The European Journal of Finance

ISSN: 1351-847X (Print) 1466-4364 (Online) Journal homepage: https://www.tandfonline.com/loi/rejf20

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To cite this article: Nurhan Davutyan & Canan Yildirim (2017) Efficiency in Turkish banking: post-restructuring evidence, The European Journal of Finance, 23:2, 170-191, DOI: 10.1080/1351847X.2015.1049282

To link to this article: https://doi.org/10.1080/1351847X.2015.1049282

The European Journal of Finance, 2017
Vol. 23, No. 2, 170–191, http://dx.doi.org/10.1080/1351847X.2015.1049282

Routledge
Taylor & Francis Group

Efficiency in Turkish banking: post-restructuring evidence

Nurhan Davutyan and Canan Yildirim*

Faculty of Economics, Administrative and Social Sciences, Kadir Has University, Central Campus, Kadir Has Caddesi, Cibali, 34083 Istanbul, Turkey

(*Received 1 December 2013; final version received 1 May 2015*)

Turkish banking sector went through a significant restructuring process in the aftermath of the country's financial crisis of 2000–2001. In this paper, we analyze the evolution of banking performance using a novel approach due to Ray [(2007). "Shadow Profit Maximization and a Measure of Overall Inefficiency." *Journal of Productivity Analysis* 27, 231–236]. We derive 'shadow unrealized profit scores' as well as 'shadow input–output prices' for each year and bank in the sector from 2002 to 2011. We argue these scores operationalize the Hicksian concept of 'monopolistic quiet life'. We provide some evidence the sector came closer to the 'zero profit condition' as well as displaying a closer approximation to the 'law of one price' over time. We show the variability of these 'shadow prices' essentially coincides with that of corresponding actual prices. We utilize shadow price information to show that business models and competitive choices of banks differ across ownership types with foreign banks competing on the broadest front compared to state-owned and privately owned Turkish banks.

Keywords: Turkish banking; efficiency; competition; shadow prices; Weak Axiom of Profit Maximization; data envelopment analysis

JEL Classifications: G21; D20; C14

1. Introduction

Over the last three decades, extensive financial reform programs aimed at increasing bank competition and performance have been initiated in various emerging economies. In many cases, these endeavors frequently implemented under adverse macroeconomic conditions and within the context of underdeveloped legal and regulatory frameworks, have been followed by financial crises. Subsequently, the focus of reform in emerging economies has shifted towards improving supervisory and regulatory standards to ensure financial stability while promoting competition and efficiency. Furthermore, in the wake of the current global financial crisis, the interactions between regulations, competitive performance, and stability have attracted renewed attention from both researchers and policy-makers.

Our paper aims to contribute to this literature by analyzing the evolution of Turkish banking performance. Turkey went through a significant restructuring process in the aftermath of its financial crisis of 2000–2001. Given the new regulatory framework and market conditions, which are marked by increased concentration and foreign bank participation, the drive to achieve higher efficiency is expected to be stronger. Accordingly, this study focuses on the following research questions: (i) How did the competitive structure evolve over the period? (ii) Is there any evidence

*Corresponding author. Email: canan.yildirim@khas.edu.tr

of differential performance across ownership types? In addition, the sampled period covers both pre-global crisis and crisis years which exhibited significant variation in international financial market conditions and regulatory frameworks worldwide. Hence an additional research question that we address is: (iii) What are the impacts on the sector's efficiency of both the changing domestic macroeconomic and institutional environment and the changes in international financial market conditions due to the global financial crisis?

We make a number of policy-oriented contributions to the literature on the link between banking reform, performance, and ownership change in an emerging markets context. We analyze how financial regulatory reform and restructuring impacted banking performance in Turkey, an underresearched emerging market. As a whole the banking sector showed considerable resilience during the global financial crisis, as well as respectable profitability and growth performance in the aftermath. This is quite unlike many other emerging banking markets, for example, Southeastern European ones. Hence, its recent reform and restructuring experience would be useful indeveloping policies for competitive and robust banking systems. Further, the study period (2002–2013) allows us to assess efficiency performance in an emerging market under two different international financial market conditions: ample liquidity prior to the onset of the global crisis and increasing cost of funds and costly regulatory reforms during crisis years.[1] Comparatively speaking, in addition to its relatively large size the Turkish banking sector is more heterogeneous with respect to ownership categories. Both state-owned banks and foreign-owned banks have substantial market shares. Given that in the aftermath of the global financial crisis there is renewed interest in the potentially stabilizing role of state-owned banks relative to foreign-owned banks, the Turkish case could hold valuable lessons.The country's recent experience allows for the analysis of competitive performances of banks across different ownership categories under changing regulatory and macroeconomic environments. The few recent studies on Turkish banking have not undertaken a comprehensive analysis of the changes in the regulatory environment and in ownership structures, nor have they looked into the implications of these for competitive conduct (see, for instance, Aysan and Ceyhan 2008; Gunay 2012).

By way of preview, it has been found that in general Turkish banks have become more competitive, average profit inefficiency decreased and the sector came closer to the 'zero profit condition' over time. However the sector's declining average profit inefficiency masks diverging results across different ownership structures. We find the decrease is mainly due to the better performance of foreign-owned banks. Similarly, the variability of 'shadow prices' exhibits a significant decline over our sample period, indicating a closer approximation to the 'law of one price' (LOP). We also show that banks' competitive choices differ based on their ownership structures. Privately owned Turkish banks display vigorous competitive behavior as the variability of both their input and output prices fall. State-owned banks show significantly reduced input price variability. However the evidence for declining output price variability is much weaker. This is consistent with their counter-cyclical lending task as well as continuing political interference in their lending decisions. As for foreign-owned banks, we note vigorous decline in output price variability but no evidence of reduction for input price variability. The former feature is fully consistent with their efforts to increase market share, whereas their behavior on the input front might reflect the relatively small share of local deposits in their overall funding.

The remainder of the paper is organized as follows. Section 2 presents the related literature on financial sector regulation and banking efficiency performance. Section 3 provides a review of the Turkish banking industry. Section 4 discusses the methodology employed, and Section 5 provides the empirical results. Section 6 presents the study's conclusions.

2. Literature review

There is extant literature on the impact of financial regulation on banking competition, performance and stability. Several studies report efficiency gains due to liberalization programs undertaken in various emerging and transition countries including Turkey (Zaim 1995; Isik and Hassan 2003), Thailand (Leightner and Lovell 1998), Hungary (Hasan and Marton 2003), India (Ataullah and Le 2006), and Egypt (Fethi, Shaban, and Weyman-Jones 2011). However, other studies have failed to report on efficiency gains as the result of financial reforms. Havrylchyk (2006) demonstrates that Polish banking efficiency did not improve during the transition process. For the Central and Eastern European (CEE) countries, Kasman and Yildirim (2006) find no continuous improvement in banking efficiency over the transition period. Kirkpatrick, Murinde, and Tefula (2008) find financial liberalization to be associated with increased x-inefficiency of commercial banks in Sub-Saharan Africa. Fu and Heffernan (2009) report that the cost x-efficiency decreased significantly as China reformed its banks. Moreover, as a number of studies illustrate, the efficiency impact of the reform process may not be immediately visible or uniform over time. Efficiency may decline at first, due to adjustment costs before improving (Burki and Niazi 2010; Hsiao et al. (2010). For the Turkish liberalization experience, both Isik and Hassan (2002) and Yildirim (2002) demonstrate that the banking system did not achieve sustained efficiency gains and efficiency decreased later on when macroeconomic instability deepened. For the Indian reform process, Zhao, Casu, and Ferrari (2010) show that while efficiency improved during the initial deregulation stage, the overall efficiency trend was negative due to later re-regulation imposing higher costs.

In addition, adjustment costs and speeds during reform and restructuring may differ due to ownership diversity. State-owned banks may continue to operate differently than privately owned ones if political interventions in their lending decisions are not contained. On the other hand, their large branch networks may give them scale advantages in addition to local monopoly status as well as access to cheaper sources of funds in the form of captive deposits. Domestic banks may operate more efficiently than foreign-owned banks as they do not suffer from distance-related organizational diseconomies and barriers other than distance such as differences in language, regulatory, and supervisory structures. Alternatively, some foreign-owned banks can overcome such cross-border disadvantages and surpass the performance of their domestic counterparts (Berger et al. 2000). Several studies have investigated these issues empirically. For Turkey, it has been reported that the efficiency impact of reform was not uniform across ownership types, and privately owned as well as foreign-owned banks benefited more (Isik and Hassan 2002, 2003; Yildirim 2002). Aysan and Ceyhan (2008), in contrast, report that while the sector achieved performance improvement after the restructuring process following the 2000–2001 crisis, there was no significant effect of foreign ownership on efficiency.[2] In China, Fu and Heffernan (2009) report the drop in efficiency was higher in the case of joint stock banks than in state-owned ones. For Pakistan and India, Burki and Niazi (2010) and Zhao, Casu, and Ferrari (2010), respectively, show the speed as well as the direction of adjustments varied across ownership types. Burki and Niazi (2010) note while privately owned and foreign-owned banks performed better than state-owned banks, the dominance of foreign-owned ones weakened later in the reform process. Banker, Chang, and Lee (2010) also report that financially sound or strategically privileged banks had higher productivity gains due to regulatory changes in Korea. As regards long-term ownership effects on banking performance, foreign-owned banks are generally found to perform better than domestic banks in the context of the transition experiences of CEE countries (see, for instance, Hasan and Marton 2003; Havrylchyk 2006; Kasman and Yildirim 2006). Yildirim and

Philippatos (2007), on the other hand, report that foreign-owned banks in transition countries were more cost efficient but less profit efficient compared to domestically owned banks.

It is difficult to empirically establish, however, the presumed positive performance effects of privatizations and foreign acquisitions. It is conceivable that better performing banks may have been chosen for privatization or targeted for acquisition without subsequent efficiency improvement (Havrylchyk 2006; Kraft, Hofler, and Payne 2006). Berger et al. (2005) analyze the static effects of different types of bank ownership (long-run performance effects related to constant domestic, foreign, or state ownership) together with selection effects and dynamic effects of changes in ownership in Argentina. They show that state-owned banks had worse long-term performance. In terms of dynamic changes, there was little difference after domestic mergers and acquisitions or foreign acquisitions while privatizations improved performance. Similarly, Williams and Nguyen (2005) find while state-owned banks underperformed, privatizations improved performance in South East Asia. The results also suggest that the potential efficiency benefits associated with foreign ownership may take longer to materialize.

More recently, the empirical literature began to take note of the heterogeneity of foreign banks. This pertains to the diversity of (home) countries from which they originate and the (host) countries which they enter, along with bank-specific characteristics impacting their relative performance. It is found that foreign banks perform better in terms of profitability in developing countries when they are from a high income country and when host country regulations are relatively weak (Claessens and van Noren 2012). Poghosyan and Poghosyan (2010) and Havrylchyk and Jurzyk (2011) highlighted the importance of entry modes (i.e. cross-border acquisition versus greenfield) affecting the relative efficiency and profitability of foreign-owned banks.

3. Overview of the Turkish banking sector

Macroeconomic imbalances and financial sector fragility characterized the Turkish economy in the 1990s. From 1990 to 2000 growth measured in terms of gross domestic product (GDP) ranged from -5.5% to 9.3% with an average of 4.7% (BDDK 2010, 6). The Turkish liberalization process, initiated in 1980, was undertaken prior to solving the public sector financing needs and developing an effective supervisory and regulatory infrastructure. These shortcomings underlay the problems faced by banks.

Despite its substantial nominal growth in the 1990s, the sector's real growth was volatile due to high inflation. More importantly, the sector came to depend on financing the government's borrowing requirements which became very lucrative and it was increasingly exposed to interest rate and foreign exchange risks, had low asset quality and an insufficient capital base. Capital adequacy dropped to 8.2% whereas the non-performing to gross loans ratio continuously increased and reached 11.1% in 1999 (BDDK 2010, 12–14).

Subsequent to a number of financial crises of varying severity and short-lived stabilization attempts since 1980, finally an exchange rate-based stabilization program was introduced in December 1999 to control inflation, correct macroeconomic fundamentals, and strengthen the increasingly fragile financial system. While the program achieved some initial success, the country experienced a liquidity crisis in November 2000 and a severe attack on the Turkish lira in February 2001.

The banking sector suffered losses due to its inability to control interest rate risk in the first crisis. The second crisis ushered in additional losses since many banks had borrowed in foreign currency only to lend in Turkish liras without any hedging. In December 2001, the losses of the sector reached 6.1% of assets and effectively wiped out its already insufficient financial capital

(BDDK 2010, 29). Therefore, in May 2001 a bank restructuring program embedded in a new economic reform package was introduced. The banking program had four major components: resolution of banks under the Savings Deposit Insurance Fund (Fund); financial and operational restructuring of state-owned banks; recapitalization of privately owned banks; and legal and institutional measures aimed at improving the regulatory and supervisory framework as well as efficiency and competition in the sector.

A new standby agreement was signed with the International Monetary Fund (IMF) in February 2002. It envisioned restructuring the banking sector, improving public sector finances, and instituting legal changes for supporting structural reforms. Accordingly, the authorities continued with the process of reforming the financial regulatory and supervisory framework with the support of international organizations. A limited deposits insurance system was introduced in 2004, replacing the previously introduced full coverage system. The governance of publicly owned banks has been reformed and independent boards of directors have been appointed for them. A new Banking Act in accordance with EU directives and international principles and standards was enacted by parliament in November 2005.

In this process, due to closures of insolvent banks as well as mergers and acquisitions, the number of banks, branches and employees decreased, and concentration levels increased. From 1999 to 2003, the total number of banks decreased from 81 to 50 while the asset share of the top-10 banks increased to 82.3% from 67.5% (BDDK 2010, 76). Simultaneously, total branch numbers in the sector declined to 6029 from 8298 while personnel numbers fell to 130,000 from 174,000 (BDDK 2010, 77).[3] State-owned banks' quasi-fiscal costs of subsidized loans, the so-called duty losses, were written off and they were given the status of a joint stock company to enable them to operate as a 'bank' free from the legal exceptions and responsibilities and to facilitate their ultimate privatizations. Hence, while still enjoying some limited privileges and benefiting from extensive branch networks, they started to operate on a commercial basis (IMF 2007). The government remained committed to the previous governments' plans to privatize the banking sector and undertake Initial Public Offerings in two of the remaining three state-owned banks. In addition, foreign penetration, previously negligible, increased considerably. Apart from foreign investors acquiring banks from the Fund, some foreign banks increased their stakes by obtaining controlling shares in Turkish banks or making strategic partnership agreements. The entrants were mainly from western European markets and were attracted to the improving macroeconomic and institutional environment as well as the sector's future growth potential given Turkey's low bank penetration level.

The recovery from the crisis involved a considerable growth performance: the average annual growth rate of real GDP from 2002 to 2007 was 6.8% (World Bank 2014). Over the same period, the commercial banking industry's assets grew about 3.8 times in terms of US dollars. Further, both asset quality and capital levels in the sector improved. Loans' share in total assets increased mainly due to economic growth and buoyant demand for consumer loans and mortgages. Meanwhile, starting from a negligible level, nonresidents' share in the sector's capital reached 41.1% in December 2007 (BDDK 2007).

Economic growth slowed in 2007 due to adverse international market developments and political troubles at home. Also, feeling the impact of the global crisis, from late 2008 onwards Turkish banks faced difficulties in raising funds internationally. However, the sector's profitability recovered strongly in 2009 thanks to the maturity mismatch between long-term assets and short-term financing sources in the face of declining interest rates (TBB 2009). Overall, the sector proved to be resilient as it was not exposed to toxic assets and traditionaly cheap domestic deposits constituted its main source of funds. Even with an increase in non-performing loans in 2008 and

2009, the sector did not need any capital injections thanks to higher profitability which helped increase capital levels. More recently, however, the measures taken by policy-makers to curb credit growth in response to a widening current account deficit together with regulations in capital and reserve requirements introduced to improve soundness increased intermediation costs and strained the sector's profitability. Nevertheless average profitability as measured by return on equity turned out to be 15% between 2008 and 2013 and the sector continued to grow: Total assets to GDP ratio increased from 74.3% to 104.7% during the same period (TBB 2014).

4. Methodology

4.1 *Shadow profit maximization*

In data envelopment analysis (DEA), the efficiency of a firm is measured by comparing its observed input–output bundle with a reference point on the frontier. Radial measures of technical efficiency are either input- or output-oriented. In a radial input-oriented model, one seeks maximum equi-proportionate reduction in all the inputs of a firm that would be possible without violating the feasibility of its output bundle. In the output-oriented approach, on the other hand, the objective is to expand all outputs by the same factor without using any additional input. When the technology exhibits non-constant returns to scale, the two approaches yield different measures of efficiency. In the case of constant returns to scale, although the efficiency measures are identical, the reference bundles for comparison are different. In a typical empirical application, one has to choose between an input-oriented and an output-oriented model. On the other hand, in those rare cases when input and output prices are available, choosing an orientation can be dispensed with and a profit-maximizing model can be implemented. In this case, the reference bundle will be the one that maximizes profit, and an inefficient firm attains full efficiency by simultaneously altering its inputs and outputs as needed. Indeed there are well-known approaches in the DEA literature that allow for changes in both inputs and outputs in order to obtain the efficient projection of an inefficient input–output bundle even without the benefit of prices. Fare, Grosskopf, and Lovell's (1985) hyperbolic efficiency approach measures the maximum scalar by which all outputs can be expanded and all inputs can be contracted at the same time. Chambers, Chung, and Fare (1996) introduced the directional distance function and the corresponding Nerlove-Luenberger measure of efficiency. Here one seeks to increase all outputs and reduce all inputs by the same proportion. In both of these approaches, however, a *single* parameter determines how the output bundle is expanded and the input bundle is contracted. In other words, neither Fare, Grosskopf, and Lovell (1985) nor Chambers, Chung, and Fare (1996) allow the reference bundle to show an increase in any input or a decrease in any output compared to observed input–output bundle of the firm. Yet, when the firm maximizes profits the optimal bundle can show either an increase or a decrease in any input or output so long as the resulting profit is higher. Determining the profit-maximizing bundle of inputs and outputs requires data on the prices faced by the firm under evaluation. The model developed by Ray (2007), which we are implementing, dispenses with this necessity and shows how *endogenously* determined *shadow prices* of inputs and outputs of a firm can be used in place of actual prices to obtain the optimal projection of its observed input–output bundle where its *shadow profit is maximized*. *Therein lays its significance*. Furthermore, as Ray (2007) demonstrates, this novel approach amounts to an application of the Weak Axiom of Profit Maximization (WAPM) formulated by Varian (1984). For further details and refinements, the reader is referred to Ray (2007) and Aparicio, Pastor, and Ray (2013) as well as to Appendix 1 of this paper.

4.2 *Model predictions*

As explained in Appendix 1 in great detail, the inefficiency score of each firm can be viewed as unrealized or foregone profits due to management preferences for a quiet life *a la Hicks*. In a survey paper Hicks (1935, 8) argued that monopoly status allowed the monopolist the luxury of being choosy regarding the advantages flowing from the position. Thus such a firm could opt for a quiet life instead of, or in addition to, above competitive profits. In other words a monopolist could afford to adopt a laid back attitude and forego some profits whereas a competitive firm would have to pinch every penny and pursue every prospect. This observation leads to two testable propositions. Firstly, in a cross section one would expect a negative correlation between banks' inefficiency scores and their actual profits. Secondly, since the magnitude of each bank's inefficiency measures deviation from competitive norm, one can interpret the average inefficiency score for all banks during a given year as the sector's deviation from perfect competition. It follows that a declining sectorial average over time would be consistent with increased competition. Another prediction of our model involves the LOP which is a characteristic of a competitive market. Our model generates shadow prices for each input and output in every year. Thus for each year we can calculate shadow price variances for each input and output. Clearly increased competitiveness implies *declining* price variability over time for each input and output. While investigating the impact of deregulation on Austrian banks, Ali and Gstach (2000) were the first to use shadow prices to perform such a test. It is worth pointing out that since researchers typically do not have access to actual prices, the strategy of using shadow prices instead can be useful in other settings as well. Ten Raa (2009) contains a very accessible discussion of the relationship between accounting and shadow prices and the uses of the latter from a managerial perspective.

4.3 *Sequential DEA*

In constructing frontiers for each year, we depart from typical DEA applications in which the evaluation of the frontier for a particular year, say 2005, uses as a reference set all observations for units in the same year. Instead we calculate the successive frontiers for each year using, as a reference set, all observations for units in all years up to and including the year in question. This approach was proposed by Tulkens and Vanden Eeckaut (1995) who also coined the term *sequential DEA*. It has been applied to both banking data (Grifell-Tatjé and Lovell 1999; Pastor 1999) and non-banking data (Lim and Lovell 2009). So the frontier for 2002 uses as a reference set all observations for banks from that year, whereas the frontier for 2003 uses as a reference set all observations for banks from 2003 and 2002. This approach builds 'learning' into the construction of the frontier and is tantamount to saying 'what was possible in the past remains possible in the future'. In other words, it posits any transformation possibilities between inputs and outputs that could be observed in 2004 are replicable in 2013 while allowing for improved possibilities, due to accumulated knowledge of the technology, in 2013. In a banking context it is particularly appropriate in situations where lessons drawn from past experience are not forgotten. Since the events and practices leading to the 2000–2001 crisis are still fresh, we believe it is a highly relevant modeling strategy for our application.

4.4 *Definition of inputs and outputs*

There exists little agreement about what banks produce. However, three main approaches to defining inputs and outputs can be identified (Humphrey 1985; Berger and Humphrey 1992):

'the intermediation approach', 'the user cost approach', and 'the production approach'. The intermediation approach assumes that banks collect funds, deposits and purchased funds, and intermediate these funds into loans and other assets. The user cost approach involves classifying financial goods into input and output categories according to their 'user costs' or signs of their derivatives in a bank profit function which is estimated empirically. According to the production approach, banks are understood to produce deposits and loans using capital, labor, and materials. Berger and Humphrey (1997) state that the production approach is preferable when evaluating the efficiencies of branches of financial institutions while the intermediation approach is preferable for evaluating the entire financial institution, as it concerns the overall costs of banking, that is, interest and non-interest expenses. In addition, Ferrier and Lovell (1990) argue that the intermediation approach is preferable when analyzing the economic viability of banks. Accordingly, following the intermediation approach, a cost- and revenue-based model is adopted in this study. More specifically, cost and revenue items from the income statement are employed as inputs and outputs following a profit-oriented specification. The two inputs are defined as interest expenses and non-interest expenses, while the two outputs are defined as interest income and non-interest income. Non-interest income includes net fees and commission income, dividend income, net trading profit, and other operating income.

This specific model has a number of virtues. First, as a parsimonious model it helps improve the discriminatory power of DEA which declines when the number of inputs and outputs increases in comparison to the number of units being analyzed. Second, it incorporates nontraditional activities of banks since efficiency measures are sensitive to the inclusion versus exclusion of such activities, and their importance for bank revenues has become critical (Rogers 1998; Clark and Siems 2002). Finally, since cost and revenue items are employed as inputs and outputs, the derived efficiency measure can be interpreted as profit efficiency incorporating the unmeasured differences in output or bank service quality. Berger and Mester (1997) note the profit efficiency measure 'accounts for the additional revenue earned by high quality-banks, allowing it to offset their additional costs of providing the higher service levels' (902). Leightner and Lovell (1998), Drake, Hall, and Simper (2006), and Sturm and Williams (2010), among others, apply the same specification to the definition of inputs and outputs.[4]

5. Empirical analysis

5.1 *Sample and data sources*

The sample includes almost all commercial banks operating in Turkey from 2002 to 2013. Annual bank level financial data were accessed through the electronic data inquiry system of the Banks Association of Turkey. Three small foreign-owned banks that left the system early in the sample period and banks taken under the control of the Fund were excluded. The final data set is an unbalanced sample of 32 commercial banks over 2002–2013 with a total of 328 bank year observations. It corresponds to about 99% of the total assets of the commercial banking sector in 2013.[5] Table A1 in Appendix 2 displays descriptive statistics on the input–output variables used in the study.

5.2 *Zero profit condition*

As discussed previously, the Ray (2007) model we use derives a measure of unrealized profit or equivalently profit inefficiency for each bank year in our sample. Table 1 presents the summary

Table 1. Evolution of profit inefficiency or unrealized profits over time.

Year	Mean	Median	Maximum	Minimum	Standard deviation	No. of observations	Weighted mean[a]
2002	1.2392	0.3450	7.5690	0	1.8915	27	0.2868
2003	2.9662	0.5852	24.9386	0	5.4921	31	0.4663
2004	6.2045	0.6298	39.1320	0	10.9048	30	0.5616
2005	10.6334	0.8932	96.9792	0	21.2742	30	0.5869
2006	15.0762	1.3393	141.0255	0	29.1483	29	0.6665
2007	6.7407	0.8954	73.3828	0	15.4232	28	0.4944
2008	3.0563	0.6414	24.9036	0	5.9449	26	0.3921
2009	1.9879	0.0600	31.2786	0	6.2402	26	0.1642
2010	1.6876	0.1629	13.4267	0	3.4518	26	0.2003
2011	4.5772	0.2802	33.7587	0	9.2943	26	0.3754
2012	2.7354	0.2618	31.1076	0	6.3594	26	0.2459
2013	2.4471	0.2237	23.7999	0	5.3729	23	0.2232
all years	5.1157	0.4713	141.0255	0	13.4531	328	0.3987

Note: The table presents summary statistics on profit inefficiency measures generated by our model following Ray (2007).
[a]Weighted by total assets.

statistics on the inefficiency measures generated according to our model. Since in each case the cost is normalized to one, the inefficiency figure is to be interpreted as a multiple of the 'average' bank's cost for that year. So according to our estimates, for 2006, mean inefficiency is about 15.1 times the average normalized cost, and in 2010 it falls to about 1.7 times. While it rises very significantly to almost 4.6 times the average cost in 2011, in the last two years it remains around 2.6 times the average cost.

As we stated in Section 4.2 the unrealized profit measure can be viewed as an indicator of 'opportunities not pursued' or 'extent of quiet life' chosen by management. Therefore we would expect a negative correlation between the unrealized and realized or actual profits of our banks. Table 2 shows both pairwise correlations and Spearman's rank correlations between unrealized and two common accounting measures of profitability in banking: Net Income to Total Assets ratio (ROA) and cost to income ratio (CI) defined as non-interest expenses to the sum of net-interest income and non-interest income. For ROA, the pairwise simple (rank) correlations are as expected, negative for every year and in 10 (11) of the 12 cases, they are statistically significant at the 95% or more significance level. For CI, the pairwise simple (rank) correlations are, again as expected, positive for all the years and significant at the 95% or more level in 10 (12) cases.

Figure 1 presents the graph of asset weighted averages of the inefficiency measures generated according our model. There is a readily observable unrealized profit or inefficiency increase from 2002 to 2006. We are inclined to think of this as adjustment to the new market environment and the regulatory changes discussed above. It can be argued that once the banking system implemented the necessary regulatory and ownership changes and adjusted to the new environment profit inefficiency started falling in 2007 and reached the lowest average of the sample period in 2009.[6] However, average inefficiency rose again in 2010 and 2011. We note that our inefficiency estimate measures 'unrealized profit on outlay'. In a sense, it measures 'missed opportunities' or 'worthwhile prospects not pursued'. From this perspective it is tempting to ascribe the increase of inefficiency and the overall volatility after 2009 to the ongoing and deepening effects of the

Table 2. Correlations between profit inefficiency or unrealized profits and actual profits.

		Pairwise correlations		Spearman's rank correlations	
Year	No. of observations	ROA	CI	ROA	CI
2002	27	− 0.5101*	0.5906*	− 0.3175	0.6264*
		(0.0066)	(0.0012)	(0.1066)	(0.0005)
2003	31	− 0.7018*	0.5452*	− 0.5863*	0.5294*
		(0.0000)	(0.0015)	(0.0005)	(0.0022)
2004	30	− 0.4898*	0.6822*	− 0.7050*	0.6467*
		(0.006)	(0)	(0)	(0.0001)
2005	30	− 0.085	0.2565	− 0.6107*	0.6454*
		(0.6553)	(0.1712)	(0.0003)	(0.0001)
2006	29	− 0.5523*	0.3436	− 0.7507*	0.7931*
		(0.0019)	(0.068)	(0)	(0)
2007	28	− 0.7566*	0.9204*	− 0.7444*	0.7838*
		(0)	(0)	(0)	(0)
2008	26	− 0.3934*	0.5338*	− 0.6650*	0.8010*
		(0.0468)	(0.005)	(0.0002)	(0)
2009	26	− 0.4419*	0.6361*	− 0.8933*	0.8195*
		(0.0238)	(0.0005)	(0)	(0)
2010	26	− 0.6145*	0.5509*	− 0.5990*	0.7078*
		(0.0008)	(0.0035)	(0.0012)	(0.0001)
2011	26	− 0.6280*	0.6739*	− 0.8277*	0.8414*
		(0.0006)	(0.0002)	(0)	(0)
2012	26	− 0.2303	0.4640*	− 0.6137*	0.4776*
		(0.2576)	(0.0169)	(0.0009)	(0.0136)
2013	23	− 0.5516*	0.7680*	− 0.7283*	0.7204*
		(0.0064)	(0)	(0.0001)	(0.0001)

Notes: The table presents pairwise simple and Spearman's rank correlations between the profit inefficiency measure of our model and two conventional measures of profit performance in banking: ROA and CI. ROA is return on total assets and CI is cost to income ratio. Probability values are given in parentheses.
*p values of 5% or less, equivalent to 95% or higher significance levels.

global financial crisis. In other words, these effects might have dampened the 'animal spirits' of Turkey's bankers. In addition, the monetary and banking policy measures taken in later years to curb credit growth in response to a widening current account deficit strained the sector's profitability by raising the cost of funds and equity (TBB 2010, 2011).

We formalize these insights by dividing our sample period into two equal sub-periods and comparing the inefficiency levels in these two sub-periods: 2002–2007 and 2008–2013. The first sub-period covers the years of adjustment to regulatory reforms and ownership changes while the second sub-period incorporates the restructured banking environment. In addition, the two sub-periods substantially differ in terms of not only international financial market conditions facing all banks but also domestic macroeconomic conditions. While prior to the global financial crisis, Turkish banks benefited greatly from ample liquidity in global markets and were able to expand both their branch networks and product arrays, later on they confronted increasing cost of funds due to changing global risk perceptions and a dramatic decline in domestic activity especially in 2008 and 2009. Largely owing to the global economic environment, the country's growth rate fell substantially over the two sub-periods: average growth rate of real GDP was 6.8% and 3.3% during 2002–2007 and 2008–2013, respectively, (World Bank 2014).

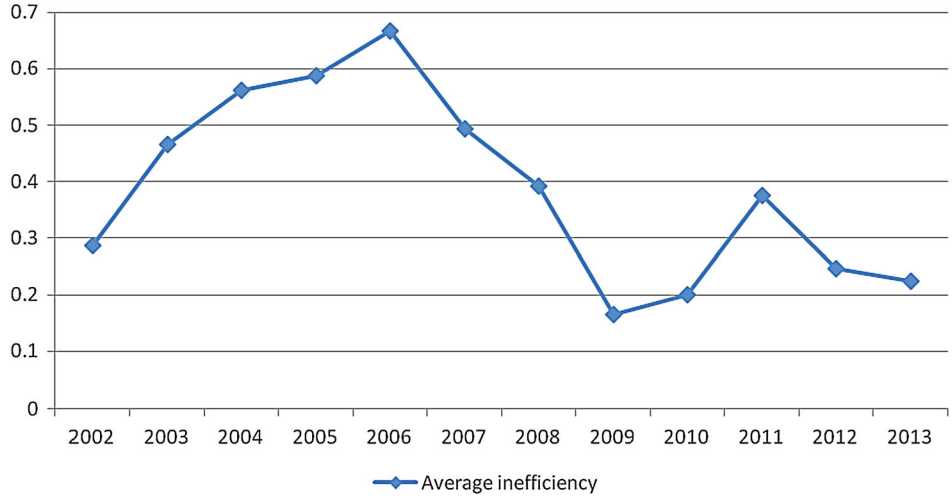

Figure 1. Average inefficiency over time.
Note: Mean inefficiency measures weighted by total assets.

Table 3. Inefficiency across two sub-periods: 2002–2007 versus 2008–2013.

	Total sample	State-owned	Private-Turkish	Foreign-owned
Second sub-period	− 3.6538***	− 0.0451	− 1.1251	− 7.4217**
	(− 2.88)	(− 1.09)	(− 0.8)	(− 2.68)
Constant	6.4083***	0.1423	4.8345**	10.0500***
	(3.97)	(1.73)	(2.67)	(3.38)
No. of observations	328	36	148	144
R^2	0.0301	0.034	0.0044	0.0799
F-stat. (sign.)	8.32	1.19	0.63	7.2
	(0.0071)	(0.3892)	(0.4366)	(0.0152)

Notes: The table presents regression results of profit inefficieny on an indicator variable for the second sub-period in alternative samples. The dependent variable is the profit inefficiency measure derived according to our model and the second sub-period is an indicator variable taking the value of one for the years 2008–2013. The model is estimated by OLS with clustered errors at bank level. *t* statistics are given in parentheses.
**Significance at the 5% level.
***Significance at the 1% level.

To test whether inefficiency measures of the two sub-periods are statistically significantly different, we employ ordinary least squares (OLS) regression models where there is only an indicator variable which is equal to one if the year is between 2008 and 2013 as the explanatory variable, and the inefficiency measure is the dependent variable.[7] For the whole sample, the coefficient estimate is negative and significant suggesting mean inefficiency to be significantly lower in the second sub-period (Table 3). However, running the same regressions for the three sub-samples based on ownership categories reveals the inefficiency reduction of the later sub-period is mainly due to the better performance of foreign-owned banks.[8]

5.3 *The law of one price*

As discussed in Section 4.2, in addition to zero profit, economic theory predicts increased competition will result in reduced price variability across producers, known as 'the LOP'. Using the above insight, namely more competition implies less price variability, we tested whether the sector as a whole came closer to LOP during our sample period, 2002–2013. In addition since the observation applies to the price variability of each input and output, it is possible to make inferences regarding competitive choices of banks across different ownership categories.

The shadow profit maximization model generates shadow prices for our inputs as well as outputs. These are relative prices and can be interpreted as valuations of the corresponding input and output variables. The optimization logic treats the bank under consideration preferentially in assigning these values. As a result, unless normalized such shadow prices are not comparable across units. Therefore we normalize the input prices as well as the output prices to sum to one. Then we compute the variance and the squared rank scores of these shadow prices for each input and each output. The cost of this normalization is the loss of one degree of freedom. As a result, for our model the test scores for interest expense and non-interest expense are identical. The same holds true for the two outputs.[9]

For each input and output variable we compare the obtained shadow price vector of the first sub-period (2002–2007) with the corresponding vector of the second sub-period (2008–2013). We perform an F test which assumes a normal, that is, Gaussian distribution, to see whether the variances of these shadow price vectors differ between the two sub-periods. However, the distribution of shadow prices commonly deviates from the Gaussian and tends to be non-symmetric. Consequently in testing whether the spread of the price distributions decreased over our sample period, we use the Conover test of differences in squared rank scores as well (1980). The test procedure is based on the squared ranks of absolute deviations from their respective means. As such, the Conover test is robust against deviations of the relevant shadow price distributions

Table 4. Shadow prices across sub-periods: 2002–2007 versus 2008–2013.

		Shadow prices for inputs		Shadow prices for outputs	
		Interest expense	Non-interest expense	Interest income	Non-interest income
Total sample	Conover Z score	− 5.137***	− 5.103***	− 6.370***	− 6.370***
(175,153)[a]	F test score	1.552***	1.552***	2.113***	2.113***
State-owned	Conover Z score	− 2.486***	− 2.501***	− 1.188	− 1.188
(18,18)[a]	F test score	3.146***	3.146***	2.509**	2.509**
Private-Turkish	Conover Z-score	− 7.142***	− 7.258***	− 7.029***	− 7.029***
(88,60)[a]	F test score	1.702***	1.702***	2.617***	2.617***
Foreign-owned	Conover Z score	0.832	0.955	− 2.315***	− 2.315***
(69,75)[a]	F test score	1.106	1.106	1.852***	1.852***

Notes: The table displays the results of Conover test of differences and an F test utilized to check variance of shadow prices in the two sub-periods: 2002–2007 versus 2008–2013 and in alternative samples. Negative z-scores indicate declining price variability from 2002–2007 to 2008–2013 sub-periods. In each case the Conover Z score and the F test score indicate the null of equal price variability between the two periods can be rejected at the indicated significance level in favor of a smaller ending period variability.

[a]Numbers in parenthesis indicate the number of observations in the two periods. Due to mergers and acquisitions observation numbers are unequal.

**Significance at the 5% level.

***Significance at the 1% level.

from the Gaussian and in that sense preferable to the F test. The Conover test statistic itself is asymptotically normal, that is, Gaussian.

The test results based on two price variability measures (Conover's squared rank scores and variance) between the two sub-periods of the whole sample are displayed in Table 4. Our findings contain evidence favoring a 'convergence to the LOP' or equivalently an increased competition interpretation both on inputs and outputs for the overall sector. Next, we group our banks as state-owned, privately owned and foreign-owned and try to detect broad differences between their competitive strategies by looking at the evolution of their shadow price variability in the two sub-periods (Table 4). Turning to state-owned banks, both test results indicate reduced price variability on inputs between the two sub-periods. Concerning outputs, however, only the F test indicates a significant decline in variance. This finding might be indicative of continuing political interferences into the output (pricing) decisions of state-owned banks as well as state-owned banks pricing their products following objectives other than profit maximization.[10] For privately owned banks both test statistics indicate a significant decrease in input as well as output price variability between the two sub-periods. In the case of foreign-owned banks, on the other hand, both tests diplay declining variability on outputs only. No reduced price variability for inputs is consistent with foreign banks being more exposed to the global financial crisis than Turkish owned ones.[11] In particular, increased volatility together with heightened risk perceptions of global markets would cause a higher variability in foreign banks' interest expenses due to their greater dependence on non-deposit funding sources.[12]

5.4 *Impact of macroeconomic conditions on measured inefficiency*

We note our study's time span includes the global financial crisis and hence covers two very distinct periods of international financial market conditions. This coupled with divergent domestic macroeconomic environments in the years preceding the crisis and its aftermath, necessitates that we isolate correctly the impact of reform and restructuring on bank inefficiency.[13] As a robustness check we considered how the changing macroeconomic environment in addition to reform and restructuring affects the estimated inefficiencies. Therefore, following Ray (1991) we performed a second-stage regression analysis. Specifically, we regressed our model's inefficiency scores on two macroeconomic variables: annual growth rate of GDP and inflation. We included real GDP growth to take account of business cycle fluctuations and overall economic conditions. Since high levels of GDP growth would provide banks with abundant business opportunities, they would be less pressed to keep costs under control. Inflation, on the other hand, could affect bank behavior and performance in a number of ways. High levels of inflation would induce banks to charge higher risk premiums which might increase profitability (Demirgüç-Kunt and Huizinga 1999). However, in high inflationary environments bank costs might also increase due to competition through excessive branch networks and higher number of bank transactions (Angelini and Cetorelli 2003).

As these macroeconomic factors are not under management control (i.e. they are non-discretionary) we can remove their effect on our model's inefficiency scores by relating measured inefficiency to non-discretionary factors as in the following regression model:

$$i_t = i(y_t, \pi_t) + \varepsilon_t, \tag{1}$$

where i_t represents measured inefficiency, and y_t, π_t are real GDP growth rate and inflation rate, respectively. $i(y_t, \pi_t)$ represents minimum inefficiency given the macro environment while $\varepsilon_t > 0$, is 'pure and avoidable inefficiency caused by mismanagement' (Ray 1991, 1623). We

Table 5. Adjusted inefficiency across two sub-periods: 2002–2007 versus 2008–2013.

	Total sample	State-owned	Private-Turkish	Foreign-owned
Second sub-period	− 3.4870**	0.0765	− 1.0157	− 7.1732**
	(− 2.76)	(1.85)	(− 0.72)	(− 2.6)
Constant	8.4194***	2.1922***	6.8965***	11.9861***
	(5.23)	(26.69)	(3.81)	(4.05)
No. of observations	328	36	148	144
R^2	0.0282	0.0005	0.0036	0.0777
F-stat. (sign.)	7.64	3.42	0.52	6.78
	(0.0095)	(0.2055)	(0.4806)	(0.018)

Notes: The table presents regression results of adjusted inefficieny on an indicator variable for the second sub-period in alternative samples. In every case the dependent variable is the adjusted residual obtained from regressing inefficency scores generated by our model on GDP growth and inflation. See also Table A2. The second sub-period is an indicator variable taking the value of one for the years 2008–2013. The model is estimated by OLS with clustered errors at bank level. t statistics are given in parentheses.
**Significance at the 5% level.
***Significance at the 1% level.

Table 6. Evolution of profit inefficiency or unrealized profits over time: balance sheet model.

Year	Mean	Median	Maximum	Minimum	Standard deviations	No. of observations	Weighted mean[a]
2002	18.6320	0.0052	348.9362	0	68.2424	27	0.7124
2003	37.8871	0.0567	627.3020	0	124.9630	31	0.7306
2004	8.7003	0.0496	199.9185	0	36.6793	30	0.3739
2005	47.0449	0.0069	1258.9170	0	230.2042	30	0.3163
2006	149.4433	0.0323	4186.8360	0	776.9049	29	0.6282
2007	6.7659	0.0035	185.1523	0	34.9619	28	0.2952
2008	26.3871	0.0164	541.5445	0	108.3450	26	0.2787
2009	48.4943	0.0073	1114.8100	0	219.1148	26	0.3378
2010	20.1660	0.0716	461.7559	0	90.6409	26	0.1490
2011	8.5404	0.0383	166.1244	0	32.8309	26	0.2615
2012	128.1089	0.0422	2591.5810	0	514.6394	26	1.0041
2013	4.5786	0.0183	67.2678	0	14.4873	23	0.1176
All years	42.6910	0.0257	4186.8360	0	293.3688	328	0.4408

Notes: The table presents summary statistics on profit inefficiency measures generated by our model following Ray (2007). We use a balance sheet approach to define inputs and outputs.
[a]Weighted by total assets.

estimated Equation (1) by OLS and adjusted the resulting $\widehat{\varepsilon_t}$ by subtracting the minimum negative residual. This yields our new inefficiency estimates which are all non-negative as required.[14] Next, using the adjusted inefficiency measures we performed analogous tests to those in Section 5.2 to assess whether mean adjusted inefficiency in the later period is lower. The results presented in Table 5 confirm the previous findings that mean inefficiency is statistically significantly lower in the second sub-period for the overall sample as well as for the foreign-owned banks category.

5.5 *Alternative input and output measures*

Our model's inefficiency scores are intuitively close to the profit inefficiency notion due to our using income statement items as opposed to balance sheet ones. In that sense it is preferable. However, the intermediation approach is consistent with other specifications as well. Accordingly, we checked the robustness of our results by using an alternative model where balance sheet variables are designated as inputs and outputs (balance sheet based model). Specifically, total deposits and borrowed funds, owners' equity, and number of personnel are defined as the three inputs while total loans, other financial assets, and off-balance sheet portfolio are defined as the three outputs. Table A1 in Appendix 2 displays descriptive statistics on the input–output variables while Table 6 presents the summary statistics on the inefficiency measures generated according to this model. While inefficiency measures under the balance sheet model display higher levels of variation and hence are less accurate compared to those under the (preferred) cost and revenue-based model, we found a significant and positive correlation beween the two sets of estimates: pwcorr = 0.4476 (sign. at 1%) and Spearman's rho = 0.2406 (sign. at 1%)

6. Conclusions

This study analyzed the Turkish banking industry's profit efficiency taking into account the sector's restructuring and ownership changes. Using a recently devised method by Ray (2007) and Aparicio, Pastor, and Ray (2013), we derive 'shadow unrealized profit scores' for Turkish banks from 2002 to 2013. We explain how these scores measure the size of an unrealized profit due to actions not taken by bank management. As such they gauge the extent of what Hicks called 'monopolistic quiet life'. Thus they can be viewed as deviations from the zero profit condition that characterizes perfect competition. It follows that declining deviations would imply convergence to 'zero profit' and thus enhanced competition. Comparisons based on the 'unrealized profit scores' provide evidence indicating greater competition over time in the Turkish banking industry. Further analysis shows that the reduction in inefficiency in the later years is mainly due to the better performance of foreign-owned banks. Our finding that foreign-owned banks performed better than the other groups is in agreement with the previous research that report differential performance effects across ownership types during reform and restructuring processes (see, Berger et al. 2005 and Burki and Niazi 2010, among others).

Our model also generates 'shadow input–output prices'. Comparing the variances and the squared ranks of these prices reveals a significant decline in variability over our sample period. We argue such declining variability indicates convergence to the 'LOP' and thus higher competition. Using shadow price information we also shed light on the competitive choices of banks depending on their ownership structure. Interestingly, comparisons of state-owned banks' shadow prices between the two sub-periods suggest that these banks may still be facing political interference in their output decisions while competing on a level basis with the other groups on the inputs front. This is consistent with some industry partipants' more recent observations that the independence of state-owned banks together with financial and economic regulatory agencies are deteriorating. However, there is also reason to believe such interference was part of the government's counter-cyclical policy during the global financial crisis. Foreign-owned banks, on the other hand, display vigorous decline in output price variability but no evidence of reduction for input price variability. The former feature is fully consistent with their efforts to increase market share, whereas the latter result might reflect the relatively small share of local deposits in their

overall funding which exposed them to the impact of the global financial crisis to a greater extent than their Turkish counterparts.

Overall our study shows the significant restructuring process introduced in the aftermath of the country's 2000–2001 banking crisis rendered the sector more profit efficient and robust as evidenced during the global financial crisis. However, our findings also suggest policy-makers should take into account adjustment costs that banks face which might initially affect their efficiency performance negatively. In addition, we show that djustment speeds to regulatory and market structure changes as well as performance effects of varying international financial market conditions differ across banks depending on their ownership structures as well as activity and funding strategies. Therefore, policies towards improving efficiency and competitiveness in the financial sector should take note that competitive strategies reflect banks' ownership structures, and the business models adopted interacting with international financial market conditions affect the subsequent performance of the sector.

Acknowledgements

We wish to thank Adel Boughrara, Adnan Kasman, Subhash Ray, Doğan Tırtıroğlu, an anonymous referee and the editors for helpful comments and suggestions. We are also grateful to participants at the ERF 19th Annual Conference 2013, the Istanbul Finance Congress 2013, the Borsa Istanbul Finance and Economics Conference 2013, and the 12th International DEA Conference 2014.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. We are grateful to an anonymous referee for pointing out the impact of international financial market conditions on measured efficiency.
2. However, the study excludes state-owned banks and does not take into account the foreign acquisitions that took place during later periods.
3. In particular, the number of branches and personnel of state-owned banks was slashed dramatically; from 2001 to 2003, the number of branches and personnel decreased by 33% and 50%, respectively (BDDK 2010, 41).
4. In this context it is worth re-emphasizing that (see Section 4.1), our score is not derived from a traditional DEA profit efficiency model which necessitates the use of market prices faced by the firm as data (e.g. Cooper, Seifor, and Tone 2006, 245–269).
5. Bank year observations with negative output measures are excluded from the final sample.
6. Asset weighted averages of the inefficiency scores are given in Table 1.
7. The regression coefficient's *t*-statistic is used to evaluate whether the two periods differ significantly in terms of mean inefficiency (Banker and Natarajan 2011, 287).
8. Following convention we define banks where non-Turkish ownership exceeds 50% as foreign-owned. Most of our privately owned banks have foreign shareholdings as well, but below the 50% benchmark.
9. Minor differences in rank-based Conover *Z* scores are due to the presence of ties.
10. Ozatay (2013, 155–162) discusses the program of subsidized loans for small and medium-sized enterprises implemented in 2009 in order to combat the negative impact of the global financial crisis. The author criticizes it for not being vigorous enough. Similarly, Bakir (2009) argues state-owned banks crucially contributed to the government's response to the crisis.
11. This is consistent with the findings of recent policy oriented research highlighting the role of multinational banks in transmitting shocks across countries. See, among others, Claessens and van Horen (2013), Choi, Martinez Peria, and Gutierrez (2013) and de Haas and Van Horen (2013).
12. As of September 2008, liabilities due to banks to total assets ratio was 5.7%, 14.6%, and 19.1% in state-owned, privately-owned, and foreign-owned banks, respectively (Yörükoğlu and Atasoy 2010, 397).

13. We are thankful to an anonymous referee for raising this point.
14. This procedure was originally derived by Greene (1980). The regression results are given in Table A2 in Appendix 2.

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Appendix 1. The non-parametric methodology

Consider a data set for N firms from an industry. Let y^j be the m-element output vector and x^j the corresponding n-element input vector of firm j ($j = 1, 2 \ldots N$). Assuming convexity of the technology, free disposability of inputs and outputs, and variable returns to scale, an inner approximation to the unobserved production possibility set of this industry is:

$$S = \left\{ (x, y) : x \geq \sum_{1}^{N} \lambda j x j; y \leq \sum_{1}^{N} \lambda j y j; \sum_{1}^{N} \lambda j = 1; \lambda j \geq 0 \, (j = 1, 2, \ldots N) \right\}. \tag{A1}$$

The efficient input-oriented projection of any observed input–output bundle (x^0, y^0) is:
$(\theta^0 x^0, y^0)$ where

$$\theta^0 = \min \theta : (\theta x^0, y^0) \in S, \tag{A2}$$

θ^0 is the input-oriented technical efficiency measure.
Similarly, the output-oriented efficient projection is $(x^0, \phi^0 y^0)$ where

$$\phi^0 = \max \phi : (x^0, \phi y^0) \in S. \tag{A3}$$

$1/\phi^0$ is the output-oriented technical efficiency measure.

We note that the selection of (A2) or (A3) involves a prior judgment about whether expanding outputs or contracting inputs is more important in a given context.

For Fare, Grosskopf, and Lovell's (1985) hyperbolic efficiency approach, the efficient projection of (x^0, y^0) is:
$(1/\delta^0 \, x^0, \delta^0 y^0)$ which is obtained from the hyperbolic distance function:

$$\delta^0 = \max \delta : (1/\delta \, x^0, \delta y^0) \in S. \tag{A4}$$

For an efficient projection δ^0 must be greater than or equal to unity. We note that input reduction and output expansion is done simultaneously.

Another measure of efficiency involving simultaneous input output changes is the Nerlove-Luenberger measure operationalized by Chambers, Chung, and Fare (1996).

$$\beta^0 = \max \beta : \{(1-\beta)x^0, (1+\beta)y^0\} \in S. \tag{A5}$$

In both (A4) and (A5), however, a *single* parameter determines how both inputs and outputs change. Note further that because (x^0, y^0) is an element of S, δ equal to unity is always a feasible solution in (A4). Hence, at the optimal solution $\delta^0 \geq 1$ holds. Similarly $\beta^0 \geq 0$ holds in (A5). That is, in both of these models each and every output may only increase and each and every input may only decrease. In other words, these two models do *not allow* input or output *substitution* based on *relative price* advantageousness.

Now suppose one had information on the output and input prices for the firm under review. Specifically, assume that p^0 and w^0 were the output and input price vectors, respectively. In that case, the optimal projection of the observed input output bundle would be (x_*^0, y_*^0) satisfying the inequality

$$P^{0t}y_*^0 - w^{0t}x_*^0 \geq P^{0t}y^0 - w^{0t}x^0 \quad \forall (x,y) \in S. \tag{A6}$$

Define $\pi_*^0 \equiv P^{0t}y_*^0 - w^{0t}x_*^0$ and $\pi^0 \equiv P^{0t}y^0 - w^{0t}x^0$. Clearly, the first expression represents the optimal and the second the actual profit levels. Thus their difference $\Delta^0 = \pi_*^0 - \pi^0$ will be a *measure of the unrealized profit of the firm*. It is worth noting that in order to get to the profit-efficient projection the firm does not increase all of its outputs or decrease all of its inputs by the same proportion. In fact, it will practice substitution between inputs as well as outputs. In other words, it may increase or reduce individual inputs or outputs appropriately so long as the resulting bundle maximizes profit.

Varian's (1984) WAPM argues that if the input–output bundle of a particular firm evaluated at the prices it faces yields a lower profit than what could be earned if it had chosen the observed input–output bundle of some other firm in the sample, then the firm under consideration could not be maximizing profit.

Lacking the necessary price information, Ray (2007) does not take that approach. Instead the endogenously determined shadow prices are used to look for the input–output bundle that maximizes profit over the entire production possibility set S at those prices. Consider output price vector u^0 and input price vector v^0 such that at these shadow prices the observed input–output bundle (x^0, y^0) yields zero profit.

$$u^{0t}y^0 - v^{0t}x^0 = 0. \tag{A7}$$

The next step involves determining the optimal bundle (x^*, y^*) such that

$$P^* \equiv u^{0t}y^* - v^{0t}x^* \geq u^{0t}y - v^{0t}x \quad \forall (x,y) \in S. \tag{A8}$$

The maximum profit P^* provides a measure of the overall inefficiency of the firm producing y^0 from x^0. One problem that remains, however, is that one can change the shadow prices of inputs and outputs by any given proportion and P^* also changes by the same proportion without violating the requirement of zero profit at the observed input–output bundle. As a result, the maximum unrealized shadow profit P^* would be unbounded. One way to overcome this problem is to normalize the shadow prices separately so that

$$u^{0t}y^0 = v^{0t}x^0 = 1. \tag{A9}$$

The shadow profit maximization for the firm under evaluation can now be formulated as:
Min P $\{P, u^{0t}, v^{0t}\}$ subject to:

$$\begin{aligned} &P \geq u^{0t}y^j - v^{0t}x^j \quad (j = 1, 2 \ldots N). \\ &u^{0t}y^0 = 1, \\ &v^{0t}x^0 = 1, \end{aligned} \tag{A10}$$

$u^{0t} \geq 0$; $v^{0t} \geq 0$; P unrestricted.

The dual of this linear programming problem consists of:
Max $\phi - \theta$ $\{\phi, \theta, \lambda_j\, j = 1, 2 \ldots N\}$ subject to:

$$\sum_{1}^{N} \lambda jyj \geq \varphi y0,$$

$$\sum_{1}^{N} \lambda jxj \leq \theta x0,$$

$$\sum_{1}^{N} \lambda j = 1, \tag{A11}$$

$\lambda_j \geq 0$; ϕ and θ unrestricted. We note that these are the decision variables

It is important to stress the main choice variables, that is, the λ_j, are used in constructing the 'composite' banks which are successful in the WAPM sense. Namely such 'banks' obtained by combining observed banks in proportions indicated by the relevant λ_j, generate the largest profit using the shadow prices which are best for the bank that is being evaluated. Thus, in such cases by invoking the WAPM we conclude that the bank under consideration cannot be maximizing profit and is therefore inefficient. On the other hand, if such a 'composite' bank cannot be constructed, equivalently when P is zero, by WAPM the bank is unsurpassed and thus efficient.

Note that (A11) combines features of both the output and the input-oriented radial models for a variable returns to scale technology. In fact, by setting θ equal to unity, we get the measure of the firm's output-oriented *inefficiency*, $(\phi^0 - 1)$. Similarly, when ϕ is preset at unity, the model yields the firm's input-oriented *inefficiency*, $(1 - \theta^0)$. Clearly, the optimal value of the objective function will be at least as large as both $(\phi^0 - 1)$ and $(1 - \theta^0)$. Thus, the optimal value of the objective function in (A11) can be interpreted as a generalized measure of the inefficiency of a firm which is no lower than the average of its output- and input-oriented technical inefficiencies. It should be stressed no matter what the input and output prices actually are, the optimal value of $(\phi^* - 1)$ in (A11) shows the proportionate increase (decrease) in the revenue without changing the output mix. Similarly, $(1 - \theta^*)$ shows the proportionate decrease (increase) in the cost with the input mix unchanged. When revenue increases $(\phi^* > 1)$ and cost falls $(\theta^* < 1)$ both contribute to an increase in profit. But even when cost increases, so long as revenue increases even more $(\phi^* > \theta^*)$, profit would increase. The same will be true when $(\phi^* < 1)$ and revenue falls but $(\theta^* < \phi^*)$ so that cost falls even more. In terms of this application we note that (A10) allows for the computing of shadow prices (u^0, v^0) for the inputs and outputs used by each bank for every year in our sample. In this way, by computing the variance of, for example, the shadow price for interest expenses for that year, we can track how close one comes to the 'LOP'. Obviously a variance that falls over time would indicate increasing competition. Similarly, solving (A10) repeatedly would yield the size of the optimal profit (P) for each bank during each year in our sample. For each firm, both revenue and cost is normalized to one and thus profit is normalized to zero. Thus via (A6) P is also a measure of the unrealized profit of the firm as a ratio on outlays or costs since $v^{0t}\, x^0 = 1$ holds. In other words, P is a measure of potential deviation from 'zero profit' for each bank in each year. Therefore, by averaging over all banks during a given year, we get an estimate of how close the banking industry comes to the 'zero profit' condition. Again, a falling average over the years would imply increasing competition. Lastly, it is worth stressing that P, our primary measure of unrealized profit, can be seen as an indicator of 'profitable activities not pursued by management' and equivalently 'extent of quiet life pursued by management'. Taking this into account and recalling Hicks's (1935, 8) dictum about 'a quiet life being the best of all monopoly profits', we can establish another logical basis for using the size of unrealized profits to measure deviations from perfect competition.

Appendix 2. Additional tables

Table A1. Summary statistics on input and output measures used in two alternative models

Variable	Mean	Median	Maximum	Minimum	Standard deviation	No. of obs.N
Cost revenue-based model						
Interest expense	1120.246	252.1531	12915.78	0.333951	1703.515	328
Non-interest expense	530.1396	230.5591	3434.083	1.403326	649.367	328
Interest income	1901.526	492.1042	17787.67	2.086731	2706.185	328
Non-interest income	401.9476	131.5414	2448.258	0.034398	578.3247	328
Balance sheet based model						
No of personnel	5480.561	2332	24887	14	6581.003	328
Owners' equity	2138.812	538.0419	12904.35	8.403496	3115.48	328
Deposits and borrowed funds	14719.51	3272.671	92399.41	4.800972	21574.55	328
Total loans	9006.835	1928.944	71482.94	0.170918	13970.47	328
Off-balance sheet portfolio	56911.97	14537.41	670664.3	0.016787	103445.6	328
Other financial assets	5675.561	942.595	50752.21	0.000568	9819.408	328

Notes: The table presents summary statistics on variables employed as inputs and outputs in the two alternative models: Cost revenue-based model and Balance sheet based model. Non-interest income includes net fees and commission income, dividend income, net trading profit and other operating income. All figures in millions of Turkish lira terms, deflated to 2005, except for no of personnel.

Table A2. Estimation results of the impact of macroeconomic factors on measured inefficiencies

	Total sample
GDP growth	.3665***
	(3.03)
Inflation	− .1127***
	(− 2.83)
Constant	4.3072***
	(2.87)
N	328
R^2	0.0284
F stat. (sign.)	5.98
	(0.0063)

Notes: The table presents regression results of profit inefficieny on Turkish GDP growth and inflation. This adjustment purges the impact of domestic macro conditions as measured by GDP growth and inflation from model generated inefficiency scores summarized in Table 1. The dependent variable is our model's profit inefficiency measure. GDP growth is the annual growth rate of real GDP while Inflation is Consumer Price Inflation. Both series are from the World Bank World Development Indicators. The model is estimated by OLS with clustered errors at bank level. t statistics are given in parentheses.
***Significance at the 1% level.