The Effects of Regulations on the Performance of Banks: Evidence from the Turkish Banking Industry

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Abstract

Purpose – To investigate the effects of regulations, macroeconomic changes, and political events on the efficiency of the Turkish banks during the period 1997-2013, when crucial changes were experienced. To analyze the effects of an extensive set of bank-specific and environmental factors on the efficiency, since the diversions could not only be related to new regulations.

Design/methodology/approach - A two-stage procedure is employed. First, the productivity changes of each bank and of the whole sector are measured by a DEA-based Malmquist Productivity Index (DEA-MPI). Second, the effects of selected internal and external factors on productivity are analyzed with regression analysis. The sector is especially handled before and after 2001, when one of the most catastrophic crises is observed and moment after which a series of new regulations are implemented.

Findings – During the period 1997-2001, the efficiency deteriorated due to the 2001 crisis; after the crisis, an improvement was observed. All models indicate the source of improvements as efficiency instead of technological changes. Rather than external, internal factors seem to be more effective on productivity. Therefore, the importance of regulations for the soundness of banks, management quality and monitoring may be more crucial than what is thought. In general, a new macroeconomic environment, particularly new regulations, have positive effects on productivity. Tighter regulations, monitoring, restrictions, strong supervision, more capital, and new reforms have a positive impact on efficiency.

Originality/value – The study spans a wide period to analyze the sector using three different perspectives. It analyzes the effect of the 2001 financial crisis and subsequent regulations. It handles an extensive set of internal and external factors; and it tests each factor with nine different DEA-MPI models for consistency. Turkey's unique environmental factors, such as the unstable macroeconomic conditions, high inflation and a subsequent disinflation period, high interest rates, new regulations and crisis experience, among others, also make the study distinctive.

Keywords: Banking regulations, bank efficiency, Turkish banking, data envelopment analysis, Malmquist Productivity Index.

Paper type: Research paper

JEL Classification codes: C14, C61, G21

The sustainability and development of an economy is closely related with a sound and healthy banking sector. Therefore, the soundness of the banking system has always been a key issue not only for domestic governments but also for international regulatory bodies and organizations. Banks function in a dynamic environment and the accelerating technological developments, innovations, and new experiences lead new rules and regulations to come into the daily life of banks. It is obvious that the banking sector is affected from all new external and internal factors, naturally, each bank to a different extent.

The first objective of this study is to examine the efficiency and technological changes in the Turkish banking sector since 1998. The second aim is to investigate the possible effects of the regulations and/or main macroeconomic changes and/or political events on the efficiency changes observed for the Turkish banks and the banking industry. Thirdly, it is targeted to analyze the causes and effects of an extensive set of bank-specific and environmental factors on the banks' efficiency changes since the diversion in productivity could not only be related to new regulations.

The study can be characterized and distinguished from other studies with different aspects. Firstly, it spans a wide time period to analyze the Turkish banking with regard to productivity changes, using three different Data Envelopment Analysis (DEA) models. Secondly, it analyzes the effect of the 2001 financial crisis and subsequent regulations that followed. Thirdly, it searches different dimensions of productivity changes such as profitability, intermediation, and a composite of both. Fourthly, it handles the effects of an extensive set of internal and external factors on productivity changes. Finally, it tests each factor with nine different DEA-based Malmquist models for consistency. Turkey's unique environmental factors, such as unstable macroeconomic conditions, high inflation and a subsequent disinflation period, high interest rates, implementing new regulations, and crisis experience etc. make the study distinctive.

This study unfolds as follows. After the introduction, the past and present of the Turkish banking sector is presented. Past studies are handled in the literature review. DEA, Malmquist Productivity Index (MPI) and the method for the second stage of analysis, and data and variable analysis are examined in the following section. Then, the figures of productivity changes measured with three different models are investigated before and after 2001 and the determinants of productivity are scanned with an extensive list of factors. The study ends with a discussion and conclusion.

The Turkish Banking Sector, Past and Present

Before 1980s, prudential regulation and supervision in banking was basically dependent on reserve requirements, liquidity constraints, portfolio requirements, and interest rate controls. Until early 1980s, high capital seemed enough for soundness to meet the obligations and main emphasis was put on a minimum level of capital (Caprio, 2013). This was widely accepted by the Turkish banking regulation authorities, as well.

Basel Committee, founded in 1975, presented a set of minimum capital requirements that evolved into a risk-based capital regulation that recognizes different risk weights for different bank assets. In 1988, Capital Accord (Basel I), that contained a minimum risk-weighted capital ratio of 8%, was introduced with a particular focus on credit risk only by means of skipping other risks such as market risk and operational risk. In 1996, capital accord took into consideration some dimensions of market risk in capital adequacy regulations. In the light of the developments in financial markets, financial products, risk management techniques, technological innovations and global convergence,

as well as taking into account the previous experiences and appeals of not only developed countries but also developing countries, the Committee published Basel II criteria in 2004. Basel II was based on three pillars: minimum capital requirements, supervisory review, and market discipline. In addition, the latest and more complex accord, Basel III, agreed upon in 2010, redefined the capital adequacy measurements and set higher capital, liquidity, and leverage requirements (Caprio, 2013).

In parallel with Turkey's economic transformation, from planned economy towards neoliberal policies starting in 1980s, the banking sector also showed similar characteristics. The 1980-2001 period can be assumed as the financial liberalization period (The Banks Association of Turkey, 2009) in which the Turkish banking sector went through a series of legal, structural, and institutional changes (Isık & Hassan, 2003), such as removing the control on deposit and credit rates, introducing more liberal exchange rate regime, and rearranging regulations in accordance with international norms (Banking Regulation and Supervision Agency, 2002). Similar to the economy, the banking sector struggled with financial and political instabilities that emerged, such as high inflation, high and volatile interest rates, volatile, and mostly overvalued domestic currency rates etc. For instance, the 1994 crisis resulted in 6.1% of gross national product (GNP) loss, diminished the value of the Turkish Lira about 250%, pushing up treasury bill rates up to 400%, bankruptcy of three banks and some intermediaries, changes of ownership of four banks, 25% loss in total asset, and 35% loss in equity. To regain the confidence and support in the sector, reserve requirements were decreased and unlimited state insurance was introduced for all saving deposits (Eken & Kale, 2013).

The fragility in both economy and banking continued until the year 2000, when the Turkish banks were confronted with one of the most devastating crises. Due to the twin crisis hitting the Turkish economy and the banking industry in 2000 and 2001, the foreign exchange regime and economic program collapsed, both of which were based on IMF stand-by agreements. The confidence in the financial markets disappeared; the Turkish Lira depreciated by more than 100%; overnight rates reached a historical peak of 3,600%; and GNP decreased by 9.4%. The banking sector lost 22.7% of its assets; the number of banks decreased from 81 to 55; the number of branches came down from 7,837 to 6,078; and about 28% of bankers lost their jobs.

In 2000, the Banking Regulation and Supervision Agency (BRSA) was established and it started to operate in order to improve the effectiveness of regulations and supervisions and to establish an independent body as the sole authority of the banking sector (BRSA, 2014). BRSA improved the regulations and applications in accordance with the international banking norms, arranged relatively more advanced risk management methods, and monitored the banking system more strictly. Besides the main authority BRSA, The Central Bank of the Republic of Turkey (CBRT) may be accepted as the secondary authority in monitoring and assessing some obligations of banks, such as liquidity and reserve requirements. The Savings Deposit Insurance Fund (SDIF), which was established in 1983 and started to operate as an independent body in 2003, is another regulatory organization whose function is to insure saving deposits for protecting rights of small depositors, to contribute to the confidence and stability of the banking system, and to resolve the failed banks.

By the year-end 2013, the Turkish banking sector was composed of 49 banks; 32 were commercial-deposit, 13 investment-development, and 4 Islamic-participation banks, with total assets of USD 767 billion which was 105% of the gross domestic product (GDP). The largest five and 10 banks constituted 58% and 86% of the sector, respectively. Owing to structural conditions of the Turkish economy (Europe's 6th largest economy, young and growing demographic profile,

increasing commercial activity, relatively higher growth expectations, etc.) and the banking sector itself (strictly regulated and monitored banking system, relatively high capital adequacy and low leverage ratio, low assets-loan-deposit to GDP ratio indicating low penetration scheme, sound balance sheet structure, educated and experienced human resources, continuously renovated innovative technology, etc.) the Turkish Banking Sector comes into prominence with high growth potential. Foreign ownership in the banking sector has increased in recent years. Excluding the share of foreigners, which is about 65% in Borsa Istanbul (stock exchange of Turkey), the foreign share in deposit banks increased to 39%, and about 20% of the banks' share is offered to the public and traded in Borsa Istanbul. The share of foreigners in an unoffered portion increased from 14.6% in 2005 to 29.6% in 2013. The asset, credit, and deposit share of foreign banks whose stocks are not traded in an exchange corresponds to about 25%.

Literature Review

Performance comparison of banks is traditionally conducted based on some key performance indicators, such as Return on Assets, Return on Equity, and other financial ratios. Efficiency studies, on the other hand, are conducted either by parametric or non-parametric frontier based techniques. Parametric efficiency methods, such as Stochastic Frontier Analysis (SFA), are based on econometric model specifications and assume a predefined production function and error distribution. Shifts from this production function are attributed to error term and inefficiencies. The non-parametric method (DEA), on the other hand, has no assumption about the production function or error distribution. Instead, it defines the sources used for production as inputs and production results as outputs.

In the banking efficiency literature, DEA seems to be much more used when compared to SFA (Berger & Humphrey, 1997; Fethi & Pasiouras, 2009; Sharma D., Sharma A., & Barua, 2013). Sherman and Gold (1985) published the first DEA study to evaluate the relative efficiency of bank branches. After that, DEA has increasingly been used to measure the efficiency of banks, bank branches, and other financial institutions.

Liu, Lu L., Lu, W., and Lin (2013) conducted a citation-based literature survey and covered 4,936 papers about DEA being indexed in the ISI Web of Science database between 1978 and August 2010. 63.7% of the papers used empirical data and banking is one of the most popular areas of application. A growth curve analysis shows that the size of the DEA literature will at least double within the next ten years.

In a study about efficiency of financial institutions, Berger and Humphrey (1997) summarized 130 frontier efficiency studies from 21 countries in which 69 applied DEA. Fethi and Pasiouras (2009) specified 196 papers about operational research or artificial intelligence methods that estimated efficiency and productivity of banks over the period of 1998-2008. They indicated that with 151 studies, DEA is by far the most commonly used operational research technique in assessing bank performance. Comparing the trend between Fethi and Pasiouras' (2009) study and Berger & Humphrey's (1997) work, the latter also shows the tendency towards DEA. Paradi and Zhu's (2013) article indicated that 195 bank and 80 bank branch efficiency studies in 24 countries were also conducted by using DEA.

Sharma D., Sharma A., and Barua (2013) reviewed 106 studies published across the world from 1994 to 2011 that focused on the efficiency and productivity of the banking sector using

parametric and non-parametric frontier techniques. They listed 66 DEA studies, as compared to 16 SFA and 6 mutual. Of the 106 studies, 37 focused on empirical evidence of the determinants of efficiency and productivity and seven of them analyzed the effects of deregulation and reforms on efficiency and productivity.

Actually, the numbers are beyond these figures. Eken and Kale (2014) listed 121 bank branch studies performing 169 models since 1985. One search of the related literature will come across almost 400 bank efficiency articles using DEA. Nonetheless, it is beyond the scope of this paper to cover all of them. Generally, the effects of internal and/or external factors on efficiency are analyzed by means of two- or three-stage models. In the first stage, the efficiency figures are calculated with DEA and, in the second stage, regularly a regression method is used to pinpoint the causes of efficiency changes. Similar to our study, Mukherjee, Ray, and Miller (2001); Pasiouras, Sifodaskalakis, and Zopounidis (2011); Delis, Molyneux, and Pasiouras (2011); Lee and Chih (2013); Barth, Lin, Ma, Seade, and Song (2013b); Kumar, Charles, and Mishra (2016); Sanchez, Hassan, and Bartkus (2013), measured the efficiency of banks in the first stage with a DEA-based Malmquist Index and then mostly used a regression method in the second stage to investigate the effects of the causes, including the regulatory changes. Barth, Caprio, and Levine (2012, 2013a) searched for the effects of regulations on efficiency based on some indices calculated from surveys. Gaganis and Pasiouras (2013) used SFA to measure the efficiency in the first stage.

Mukherjee et al. (2001) analyzed the productivity growth of 201 United States commercial banks over the initial post-deregulation period between 1984 and 1990. They measured the productivity changes with DEA Malmquist Index and decomposed these changes into technical changes, technical efficiency changes, and scale efficiencies. Then, to explain the differences in productivity changes, they used panel-data regression with a number of variables like asset size, diversification, risk exposure, capital adequacy, and regional location. Panel regression showed that larger asset sizes and specialization of product mixes was associated with higher productivity; on the other hand, higher equity to asset ratios indicated lower productivity growth.

Pasiouras et al. (2011) investigated the cost efficiency of Greek cooperative banks over the period 2000-2005 in two stages. They first estimated the technical, allocative, and cost efficiencies of each bank with DEA and then used Tobit regression to determine the influences of internal and external factors. In the first step, they employed the intermediation approach and the results indicated that the dominant source of cost inefficiency was allocative rather than technical. Second-stage results showed that bank total assets (bank size), the equity to assets ratio, the GDP per capita, and the unemployment rate in the region influenced efficiency figures, but their impact was not robust.

Delis et al. (2011) examined the relationship between the regulatory and supervision framework and the productivity of banks in 22 countries over the period 1999–2006 with Malmquist index and bootstrap regressions. Their findings indicated that regulations and incentives that promote private monitoring and restrictions on banks' activities (securities, insurance, real estate and ownership of non-financial firms) had a positive impact on efficiency. On the other hand, regulations relating to capital requirements and official supervisory power did not have a significant impact on productivity.

Lee and Chih (2013) examined the effects of regulations (including imposing stricter requirements on capital bases, leverage, provision and liquidity, known widely as the China version of the new Basel III) imposed by the China Banking Regulatory Commission (CBRC) on

efficiencies and risk taking activities of banks. They used a profit model of the DEA in the first stage for the period of 2004-2011, and then used the Tobit regression model to determine the relationship between financial regulation and efficiency, and used the Ordinary Least Squares (OLS) regression model to determine the relationship between regulations and risks. They indicated that big and small banks were differently affected by each regulation ratio and the current ratio did not affect the risk takings by banks.

Gaganis and Pasiouras (2013) investigated the interaction between bank profit efficiency and supervision regime (the central bank's involvement in financial supervision, the unification of financial authorities, and the independence of the central bank), using nearly 4,000 commercial banks operating in almost 80 countries over the period 2000–2006, by employing the stochastic frontier model and intermediation approach. They concluded that: (a) efficiency decreased as the number of financial sectors that were supervised by the central banks increased; and (b) banks operating in countries with greater unification of supervisory authorities were less profit efficient and central bank independence had a negative impact on bank profit efficiency.

Barth et al. (2013b) examined whether bank regulation, supervision and monitoring enhanced or impeded banks' operating efficiencies based on three worldwide surveys sponsored by the World Bank covering 4,050 banks observations in 72 countries over the period of 1999–2007. They applied the DEA in the first stage by intermediation approach to obtain bank efficiency scores and then performed second-stage regressions to examine the relationship between bank regulation, supervision and monitoring, and bank efficiencies. They found that:

> Tighter restrictions on bank activities were negatively associated with banks' efficiencies, while greater capital regulation stringency was marginally and positively associated with banks' efficiencies. They also found that a strengthening of official supervisory power was positively associated with bank efficiency only in countries with independent supervisory authorities. Moreover, independence coupled with a more experienced supervisory authority tends to enhance bank efficiency. Finally, market-based monitoring of banks in terms of more financial transparency was found positively associated with bank efficiency.

Barth et al. (2013a) presented a database of bank regulation and supervision in more than 180 countries for the period of 1999–2011 based on the World Bank's survey. They constructed indices from answers and measured the key features of the regulatory and supervisory approaches to what banks could do, capital standards, the powers of official supervisory agencies, regulations on the entry of new banks, the degree to which the authorities encouraged the monitoring of banks by private investors, the nature of the deposit insurance regime, and an assortment of other policies towards banks. Their database also enabled cross-country and cross-time comparisons. They stated that, in spite of some convergences, there still existed a substantial heterogeneity in bank supervisory policies across countries, and it was still possible to observe an opposite direction between different countries about a regulation.

Barth et al. (2012) argued that although many countries had reformed their bank-regulatory regimes in the last twelve years, there was no evidence for better improvements. Many countries had obeyed the Basel guidelines and strengthened capital regulations and empowered supervisory agencies; but existing evidence did not support that this would improve the banking-system stability, enhance the efficiency of intermediation, or reduce corruption in lending.

Kumar, Charles, and Mishra (2016) evaluated the performances of the Indian banking sector for the post-reform period and global financial crisis between 1995 and 2009. They indicated that the reforms resulted in a positive change in the Total Factor Productivity of the banking sector through technological changes.

Sanchez et al. (2013) concluded that the financial liberalization had led to productivity increases as a consequence of the technological progress rather than enhanced technical progress in Latin America during the period 1996–2007.

Related to the Turkish Banking Sector, Isik and Hassan (2003) analyzed the effects of deregulations on the efficiency of banks, and Aysan and Ceyhan (2008) shed light on some other environmental factors in a different time period.

Isik and Hassan (2003) analyzed productivity growth, efficiency change, and technical progress in Turkish commercial banks by using DEA-type Malmquist Total Factor Productivity Change Index during the deregulation period of financial markets: 1981–1990. By dividing this period into two segments, 1981–1986 and 1987–1990, they found that there was a significant productivity increase in the banking sector and this improvement was driven by efficiency increase rather than by technical progress. The greater source of efficiency increase resulted from resource management practices instead of scale efficiency. They indicated that in the new environment the private banks performed better than public banks.

Aysan and Ceyhan (2008) investigated the effects of some factors on the Turkish banking industry for the period of 1990-2006. They concluded that the branch number had a negative effect on efficiency; both bank capitalization and loan ratios had a positive effect and foreign ownership was insignificant. They indicated that restructuring attempts during post-crises improved efficiency.

There are many other studies that have used the MPI to analyze the effects of internal and external factors on bank productivity. These studies can be grouped into two categories based on employing a second stage analysis or not. After applying MPI, some studies conducted econometric methods while some interpreted the results without an econometric analysis. We found more than one hundred studies all around the world that used Malmquist Index to measure efficiency changes in banking. Table 1 lists only some of them.

Table 1
Some Bank Efficiency Studies with MPI

Year	Author	Times cited	Country	Period	Appr.	Second Stage	Objective	Conclusion
2013	Sanchez, B. et al.	3	Latin America	1996-2007	I	Reg.	Determinants of efficiency changes during recent financial liberalization.	Liberalization has brought productivity increases as a consequence of technological progress.
2012	Kumar, M. et al.	5	India	1995-2010	I	NA	Performance of Indian banking sector during the post liberalization period.	The reform has clearly re-energized the Indian banking sector as a whole, resulting in a positive change in TFP through technological change.
2011	Sufian, F.	20	Malaysia	1994-2004	I	Reg.	Productivity of the Malaysian banking sector.	Sector has exhibited productivity regress due to technological regress rather than efficiency decline.
2010	Fiordelisi, F., & Molyneux, P.	38	Europa	1995-2002	I	Reg.(*)	Shareholder value drivers, focusing on the efficiency and productivity.	TFP change, with main component of technological progress, best explains variations in shareholder value.
2010	Liu, J-S. et al.	12	Taiwan	1997–2001	I	NA	TE and productivity change of the commercial banks over the post Asian crisis.	Widespread relaxation of the financial system has resulted in a more efficient financial market and enhanced financial technology.
2010	Zhang, T., & Matthews, K.	48	China	1997-2007	I, Prd	NA	Bank productivity.	Reform of the banking system and domestic competition resulted in an increase in bank productivity growth over 1998–2002, but regress over the period 2003–2007.
2009	Tanna, S.	9	75 countries	2000-2004	I	Reg.	The impact of FDI on TFP.	Inward FDI has a negative short-term level effect but a positive long-term rate effect on TFP change.
2008	Huang et al.	6	Taiwan	2001-2004	I	Reg.	Investigate the effects of the first financial restructuring on productivity.	Productivity increase mostly due to technological progress.
2008	Tortosa Ausina	108	Spain	1992–1998	I	NA	Productivity growth and productive efficiency.	Productivity growth occurred due to improvement in production possibilities, and that means efficiency has remained fairly constant over time.
2008	Zhao et al.	38	India	1992–2004	I	NA	Impact of regulatory reform on the performance of Indian commercial banks.	After initial adjustment, sustained productivity grew.
2007	Al Muharrami	16	Gulf CC	1993-2002	I	NA	Productivity change.	Slight downward shift in average efficiency.
2007	Isik, I.	26	Turkey	1981-1990	I	Reg.	Performance improvements in state, private and foreign banks in the deregulated period.	Productivity increase over the deregulation period.
2007	Lin et al.	17	Taiwan	2002-2003	Prf	NA	Investigate relative efficiency of management and variation of managerial efficiency.	Efficiency of 20 banks increased, 17 decreased.

Year	Author	Times cited	Country	Period	Appr.	Second Stage	Objective	Conclusion
2007	Ramanathan, R.	48	Gulf CC	2000-2004	I	NA	Assess the performance of banks in countries of the GCC.	No change in productivity, technology change declined.
2006	Isik, I.. & Akcaoglu, E.	4	Turkey	1980-1990	I	NA	Initial changes in the productivity and efficiency of the "traditional" banks in an era of financial liberalization.	Significant upward trend in the productivity and efficiency of the traditional Turkish banks.
2006	Isik & Uysal	10	Turkey	1981-1990	I	NA	The sources of productivity changes in public, private and foreign banks during liberalization.	Publicly owned banks realized the slowest productivity growth and foreign banks experienced the fastest after liberalization.
2006	Lozano Vivas & Pastor	10	15 OECD	1980-1997	I	Reg.	Relations of banking and economic productivity.	Banking performance and banking innovation play an important role in boosting growth through productivity enhancement.
2000	Mendes, V.. & Rebelo, J.	38	Portuguese	1990-1997	I	NA	Productivity change.	Productivity increased and strong technological progress.
2006	Rezitis, A. N.	96	Greece	1982-1997.	I	Tobit reg.	Productivity change.	Productivity growth after deregulation; size and specialization have positive effects on both pure and scale efficiency.
2005	Casu, B., & Girardone, C.	59	Europa	1994-2000	I	NA	Effect of OBS items in TFP change.	OBS items result in an increase in productivity levels for all countries. But, the impact is the biggest on technological change rather than efficiency.
2004	Asmild, M. et al.	155	Canada	1981–2000	Prd	NA	Compare windows analysis and Malmquist TFP.	The results of both methods are not parallel.
2004	Chen et al.	4	Taiwan	2000-2002	I	NA	Operating performance and corresponding productivity growth.	Average productivity is increasing; the growth is due to innovations rather than improvements in efficiency.
2004	Krishnasamy, G. et al.	7	Malaysia	2000-2001	I	NA	Changes in productivity of the merged ten commercial banks.	TFP increased.
2004	Mohan, T. T. & Ray, S.	30	India	1992-2000	Prf	NA	Comparison of productivity of public, private and foreign banks.	Similar productivity growth.
2004	Neal	83	Australia	1994-1999	I	NA	X-efficiency and productivity change in banking.	Productivity is increasing; the growth is due to technological change, slight technical efficiency decrease.
2003	Dogan, E. & Fausten, D.	34	Malaysia	1989-1998	Prd	OLS	Impact of deregulation and technological change on the productivity of banks.	Regulatory reform and liberalization are not sufficient conditions for productivity improvement.
2003	Isik, I. & Hassan, M. K.	246	Turkey	1981-1990	I	NA	Financial deregulation and TFP change.	Performance of all types of banks significantly improved after deregulation. Productivity growth was mainly driven by efficiency but technology has not advanced as expected.
2003	Krishnasamy	84	Malaysia	2000-2001	I	NA	Productivity change.	Productivity is increasing after merging; the growth is due to technological change rather than TE change.

Year	Author	Times cited	Country	Period	Appr.	Second Stage	Objective	Conclusion
2003	Tsionas, E. G. et al.	62	Greece	1993 1998	I	NA	Performance of the Greek banking system in view of the EMU.	Majority of Greek banks operate at high overall efficiency, a positive but not substantial TE change.
2002	Sathye	59	Australia	1995-1999	I	NA	Productivity change.	TFP and TE are declined.
2001	Mukherjee, K. et al.	221	USA	1986-1995	I	Reg.	Productivity growth in large US commercial banks to analyze post-deregulation period.	Overall productivity growth in deregulation period; larger asset size and specialization results to higher productivity; higher equity/assets associate lower productivity.
2000	Avkiran, A. F.	95	Australia	1986-1995	I	NA	Productivity change in deregulation period.	Overall rise in total productivity driven more by technological progress rather than TE in deregulation period.
1998	Gilbert & Wilson	241	Korea	1980–1994	I	NA	Effects of deregulation on the productivity of Korean banks.	Privatization and deregulation enhanced potential output and productivity.
1998	Leightner & Lovell	266	Thailand	1989–1994	I, Prf	NA	Impact of financial liberalization on the performance of Thai banks.	Different results according to different objectives.
1997	Pastor et al.	286	Europa, USA		I	NA	Analyze the productivity and differences in technology of several banking systems.	Different results for different banking sectors.

Note. I = Intermediation, Prf = Profitability, Prd = Production, NA = Not available, TFP = Total Factor Productivity, TE = Technical efficiency, Reg = Regression. (*) Efficiency is an independent variable.

Methodology, Data, and Analysis of Variables

First Stage: Data Envelopment Analysis

In line with a great majority of efficiency analyses in banking, we prefer to use a non-parametric method: DEA for productivity measurement. DEA measures the efficiency of Decision Making Units (DMUs) that have more than one input and output. Each input and output is given a weight so that the ratio of outputs (virtual output) to inputs (virtual input) is maximized. The DMUs with maximum ratio are assumed to be fully efficient, i.e., they are located on the efficient frontier and the efficiencies of the other units are evaluated in accordance with the frontier by benchmarking. The best units are accepted to have an efficiency of 1 while the others comparatively between 0 and 1. Maximizing the ratio of weighted outputs to weighted inputs provided that efficiencies determined between 0 and 1 are first expressed in fractional form. Then, the fractional forms are transformed into linear problems and they are solved by simplex method by converting to dual form. All forms of the problem have the same solution set.

The original model of DEA, named CCR, was introduced by Charnes, Cooper, and Rhodes (1978) and it assumes that the efficiency of decision units possesses the Constant Returns to Scale (CRS) characteristics, implying that increasing inputs with a certain proportion results in the outputs to increase with the same proportion. Later, Banker, Charnes and Cooper (1984) relaxed the CRS assumption and developed the BCC model, which assumes that when increasing inputs, the rate of increase in outputs may be different (Variable Returns to Scale, VRS). CCR evaluates the technical efficiency of a production unit that represents the overall success of a production unit as converting inputs into outputs and operating at right returns to scale. Technical efficiency is composed of two components, pure technical efficiency and scale efficiency. BCC model measures the pure technical efficiency and it shows the success of a unit at converting inputs to outputs. Using both CCR and BCC enables us to measure the scale efficiency and success of a unit operating at optimum scale, which is called most productive scale size. In addition to these two basic models, many other options and variations of DEA were developed, such as, Slacks-based Model (SBM), Network-DEA, and Dynamic-DEA, to cover the real life situations.

CCR and BCC are radial models, i.e., input reduction and output expansion are determined radially with a certain rate for all inputs and outputs. Whereas, generally, inputs and outputs are need to be adjusted un-proportionally in real life. Another disadvantage of radial models is that they neglect the slacks in calculating the efficiency scores. In reality, there may be a lot of non-radial slacks in inputs or outputs. Therefore, SBMs seem to be more reasonable as they fit better to the real life (Tone, 2011). Therefore, we will use the slacks-based approach of the DEA-Malmquist model to measure the maximum extent of inefficiency. Since our purpose is not to increase efficiency either by input minimization and/or output maximization, and we target to calculate the efficiency over time and later analyze the influence of internal and external factors on efficiency, instead of input- or output-oriented models, covering both facets and preferring non-oriented option, serve better to our goals.

Malmquist Productivity Index

There are two non-parametric approaches for measuring the efficiency over time, Window Analysis (WA) and MPI. In WA a decision unit in different time is assumed as a different unit and

all units are evaluated in the same pool. Therefore, this enables the user to compare a bank with both its previous situation and with other banks. WA is helpful especially when less data is available. In WA, window size becomes critical since a short period may lead to less discrimination and a long period may result in many irrelevant factors to be included (Paradi, Yang, & Zhu, 2011). Sufian (2011) examined the efficiency of the Malaysian banks over the 1994–2004 period by applying MPI with intermediation approach in the first stage and then regression analysis in the second stage. Asmild et al. (2004) measured and compared the efficiency changes of the Canadian banks over the period of 1981–2000 with both WA and MPI, assuming a production approach. Webb (2003) investigated the relative efficiency levels of UK retail banks during the period of transition 1982-1995 by using a variant of the intermediation approach. Hartman and Storbeck (1996) investigated the development of efficiency in loan operations in Swedish banks between the deregulation period of 1983–1992. Avkiran (2004) examined the pure technical and scale efficiencies of banks in Australia again for the deregulation period of 1986-1995, using a variant of the intermediation approach.

MPI was introduced by Malmquist (1953) and it represents the Total Factor Productivity (TFP) change of a unit with multiple inputs and multiple outputs between two time periods (Cooper, Seiford, & Tone, 2007). The productivity index is decomposed into two terms: *catch-up* and *frontier-shift*. The catch-up means the degree to which a unit improves or worsens its efficiency and is related to the unit itself. It shows the relative change compared to other decision units. On the other hand, the frontier-shift term shows the change in the efficient frontiers and is generally associated with the technological progress or regress that affects every unit. Both catch-up and frontier shift components imply that it is not sufficient for a production unit to improve in addition to benefiting from innovations and general technological progress. A firm must also improve relative to others (Bogetoft, 2013).

The catch-up effect from time 1 to time 2 is evaluated through formula 1 by the efficiencies being measured as the distances from the respective frontiers. In the case of one input and one output, suppose that a decision unit is moved from point G at time 1 (P_{t_1}) to point H at time 2 (P_{t_2}) as illustrated in Figure 1 (Cooper, Seiford, & Tone, 2007).

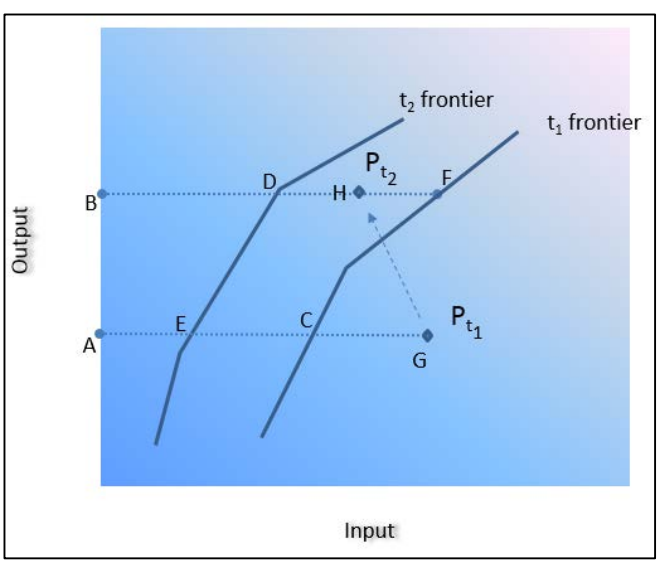

Figure 1. Frontier shift and catch-up effect.

$$Catch-up = \frac{Eff\ of\ P_{t_2}\ wrt\ t_2\ frontier}{Eff\ of\ P_{t_1}\ wrt\ t_1\ frontier} = \frac{BD/_{BH}}{AC/_{AG}} \quad (1)$$

Comparing relative efficiency change from time 1 to time 2, catch-up > 1 indicates progress; catch-up = 1 indicates no change; and catch-up < 1 indicates regress in efficiency. As can be seen from Figure 1, when CCR is used the efficiency change is actually technical efficiency change. On the other hand, when BCC is used the efficiency change is actually pure technical efficiency change. In the cases of basic CCR and BCC models, scale efficiency changes can also be calculated from technical efficiency and pure technical efficiency results.

Considering the frontier-shift, as can be seen from Figure 1, point C is moved to point E and point F is moved to point D, i.e., frontier of time 1 is moved to frontier of time 2. To calculate the frontier-shift effect first, the frontier-shift effect at point P_{t_1} and then the shift effect at point H is measured. The frontier-shift effect for the decision unit is defined as the geometric mean of frontier-shift at time 1 and time 2.

Frontier-shift at P_{t_1}:

$$\theta_1 = \frac{AC}{AE} = \frac{AC/_{AG}}{AE/_{AG}} = \frac{Eff\ of\ P_{t_1}\ wrt\ t_1\ frontier}{Eff\ of\ P_{t_1}\ wrt\ t_2\ frontier}. \quad (2)$$

Frontier-shift at P_{t_2}:

$$\theta_2 = \frac{BF}{BD} = \frac{BF/_{BH}}{BD/_{BH}} = \frac{Eff\ of\ P_{t_2}\ wrt\ t_1\ frontier}{Eff\ of\ P_{t_2}\ wrt\ t_2\ frontier}. \quad (3)$$

Frontier-shift of decision unit:

$$Frontier-shift = \theta = \sqrt{\theta_1 * \theta_2} = \sqrt{\frac{AC}{AE}\frac{BF}{BD}}\ . \quad (4)$$

Frontier-shift represents the conditions, such as the technological changes, innovations, regulatory environments, competition etc., which equally influence all the decision units. Frontier-shift > 1 indicates progress; frontier-shift = 1 indicates no change; and frontier-shift < 1 indicates regress in frontier technology.

The MPI is the product of catch-up (relative change in efficiency) and frontier-shift (relative change in frontier).

$$MPI = (Catch-up) * (Frontier-shift) = \frac{AG}{BH}\sqrt{\frac{BF}{AC}\frac{BD}{AE}} = \quad (5)$$
$$MPI = (Technical\ Efficiency\ Change\ ) * (Technological\ Change)$$

MPI > 1 indicates progress; MPI = 1 indicates no change; and MPI < 1 indicates deterioration in the total factor productivity of the decision unit from time 1 to time 2. Using non-

parametric methods, MPI is evaluated with one of the DEA approaches either using radial or non-radial and either employing oriented or non-oriented models.

If VRS is employed, technical efficiency changes can be further decomposed into two parts: pure technical efficiency change and scale efficiency change.

For our purpose, it seems more reasonable to use DEA-based MPI instead of WA. MPI enables to identify and separate the effects of technological changes due to systematic changes such as technological improvements and economic conditions and technical efficiency change, whereas WA does not consider frontier shift. Efficiency changes can also be decomposed into their components as scale and pure technical efficiencies, if desired. Alternative approaches, such as the SBM, which considers input excess and output shortfall simultaneously, can also be associated with MPI.

Second Stage: Ordinary Least Squares (OLS) Regression Analysis

The effects of internal and external factors, such as size, ownership, regulations, deregulations, and crisis are generally conducted in two stages. In the first stage, the efficiencies of banks are measured with DEA and in the second stage the influences of independent variables on efficiencies are regressed with an econometric method like Tobit regression (Hauner, 2005; Rezitis, 2006), OLS (Ataullah & Lee, 2006; Dogan & Fausten, 2003) or Maximum Likelihood, generalized method of moments estimations (Ataullah & Lee, 2006) or Generalized Least Squares (Isik, 2007). It is observed that, generally, Tobit Regression is widely used in the second stage and it seems to be the only optimum technique. Tobit regression is suitable when the dependent variables are either censored or corner solution outcomes. As in the case of DEA, the scores take values between 0 and 1, the corner solution variable falls between an upper and lower limit, i.e., greater than or equal to lower limit and/or less than or equal to upper limit. It seems suitable to use a two-limit Tobit regression to model the influence of independent variables on efficiency. Hoff (2007) criticized using only Tobit regression as a second stage tool and compared it with other three models: Papke-Wooldridge (PW) model, unit-inflated beta (Beta) model, and OLS regression. He concluded that OLS seems to perform at least as well as the other three models; Unit-Inflated Beta model is the worst performing model; Tobit and Papke-Wooldridge are more or less equal.

Banker and Natarajan (2008) found that a two-stage procedure consisting of DEA in the first stage and then OLS regression analysis in the second stage yields consistent estimators of the impact of contextual variables.

McDonald (2009) analyzed using Tobit Regression and OLS in the second stage and criticizes Hoff (2007), stating that a censoring process does not generate DEA scores; instead, they are fractional data. He argues that Tobit is an inappropriate procedure and inconsistent and the best thing about Tobit estimates is that they are often similar to the OLS result. On the other hand, OLS is a consistent tool and should be used as it is familiar, easy to use, and understandable by a broad community tool.

In the light of above the discussion, we preferred to use multivariate OLS regression analysis to measure the effects of internal and external factors on efficiency changes.

Data and Analysis of Variables

By the end of 2013, the Turkish banking sector reached to USD 767.6 billion-asset size. This study covers the 19 largest commercial banks, which constitute 93.3% of the whole banking system. The top 5 banks' share is 58% while top 10's aggregate share is 86% of the sector.

We used the data for the period 1997–2013, which is gathered from the Banks Association of Turkey. Banks with un-continuous data were eliminated from the study. The list of banks and their characteristics as of 2013 are presented in Table 2. This table is for illustrative purposes and each bank is evaluated with its real property in the related year. For instance, Finansbank was domestic in 2005 but foreign in 2006, TEB was small in 2001 and medium in 2002; weighted average is calculated according to the related year's asset. Since inactive banks are not included in the study, the share of covered banks is less in the past. The coverage ranges from 64% in the past, and reaches to 99% in the most recent years.

Table 2
Covered Banks and Their Characteristics as of 2013

Banks	Assets (USD M)	F/D	St/P	S/M/L
Akbank	86.245	D	P	L
Alternatifbank	4.873	F	P	S
Anadolubank	3.513	D	P	S
Burgan Bank	3.197	F	P	S
Citibank	3.037	F	P	S
Denizbank	27.895	F	P	M
Finansbank	30.985	F	P	M
Garanti Bank	92.422	D	P	L
Halk Bank	65.689	D	St	L
HSBC Bank	17.006	F	P	M
ING Bank	15.675	F	P	M
Is Bank	98.808	D	P	L
Şekerbank	8.789	D	P	S
TEB	25.070	D	P	M
Tekstilbank	1.807	D	P	S
Turkish Bank	528.000	D	P	S
Vakifbank	63.601	D	St	L
Yapı & Kredi	69.884	D	P	L
Ziraat Bank	97.414	D	St	L

Note. D = Domestic, F = Foreign, St = State, P = Private, S = Small, M = Medium, L = Large.

Specifying inputs and outputs is not a straightforward decision. It depends on the purpose of the study and the researcher's way of modelling the banks. Generally, for the sake of brevity, these views can be categorized into three approaches. First, the production approach assumes banks as production units that use personnel, equipment, and other non-interest expenses as input to produce deposits, earning assets, non-earning asset,s and other products. Mostly, bank branch studies apply a

production approach. Second, the profitability approach measures the efficiency of generating income and profit while using interest and non-interest expenses. Third, intermediation approach estimates the efficiency of banks in converting deposits, other resources and equity into earning assets like loans, other earning assets, etc. During the intermediation process they make non-interest expenses and earn non-interest income.

In this study, we employed three models. The first model can be assumed as a profit-oriented model that uses two inputs, interest expenses and non-interest expenses, and two outputs, interest income and non-interest income. The second model is an intermediation model that covers the process of converting resources into assets in which total deposits and other loanable funds and total shareholder's equity are inputs; total loans and receivables and other earning assets are outputs. The third model is a composite model of the other two models with three inputs and three outputs, using total shareholder's equity, total deposits and other loanable funds, and non-interest expenses as inputs, and total loans and receivables, other earning assets, and non-interest income as outputs.

All the data are derived from the balance sheets of banks. We think that all balance sheet and income statement items are included through these inputs and outputs. *Total deposits and other loanable* funds indicates all the foreign resources (all kinds of foreign and domestic currency denominated, time and sight deposits, issued securities, etc.) that can be placed as loans. In a way it may be assumed as total liabilities plus total shareholder's equity in balance sheet. One of the inputs, *total shareholder's equity*, covers the total usable own resources of banks. In addition, the other input, *non-interest expenses,* partially represents the cost of conversion of intermediation process, which covers all expenses excluding interest. Interest expenses stem from payment for total deposits and other loanable funds. The asset side of balance sheet is constituted as a result of intermediation process. The first output is *total loans and receivables* that covers all type of loans with different maturities. The second output, *other earning assets*, covers the financial assets available for sale, public sector debt and other marketable securities held to maturity, money market placements. The third output, *non-interest income*, represents all fees and commissions. The importance of non-interest income item is more than apparent because not only it covers all on-balance sheet-banking activities, but it may be assumed as a proxy for all off-balance sheet activities, as well. And the last output interest income is the funds coming from loans and earning assets.

Empirical Results and Analysis

An Overview

The technical efficiency (catch-up effect) and technological development (frontier shift) of the Turkish banking sector from 1997 to 2013 under profit, intermediation, and composite model are presented in Table 3. We measured the year-to-year change for all 19 banks first and then calculated the asset-based weighted arithmetic average for each year, i.e., column, to cover the whole banking sector. The average for a time period, i.e., row, is calculated based on the geometric mean. Some studies (Ali & Gstach, 2000; Casu & Girardone, 2005; Dogan & Fausten, 2003; Grifell-Tatjé & Lovell, 1996; Jaffry, Ghulam, Pascoe, & Cox, 2005; Pasiouras & Sifodaskalakis, 2010; Ramathan, 2007; and Tanna, 2009) used the geometric mean to calculate both annual and periodic average without weighting. Nonetheless, we prefer to use the arithmetic average for annual change based on each years' bank assets which reflects better the whole banking sector. Using a

geometric mean for a time period seems to be more consistent with MPI and reflects more accurately the average percentage change. Avkiran (2000) used the arithmetic average for annual TFP change and the geometric mean across the time period. Note that the arithmetic average is always greater than (but slightly) or equal to the geometric mean. Because of the average of technical efficiency, the technological change and MPI are calculated based on the total assets of banks; the MPI in Table 3 is not a product of catch-up and frontier. To eliminate the effect of outliers and extraordinary events (e.g., one of the state banks Emlakbank merged into Ziraatbank and Halkbank after the 2001 crisis), although rarely required, catch-up and frontier changes are limited between 75% of contraction and 250% of expansion.

We employed all the models with nominal data first and then adjusted for inflation and conducted with real data. Both nominal and real data resulted to same MPI change values. Since all the data is derived from balance sheets and income statements and the unit of all data is monetary; to convert nominal values to real, the same inflation rates applied to all values. Because the SBM is unit invariant, both nominal and real data yielded the same results.

Table 3
The Catch-up, Frontier Shift, and MPI of Turkish Banks According to Different Approaches

Model	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	GM	97-01	01-13	Compound
Catch-up	1.21	1.01	1.04	0.75	1.14	1.21	1.03	1.00	1.05	1.04	1.04	1.03	0.97	0.99	0.97	1.00	1.024	0.986	1.036	1.454
Frontier	0.84	1.04	0.88	1.17	1.07	0.92	1.00	0.95	0.99	1.00	0.92	1.05	1.04	0.94	1.01	0.98	0.984	0.975	0.987	0.771
Profit TFP	**0.92**	**1.04**	**0.91**	**0.86**	**1.22**	**1.10**	**1.03**	**0.95**	**1.03**	**1.03**	**0.95**	**1.08**	**1.01**	**0.93**	**0.98**	**0.98**	**0.998**	**0.932**	**1.021**	**0.972**
Catch-up	1.05	0.61	1.32	0.62	1.82	1.03	1.10	1.09	1.05	0.98	1.01	1.05	1.01	0.91	0.93	1.08	1.011	0.848	1.072	1.188
Frontier	0.86	1.54	0.64	0.89	1.23	1.02	1.01	1.05	1.06	1.05	1.01	0.96	1.01	1.08	0.96	0.93	1.004	0.932	1.029	1.062
Intermediation TFP	**0.87**	**0.90**	**0.84**	**0.53**	**2.22**	**1.04**	**1.12**	**1.15**	**1.11**	**1.02**	**1.02**	**1.01**	**1.02**	**0.98**	**0.89**	**1.00**	**1.005**	**0.767**	**1.100**	**1.088**
Catch-up	0.88	1.19	1.10	0.67	1.66	1.00	1.07	1.01	1.05	1.02	0.99	1.01	1.00	1.00	0.98	1.00	1.025	0.941	1.055	1.480
Frontier	1.00	0.95	0.81	0.96	1.11	1.24	0.99	1.10	1.08	1.01	1.04	0.99	1.05	1.00	0.93	1.01	1.012	0.928	1.042	1.215
Composite TFP	**0.87**	**1.04**	**0.87**	**0.65**	**1.90**	**1.23**	**1.05**	**1.12**	**1.13**	**1.02**	**1.02**	**0.99**	**1.06**	**1.00**	**0.91**	**1.01**	**1.030**	**0.846**	**1.099**	**1.596**

Note. GM = Geometric mean.

Considering the whole period, according to all three models, the effects of the frontier shift is less than the catch-up effect. Even in the profitability model, the frontier effect and MPI are negative and, on average, a regress is observed in banking. In an intermediation model, a slight progress and in composite model about 3% average increase is experienced, compounding to 59.6% as a whole. In the 1997–2001 period, all components of all models indicated a deterioration with the influence of the 2001 crisis, also. The period before the 2001 crisis can be characterized by unstable and volatile macroeconomic conditions. The great portion of decline in profit MPI can be attributed to private, domestic, and large banks. In the 2002–2013 period, all components—except for frontier component of profitability model—of all models indicated progress. In a profitability model, the progress of the second period is not enough to compensate the first period, while all the other models compensate the regress.

Our findings are in parallel with some of the results of Aysan and Ceyhan (2008), Barth et al. (2013b), Delis et al. (2011), and Kumar, Charles, and Mishra (2016), which stated that tighter regulations, monitoring, tighter restrictions, strengthened supervision, capitalization and reforms have a positive impact on efficiency. This may contradict the idea that deregulations and looser monitoring lead to efficiency increase through profitability gain. Although efficiency increases are observed in some deregulation periods, it is generally not sustainable due to unstable macroeconomic environment and/or bad management under flue supervisory conditions.

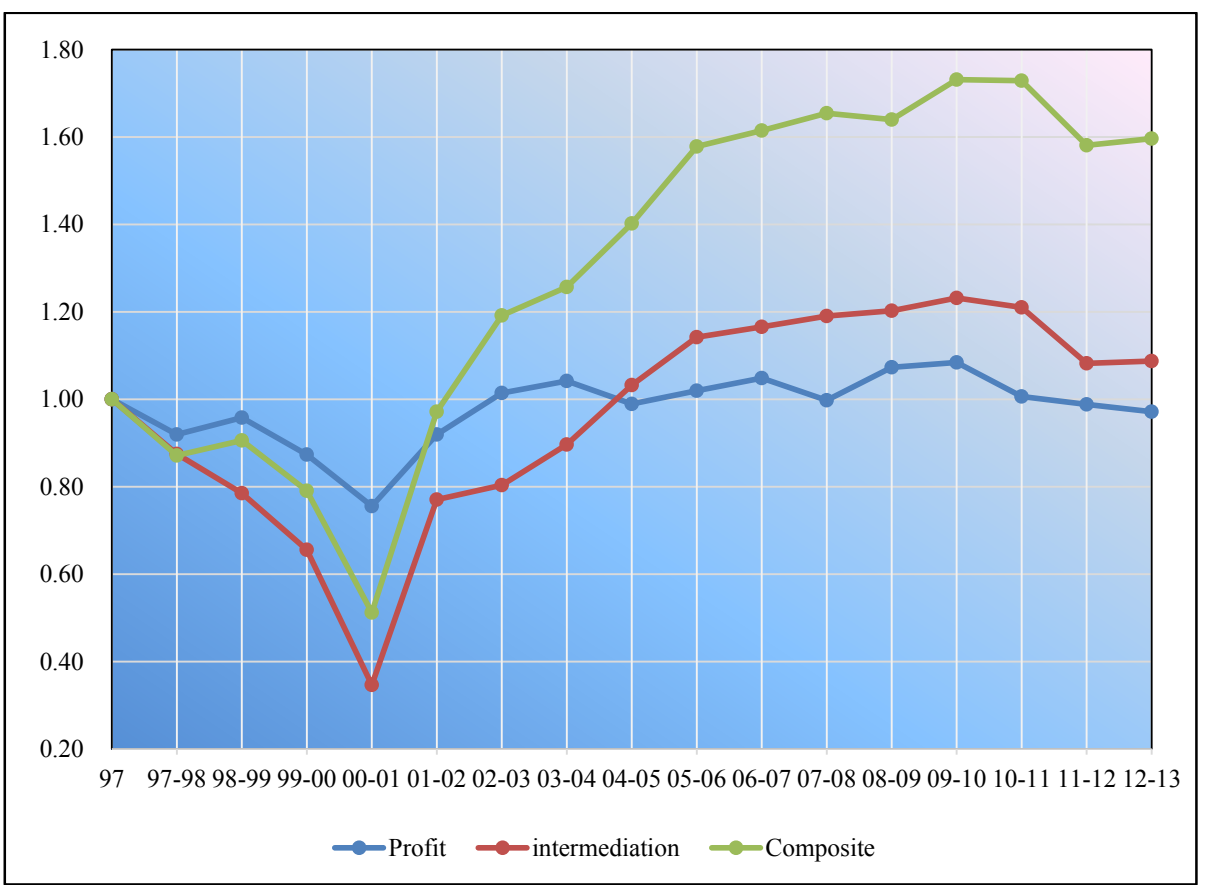

Figure 2. Compound productivity change according to different models (1997 = 100).

For the sake of brevity, only the results of the composite model are presented in Table 4. As can be seen, the best performing bank is Citibank, whose greater success comes from efficiency gain; while the worst is Halkbank, which was equally affected by efficiency and technological regress.

Table 4
Malmquist Productivity Change of Banks

CompositeMPI	**97-98**	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	**GM**	97-01	01-13	**Compound**
Akbank	1.14	0.90	0.69	1.06	1.14	1.06	0.98	1.11	1.06	1.02	0.90	1.14	1.00	1.10	0.90	1.06	**1.01**	0.93	1.04	**1.14**
Alternatifbank	0.85	1.21	1.07	0.99	1.00	0.95	0.90	1.18	1.02	1.00	0.90	1.07	1.05	1.08	1.04	1.00	**1.02**	1.02	1.01	**1.29**
Anadolubank	0.25	1.51	1.09	2.07	1.00	0.97	0.96	1.00	1.04	0.80	1.50	1.21	1.04	0.98	1.07	0.67	**0.99**	0.96	1.00	**0.87**
Burgan	1.27	1.00	1.00	1.17	0.94	0.90	0.91	1.01	1.09	0.92	1.18	0.75	1.07	1.02	0.85	1.28	**1.01**	1.10	0.98	**1.23**
Citibank	1.79	0.82	1.19	1.46	1.20	1.48	0.73	1.45	0.59	1.05	1.62	0.76	0.95	1.44	0.88	1.08	**1.10**	1.26	1.05	**4.79**
Denizbank	0.60	1.40	1.69	1.10	1.44	1.23	0.61	1.10	1.48	1.03	1.16	0.89	1.05	0.94	0.97	1.15	**1.07**	1.12	1.06	**3.16**
Finansbank	1.00	0.83	0.82	1.18	0.87	1.01	1.01	1.00	1.09	0.91	1.08	0.88	1.09	1.02	0.95	0.90	**0.97**	0.94	0.98	**0.63**
GarantiBank	1.07	0.96	0.89	0.87	1.11	1.77	0.67	1.07	1.21	1.06	0.95	1.00	1.05	1.00	0.89	0.99	**1.02**	0.95	1.04	**1.27**
HalkBank	0.58	1.43	0.73	0.24	2.56	0.95	1.00	1.08	0.91	0.98	1.05	0.98	1.03	1.00	0.89	1.00	**0.93**	0.62	1.07	**0.33**
HSBCBank	2.27	1.17	0.67	0.93	0.98	0.98	0.99	0.96	1.22	1.02	1.05	1.05	1.17	1.02	0.86	1.35	**1.07**	1.13	1.05	**2.90**
INGBank	0.95	0.81	1.12	0.47	1.19	1.26	1.01	1.02	1.02	1.02	0.98	0.95	1.00	1.08	1.01	1.00	**0.97**	0.80	1.04	**0.66**
IsBank	1.13	0.86	1.07	0.88	1.02	1.26	0.98	1.15	1.26	1.01	1.13	0.93	1.09	1.02	0.95	1.00	**1.04**	0.98	1.06	**1.90**
Şekerbank	0.98	0.72	0.51	0.55	3.07	0.96	0.91	0.94	1.07	1.00	1.28	1.00	1.00	0.92	0.95	1.06	**0.97**	0.67	1.10	**0.63**
TEB	1.01	0.69	1.01	1.41	1.01	1.35	1.02	1.39	1.13	0.87	0.82	1.01	1.17	0.94	1.08	1.04	**1.04**	1.00	1.06	**1.93**
Tekstilbank	0.90	0.95	0.20	1.36	0.72	1.05	1.17	1.26	0.80	1.45	0.73	1.41	1.18	1.00	0.98	1.01	**0.94**	0.69	1.04	**0.35**
TurkishBank	0.89	0.94	0.38	2.37	0.60	1.12	1.39	0.64	1.82	2.47	0.80	0.59	0.94	1.22	0.78	1.21	**1.00**	0.93	1.03	**1.03**
Vakifbank	1.16	1.01	0.86	1.05	1.04	0.93	1.03	1.04	1.10	1.20	0.97	0.95	1.14	1.02	1.00	0.91	**1.02**	1.01	1.02	**1.42**
Yapı&Kredi	0.84	1.05	0.93	0.45	2.37	1.09	1.07	1.40	1.38	0.93	1.05	0.86	1.16	1.00	0.87	1.08	**1.04**	0.78	1.14	**1.78**
ZiraatBank	0.56	1.05	0.91	0.23	3.38	1.40	1.44	1.07	1.00	1.04	1.02	1.07	0.96	0.87	0.83	0.95	**0.98**	0.59	1.15	**0.67**
Max	2.27	1.51	1.69	2.37	3.38	1.77	1.44	1.45	1.82	2.47	1.62	1.41	1.18	1.44	1.08	1.35	**1.10**	1.26	1.15	**4.79**
Min	0.25	0.25	0.20	0.20	0.23	0.60	0.61	0.61	0.59	0.59	0.73	0.59	0.59	0.87	0.78	0.67	**0.93**	0.59	0.59	**0.33**
SD	0.44	0.23	0.33	0.56	0.81	0.23	0.20	0.19	0.26	0.36	0.22	0.18	0.08	0.12	0.08	0.15	**0.04**	0.19	0.04	**1.12**

Note. GM = Geometric mean, MPI = Malmquist Productivity Index.

Total MPI results in Table 5 show that, similar to the findings of Lee and Chih (2013), the small and big banks were differently affected under different macroeconomic environments. During an unstable period, small banks outperformed large banks with an average of 15% expansion, compared to 18% depression of large banks. Whereas during the stable period, large banks performed better than small banks with 11% increase compared to 3%.

Although Aysan & Ceyhan (2008) found no relation between foreign ownership and efficiency, our results indicate that foreign banks performs better during the unstable period compared to the superiority of domestic banks in stable times.

Profitability vs. Intermediation

Among 19 banks, only three banks, namely Turkishbank, HSBC, and Citibank, are the most improved banks in terms of profitability and three banks, namely Anadolubank, Burganbank, and Yapı&Kredi are the worst. In the intermediation approach, Citibank, Burganbank, and HSBC are the best, whereas Sekerbank, Ziraatbank, and Halkbank are the most regressed. Especially Citibank and HSBC improved in both directions. They converted deposit and equities into loans and other earning assets effectively with considerable high net interest margin and made relatively high profit. Turkishbank seems to attain high profitability with relatively low intermediation improvement. This may be assumed as the most desirable situation as it may mean either low credit risk or a rich source of non-interest income, also. Banks with high intermediation but low profitability should revise their positions. There may be either bad loans or a very low net interest margin where both are unsustainable.

Sekerbank possesses the best profitability improvement per intermediation improvement, followed by Ziraatbank and Halkbank. Some small banks seem not to progress enough due to tough competition in the industry.

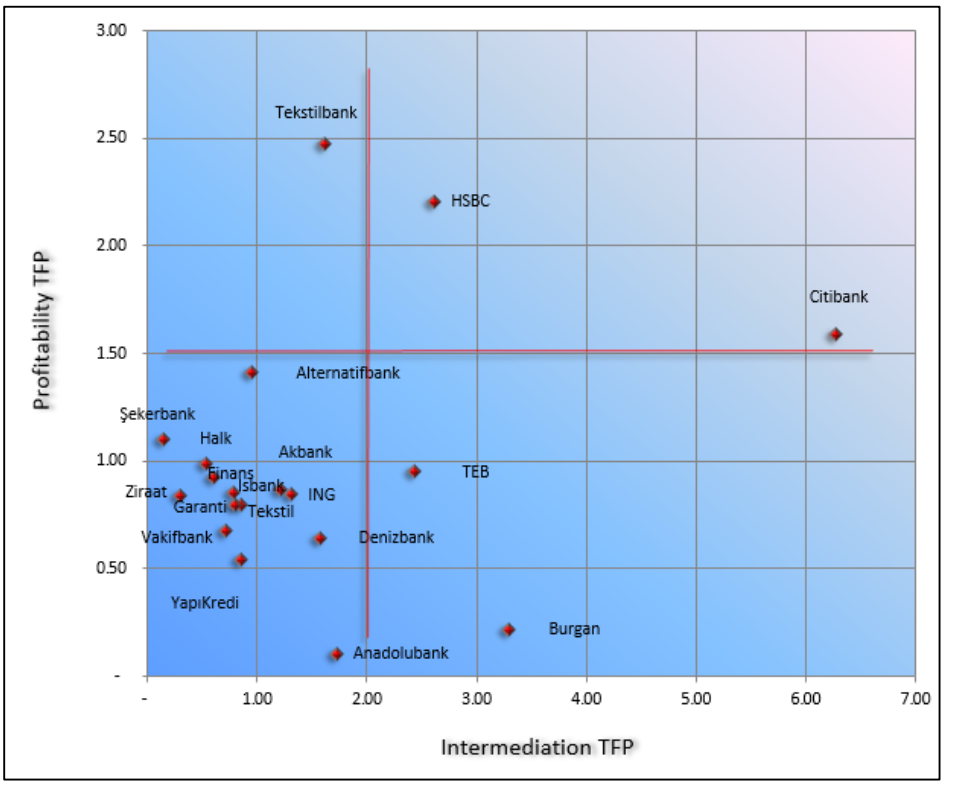

Figure 3. Compound total factor productivity change according to profitability and intermediation approaches (1997 = 100).

Unstable Period: 1997–2001

Since 2001, there is an important turning point for both the Turkish economy and the banking industry; we preferred to analyze the sector for the periods 1997–2001 and 2002–2013. The productivity changes of different banking groups according to the composite approach are presented in Table 5. Generally, the first period can be characterized by unstable macroeconomic conditions and the second period as a restructuring endeavor with the help of global convenience.

From 1997 to 1998, because of the contagion of the Russian crisis, Turkey passed through a difficult period. About USD 6 billion of hot money escaped from the country and GNP fell by 6.4%. All models in our study indicate a regress in productivity for this period. Considering the composite model, we observe the adverse effects of productivity changes mostly for state, large, and domestic banks. Foreign banks indicate significant improvements.

In the middle of 1999, a new government was formed after the 1999 general election and, at the end of the same year, Turkey agreed with IMF for a three-year standby arrangement that contained a pre-announced exchange rate path. Program caused both inflation and interest rates to decrease and from 1998 to 1999 the productivity in terms of profitability slightly recovered with the influence of foreign banks. This may show the ease of adaptation of these banks to new economic conditions. But still the economic environment was not suitable to improve intermediation and especially the mid-sized banks continued to deteriorate.

Years from 1999 to 2001 were the worst period for the Turkish economy. The confidence in the economic program, which was designed together with IMF, disappeared; exposure to foreign exchange movements and interest rate fluctuations was very high; macroeconomic instabilities continued and crucial structural reforms could not be placed in economy and banking sector due to different opinions of the political parties of the coalition government on power. As a result, in November 2000 and February 2001, two crises exploded and all macroeconomic parameters collapsed, non-performing loans reached to 30%, and GNP decreased by about 9.4%. Because the negative effect of the crisis mostly influenced the state banks, both organization schemes and balance sheets were fundamentally restructured; one of the state banks was closed down and merged with the other two state banks. As a result, banking intermediation and profit productivity dramatically decreased during this period. The decreases were mainly observed at large domestic state banks.

Considering the period of 1997–2001, only foreign and small banks indicated progress, while the other groups experienced deterioration. Fragile-unstable-unsustainable macroeconomic conditions justified these deteriorations.

The period of 1997–2004 in the Turkish economy can be assumed as disinflation period when the yearly inflation decreased from about 100% in 1997 to about 10% in 2004. High inflation means high nominal interest rates, high nominal interest margin, and high nominal profitability not guaranteed in terms of real figures. Our results show that macroeconomic stability is compulsory for productivity improvement. Unstable conditions prevent banks from effectively converting deposits into loans with satisfying profit margins.

Table 5

Productivity Change of Different Banking Groups According to the Composite Approach

CompositeTFP		97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	**GM**	97-01	01-13	**Compound**
Catch-up	State	0.68	1.55	1.04	0.39	2.20	0.93	1.17	1.03	0.98	1.00	1.04	1.06	0.93	0.95	1.01	0.96	**1.00**	0.81	1.07	**1.00**
	Private	1.07	0.87	1.16	0.91	1.31	1.04	1.00	1.00	1.08	1.03	0.97	0.98	1.04	1.03	0.97	1.02	**1.03**	1.00	1.04	**1.51**
	Foreign	1.70	0.85	1.32	1.12	1.04	0.95	0.93	1.08	0.90	0.97	1.10	0.87	1.02	1.06	0.98	1.06	**1.04**	1.21	0.99	**1.98**
	Domestic	0.87	1.20	1.10	0.66	1.68	1.00	1.07	1.01	1.05	1.02	0.97	1.03	1.00	1.00	0.98	0.99	**1.02**	0.93	1.06	**1.45**
	Small	1.04	1.02	1.24	1.66	0.99	0.95	0.95	1.03	0.89	1.07	1.18	1.00	1.00	1.05	1.01	1.03	**1.06**	1.22	1.01	**2.50**
	Medium	1.09	0.61	1.54	1.05	1.37	1.07	0.92	0.98	1.08	0.97	1.03	0.91	1.04	1.01	1.03	1.04	**1.03**	1.02	1.03	**1.53**
	Large	0.86	1.24	1.06	0.59	1.73	0.99	1.09	1.02	1.05	1.02	0.98	1.02	1.00	1.00	0.97	0.99	**1.02**	0.91	1.06	**1.33**
Frontier	State	1.00	0.78	0.83	0.93	1.26	1.28	1.06	1.03	1.03	1.07	0.97	0.96	1.10	0.99	0.88	0.99	**1.00**	0.88	1.05	**1.03**
	Private	0.99	1.11	0.80	0.99	1.01	1.22	0.94	1.15	1.10	0.98	1.07	1.00	1.03	1.00	0.95	1.01	**1.02**	0.97	1.04	**1.33**
	Foreign	1.16	1.13	0.72	1.07	1.01	1.19	0.99	1.01	1.17	1.03	1.02	1.05	1.05	0.98	0.96	1.01	**1.03**	1.00	1.04	**1.58**
	Domestic	0.99	0.95	0.81	0.96	1.11	1.25	0.99	1.10	1.07	1.01	1.04	0.98	1.06	1.00	0.93	1.01	**1.01**	0.93	1.04	**1.20**
	Small	1.15	1.14	0.77	0.88	1.02	1.13	0.99	1.08	1.07	1.03	1.05	0.99	1.02	1.03	0.94	0.99	**1.01**	0.97	1.03	**1.24**
	Medium	1.01	1.40	0.61	1.02	0.96	1.07	0.99	1.09	1.10	1.00	1.01	1.05	1.05	0.99	0.95	1.02	**1.01**	0.97	1.02	**1.16**
	Large	0.99	0.91	0.83	0.96	1.13	1.27	0.99	1.11	1.07	1.01	1.04	0.98	1.06	0.99	0.92	1.01	**1.01**	0.92	1.04	**1.21**
Malmquist Index	State	0.67	1.15	0.84	0.36	2.74	1.20	1.25	1.06	1.01	1.07	1.01	1.02	1.03	0.94	0.89	0.95	**1.00**	0.70	1.12	**0.93**
	Private	1.06	0.94	0.90	0.89	1.36	1.24	0.93	1.15	1.19	1.00	1.03	0.98	1.07	1.03	0.92	1.03	**1.04**	0.95	1.07	**1.82**
	Foreign	1.93	0.95	0.96	1.17	1.06	1.14	0.92	1.09	1.07	0.98	1.11	0.91	1.07	1.03	0.94	1.07	**1.07**	1.20	1.03	**2.96**
	Domestic	0.85	1.04	0.87	0.64	1.92	1.23	1.06	1.12	1.13	1.03	1.01	1.00	1.05	0.99	0.91	1.00	**1.03**	0.84	1.10	**1.54**
	Small	1.16	1.15	0.92	1.41	0.97	1.07	0.95	1.10	0.95	1.10	1.23	0.99	1.03	1.07	0.96	1.02	**1.06**	1.15	1.03	**2.55**
	Medium	1.11	0.79	0.89	1.07	1.37	1.14	0.92	1.07	1.19	0.97	1.04	0.94	1.09	1.00	0.98	1.06	**1.03**	0.96	1.06	**1.61**
	Large	0.84	1.05	0.87	0.58	2.01	1.24	1.07	1.12	1.12	1.03	1.01	1.00	1.05	1.00	0.90	1.00	**1.02**	0.82	1.11	**1.48**
Weighted Average	Catch-up	0.88	1.19	1.10	0.67	1.66	1.00	1.07	1.01	1.05	1.02	0.99	1.01	1.00	1.00	0.98	1.00	**1.02**	0.94	1.05	**1.48**
	Frontier	1.00	0.95	0.81	0.96	1.11	1.24	0.99	1.10	1.08	1.01	1.04	0.99	1.05	1.00	0.93	1.01	**1.01**	0.93	1.04	**1.21**
	Malmquist	0.87	1.04	0.87	0.65	1.90	1.23	1.05	1.12	1.13	1.02	1.02	0.99	1.06	1.00	0.91	1.01	**1.03**	0.85	1.10	**1.60**

Note: GM = Geometric mean.

Recovering from the Crisis: The 2002–2013 Period

The years 2001 and 2002 can be assumed as a turning point in the Turkish economy for passing from crisis to stability. After 2001, the IMF program covering the 2002–2004 period, fiscal and monetary reforms were carried out. As a result of the economic restructuring, precautions taken by the government successfully decreased the public sector financing requirement and, as a result, the banking sector, which previously earned most of its revenue from the financing of the government, searched for new areas to earn revenue. The share of treasury products in the banks' balance sheets decreased. In parallel with the macroeconomic recovery, banks started to extend more credits to corporations and individuals and, as a result, intermediation and profit efficiency started to recover.

After a new stand-by agreement with the IMF, the banking sector also had undergone a series of fundamental structural reforms. State banks were restructured, 13 banks were transferred to the Savings Deposit Insurance Fund (SDIF) for resolution; the regulatory and supervisory framework was improved and updated; asset management companies for bad loans were established; and some non-performing loans were sold to these companies; some bad loans were resolved as a result of new re-arrangements such as the Istanbul Approach; and the financial condition and capital adequacy of banks was strengthened (BRSA, 2009). Shortly, the banking system started to function more effectively and economic indicators finally departed. When we look at the productivity changes of banks, it is possible to trace the adaptation of banks to new conditions. Profitability changes were moderate because of the effects of crises and also falling real interest rates, but the figures of intermediation efficiency started to improve because of the changing nature of bank operations, i.e., instead of investing in Treasury bonds, banks started to extend commercial, consumer, and mortgage loans and, as a result, the asset side of banks got strengthened with considerable improvements in the balance sheets of all banks with a particular improvement for state banks. Thus, the increases in intermediation efficiency mainly came from large state banks at first.

With the help of global conjuncture and liquidity, the applied economic program annual interest rates and inflation fell from 60% and 30% in 2002 to 17% and 8.4% in 2007, respectively. GNP rose by an annual average rate of 6.6% during this period. Between 2008 and 2009, the effects of the global financial crisis caused the Turkish economy and GNP to increase only by 0.7% in 2008 and to fall by 4.8% in 2009. Inflation and interest rates slightly increased but USD exchange rates rose by 31% in 2008. Coming to 2013, macroeconomic stability was attained in a way where inflation and treasury bills' rates fell to 6% and 10%, respectively. Because of the decreasing public sector debt requirement, the restructuring of public and falling interest rates, banks started to divert their resources from government securities towards bank loans. Due to an increasing loan volume, the share of total loans and receivables in total assets increased from 14% in 2002 to 59% in 2013. The ratio of total loans to GDP increased from 16% to 65% during this time. The structure of the liability side of the banks' balance sheet also changed considerably. Banks started to diversify their resources and the share of deposit in resources decreased from 72% to 67% from 2002 to 2013 and the share of non-deposit funds rose from 13% to 19%. The income statement also changed during this period. Because of the decreasing net interest margins, banks focused more on the non-interest income. The fees and commissions increased by 5.3 times while the net-interest income increased by 3.4 times between 2002 and 2013.

As can be seen in Table 5, the composite model reflects the average productivity increase for all banking groups during the period 2002–2013. In contrast to the average regress of 15% between 1997 and 2001, the total productivity of the banking system improved by 10% during the period 2002–2013. Similar to the previous period, progress in efficiency is slightly greater than the frontier improvement. The (geometric) average efficiency improvement was 5% compared to 4% of technological change. In this period, new foreign banks penetrated the sector where foreign banks' share increased to about 40% of commercial banks, excluding their share in stock exchange. Because of the base effect and recovery large state banks indicated more progress. But after 2009, according to all three approaches, a slowdown was observed in productivity both as a result of global recession and the decreased net-interest margins and decelerated consumer loans.

Determinant of productivity

What can cause the productivity, i.e., efficiency and/or technological change of the banking sector in Turkey? What are the direction and magnitude of these factors? To answer these questions, it is needed to analyze the effects of bank specific and environmental factors on efficiency changes. We will utilize an OLS regression model in the second stage using the results of the first stage as independent variables. Rather than other methods, such as, the Tobit regression, OLS seems to be the most suitable for the second stage, as Banker and Natarajan (2008), Hoff (2007), and McDonald (2009) suggested.

Using the productivity changes as dependent variables, the internal and external factors as independent variables can be defined in the multivariate regression models as follows:

$$\begin{aligned}\Delta MPI_{it} = c &+ \beta_1 CAP\_A + \beta_2 LIQ + \beta_3 ROE + \beta_4 NPL + \beta L5_5 INC\_DIVERS + \beta_6 BANKSIZE \\ &+ \beta_7 BRSIZE + \beta_8 BRNUM + \beta_9 SECSHARE + \beta_{10} GDP + \beta_{11} INFLATION \\ &+ \beta_{12} STOCK\_INDEX + \beta_{13} TRL\_USD + \beta_{14} DEPOSIT\_RATE \\ &+ \beta_{15} KOF\_GLOBIND + \beta_{16} DUM\_2001 + \beta_{17} DUM\_GFC + \varepsilon_{it}\end{aligned}$$

where the dependent variable ΔMPI_{it} is the change in MPI of the i[th] bank at time t. MPI_{it} comes from the first stage calculations of DEA-based Malmquist models with non-radial and non-oriented SBM, non-radial input oriented SBM, radial input-oriented models with CRS according to profitability, intermediation, and composite models, and ΔMPI_{it} is the change in the index. Therefore, we get nine dependent variables and nine regression models, and we have the chance to test the effects of each independent variable with nine different models. The list of internal and external variables for explaining the efficiency and/or technological change, their descriptions, and the expected effects are presented in Table 6.

Table 6
Variables, Descriptions, and Their Expected Effect in Multivariate Regression Models

Variables	Description	Calculation	Exp. Sign
Dependent Variables			
PROF SBM (NR, NO)	MPI change in profitability model (%)	DEA-SBM with non-radial, non-oriented options	
PROF SBM (NR, I)	MPI change in profitability model (%)	DEA-SBM with non-radial, input-oriented options	

Variables	Description	Calculation	Exp. Sign
PROF CCR (R, I)	MPI change in profitability model (%)	DEA-CCR with input oriented options	
INT SBM (NR, NO)	MPI change in intermediation model (%)	DEA-SBM with non-radial, non-oriented options	
INT SBM (NR, I)	MPI change in intermediation model (%)	DEA-SBM with non-radial, input-oriented options	
INT CCR (R, I)	MPI change in intermediation model (%)	DEA-CCR with input oriented options	
COMP SBM (NR, NO)	MPI change in composite model (%)	DEA-SBM with non-radial, non-oriented options	
COMP SBM (NR, I)	MPI change in composite model (%)	DEA-SBM with non-radial, input-oriented options	
COMP CCR (R, I)	MPI change in composite model (%)	DEA-CCR with input oriented options	
Bank-specific factors			
CAP_A	Capital adequacy ratio (%)		+,-
LIQ	Liquidity (%)	Liquid assets / (Deposits + Non-Deposit Funds)	+,-
ROE	Return on equity (%)		+
NPL	Non-performing loans (%)	Loans under follow-up (gross) / Total loans and receivables	-
INC_DIVERS	Income structure, proxy for product diversification (%)	Non-interest income/Net interest income	+
BANKSIZE	Bank size, total assets (billion USD)		+,-
BRSIZE	Branch size, asset size per branch (billions USD)	Total assets / No. of branches	+,-
BRNUM	Branch number of bank		+,-
SECSHARE	Sector share by asset (%)	Bank's total assets/Sector's total assets	+,-
Environmental factors			
GDP	GDP change (%)		+
INFLATION	Change in consumer price index (%)		+,-
STOCK_INDEX	Change in Borsa Istanbul stock index (%)		+
TRL_USD	Change in Turkish Lira-USD rate (%)		-
DEPOSIT_RATE	Nominal deposit rate (%)		+,-
KOF_GLOBIND	Change in KOF Index of Globalization for Turkey (%)		+
DUM_2001	Dummy for year 2001 crisis and regulations	2001 and before 0, after 1	+,-
DUM_GFC	Dummy for global financial crisis	2007-2009 1, other 0	-

With nine internal factors, the extensive bank activities and characteristics are captured for analysis. Therefore, we are able to investigate the effects of balance sheet figures (capital adequacy, liquidity, return on equity, non-performing loans, product diversification, and bank size), branch specific factors (branch size and branch number), and sector share.

With six external factors we try to capture the effects of some macroeconomic factors (GDP, inflation, change in stock index, change in TRL/USD exchange rate, and change in interest rates). Introducing a global factor may be interesting to investigate the non-country related external factor on the frontier shift. The KOF Index of Globalization measures the three main dimensions of globalization: economic, social, and political. We will use only the economic dimension for Turkey.

A dummy variable will be associated to see the effect of the 2001 crisis, which is a turning point both in the Turkish banking sector and the Turkish economy. 2001 is also the year when BRSA started to operate, capital adequacy regulations were changed, new risk management and monitoring techniques became compulsory, and a new series of other regulatory and supervisory improvements were implemented. The global financial crisis is another global factor to be analyzed.

The possible effects of capital adequacy on productivity are expected to be twofold depending on the success of management. High capital adequacy ratio may mean low risk, excess use of resources and, therefore, low productivity. Low capital adequacy may also mean high exposure to risks, high loss, being stuck to make use of profitable opportunities, and low productivity. The same situation applies to liquidity, as well. Return on equity is a result of high interest margins and non-interest income; therefore, high ROE should mean high intermediation and profitability. Income structure reflects how much a bank earns from interest-related activities and non-interest operations. It may be accepted as a proxy for product diversification. That's why we expect high diversity to positively affect productivity. Non-performing loans mean realized credit risk, high reserve for possibility of loss and revenue loss. Hence, increasing NPLs means decreasing productivity. Income diversification shows how much income is gathered from non-interest related sources. It is calculated as the ratio of non-interest income to net-interest income, and, therefore, it actually represents product diversification of the bank. Bank size, branch size, branch number and sector share are all size-related parameters. Depending on the management quality and/or industry conditions, large sizes sometimes indicate high productivity due to economies of scale and advantages in competition, but sometimes it may mean bulky operations, ineffectiveness, and low productivity.

GDP and stock index increases mean favorable economic conditions and expectations; therefore, a positive relationship is expected. High inflation and interest rates sometimes mean higher interest margin and higher productivity. But generally they are the results of unstable macroeconomic conditions. That is why their effects may be twofold. The KOF Index of Globalization measures the economic, social, and political dimensions of globalization since 1970, and is tracked by KOF Swiss Economic Institute. High globalization should mean more international integration, more competition, new financial instruments, more direct and/or portfolio investments, and as a result, more productivity. Changes in TRL/USD parity rate generally mean unstable macroeconomic conditions and loss of confidence in Turkey. We expect a negative relationship between exchange rate volatility and productivity. The dummy variable for 2001 divides the banking sector as before and after 2001, where a new economic program is applied, the banking sector is restructured and a series of new regulations implemented. More and strict regulations do not always mean more productivity. The dummy variable GFC reflects the global financial crisis and it is expected to regress the bank productivity during crisis.

Brooks (2014) stated that a fixed effect model is more plausible when the entities in the sample effectively constitute the entire population; but the random effects model is more appropriate when the entities in the sample are randomly selected from the population. To decide between the fixed-effects and random-effects model, Hausman test is applied and the results

indicated that the random-effect model is more appropriate. The results of 9 regressions are presented in Table 7.

Considering the significant figures, first, dum_2001 shows that 2001 crisis is the turning point in terms of observing changes in the banks' productivity figures. The findings are statistically significant for intermediation and composite approaches with all DEA models. The results indicate that regulation and restructuring after the year 2001 caused intermediation to progress significantly, a result also observed by Charles, Kumar, Zegarra, and Avolio (2011) in the case of the Peruvian banks. The dummy variable for global financial crisis has no significant effect on productivity changes in any models.

Except for non-radial, non-oriented SBM, almost all models show that as capital adequacy increases, productivity also increases. The sign of coefficient is consistent and positive in all models. But the capital adequacy seems to be more dominant in the composite approach as coefficients are relatively higher. Findings are in parallel with that of Aysan and Ceyhan (2008) that capital increases result in efficiency increases.

The coefficient of liquidity is negative and significant in two models, but positive in one profitable model with 10% confidence. ROE is only significant in two models, but the sign contradicts our expectations. Interestingly, it is affectless in profitability models in contrast to the general expectations.

The non-performing loan is expected to be more influential in the profitability models. But it is more effective in composite models. It can be concluded that bad loans are also defective factors in bank intermediation. Bank size is significant in only one model with 10% confidence level and branch size is significant in one intermediation model. We may think that the size effect is slight on productivity. This finding confirms the study by Pasiouras (2011), which stated that total assets and cost efficiency are irrelevant.

The effects of changes in GDP, TRL/USD exchange rate and changes in interest rates on productivity changes cannot be traced in regression results, where we expected a close relationship. Pasiouras (2011) also couldn't find a relationship between GDP per capita and cost efficiency. Inflation seems to positively affect productivity changes in some models as opposed to our expectations.

As a whole, regression results show that internal factors, rather than external factors, are greatly dominant in productivity changes of Turkish banks in all models. Therefore, the importance of management quality and soundness of banks may be more crucial than external factors. Generally, new macroeconomical environment and particularly new regulations have prositive effects on productivity.

Table 7

Results of Regression Models: *Effects of Internal and External Factors on Productivity Change*

Approach	Profitability Model						Intermediation Model						Composite Model					
MPI Model	SBM (NR, NO)		SBM (NR, I)		CCR (R, I)		SBM (NR, NO)		SBM (NR, I)		CCR (R, I)		SBM (NR, NO)		SBM (NR, I)		CCR (R, I)	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
C	-15.183	0.206	-13.086	0.293	-17.171	0.166	-102.838	**0.000**	-43.833	**0.011**	-38.252	**0.008**	-66.870	**0.000**	-50.138	**0.002**	-50.224	**0.001**
CAP_A	**0.358**	**0.001**	**0.236**	**0.026**	**0.194**	**0.066**	0.286	0.160	**0.323**	**0.027**	**0.546**	**0.000**	**0.455**	**0.004**	**0.489**	**0.001**	**0.671**	**0.000**
LIQ	0.104	0.352	0.163	0.161	**0.206**	**0.076**	-0.301	0.178	-0.253	0.115	**-0.259**	**0.054**	**-0.285**	**0.099**	-0.158	0.297	-0.137	0.322
ROE	-0.001	0.925	-0.001	0.904	-0.003	0.750	-0.031	0.139	0.003	0.843	-0.019	0.130	-0.016	0.324	**-0.040**	**0.006**	**-0.079**	**0.000**
NPL	0.052	0.595	0.051	0.611	0.087	0.388	-0.274	0.159	-0.223	0.112	-0.113	0.333	**-0.248**	**0.100**	**-0.355**	**0.008**	**-0.306**	**0.012**
INC_DIVERS	0.000	0.582	0.000	0.427	0.000	0.243	0.000	0.242	0.000	0.284	0.000	0.256	0.000	0.147	**0.000**	**0.064**	**0.000**	**0.041**
BANKSIZE	0.239	0.514	0.265	0.486	0.215	0.571	0.527	0.471	0.414	0.431	0.365	0.406	0.893	0.115	0.799	0.109	**0.763**	**0.093**
BRSIZE	0.019	0.566	0.009	0.788	-0.009	0.795	0.005	0.937	**0.098**	**0.039**	0.023	0.561	-0.004	0.944	0.042	0.350	0.030	0.463
BRNUM	-0.029	0.258	**-0.054**	**0.040**	-0.057	**0.031**	**-0.133**	**0.009**	**-0.083**	**0.023**	**-0.093**	**0.002**	**-0.185**	**0.000**	-0.140	**0.000**	**-0.132**	**0.000**
SECSHARE	**3.473**	**0.100**	0.451	0.836	-0.958	0.659	-6.143	0.143	**-6.287**	**0.038**	**-4.855**	**0.055**	-1.468	0.651	-3.986	0.163	-3.933	0.132
GDP	**-0.957**	**0.092**	-0.631	0.282	-0.456	0.435	0.488	0.665	0.240	0.767	-0.153	0.821	0.359	0.681	0.793	0.301	0.184	0.792
INFLATION	0.578	0.189	0.530	0.245	0.664	0.144	**1.667**	**0.057**	0.536	0.395	0.519	0.324	**1.144**	**0.092**	**1.203**	**0.044**	**0.943**	**0.083**
STOCK_INDEX	0.017	0.395	0.008	0.688	0.008	0.719	-0.088	**0.030**	-0.043	0.136	-0.018	0.458	-0.018	0.566	0.020	0.466	0.017	0.494
TRL_USD	-0.236	0.156	-0.148	0.391	-0.111	0.519	-0.171	0.605	0.032	0.893	-0.078	0.693	-0.001	0.996	0.044	0.844	0.076	0.711
DEPOSIT_RATE	-0.203	0.2927	-0.217	0.2767	-0.278	0.1619	0.455	0.2351	0.249	0.3665	0.130	0.5723	-0.008	0.9776	-0.400	0.125	-0.215	0.3672
KOF_GLOBIND	-0.681	0.138	-0.151	0.750	-0.150	0.752	-1.135	0.214	-0.894	0.173	**-1.243**	**0.024**	-0.999	0.158	-0.270	0.663	-0.870	0.125
DUM_2001	11.702	0.197	11.016	0.241	14.392	0.124	**85.031**	**0.000**	**34.929**	**0.007**	**27.121**	**0.013**	**53.190**	**0.000**	**36.682**	**0.003**	**36.152**	**0.001**
DUM_GFC	-0.397	0.935	2.130	0.671	2.965	0.553	3.677	0.702	-1.155	0.868	0.181	0.975	5.378	0.470	8.494	0.195	5.004	0.403
R2	0.149		0.116		0.121		0.261		0.189		0.251		0.228		0.210		0.330	
Adj. R2	0.095		0.060		0.065		0.213		0.137		0.204		0.179		0.160		0.287	

Note. Number of observations = 285, **0,026** = Significance level 0-5%, **0,083** = Significance level 5-10%.

Conclusion

The productivity of the banking sector has a crucial role in the health of the banking sector and economy of any country. In a dynamic environment there will always be new developments in the markets and, therefore, there will be needs for new regulations. New developments, international convergences and experiences sometimes accelerate the changes in the productivity of banks. Estimating the effects of implementing and/or adapting to new developments on banks' productivity has always been important.

In this study, we examined the productivity changes in the Turkish banking industry considering different dimensions, such as profitability, intermediation, and a composite model of both, with MPI during the period 1997–2013. As a result of Turkey's own local crisis and global conjuncture, the Turkish banking sector experienced fundamental changes in regulations, economic measures, and restructuring. To see the effects of these changes on the productivity of the banking sector, a two-stage procedure is employed. In the first stage, the productivity changes of each bank, banking groups, and the whole sector are measured with non-parametric DEA-based MPI. In the second stage, the effects of some selected internal and external factors on productivity are analyzed. Especially, the sector is handled before and after 2001 when one of the most catastrophic crises was seen and then a series of new regulations were implemented both for the economy and banking sector, particularly.

Considering the first stage and the whole period, productivity changes in intermediation and the composite model seem to outperform the findings of the profitability model. According to the results of all three models, the effects of frontier shift are less than the catch-up effect. The effects of the 2001 financial crisis are obviously observed on the productivity change. During the 1997–2001 period, all components of all three models indicate deterioration in productivity with the influence of the 2001 crisis. During the 2002–2013 period, almost all components of all models indicate progress in the banks' efficiency figures. In the profitability model, the progress of the second period is not enough to compensate the first period, while all other models compensate the decrease.

Our findings indicate that tighter regulations, close monitoring, tighter restrictions, strengthened supervision, and more capital and reforms have a positive impact on efficiency. Although deregulation and loose supervision sometimes seem to result in efficiency increases, it is generally not sustainable due to unstable macroeconomic environment and/or bad management practices stemming from unspecified supervisory conditions.

Total MPI results show that the large and small banks are not similarly affected under different macroeconomic environments. During unstable periods, small banks outperform large banks, while during stable periods large banks perform better than small banks. The stability of the economy also affects the efficiency of banks in such a way that foreign banks perform better during unstable periods when compared to the superiority of domestic banks in stable times.

In the second stage, after measuring the productivity changes by profitability, intermediation, and the composite approaches with three DEA-based MPI models, non-radial and non-oriented SBM, non-radial, input-oriented SBM and input-oriented CCR, we searched for the effects of capital adequacy ratio, liquidity, return on equity, non-performing loans, product diversification, bank size, branch size, branch number and sector share by asset, GDP, inflation,

stock index, TRL/USD rate, deposit rate, globalization, and the 2001 global financial crisis. Considering statistically significant figures, we can conclude that the years after 2001 make a key period in productivity progress of Turkish banking industry. The global financial crisis has no or slightly positive effect on the efficiency figures of the Turkish banking industry. As capital adequacy ratio increases, productivity also increases in all models. It is also observed that bad loans are a defective factor in bank intermediation. Results also indicate that the bank size, branch size, number of branch, and sector share do not have an effect on productivity changes.

The findings show that, compared to external factors, internal factors are more effective on productivity. Therefore, the importance of regulations for the soundness of banks and for monitoring them may be less crucial than the management quality in contrast to what is believed.

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