+$ is a $(M \times 1)$ nonnegative output vector (services provided by banks), $Z = (z_1, \ldots, z_Q)' \in R^Q_+$ is a $(Q \times 1)$ vector of nonnegative quasi-fixed inputs, t is a trend variable capturing technical change, $\lambda \geq 0$ measures input-oriented technical inefficiency and R_s are quantitative or qualitative constraints due to regulation. In banking, for example, the constraints may be additional reserve requirements, higher capital requirements, higher deposits insurance fees and other regulatory burdens imposing additional cost on banks.

If we write the first-order conditions of the above optimization problem as MRTS_{jk} (marginal rate of technical substitution between inputs j and k) $= w^*_j/w^*_k$ where w^*_j is the shadow (distorted) price of input j, it is clear that the relevant input prices in the solution of optimal input quantities are the shadow prices (which are not the same as the observed market prices if the regulatory constraints are binding).[6] This suggests that the relevant cost that a bank minimizes is shadow cost, defined as $C^* = \sum w^*_j x^e_j$ where $x^e_i = x_j e^{-\lambda}$is the efficiency-adjusted quantity of x_j. That is, the first-order conditions of minimizing shadow cost C^* defined above (with respect to x^e_j) subject to $F(Y, X^e, Z, t) = 0$ will be exactly the same as before. The advantage of starting from the shadow cost function approach is that the Shephard's lemma can be used to obtain the optimal input quantities, i.e., $\partial C^*(Y, W^*, Z, t)/\partial w^*_j = x^e_j$. This result can also be expressed as $x^e_j = S^*_j C^*(w^*_j)^{-1}$ using the Shephard's lemma to the logarithmic cost function, i.e., $\partial \ln C^*/\partial \ln w^*_j = w^*_j x^e_j/C^* = S^*_j$. Multiplying both sides of the actual cost $C^a = \sum_j w_j x_j$ by $e^{-\lambda}$ gives $C^a e^{-\lambda} = \sum_j w_j x^e_j = \sum_j w_j S^*_j C^*/w^*_j = C^* \sum_j w_j S^*_j/w^*_j$. Thus, $\ln C^a = \ln C^* + \ln H + \lambda$ where $\text{H} = \sum_{j=1}^J (w_j/w^*_j) S^*_j$. To separate costs of technical inefficiency from allocative distortions we rewrite the above relationship as

$$\ln C^a = \ln C^* + \ln H + \lambda \equiv \ln C^0 + (\ln C^* - \ln C^0 + \ln H) + \lambda \qquad (1)$$

where C^0 is the minimum (neoclassical) cost function obtained from the shadow cost function by imposing the restrictions $w^*_j/w^*_k = w_j/w_k$.

From the above relationship it is clear that cost for each bank is increased by λ percent (which is labeled as the cost of technical inefficiency). The percentage increase in cost due to allocative distortions (when multiplied by 100) is $\ln C^* - \ln C^0 + \ln H$, which is non-negative for a well-behaved cost function. Since the shadow cost function and shadow prices are unobserved, one has to relate the shadow input price to the actual input price. The relationship that is widely used in the literature is $w^*_j = \theta_j w_j$, where $\theta_j > 0$. One advantage of using the model in (1) is that technical and allocative inefficiencies can be correlated via some common covariates (which is not allowed in the stochastic cost system). This correlation is quite important for our study and we discuss it further after introducing the complete econometric model.

[6] The Lagrangian of the problem is $\Lambda = \sum w_j x_j + \mu F(Y, X \cdot e^{-\lambda}, Z, t) + \sum \lambda_s R_s(Y, X \cdot e^{-\lambda}, Z, t)$ which gives the following first-order condition: $MRTS_{jk} = F_j/F_k = (w_j + \sum \lambda_s \partial R_s/\partial X_j)/(w_k + \sum \lambda_s \partial R_s/\partial X_k) \equiv w^*_j/w^*_k$.

To estimate the above model, we need to specify a parametric form for $\ln C^*$. To make it flexible we use a multi-output translog cost function for $\ln C^*$.[7] The translog cost frontier has several virtues: (i) it accommodates multiple outputs without necessarily violating curvature conditions; (ii) it is flexible, in the sense that it provides a second-order approximation to any well-behaved underlying cost frontier at the mean of the data; and (iii) it forms the basis of much of the empirical estimation and decomposition of cost efficiency based on a system of equations. Following Kumbhakar and Sarkar (2003),[8] we specify $\ln C^*$ as:

$$\begin{aligned}
\ln C^*_{it} = {} & \alpha_0 + \sum_m \alpha_m \ln y_{mit} + \sum_j \beta_j \ln w^*_{jit} + \sum_q \gamma_q \ln z_{qit} + \beta_t t \\
& + \frac{1}{2}\left\{ \sum_m \sum_l \alpha_{ml} \ln y_{mit} \ln y_{lit} + \sum_j \sum_k \beta_{jk} \ln w^*_{jit} \ln w^*_{kit} \right. \\
& \left. + \sum_q \sum_s \gamma_{qs} \ln z_{qit} \ln z_{sit} + \beta_{tt} t^2 \right\} \\
& + \sum_m \sum_j \rho_{mj} \ln y_{mit} \ln w^*_{jit} + \sum_m \sum_s \psi_{ms} \ln y_{mit} \ln z_{sit} \\
& + \sum_m \alpha_{mt} \ln y_{mit} t + \sum_j \sum_q \delta_{jq} \ln w^*_{jit} \ln z_{qit} \\
& + \sum_j \beta_{jt} \ln w^*_{jit} t + \sum_q \gamma_{qt} \ln z_{qit} t + \tau_i D_i \qquad (2)
\end{aligned}$$

where $i = 1, \ldots, I$ is the index for banks and $t = 1, \ldots, T_i$ is the index for time. We use dummy variables for each bank (D_i) to capture cost differences due to unobserved bank-specific factors.[9] We also impose the following symmetry conditions in the above

[7] Other popular functional forms such as the minflex Laurent (e.g., Hunter et al. 1990) and flexible Fourier. (e.g., Berger and Mester 1997; DeYoung and Hasan 1998; DeYoung and Nolle 1996; Mitchell and Onvurall 1996) are more flexible than translog. However, Altunbas and Chakravarty (2001) have shown that the slightly better goodness-of-fit typically shown by the flexible Fourier form does not reliably translate into improved forecasting of bank costs. This shortcoming might result partly from overfitting and multicollinearity. Furthermore, Berger and Mester (1997) have reported that the efficiency rankings of banks are highly correlated between translog and flexible Fourier estimates.

[8] The difference between this model and Kumbhakar and Sarkar (2003) model is that we estimate technical inefficiency (and added covariates to explain it) besides allocative distortions.

[9] There is a possibility that cost frontiers may be different across ownership groups and years of service (for example, matured/established versus de novo banks). However, given the size of our sample, it was not possible (lack of degrees of freedom) to estimate one model for each ownership group as in Mester (1989) and Hughes and Mester (1993). This will result in estimating four times the number of current parameters. To save degrees of freedom, we allowed the first-order coefficients of the translog function to be different for different ownership groups. We failed to reject the hypothesis that technology differs across ownership groups at the 5% level of significance. Thus, we come to the conclusion that technology does not differ significantly across ownership groups. A similar conclusion is reached in terms of matured versus de novo banks.

cost function, viz., $\alpha_{ml} = \alpha_{lm}$, $\beta_{jk} = \beta_{kj}$ and $\gamma_{qs} = \gamma_{sq}$. To ensure linear homogeneity (in prices) of the cost function, the following constraints must be imposed:

$$\sum_j \beta_j = 1; \sum_j \beta_{jk} = 0, \quad \forall k; \sum_j \rho_{mj} = 0, \quad \forall m; \sum_j \beta_{jt} = 0; \sum_j \delta_{jq} = 0, \quad \forall q.$$

To improve efficiency in estimating the parameters of the above cost function we add $(J-1)$ cost share equations $S_j^a = (w_j x_j)/C^a$, which can be written as:

$$S_{jit}^a = S_{jit}^*/(H_{it}\theta_j) \tag{3}$$

where

$$S_{jit}^* = \partial \ln C_{it}^*/\partial \ln w_{jit}^* = \beta_j + \sum_k \beta_{jk} \ln w_{kit}^* + \sum_m \rho_{mj} \ln y_{mit} + \sum_q \delta_{jq} \ln z_{qit} + \beta_{jt} t \tag{4}$$

$$\mathrm{H}_{it} = \sum_j S_{jit}^*/\theta_j. \tag{5}$$

Finally, we added classical error terms (v_{it}) to the cost function and (η_{jit}) to the cost share equations. The system consists of the cost function in (1) in conjunction with (2) and the cost share equations in (3) in conjunction with (4) and (5). We make the following assumptions to estimate the system: (i) To accommodate variables that can explain technical inefficiency, we assume that technical inefficiency follows a truncated normal distribution with constant variance, i.e., $\lambda_{it} \sim N(\mu_{it}, \sigma_\lambda^2)$, $\lambda_{it} \geq 0$ where the mean μ is specified as

$$\mu_{it} = \delta_0 + \delta_f D_f + \delta_p D_p + \delta_{ro} D_{ro} + \delta_{Pol} POLICY_t + \delta_{CAMPL} CAMPL_{it} + \delta_t Time \tag{6}$$

The variables in the μ function are dummies for foreign owned banks (D_f), domestic private banks (D_p) and representative offices (D_{ro}), a proxy for policy tightening $(POLICY_t)$, a proxy for managerial performance $(CAMPL_{it})$ and a time trend $(TIME)$ variable. These variables in the μ function are viewed as determinants of technical inefficiency. (ii) $v_{it} \sim N(0, \sigma_v^2)$; (iii) $\eta_{it} \sim N(0, \Sigma)$ and (iv) λ and v are independent of each other and are also independent of the elements of η_{it}.

The likelihood function and estimates of technical inefficiency are derived in Kumbhakar and Lovell (2000) for the single output case. Its extension to the multiple output case is straightforward. The log-likelihood function can be maximized to obtain estimates of the parameters of the shadow cost function. These parameter estimates are then used to estimate λ_{it} using the Jondrow et al. (1982) formula

$$\hat{\lambda}_{it} = E\left(\lambda_{it}|(v_{it}+\lambda_{it})\right) = \mu^*_{it} + \sigma^*_{it}\left[\frac{\phi(\mu^*_{it}/\sigma^*_{it})}{\Phi(\mu^*_{it}/\sigma^*_{it})}\right],$$

where $\mu^*_{it} = \frac{\sigma^2_\lambda(\lambda_{it}+v_{it})+\mu_{it}\sigma^2_v}{\sigma^2_\lambda+\sigma^2_v}$,$\sigma^{*2}_{it} = \frac{\sigma^2_\lambda\sigma^2_v}{\sigma^2_v+\sigma^2_v}$ and $\phi(\mu^*_{it}/\sigma^*_{it})$ and $\Phi(\mu^*_{it}/\sigma^*_{it})$ are the probability density and distribution functions of standard normal variables. The marginal effect of the kth element of the μ function can be calculated using the formula:

$$\frac{\partial E(\lambda_{it})}{\partial \mu[k]} = \delta[k]\left[1 - \Lambda\left\{\frac{\phi(\Lambda_{it})}{\Phi(\Lambda_{it})}\right\} - \left\{\frac{\phi(\Lambda_{it})}{\Phi(\Lambda_{it})}\right\}^2\right] \tag{7}$$

where $\delta[k]$ is the parameter associated with kth element of μ function and $\Lambda_{it} = \frac{\mu_{it}}{\sigma_\lambda}$ and (see Wang 2002 for details). Since the expression under $[\cdot]$ in (7) is positive (follows from properties of normal distribution) the sign of the marginal effect is determined by $\delta[k]$.

Standard microeconomic theory tells us that binding constraints act as a tax, which increase the effective price of inputs on which the tax is levied. To estimate the potential distortions caused by the policy change we specify the distortion parameter (θ_j) as a function of the same variables of interest as in Eq. 6. However, it is not possible to identify θ_j for all inputs $j = (1, \ldots, J)$ because the shadow cost function is homogeneous of degree one in shadow prices. Thus, it is necessary to normalize one of the θ_j to unity and estimate the remaining θ_{j-1}. In this paper, due to data constraints, we consider only two variable inputs (deposits and labor). We normalize θ_L to unity (i.e., the distortion in the price of labor is normalized to unity). Therefore, we can interpret θ_D as the distortion in deposit prices relative to wages. Furthermore, we specify θ_D as

$$\theta_{jit} = 1 + \theta_0 + \theta_f D_f + \theta_p D_p + \theta_{ro} D_{ro} + \theta_{Pol} POLICY_t + \theta_t TIME \tag{8}$$

to examine the impact on price distortions of policy change while controlling for ownership differences and other time-dependent omitted variables. In this framework, θ_f, θ_p and θ_{ro} measure, *ceteris paribus*, whether the distortions are different for foreign, domestic private banks and representative offices relative to the state-owned banks, θ_{Pol} measures the distortionary impact of policy change while θ_t measures the temporal behavior of these distortions. Since price distortions are by assumption external (not management induced), we do not include the *CAMPL* score in Eq. (8).

In our modeling approach technical inefficiency is assumed to be random (which is the case in stochastic frontier models). The mean of technical inefficiency μ_{it} is assumed to be a function of policy change, ownership dummies and management quality proxies. Since the same variables appear both in the μ_{it} and θ_{jit} functions, a correlation between technical and allocative inefficiency is introduced. That is, these variables are allowed to affect cost through both types of inefficiencies.[10] As a result,

[10] This is not possible in the stochastic frontier system models in which technical and allocative inefficiencies are assumed to be independent (see Chap. 4 of Kumbhakar and Lovell 2000 and references cited in there).

the policy change proxy can increase cost by distorting prices, but it can reduce cost of technical inefficiency much more so that the net effect of policy change might be beneficial.

5 Data

We obtained the annual balance sheets and profit and loss statements for all commercial banks for the period 1996–2002 from the Ministry of Finance of Romania. Since the tax authorities use these reports to determine the annual tax liabilities of each bank, we believe that this data set is of high quality.[11] Although we have the entire population of Romanian banks, we dropped some of the observations that were inappropriate for our analysis, such as: banks with fewer than 3 years of activity, extreme outliers and banks with fewer than two observations.[12] This resulted in a sample of 186 observations. Our data set includes financial information on state-owned banks, private domestic banks, foreign commercial banks and representative offices.[13] Table 1 reports the composition of the sample based on ownership type. The structure of the banking system changed significantly in 1998. With the privatization of a few state-owned banks, the share of total assets held by foreign banks increased by 26 basis points, while the share of domestic private banks decreased slightly.

In the banking literature there is no agreement regarding the inputs and outputs for a bank. In the intermediation approach, suggested by Sealey and Lindley (1977), banks are viewed as financial firms who use deposits or deposit costs (treated as inputs) to

[11] We also checked the data reported with the corresponding financial information reported in the annual reports posted by banks on their web sites. Reputable auditing firms audited most of the financial statements reported by banks in their annual reports. Moreover, we checked the aggregated values for the entire banking system against the values reported by the National Bank of Romania. We found only a few insignificant differences.

[12] In the context of the US banking, studies some authors (e.g., DeYoung and Hasan 1998; Shaffer 1998) suggested that it might be desired to drop banks that are in existence for less than 9 years. An anonymous referee suggested that we apply this criterion in selecting a sample of the Romanian banks. The problem is that Romania switched to the modern banking system only after 1991. Thus, virtually all banks can be labeled de novo banks. Given this and the fact that the number of banks in Romania is relatively small, we could not drop banks with more than the first 3 years of activity without reducing the sample size substantially. This is the typical situation for the transition economies where modern banking (US style) started only after 1991. Until 1990, the Romanian single-tier banking system consisted of the National Bank of Romania (that coordinated most of the payments requested by the central planners) and four specialized banks: the Romanian Foreign Trade Bank, the Investment Bank (which financed long-term projects), the Bank for Agriculture and Food Industry, and the Savings Bank (CEC). In December 1990, a two-tier banking system was enacted by changing these banks into universal commercial banks. At the same time, the NBR transferred its commercial functions to a new entity called Romanian Commercial Bank.

[13] State-owned includes banks with state participation more than 50%. Private includes banks that were in private hands at a given time period. They include de novo and privatized enterprises. Due to insufficient information, we cannot separate them. Foreign includes branches of foreign banks in which the foreign investor holds at least 50%. In the Romanian Law, a foreign legal entity may establish a branch or a representative office. From a legal perspective, a representative office cannot commit to any contractual engagements in its own name but can act as a loan production office, generating loan business for its parent bank at home. The office basically serves as a liaison and marketing function for the parent bank. Representative offices were often established as a first step in committing to enter Romania's market. From a loan production perspective, however, they act as any other commercial bank.

create loans and services (outputs). A second approach, the value added framework (Berger et al. 1987) classifies deposits as an output. This approach recognizes that banks do not passively collect deposits but provide services related to deposits (check clearing, withdrawals, etc). The third approach, the user cost framework (Hancock 1985; Fixler and Zieschang 1991) defines outputs and inputs based on the net contribution to revenue. If the financial returns on an asset exceed the opportunity cost of funds or if the financial costs of a liability are less than the opportunity cost, then the instrument is considered to be a financial output. Otherwise, it is considered to be a financial input.

Like many studies on banking efficiency (e.g., Aly et al. 1990; DeYoung and Nolle 1998; Berger and Mester 1997; Resti 1997; DeYoung and Hasan 1998; Isik and Hassan 2002; Havrylchyk 2006), we adopt the intermediation approach in this paper. Accordingly, we view commercial banks as multi-product firms, producing 4 outputs and employing 2 inputs and 3 quasi-fixed inputs.[14] From the balance sheet data, we define the following output variables (Y): current loans (L), portfolio investment (I), fee and commission income (F) as a proxy of non-interest services offered by a bank and number of branches (B). We included the number of branches as a proxy for the output quality and convenience that a bank offers to its customers (Kumbhakar and Sarkar 2003). Our input variables are: (i) total loanable funds (D), the sum of deposits (demand and time) and non-deposit funds[15] and (ii) number of employees (E). In addition, we consider three quasi-fixed inputs (Z): (i) share capital (K), (ii) physical assets (A) and (iii) all expenses except interest and labor costs (O). The size of a bank's share capital can be an important buffer in absorbing portfolio losses and is an important variable to account for when studying efficiency. The share capital is considered as a quasi-fixed input because it changes slowly and because its price is difficult to measure (see Berger and Mester 1997). Physical capital (premises and equipment) is considered to be quasi-fixed since it takes time to accumulate or depreciate. The total cost (COST) is the sum of interest cost and labor cost. Expenditures on these inputs account for majority of all banking costs in Romania. We obtained the price of labor (W_L) by dividing total labor expenses to number of employees and the price of deposits (W_D) by dividing total interest expense to total deposits.

Of course, we are aware of data problems that are relevant for all transition countries. Accounting standards are not strictly enforced and non-compliance to rules set by the supervisory authorities may have been widespread.[16] However, we believe that such behavior is equally practiced by all market participants and, therefore, should not significantly influence the results. To allow the possibility that loan quality might be different in the first half of our sample, we express it as $L[(1+\kappa)\text{REGIME}]$ where the dummy REGIME takes the value unity during the period 1996–1999 and zero afterward. Thus the κ parameter captures possible loan quality differences. Moreover, to avoid the "zero-output" problem we aggregate the loans (L) and portfolio investment (I) outputs as follows: $\ln y_{LI} = \ln [a_1 L + (1 - a_1) I]$. With this specification of L,

[14] All nominal variables are inflation-adjusted.

[15] Non-deposit funds include borrowed funds from inter-bank market, central bank, and others.

[16] For a more detailed discussion about data problems for transitional economies see Grigorian and Manole (2006).

the hedonic output function is $\ln y_{LI} = \ln [a_1 L\{(1+\kappa)\text{REGIME}\} + (1-a_1)I]$. This specification accommodates zero values of outputs and also corrects for potential measurement problems and/or differences in quality of loans in the pre-regulation period. In this aggregator/hedonic output function, the a_1 parameter indicates weight of real current loans and the κ parameter indicates quality difference in loans. If the loans prior to 1999 were overstated, one would expect a negative value for the quality correction parameter, κ.

Table 2 reports the summary statistics of the variables used in the model. The mean value of total loans adjusted for inflation increased substantially from 395 million Romanian Leu (ROL) in 1996 to 3,757 million ROL in 2002. The trend of the portfolio investment reflects the development of the securities market in Romania. The mean value of portfolio investment increased significantly from 5 million ROL in 1996 to 953 million ROL in 2002. Following the major restructuring of the banking system, privatizations, increased competition from foreign banks and the improvement in the business environment, the mean number of branches increased from 10 in 1996 to 102 in 2002. As the banking system expanded, the mean of the sum of interest and labor cost adjusted for inflation increased from 155 million ROL in 1996 to 670 million ROL in 2002.[17]

Table 3 reports selected performance measures of Romanian banks. Looking at the industry solvency ratios, we can see that around 1998 the banking industry as a whole was in danger of collapse. At the beginning of 1999, the accumulation of unresolved problems led to an escalation of the industry's share of non-performing loans classified under "doubtful" and "loss" in the total loan portfolio to 59% , while the ratio of doubtful and overdue claims (net value) to banks' equity increased to 254%. As a matter of fact the central bank reports that "should at least half of those claims not have been recovered, the overall banking system would have virtually gone bankrupt".[18] If we adjust the solvency ratios with the expected earnings and the overall riskiness of a bank, as measured by the probability of insolvency (see Hannan and Hanweck 1988), it can be seen that the median bank was in bad shape as well. The imminent collapse of a small number of banks prompted the fear of a domino effect that would generate a systemic failure.

[17] It can be seen (from the maximum and minimum values) that variations in W_L and W_D are quite large. Variations in wages can be explained in terms of different levels of skill and experience of the clerical and managerial staff. The wage difference is pronounced when comparing state-owned and foreign-owned banks. Foreign banks operate mostly in the cities and they hire people who are, on average, more skilled. Reluctance of politicians to restructure high profile state-owned banks by laying-off workers can also explain some of the difference in wages. The other reason is that in transition economies labor markets are not fully competitive. The short transition period did not allow wages to fully adjust to competitive wages. Similarly, differences in deposit prices capture quality and types of deposits. Since we use a cost function approach in which input prices are explanatory variables, price variations that capture quality differences in the inputs do not pose any problem. Note that the presence of high skilled/quality workers (which are more expensive) does not mean that a bank will hire more of them. The standard microeconomic theory tells us that a cost minimizing bank should use inputs in such a way that on the margin the return from a dollar is the same from all inputs. Thus, for example, if a high skilled worker is four times more productive (relative to a low skilled worker) and it also cost the bank four times more to hire a high skilled worker, there is no reason why a cost minimizing bank will hire more of high skilled worker. Furthermore, we use a shadow cost function model, which captures deviations from the cost minimizing conditions through shadow prices.

[18] Annual Report of the National Bank of Romania, 1999, p. 357.

Table 2 Selected statistics of sample of Romanian banks

Variable	Units	1996	1997	1998	1999	2000	2001	2002
Outputs								
Loans (L)—mean value	mil. rol	395	386	888	939	1,338	2,424	3,757
Max		2,126	1,864	3,884	5,118	9,159	13,231	25,286
Min		105	123	257	274	191	398	552
Portfolio Investment (I)—mean value	mil. rol	5	88	170	205	226	401	953
Max		6	422	426	783	795	910	2,704
Min		3	46	67	67	171	259	701
Fees and Commissions (F)—mean value	mil. rol	32	36	49	61	83	140	249
Max		178	214	246	338	502	760	1,245
Min		3	8	9	12	14	31	46
Number of Branches (B)—mean value	#	10	11	17	15	14	24	102
Max		27	27	39	39	50	131	233
Min		2	2	3	3	3	4	4
Quasi-inputs								
Other cost (O)—mean value	bil. rol	24	50	126	266	285	606	503
Max		66	139	273	598	834	1,229	1,256
Min		3	3	12	26	29	52	61
Property and Equipment (A)—mean value	bil. rol	13	23	50	125	159	234	320
Max		28	72	133	442	708	1,049	1,256
Min		3	5	11	33	67	79	92
Share Capital (K)—mean value	bil. rol	11	13	63	137	188	361	518
Max		18	21	115	234	420	761	764
Min		7	10	13	120	140	311	462
Price of Inputs								
Price of Deposits (WD)—mean value	%	11.0	15.9	16.0	16.9	11.5	7.4	6.3
Max		13.1	25.8	27.7	32.3	22.1	13.1	9.5
Min		8.0	7.0	8.0	7.0	5.0	4.0	4.0
Real Price of Labor (WL)—mean value	thou. rol	323	387	801	1,467	2,321	3,304	3,990
Max		744	898	1,917	3,421	4,668	5,682	5,884
Min		137	170	542	753	1,293	1,768	2,781
Sum of Real Interest and Labor Cost (COST)—mean value	mil. rol	155	230	484	502	458	584	670
Max		996	1,632	2,387	2,983	4,112	4,635	4,927
Min		25	27	28	21	36	39	41

Note: The above statistics do not include the data for the first 3 years of activity of all banks and banks with fewer than two observations. All nominal variables are inflation-adjusted

Table 3 Operating performance measures

Variable	Units	1996	1997	1998	1999	2000	2001	2002
Capital adequacy								
Solvency ratio 1 (median)	%	21.5	19.5	36.7	43.9	46.7	37.2	35.0
Solvency ratio 1 (Industry)[a]	%	2.0	2.2	17.3	18.8	26.3	34.4	33.9
Asset quality								
General risk ratio (median)	%	42.2	35.9	40.1	37.7	39.5	49.7	52.7
Overdue claims to equity (Industry)[a]	%	103.3	160.6	253.6	31.2	3.3	2.7	2.0
Overdue loans to total loans ratio (median)	%	1.7	3.3	4.2	2.8	1.3	1.7	0.1
Overdue loans to total loans ratio (Industry)[a]	%	43.7	52.6	58.5	35.4	3.8	2.5	1.1
Management								
Probability of insolvency (median)	%	18.3	59.3	23.8	42.6	24.1	27.4	18.2
Profitability								
ROA (median)	%	5.1	4.3	3.4	3.5	2.0	2.8	2.8
ROE (median)	%	31.1	37.5	27.3	20.5	11.6	15.8	14.0
Liquidity								
Immediate liquidity ratio (median)	%	22.3	54.5	45.3	54.8	62.0	6.2	8.3
CAMPL score (mean)	1–5	3.55	3.41	3.00	2.61	2.34	2.38	2.20

[a] *Source:* Annual reports of the National Bank of Romania, 2002

The large discrepancy between the median bank versus the industry insolvency ratios and overdue loans relative to total loans is due to two very large state-owned banks. We excluded those banks from estimation
Note: To obtain a more compact measure of bank performance, we use a methodology devised by the NBR to assign to each economic indicator a score from one to five (a score of one describes a bank in strong financial standing) based on its relative standing comparing to its peers. To obtain the final *CAMPL* score we averaged the scores for each economic indictor for each bank in every year. A *CAMPL* score of one describes a bank in strong financial standing. Solvency Ratio 1 (legal limit $\geq 12\%$) = Total risk-based capital (own funds) / Risk-weighted assets. Core Capital (Tier-1) consists of common shareholders equity, perpetual preferred shareholders equity with non-cumulative dividends, retained earnings, and minority interests in the equity accounts of consolidated subsidiaries. Supplementary Capital (Tier-2) consists of subordinate debt, intermediate-term preferred stock, cumulative perpetual, long-term and convertible preferred stock, perpetual debt and other hybrid debt/equity instruments and a proportion of the bank's allowance for loan and lease losses (general reserves only). Deductions from total capital consist of investments in unconsolidated banking and finance subsidiaries, reciprocal holdings of capital securities, and other deductions as determined by supervisory authority with handling on a case-by-case basis or as matter of policy after formal rulemaking. Total risk-based capital = Tier-1 + Tier-2–Deductions. Due to the lack of more detailed data we constructed the Risk-Weighted Assets variable based on the following risk category and weights: (1) cash and equivalents, zero percent, (2) portfolio investment: securities and government T-bills, fifty percent and (3) loans, one hundred percent. The total of Tier-2 capital is limited to 100 percent of Tier-1 capital. ROE = return on equity. ROE = Net profit / Own capital. General Risk Ratio = Risk-weighted assets / Total assets (book value, including off-balance sheet elements). For probability of insolvency see Hannan and Hanweck (1988). Return on assets (ROA) = Net profit / Total assets. Immediate liquidity = Demand and time deposits of banks at other financial institutions / Attracted and borrowed sources. In defining these variables we used the regulations set by the NBR in Norm 8/1999

To better capture the complexity of multidimensional bank performance measures into a single measure of managerial performance we further reduce this multivariate system to a synthetic measure which we call the *CAMPL* (Capital, Assets, Management, Profitability and Liquidity) score. Each economic indicator is assigned a score from one to five (a score of one describes a bank in strong financial standing) based on its standing relative to its peers.[19] To obtain the final *CAMPL* score we average the scores for each economic indictor for each bank in every year. The median values of selected financial ratios and the mean values of *CAMPL* score are reported in Table 3. The note in this table describes the methodology used for computing some of its components. This indicator is popular among financial analysts in evaluating the financial performance of a bank and has been used previously as a proxy of managerial performance (DeYoung 1998).

6 Results

We estimate the cost system consisting of (1) in conjunction with (2) and the cost share equations in (3) in conjunction with (4) and (5). Since we have only two variable inputs, the system consists of the cost function and a cost share equation. Unlike the simpler functional form such as the Cobb-Douglas, the coefficient estimates of the translog cost function are not directly interpretable. Because of thus we do not report them here.[20] However, we checked for violations of regularity conditions of the estimated cost function (see Appendix 2). We do not find a significant number of violations of cost function properties in our data for the translog model. The low share of investment in securities can be explained by the lack of sufficient investment alternatives given by the low degree of market depth in the early stages of transition.[21] The estimate of the loan quality adjustment coefficient κ is -0.46 (s.e. 0.18) and is statistically significant at the 1% level of significance, indicating that the quality correction was necessary.

Table 4 reports the median values of the cost of technical inefficiency for all banks in our sample and for each ownership group. These values show, in percentage terms, by how much a bank's cost is increased due to technical inefficiency. The average cost of technical inefficiency for the period from 1996 to 2002 is found to be approximately 32%. This estimate of cost of technical inefficiency is somewhat lower than the results reported in the literature. For Romanian banks, Grigorian and Manole (2006) report an average inefficiency of 51% and 72%, depending on the definition of output. Fries and Taci (2005) estimate an average inefficiency of 45% and 53% when controlling for country-specific factors. The lower estimates we obtained might be due to the fact that we separated the cost of technical inefficiency from the cost of allocative distortions and used a system approach. Kumbhakar and Wang (2006) show that ignoring allocative distortions and use of a single equation cost function results in inconsistent parameter

[19] In computing the *CAMPL* score we use the methodology devised by the National Bank of Romania. The NBR uses the CAMEL scores to assess the performance of banks.

[20] These estimates are available from authors upon request.

[21] As the domestic financial market becomes more liquid, the government issued more securities, which were purchased by domestic investors (mostly banks). For most of the period studied, the corporate securities have a very small weight in corporate financing.

Table 4 Cost of technical inefficiency

Year	All banks	State-owned	Domestic private	Foreign	Representative Offices
1996	36.03	54.66	39.60	27.07	12.54
1997	37.55	50.39	42.89	33.76	14.28
1998	45.85	51.27	55.60	40.73	24.39
1999	43.69	52.69	55.87	42.79	26.20
2000	23.56	56.17	19.97	20.95	22.55
2001	19.70	41.99	17.26	18.81	16.43
2002	19.45	28.12	16.07	19.51	16.57
Mean cost of technical inefficiency (%)					
Pre 2000	40.78	52.25	48.49	36.09	19.35
Post 2000	20.91	42.09	17.77	19.76	18.52
1996–2002	32.26	47.90	35.32	29.09	18.99

Note: These values show in percentage terms by how much the actual cost is higher than the benchmark minimum cost. We report the median values of cost of technical inefficiencies in percentage terms for all banks in the sample and separately for each type of ownership. We calculated the mean of the values reported for each year for the entire period and separately for the pre-regulation and post-regulation period

estimates, and biased estimates of the cost of inefficiency. Moreover, as we report in Table 4 the mean cost inefficiency estimates for the pre-regulation is 41% while in the post-regulation period is 21%. This pattern is the same across all types of ownership. This decrease in cost inefficiency between to two periods could be the result of changes in corporate governance (brought by ownership change), change in the policy regime, improvement in managerial practices, etc.

To disentangle the effects of the factors mentioned above on technical inefficiency, we turn to Eqs. 6 and 7.[22] Equation 6 specifies the mean technical inefficiency (μ_{it}) as a function of same organization-specific variables, a policy change proxy, and a time trend to capture any other omitted factors affecting efficiency over time (e.g., improvements in efficiency due to learning-by-doing, etc.). We call these variables correlates of technical inefficiency. Although the coefficients of correlates in (6) do

[22] Some studies (reviewed in Berger and Mester 1997) have performed this analysis using a two-step procedure, whereby individual bank efficiency is estimated using a single equation stochastic frontier approach. These efficiencies are then regressed on, and tested for correlation with, a set of variables describing the characteristics being investigated. As Berger and Mester (1997) point out some econometric issues make such analyses suggestive but not conclusive. First, the dependent variable in the regressions, efficiency, is an estimate, but the standard error of this estimate is not accounted for in the subsequent regression or correlation analysis. Second, none of the variables used in the regressions is completely exogenous, and the endogeneity of any regressor can bias the coefficient estimates on all the regressors. Wang and Schmidt (2002) explain why the two-step procedure is bad, and present Monte Carlo evidence showing that the bias from the two-step procedure can be severe. Their evidence argues strongly for single-step estimation procedure when one is interested in the effects of firm characteristics on efficiency levels. We used a single-step estimation of the cost function and along with the correlates of inefficiencies. In particular, the estimation procedure allows for bank inefficiencies to have a truncated-normal distribution that is independently but not identically distributed over different banks. The mean of the inefficiency term is modeled as a linear function of a set of bank-level variables.

not have the same interpretation as the OLS coefficients, the signs are informative. Since $TE \simeq 1 - \lambda \Rightarrow \quad \partial E(TE)/\partial \mu[k] = -\partial E(\lambda)/\partial \mu[k]$ technical efficiency change due to a change in the correlates can be obtained from (7) simply by changing the sign. The specification in (6) allows us to conduct a statistical test on the correlation between mean inefficiency and variables of interest.

The estimates of cost inefficiency reported in Table 4 suggest that, for the entire period studied, state-owned banks have higher cost inefficiency (48%) than domestic private (35%), foreign branches (29%) and representative offices (19%). However, the coefficients of the correlates of technical inefficient reported in Table 5 reveal some interesting findings. Although the mean estimate of the cost inefficiency suggest that domestic private banks are more efficient than government-owned banks, the coefficient for domestic private ownership relative to state-owned (the omitted category) indicates that this relationship is not statistically significant. During the period studied, some private domestic banks faced serious financial difficulties, in some cases leading to bankruptcy.[23] The large number of domestic private banks that faced financial problems in the first part of the period might explain the insignificant difference in the performance of state-owned and domestic private. This result is not entirely uncommon in the literature. Bonin et al. (2005) found that for eleven transition economies government-owned banks are less efficient than domestic private banks, but not significantly so. They also find significant and substantial effects of foreign ownership on bank efficiency. In our case, foreign banks and representative offices have both lower estimates of cost inefficiency and a statistically significant correlation with technical inefficiency (-0.30 and -1.25 respectively).[24] The lower values for the foreign banks and representative offices were mostly, in our opinion, due to the fact that these banks were bringing better know-how and lending practices due to their parent companies. Furthermore, for most of our study period they were concentrating on serving the local branches of other multinational companies in Romania.

The statistically significant estimate of 0.06 for the *CAMPL* score suggests that changes in the financial performance is positively correlated with cost efficiency during this period. As described earlier, a *CAMPL* score of 1 describes the best-practices bank and a score of 5 the worst-practices bank. Thus, a decrease in the *CAMPL* score (improvement of financial standing) is likely to decrease the cost of technical inefficiency. Improvements in financial performance provide banks with funds to initiate changes that can lead to higher cost efficiency. For example, improvements in financial

[23] Some of these banks included: Banca Internationala a Religiilor (closed in 2001), Banca Romana de Scont (closed in 2002), Bankcoop (closed in 2000), Credit Bank (closed in 1999), Banca Dacia Felix (restructured 2000), Banca Columna (closed in 2000) and Banca Anglo-Romana (closed in 1998).

[24] Lower cost inefficiency of foreign banks in transition economies are also found by Nikiel and Opiela (2002) for Poland. For Hungary, Hasan and Marton (2003) found cost of technical inefficiency on the order of 34% for domestic and 26% for foreign banks. They differ from those of Yildirim and Philippatos (2002, unpublished paper), who find that majority foreign-owned banks are significantly more cost, but less profit, efficient than other banks in these transition countries. However, while differences between ownership types may be informative qualitatively in cross-countries comparisons, it should be noted that the comparing absolute results across countries might be misleading. The comparability of these estimates across countries is limited by the fact that each country's efficiency estimate is determined relative only to the frontier of that country. Since frontiers may differ across countries, these estimates are relative to each country's best-practice frontier rather than the global best-practice frontier.

Table 5 Correlates of Inefficiency and Allocative Distortions

Correlates of inefficiency (μ_{it})			Correlates of distortion fun. (θ_D)			Allocative distortions			
Parameter	Estimate	Std. error	Parameter	Estimate	Std. error	Year	Required reserve ratio	Allocative distortions (θ_D)	Percentage cost increase
Intercept (δ_0)	0.29	0.17	θ_0	−0.50***	0.18	1996	7.5	1.00	0.0
Foreign (δ_f)	−0.30*	0.16	θ_f	−0.34**	0.14	1997	8.8	1.02	1.3
Private (δ_p)	−0.05	0.13	θ_p	−0.07	0.14	1998	13.3	1.05	1.4
Representative offices (δ_{ro})	−1.25***	0.18	θ_{ro}	−0.37**	0.16	1999	18.8	1.00	0.0
Time (δ_t)	0.01	0.02	θ_t	0.03	0.02	2000	30.0	1.32	6.0
Policy change (δ_{Policy})	−0.18**	0.09	θ_{Policy}	0.31***	0.10	2001	28.0	1.33	6.3
Campl score (δ_{CAMPL})	0.06**	0.03				2002	22.1	1.35	7.0

Note: Coefficient statistically significant at 1% (***), at 5% (**) and at 10% (*), using a two-sided t-test. The table reports the coefficient estimates and standard errors for correlates of inefficiency estimated by Eq. 6, the coefficient estimates and standard errors for correlates of distortion function estimated by Eq. 8, the median computed values of the allocative distortions function and the median percentage cost increases due to allocative distortions

performance may provide material incentives and better monitoring of workers, which can increase labor productivity. To obtain an analogous interpretation to OLS coefficients, we employ Eq. 7 to compute the marginal effects (Wang 2002) using the coefficients of the correlates of inefficiency function (Eq. 6 and Table 5). The computed marginal effect for the *CAMPL* score is 0.05. Since the mean *CAMPL* score decreases from 2.6 in 1999 to 2.2 in 2002 (improvement in managerial performance), this change is associated with an average decrease in cost of technical inefficiency of 2.0 basis points (0.05×0.4).

As described in Sect. 3, tightening of regulations in 1999 might have affected banks' behavior and performance. Some of the measures implemented by the NBR involved an increase in the required reserve ratio from an average of 13% in 1998 to 19% in 1999 and to 30% in 2000. Banks were also required to increase their minimum registered capital and the capital adequacy ratio was raised from 8% to 12% in 1998; new prudential rules regarding provisioning and limits on lending to a single borrower were designed and implemented; new legislation gave NBR the enhanced powers to conduct a more effective banking supervision and initiate prompt corrective measures. We consider a number of possible variables that can serve as a proxy for policy change ($POLICY_t$): a dummy variable taking the value zero before 1999 and unity afterwards, average required reserve ratio and capital adequacy ratio. Due to the high correlation between these regulatory variables, we do not include all of them together in estimation. In Table 5, we report the estimated coefficients of the mean inefficiency function. The coefficient for the policy change dummy has an estimate of -0.18. The negative sign and the statistical significance of the proxy for policy change suggest that the policy tightening is associated with a decline in technical inefficiency in the post-regulation period. To obtain an analogous interpretation to OLS coefficients, we used Eq. 7 to compute the marginal effects (Wang 2002) using the coefficients of the correlates of inefficiency function (Eq 6 and Table 5). The marginal effect estimate for the policy change is -0.15. This means that the policy change is associated with a 15 basis points decrease in cost of technical inefficiency for the post-regulation period. As a robustness test of the correlation between mean technical efficiency and various proxies for the policy change variable we replaced the dummy variable with some of the major regulatory variables that changed during this period. Everything else being equal, the coefficient for the required reserves is -0.11 (s.e. 0.002) and statistically significant while the coefficient for the capital adequacy requirement ratio is -0.09 (s.e. 0.081) but not statistically significant.

These results above are consistent with the previous findings in the literature. Grigorian and Manole (2006) find some weak evidence that prudential regulation is correlated with efficiency of banks, but the effects are not uniform across instruments of prudential regulation. Higher capital adequacy ratios are associated with higher bank efficiency while other types of prudential regulation, such as limits on lending to a single borrower do not correlate with bank efficiency. Barth et al. (2004) examine the relationships between a broad array of bank regulations and supervisory practices and bank development, performance and stability using a comprehensive cross-country database. They find that capital regulatory stringency is correlated with bank development and fewer nonperforming loans, but this relationship disappears when controlling for other regulations and supervisory practices. Capital stringency

is not robustly linked with banking crises or efficiency when controlling for other supervisory/regulatory policies. They also find some weak evidence that supervisory forbearance discretion is positively related to accounting measure of bank efficiency (but this is not robust either).

The studies mentioned above estimate the relationship between regulation and bank performance but they do not investigate whether regulatory changes also generate other side effects in the banking industry. Estimates of the coefficients in the price distortion Eq. 8 are reported in Table 5. The coefficient associated with the dummy variable (θ_{Dummy}) is 0.31 and statistically significant. This suggests that the there is a significant increase in price distortions following policy tightening. The policy dummy and the wedge between the effective and observed prices are positively related. As in the case of technical inefficiency, we replace the dummy variable with the average value of required reserve ratio and the capital adequacy ratio over the period of interest as a robustness test. The required reserve ratio has a statistically significant coefficient estimate of 0.18 (s.e. 0.02). The capital adequacy ratio has a statistically significant coefficient estimate of −0.02 (s.e. 0.01). These two results are consistent with a priori expectations. Required reserves are a tax on deposits held by banks. As the tax increases the deposit price distortions increase. On the other hand, since deposits and capital may serve as substitutes in production, an increase in capital requirements is, *ceteris paribus*, associated with a decrease in deposit price distortion.

Using the estimated parameters of equations (8) reported in Table 5 we computed the value of the distortion function θ_D and the cost of these distortions, which we also report in Table 5. We normalized the θ parameter to unity for the first year of the sample period. The median value of θ_D is greater than unity for the entire time period, which implies that the effective (shadow) price of deposits relative to labor was greater than their observed counterparts. These results are consistent with the micro-theoretic argument that binding constraints act as a tax and increase the effective price of inputs on which the tax is levied. Moreover, the median value of $\theta_D$displays a sharp increase in 2000, which coincides with the policy change for the period of our study. The estimated parameters corresponding to ownership type, viz., θ_f, θ_{ro}, in Eq. 8 show that distortionary effect for the foreign banks and representative offices was lower relative to state-owned banks while there was no significant difference in input price distortions for state-owned and domestic banks. These differences across ownership type might be the result of a larger share of deposits in domestic currency held by state-owned and private domestic banks and a better management of the input mix used by foreign banks. The median percentage increase in cost due to allocative distortions, reported in Table 5, shows that the effective cost is increased up to 6% in the first year of the policy change and up to 7% in year 2002.

7 Conclusions

In this paper we estimated costs of technical inefficiency and allocative distortions and related these with policy changes introduced by the central bank of Romania as well as some other covariates. To do so, we used a model that combines the shadow cost function and the stochastic cost frontier approach. Technical inefficiency is specified

as a function of management quality and a policy change variables. Allocative inefficiency/distortions are specified as a function of policy change, ownership type and a time trend variable. Thus the model used introduces correlation between technical and allocative inefficiencies through the common explanatory variables.

We find that technical efficiency improved in the post-regulation period for all types of banks. On average, the cost increase due to technical inefficiency in the pre-regulation period is 41% while in the post-regulation period it is 21%. This reduction is mostly attributed to the policy changes introduced by the central bank (15 basis points). The policy change proxy is found to be positively correlated with improvement in technical efficiency, controlling for managerial practices. A smaller part of the reduction in technical inefficiency is attributed to changes in corporate governance (2 basis points). Consistent with other studies on transitional economies, foreign banks and foreign representative offices are the most efficient followed by private domestic and state-owned banks. However, some of the policy changes introduced by the central bank to stabilize the banking system might have generated some costly side effects. The policy change proxy is found to be positively correlated with allocative distortions, which increased the total cost for the period from 2000 to 2002 by 19%.

We conclude that despite the fact that the short-run increase in cost (due to policy-induced distortions) exceeds the cost inefficiency reduction, the regulations implemented by the central bank in 1999 has been successful at stabilizing the banking system. The evolution of the Romanian banking system post-2000 seems to indicate that the tightening of regulations by the central bank has generated other benefits besides reduction of technical inefficiency. For example, the share of loans and interest listed as "doubtful" and "loss" in total loan portfolios decreased from 35.4% in 1999 to 1.1% in 2002 and hovered around 2.6% in 2006. This compares with a delinquency rate of 0.78% of US bank loans as of December 31, 2006. Following, the relative stabilization of the banking system, the central bank reduced some of the previous regulatory constraints after 2004. For example, the required reserve ratios for the deposits in domestic currency were reduced from a peak of 30% in 2000 to 16% in 2006.

Our study highlights the challenges in devising a regulatory framework that enables the banking system to be a more resilient absorber of shocks without negatively affecting the volume of financial intermediation. The experience of Romania indicates that tightening of regulation might help in improving X-efficiency and stabilizing the banking system, but the over-tight regulation should be short lived since this type of regulatory constraints are very costly for banks. Experiences from other countries show that the positive impact of new regulation may become apparent over long-run (Caprio et al. 1994; Caprio and Klingebiel 1997) but banks may feel the complying costs almost instantaneously. Overall, tightening of regulation has both beneficial and detrimental effects. It may improve bank management (e.g., reduce ill-advised lending). On the other hand, in emerging countries, it may induce an aggregate credit slowdown, thus exacerbating liquidity constraints and negatively affecting real activity. At the beginning of the transition period, Romania had a ratio of lending to GDP of 67%, comparable with other transitional economies. In 2002 this ratio was the lowest among Eastern-European economies standing at 14%, well below the average of 45% for its peers. Accordingly, our analysis suggests using caution in the process

of regulation tightening in emerging economies, where financing channels alternative to the banking system are generally weaker.

Appendix 1

Table A Major regulatory and related developments in the Romanian banking system

Year	Major change	Details
Until 1990	One-tier banking system	National Bank of Romania (NBR) plus 4 specialized banks: the Romanian Foreign Trade Bank, the Investment Bank (which financed long-term projects), the Bank for Agriculture and Food Industry, and the Savings Bank (CEC). Also 860 Credit Unions and 4 foreign banks.
1991	Basic institutional framework and structural regulation for two-tier banking system	Domestic banks as well as foreign banks and subsidiaries of foreign banks are licensed to function as universal banks. No restrictions of entry of sound domestic and foreign banks. The NBR is the supervisory authority of banking. The commercial activities of the NBR are transferred to the Romanian Commercial Bank (BCR).
1992	Setting up the basic conduct and prudential regulation	Required capital is set to the equivalent of ECU 5 million. Banks are required to set up reserve accounts at the central bank. Restricts connected lending and sets limits on the exposure to a single borrower. No limitations on lending and deposits interest rates or fee restriction. No restriction in branch expansion.
1993		Bans equity investments of state-owned companies and regies autonomes in banks.
1994		Restricts bank activity in the capital markets.
1995	Bankruptcy procedures for all types of enterprises	Details the judicial reorganization procedures and allows the NBR to withdraw the license of insolvent banks.
1996	Bankruptcy procedure for banks	Banks which stop payments are subject to the recovery and judicial liquidation proceedings, while the banks whose licenses have been withdrawn by the NBR will begin the liquidation procedure.
	Set up the bank deposit guarantee fund	All banks are required to insure their deposits. The Fund changes the limit every year to keep up with inflation. 15 July–24 august 1999 the Bank Deposit Guarantee Fund made first payments since its set-up.
	NBR - lender of last resort	The NBR can lend troubled banks to accommodate request of individual withdrawals to a specific limit.
1997	Privatization law for state-owned banks	It is carry out either by (1) increase in capital through the sales of shares through public offering or from direct purchase, (2) sale of shares held by the State Ownership Fund and (3) a mix of the two methods.
	Refining of prudential regulation	Calculation formula for own funds. Own funds are used in calculation the required solvency ratios.
1998	Major policy shift	Independence and increased supervision powers of the central bank.
	New capital requirements	The NBR raises capital adequacy requirements to 12% and regulates off-balance sheet activities.

Table A continued

	Bank asset recovery agency	Legal framework for the recovery of some non-performing assets on the balance sheets of state–owned banks.
1999	Tightening of prudential regulation, capital requirements and supervision	The NBR raises the required reserve ratio from an average of 19% to 30%. Banks are required to calculate the amount of own funds on a monthly basis and submit the forms to the Supervision Department at the NBR. Financial reports are designed to help detect insolvent banks and serve as a trigger for bankruptcy procedures. The NBR monitors the solvency, large exposures and connected loans. It specifies the calculation procedure of selected indicators and sets their upper and lower bounds for supervision purposes. Enforcement of the new NBR Act, the Banking Act and the Bank Insolvency Act led to the strengthening of the central bank's independence and authority, whereas the amendment of secondary legislation (norms, and other regulations issued by the central bank) envisaged consolidation of the NBR's capacity to regulate, supervise and, if necessary, close ailing banks, as well as to forming a basis for more effective banking supervision. Banks are required to increase their registered capital to a minimum of ROL 100 billion by 30 April 2000 (Norms No. 5/15 April 1999). Banks' obligation to improve their prudential behavior by making full provisions for 90 day overdue interests on loans given to non-bank customers, as well as for loans granted to and deposits with banks, overdue for 30 days, irrespective of the value of collateral (Circular No. 67, 26 April 1999 issued by the NBR).
	Credit risk information bureau (CRIB) and early warning system	CRIB collects and disseminates information of bank debtors. Started operations in 2000. Early Warning System uses a variant of CAMEL bank-rating system to identify potential financial problems.
2000	Refining prudential regulation	Classification of loans based on the degree of risk. Changes the conditions for provisioning for credit risk. Specifies the coefficients assigned to each risk category of credit and the provisioning for each category.
	Regulation of new operations	Mortgage loans regulation. Mergers and acquisition. Settlement of interbank operation for bankruptcies.
2001	Refining of prudential regulation	New liquidity ratio requirements. Changes to exposure limits and calculations of solvency ratio.
2002		Changes to classifications of credit risk.
	Regulation of new operations	Regulates the types of operations with derivatives. Requires banks to collect a database about their clientele in order to better assess risks.

Appendix 2

Regularity conditions of the estimated cost function We checked the following properties of cost function.

(a) *Non-negativity*: $C(W^*, Y, Z, t) > 0, W^*, Y > 0$. This condition is satisfied at each data point.

(b) *Monotonocity in output (Y)*: if $Y' \geq Y$, then $C(W^*, Y', Z, t) \geq C(W^*, Y, Z, t)$. Alternatively, for each output m, $\partial \ln C^*_{it}/\partial \ln y_{mit} > 0$, where $\partial \ln C^*_{it}/\partial \ln y_{mit} = \alpha_m + \sum_l \alpha_{ml} \ln y_{mit} + \sum_j \rho_{mj} \ln w^*_{jit} + \sum_s \psi_{ms} \ln z_{sit} + \alpha_{mt} t$. This monotonocity condition is violated for 21 out of 186 data points.

(c) *Monotonocity in input prices (w)*: if $W^{*\prime} \geq W^*$, then $C(W^{*\prime}, Y, Z, t) \geq C(W^*, Y, Z, t)$. Alternatively, $\partial \ln C^*/\partial \ln w^*_j > 0$, where $\widehat{S}^*_{jit} \equiv \partial \ln C^*/\partial \ln w^*_j = \beta_j + \sum_k \beta_{jk} \ln w^*_{kit} + \sum_m \rho_{mj} \ln y_{mit} + \sum_q \delta_{jq} \ln z_{qit} + \beta_{jt} t$. This condition is violated for 14 out of 186 observations.

(d) *Homogeneity of degree one in input prices*: $C(\zeta \cdot W^*, Y, Z, t) = \zeta C(W^*, Y, Z, t)$. This condition is imposed and therefore there are no homogeneity violations.

(e) *Concavity*: $C(W^*, Y, Z, t)$ is concave in W^*. To check for concavity of the cost function we follow Diewert and Wales (1987) and write the Hessian (matrix of second derivatives) as $H = B - \text{diag}(\hat{S}^*) + \hat{S}^* \hat{S}^{*\prime}$where B=$\left[\beta_{jk}\right]$ is the matrix of second partials (with respect to $\ln W^*$) of the cost function in (2) and $\hat{S}^*$is the vector of cost (shadow) shares, viz., $\widehat{S}^*_{jit} \equiv \partial \ln C^*_{it}/\partial \ln w^*_{jit}$. For concavity, the Hessian has to be negative definite thereby meaning that the eigenvalues of H has to be negative. Since $\widehat{S}^*_{jit}$ varies from observation to observation, the H matrix will also change and so will the eigenvalues. We have 18 (out of 186) concavity violations.

References

Altunbas, Y., & Chakravarty, S. P. (2001). Frontier cost functions and bank efficiency. *Economics Letters, 72*, 233–240.

Aly, H. Y., Grabowski, R., Pasurka, C., & Rangan, N. (1990). Technical, scale, and allocative efficiencies in U.S. banking: An empirical investigation. *Review of Economics and Statistics, 72*, 211–218.

Barth, J. R., Caprio, G., & Levine, R. (2004). Bank regulation and supervision: What works best? *Journal of Financial Intermediation, 13*, 205–248.

Bauer P. W., Berger, A. N., & Humphrey, D. B. (1993). Efficiency and productivity growth in U.S. banking. In H. O. Fried, C. A. K. Lovell, & S. S. Schmidt (Eds.), *The measurement of productive efficiency: Techniques and applications* (pp. 386–413). Oxford: Oxford University Press.

Berger, A. N., Hanweck, G. A., & Humphrey, D. B. (1987). Competitive viability in banking: scale, scope and product mix economies. *Journal of Monetary Economics, 20*, 501–520.

Berger, A. N., Herring, R. J., & Szego, G. P. (1995). The role of capital in financial institutions. *Journal of Banking and Finance, 19*, 393–430.

Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions. *Journal of Banking and Finance, 21*, 895–947.

Berger, A. N., & Hannan, T. (1998). The efficiency cost of market power in the banking industry: A test of the "quiet life" and related hypotheses. *Review of Economics and Statistics, 80*, 454–465.

Berger, A. N., & Mester, L. J. (2003). Explaining the dramatic changes in performance of U.S. banks: Technological change, deregulation, and dynamic changes in competition. *Journal of Financial Intermediation, 12*, 57–95.

Bonin, J. P., Hasan, I., & Wachtel, P. (2005). Bank performance, efficiency and ownership in transition countries. *Journal of Banking and Finance, 29*, 31–53.
Caprio G, Jr., Atiyas, I., & Hanson, J. A. (Eds.). (1994). *Financial reform: Theory and experience*. New York: Cambridge University Press.
Caprio, G, Jr., & Klingebiel, D. (1997). Banking insolvency: Bad luck, bad policy, or bad banking? In: Proceedings of the World Bank Annual Conference on Development Economics, 1996, Supplement to the World Bank Economic Review and the World Bank Research Observer. 79–104.
Chiuri, M. C., Ferri, G., & Majnoni, G. (2002). The macroeconomic impact of bank capital requirements in emerging economies: Past evidence to assess the future. *Journal of Banking and Finance, 26*, 881–904.
Corsetti, G., Pesenti, P., & Noreil, R. (1998). What caused the Asian currency and financial crisis? Part I and Part II, NBER Working Papers, No. 6833 and 6844.
DeYoung, R. (1998). Management quality and X-inefficiency in national banks. *Journal of Financial Services Research, 13*(1), 5–22.
DeYoung, R., & Hasan, I. (1998). The performance of *de novo* commercial banks: A profit efficiency approach. *Journal of Banking and Finance, 22*, 565–587.
DeYoung, R., Hasan, I., & Kirchhoff, B. (1998). The impact of out-of-state entry on the efficiency of local banks. *Journal of Economics and Business, 50*, 191–204.
DeYoung, R., & Nolle, D. E. (1996). Foreign-owned banks in the United States: Earning market share or buying it. *Journal of Money, Credit and Banking, 28*, 622–636.
DeYoung, R., & Nolle, D. (1998). Foreign-owned banks in the U.S.: Earning market share or buying it? *Journal of Money, Credit, and Banking, 28*, 622–636.
DeYoung, R., Hughes, J. P., & Moon, C.-G. (2001). Efficient risk-taking and regulatory covenant enforcement in a deregulated banking industry. *Journal of Economics and Business, 53*, 255–282.
Diewert, W. E., & Wales, T. J. (1987). Flexible functional forms and global curvature conditions. *Econometrica, 55*, 43–68.
Evanoff, D. D., & Israilevich, P. R. (1991). Productive efficiency in banking. *Federal Reserve Bank of Chicago, Economic Perspectives, 15*(4), 11–32.
Fare, R., Grosskopf, S., & Lovell, C. A. K. (1985). *The measurement of efficiency of production*. Boston: Kluwer.
Farrell, M. J. (1957). The Measurement of productive efficiency. *Journal of the Royal Statistical Society, Series A, General, 120*(Part 3), 253–281.
Fixler, D. J., & Zieschang, K. D. (1991). Measuring the nominal value of financial services in the national income accounts. *Economic Inquiry, 29*, 53–68.
Fries, S., & Taci, A. (2005). Cost efficiency of banks in transition: evidence from 289 banks in 15 post-communist countries. *Journal of Banking and Finance, 29*, 55–81.
Granderson, G., & Linvill, C. (2002). Regulation, efficiency, and Granger causality. *International Journal of Industrial Organization, 20*, 1225–1245.
Grigorian, D. A., & Manole, V. (2006). Determinants of commercial bank performance in transition: An application of data envelopment analysis. *Comparative Economic Studies, 48*, 497–522.
Havrylchyk, O. (2006). Efficiency of the Polish banking industry: Foreign versus domestic banks. *Journal of Banking and Finance, 30*, 1975–1996.
Hancock, D. (1985). The financial firm: Production with monetary and nonmonetary goods. *Journal of Political Economy, 93*, 859–880.
Hannan, T. H., & Hanwek, G. A. (1988). Bank insolvency risk and the market for large certificates of deposit. *Journal of Money, Credit and Banking, 20*(2), 203–211.
Hasan, I., & Marton, K. (2003). Development and efficiency of the banking sector in a transitional economy: Hungarian experience. *Journal of Banking and Finance, 27*, 2249–2271.
Hughes, J. P., Lang, W., Mester, L. J., & Moon, C. J. (1999). The dollars and sense of bank consolidation. *Journal of Banking and Finance, 23*, 291–224.
Hughes, J. P., Lang, W., Mester, L. J., Moon, C.-G., & Pagano, M. S. (2003). Do bankers sacrifice value to build empires? Managerial incentives, industry consolidation, and financial performance. *Journal of Banking and Finance, 27*, 417–447.
Hughes, J. P., & Mester, L. J. (1993). A quality and risk-adjusted cost function for banks: Evidence on the "too-big-to-fail" doctrine. *Journal of Productivity Analysis, 4*, 293–315.
Humphrey, D. B., & Pulley, L. B. (1997). Banks' responses to deregulation: Profits, technology, and efficiency. *Journal of Money, Credit and Banking, 29*, 73–93.

Hunter, W. C., Timme, S. G., & Yang, W. K. (1990). An examination of cost subadditivity and multiproduct production in large U.S. banks. *Journal of Money, Credit, and Banking, 22*(4), 504–525.
Isik, I., & Hassan, M. K. (2002). Technical, scale and allocative efficiencies of Turkish banking industry. *Journal of Banking and Finance, 26*, 719–766.
Jemric, I., & Vujcic, B. (2002). Efficiency of banks in Croatia: A DEA approach. *Comparative Economic Studies, 44*, 169–193.
Jondrow, J., Lovell, C. A. K., Materov, L., & Schmidt, P. (1982). On estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics, 19*, 233–238.
Keeley, M. (1990). Deposit insurance, risk, and market power in banking. *American Economic Review, 80*, 1184–1200.
Kraft, E., & Tirtiroglu, D. (1998). Bank efficiency in Croatia: A stochastic-frontier analysis. *Journal of Comparative Economics, 26*, 282–300.
Kumbhakar, S. C. (1996). Efficiency measurement with multiple outputs and multiple inputs. *Journal of Productivity Analysis, 7*, 225–255.
Kumbhakar, S. C.,& Lovell, K. C. A. (2000). *Stochastic production frontier*. Cambridge University Press.
Kumbhakar, S. C., & Sarkar, S. (2003). Deregulation, ownership and productivity growth in the banking industry: Evidence from India. *Journal of Money Credit and Banking, 35*(3), 403–424.
Kumbhakar, S. C., & Wang, H.-J. (2006). Pitfalls in the estimation of a cost function that ignores allocative inefficiency: A Monte Carlo analysis. *Journal of Econometrics, 134*, 317–340.
Kumbhakar, S. C., Lozano-Vivas, A. (2005). Deregulation and productivity: The case of Spanish banks. *Journal of Regulatory Economics, 27*, 331–351.
Kwan, S. H., & Eisenbeis, R. A. (1996). An analysis of inefficiencies in banking: A stochastic cost frontier approach. *Federal Reserve Bank of San Francisco Economic Review, 2*, 16–26.
Leibenstein, H. (1966). Allocative efficiency vs. X-efficiency. *American Economic Review, 56*, 392–415.
Matousek, R., & Taci, A. (2002). Banking efficiency in transition economies: Empirical evidence from the Czech Republic. Discussion Paper No. 02–3, Centre for International Capital Markets, London Metropolitan University.
Mitchell, K., & Onvurall, N. M. (1996). Economies of scale and scope at large commercial banks: Evidence from the Fourier flexible functional form. *Journal of Money, Credit, and Banking, 28*, 178–199.
Mester, L. J. (1989). Testing for expense preference behavior: Mutual versus stock savings and loans. *RAND Journal of Economics, 20*(4), 483–498.
Mishkin, F. S. (1999). Lessons from the Asian crisis. *Journal of International Money and Finance, 18*(4), 709–723.
Mishkin, F. S. (2000). Prudential regulation: Why is it important and what are the issues? NBER Working paper 7926.
National Bank of Romania (1999), (2000), (2001), (2002). Annual Reports.
Nikiel, E. M., & Opiela, T. P. (2002). Customer type and bank efficiency in Poland: Implications for emerging banking market. *Contemporary Economic Policy, 20*, 255–271.
Resti, A. (1997). Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joint application of parametric and non-parametric techniques? *Journal of Banking and Finance, 21*, 221–250.
Schmidt, K. M. (1997). Managerial incentives and product market competition. *The Review of Economic Studies, 64*(2), 191–213.
Sealey, C. W., & Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *Journal of Finance, 32*(4).
Shaffer, S., (1998). The Winner's Curse in Banking. *Journal of Financial Intermediation, 7*, 359–392.
Wang, H.-J. (2002). Heteroscedasticity and non-monotonic efficiency effects of a stochastic frontier model. *Journal of Productivity Analysis, 18*(3), 241–253.
Wang, H.-J., & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis, 18*, 129–144.
Weill, L. (2003). Banking efficiency in transition economies: The role of foreign ownership. *Economics of Transition, 11*, 569–592.