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An empirical analysis of Iran's banking performance

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Findings – The banking industry's technical efficiency level – which had improved between 2003 and 2006 – deteriorated after regulatory changes were introduced in Iran. The results obtained also show that during 2006-2007, the industry's total factor productivity increased by 32 per cent. However, the industry experienced its highest negative scale efficiency rate of 38 per cent (DROSE ¼ 0.62) and its highest negative efficiency growth of 43 per cent (DEff ¼ 0.57) during this period. The industry also witnessed a strong drop in productivity in 2007-2008. Overall, changes in the production possibility set and scale-efficiency changes exerted dominant effects on productivity changes.

Originality/value – This study is the first to use a comprehensive decomposition of the Hicks-Moorsteen TFP index to analyse efficiency and productivity changes in a banking context.

Keywords Efficiency, Productivity,Banking,Data envelopment analysis (DEA),MalmquistTFP index, Hicks-Moorsteen TFP index, Performance management.

Keywords
analysis, banking, empirical, iran, performance

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Paper type – Research paper

I. Introduction

There are 10 state-owned banks (including six commercial and four specialised banks[1]) in Iran, supplemented by six private commercial banks. The Central Bank of the Islamic Republic of Iran (CBI) is responsible for the design and implementation of monetary and credit policies concerning the general economic policy of the country. Iranian state-owned banks are among the largest Islamic banks in the world, comprising seven of the top 10 (Asian Banker Research, 2008). The state-owned banks have also been the most successful in acquiring domestic market share since the private banks joined the market after 2001.

During the last decade the industry has undergone extensive changes due to factors such as increased government regulation and technological advances. Changes in policy have affected both state-owned and private banks. Generally, it appears that state-owned banks have been more noticeably affected by the Iranian government's regulatory initiatives launched in 2005, which obliged all banks to markedly reduce deposit and loan interest rates. The government also imposed different interest rates and conditions on state-owned versus private banks. For instance, state-owned banks were obliged to assign higher priority in their lending operations to areas such as advanced technology projects, small and medium-sized enterprises and housing projects for low-income earners. As a result, state-owned banks raised their loans and advances to the private sector by 30 percent and 29 percent in 2006 and 2007, respectively. According to CBI (2008) the share of the private sector in total loans and advances increased from 90 percent in 2005 to 93 and 94 percent in 2006 and 2007, respectively. However, the level of non-performing loans (NPLs) of state-owned banks increased considerably in the same period. According to CBI (2005, 2007), the ratio of state-owned banks' NPLs to their total loans was approximately 5 percent in 2005, but this number increased to 10.4 and 9.7 percent in 2006 and 2007, respectively. Hence, it seems that government control of the state-owned banks has tended to limit the ability of managers to allocate their resources efficiently and to operate at an efficient scale.

Despite these important changes in the banking system, there has been little empirical research in relation to the effect of this reform on the efficiency and productivity of the Iranian banking industry. There does, however, exist vast literature examining bank performance in general, and in countries other than Iran. Fethi and Pasiouras (2010), in their comprehensive survey of 196 bank performance studies, revealed that of those studies where estimates of total factor productivity growth are obtained, almost all employed a DEA-like Malmquist index. The Malmquist index has, therefore, been widely used to examine total factor productivity growth for the banking industry (e.g. Berg et al., 1992; Gilbert and Wilson, 1998; Wheelock and Wilson, 1999; Worthington, 1999; Mukherjee et al., 2001; Sathye, 2002; Casu and Girardone, 2004; Casu et al., 2004; Sturm and Williams, 2004; Sufian, 2006; Chen and Lin, 2007)[2].

Despite the extensive literature on the Malmquist index and its evident popularity as a measure of productivity change, the pros and cons of using constant returns to scale (CRS) to estimate Malmquist indices have been extensively discussed. Grifell-Tatje and Lovell (1995) demonstrate that with non-constant returns to scale the Malmquist productivity index does not precisely measure productivity change. They suggest that the bias is systematic and relies on magnitude-of-scale economies. Coelli and Rao (2005) maintain the importance of imposing CRS upon any technology used to estimate distance functions for the calculation of a Malmquist TFP index, applicable to both firm-level and aggregate data; without CRS the result may incorrectly measure TFP gains or losses arising from scale economies. Ray and Desli (1997) and Wheelock and Wilson (1999) argue that the decomposition of the Malmquist index performed by Färe et al. (1994) is not reliable. Wheelock and Wilson (1999) demonstrate that when a firm's location (from one period to another) has not changed, and scale-efficiency change is entirely due to a shift in the variable returns to scale (VRS) estimate of technology, there appears to be no resulting technical change under CRS. They thus conclude that under such circumstances the CRS estimate of technology is statistically inconsistent.

To avoid these problems O'Donnell (2008) proposed a new way to decompose multiplicatively complete TFP indices into a measure of technical change and various measures of efficiency change, without any assumptions about firms' optimising behaviour, the structure of markets, or returns to scale for a multiple-input multiple-output case. According to O'Donnell (2010b), any TFP index that can be expressed in terms of represents the ratio of aggregate outputs and to aggregate inputs is said to be "multiplicatively complete", where completeness is an essential requirement for an economically meaningful decomposition of the TFP change. He further demonstrates that the group of complete TFP indices includes the Fisher, Konus, Törnqvist and Hicks–Moorsteen indices, but not the popular Malmquist index of Caves et al. (1982). Apart from special cases such as constant returns to scale, O'Donnell (2010b) states that the Malmquist index of Caves et al. (1982) is not complete, implying that it may be an unreliable measure of TFP change. Consequently, the popular Färe et al. (1994) decomposition of the Malmquist index may also generally lead to unreliable estimates of technical change and/or efficiency change (O'Donnell, 2008, 2010b).

In the context of the Iranian banking system, since the banks are not operating at optimal scale and they face imperfect competition, government regulations and constraints on finance, the VRS assumption seems more appropriate than the CRS assumption. Therefore, in the current study the new decomposition of the Hicks–Moorsteen TFP index, is employed allowing one to analyse changes in the productivity of firms under the VRS assumption[3]. This assumption is entirely consistent with the findings of a number of studies that showed that banks face non-constant returns to scale (see McAllister and McManus, 1993; Mitchell and Onvural, 1996; Clark, 1996; Wheelock and Wilson, 1997, 1999).

The remainder of this paper is structured as follows: Section II provides brief literature review of the related studies. Section III presents the Hicks–Moorsteen TFP index and its decompositions. It also describes how a multiplicatively-complete TFP index can be decomposed into implicit measures of technical change and technical-efficiency change, in addition to measures of mix- and scale-efficiency change. Section IV explains the data employed in the paper, and Section V discusses the results, followed by some concluding remarks in Section VI.

II. Related studies

The literature on the productivity of financial institutions is vast. As mentioned earlier, Fethi and Pasiouras (2010) argue that the Malmquist index has been the most popular TFP index used for investigation of banking systems. Some important applications of this index include Berg et al. (1992) for Norwegian banks, Gilbert and Wilson (1998) for Korean banks, Grifell-Tatje and Lovell (1997) for Spanish banks, Wheelock and Wilson (1999) and Mukherjee et al. (2001) for US banks, Casu and Girardone (2004) for Italian banks, Casu et al. (2004) and Figueira et al. (2009) for European banks, Sufian (2006, 2008) for Malaysian financial institutions and Worthington (1999), Sathye (2002), Sturm and Williams (2004) and Chen and Lin (2007) for Australian financial institutions.

Berg et al. (1992) was among the earliest studies which investigated TFP changes in a banking context. They analysed the performance of Norwegian banks for the period 1980–1989 and found that the banks' productivity, on average, decreased in the pre-deregulation period but grew rapidly after deregulation. Grifell-Tatje and Lovell (1997) compared Spanish commercial banks and savings banks over the period 1986–1993. Their results showed that, overall, commercial banks had a lower productivity growth than the savings banks. Worthington (1999) also utilised the Malmquist TFP index to study changes in the productivity of Australian credit unions and found evidence of productivity progress in the performance of credit unions after deregulation. Among recent studies, Sufian (2008) investigated the efficiency and productivity changes of Malaysian non-bank financial institutions. The results showed that the institutions experienced productivity growth during the period 2000–2004, which was mainly attributed to the technological development of the firms. Figueira et al. (2009) analysed the efficiency and productivity of banks in Portugal and Spain during the period 1992–2003. Their findings revealed that although the performance of banks operating in both countries improved over time, banks located in Spain had a tendency to perform better than those in Portugal. Figueira et al. (2009) also found that technological change was the main reason behind improvements in the banks' performance.

There are very few studies that investigate the performance of the Iranian banking industry in the literature. Using standard DEA models, Hadian and Hosseini (2004) examined the performance of all Iranian state-owned banks during the period 1997–1999, and found that the specialised banks were more technically efficient than the commercial banks. Hasanzadeh (2007) also used a similar approach to investigate the technical efficiency of 14 Iranian banks during the period 1997–2003 and found that private banks were more efficient than state-owned banks. Other studies of the Iranian banking system have only focused on the efficiency of a single bank's branches (Dadgar and Nemat, 2007; Hakimabady et al., 2006).

However, as stated earlier, there are some drawbacks to the use of the Malmquist index. In this study, the main reasons for employing the Hicks–Moorsteen TFP index instead of the Malmquist index are: 1) it is free from any assumptions regarding firms' returns to scale; 2) as a complete TFP index it can be decomposed in an economically-meaningful way[4]. Using this index, we decomposed the banks' productivity changes into a simple measure of technical change and three recognizable measures of efficiency change (pure technical efficiency, scale efficiency and mix efficiency). To the best of our knowledge, there are only four applications of the Hicks–Moorsteen TFP index in the current literature: O'Donnell (2009, 2010b, 2010c) and Hoang (2011) who have all used this TFP index for measuring and decomposing changes in agricultural productivity. Hence, our study is the first to use the new decomposition of the Hicks–Moorsteen TFP index to analyse efficiency and productivity changes in a banking context. The following section focuses on the description of the methodology used to analyse banking efficiency and productivity in the paper.

III. Hicks–Moorsteen TFP index and its components

In the case of a multiple-input multiple-output firm[5], O'Donnell (2008) used the usual definition of total factor productivity following Jorgenson and Grilliches (1967), and Good et al. (1997): $TFP_{nt} = Y_{nt}/X_{nt}$, where TFP_{nt} indicates the TFP of firm n in period t, $Y_{nt} \equiv Y(y_{nt})$ and $X_{nt} \equiv X(x_{nt})$, where Y_{nt} and X_{nt} are aggregate output and aggregate input, respectively. This definition allows one to define TFP changes as the ratio of an output quantity index to an input quantity index. Index numbers formed in this way are referred to as multiplicatively complete indices.

The Hicks–Moorsteen TFP index is the only multiplicatively complete index that can be computed without price data. This index is actually a ratio of Malmquist output and input quantity indices, so named because Diewert (1992, p. 240) attributes its origins to Hicks (1961) and Moorsteen (1961). Although Caves et al. (1982) advocated the application of a Malmquist index they did not apply ratios of these indices to develop a complete TFP index in the form of the ratio of an aggregate output to an aggregate input[6]. Their indices are complete if and only if the technology is of a restrictive form[7]. The Hicks–Moorsteen TFP index operates as follows:

$$TFP_{HM}^{t,t+1} = \left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1}) D_o^t(x^t, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^t) D_o^t(x^t, y^t)} \frac{D_I^{t+1}(x^t, y^{t+1}) D_I^t(x^t, y^t)}{D_I^{t+1}(x^{t+1}, y^{t+1}) D_I^t(x^{t+1}, y^t)} \right)^{1/2}. \tag{1}$$

$D_o(x, y)$ and $D_I(x, y)$ are output and input distance functions, respectively, defined by Shephard (1953) as $D_O^T(x, y) = \min\left\{\delta > 0 : (x, y/\delta) \in P^T\right\}$, and $D_I^T(x, y) = \max\left\{\rho > 0 : (x/\rho, y) \in P^T\right\}$, where P^T denotes the period-T production possibilities set[8]. Using data envelopment analysis (DEA), one can calculate these distance functions. O'Donnell (2010b) developed a DEA methodology for computing and decomposing the Hicks–Moorsteen TFP index. All DEA problems necessary for computing and decomposing the Hicks–Moorsteen TFP indices are detailed in O'Donnell (2010b). As in Hoang (2011) and O'Donnell (2010b), DEA is used in this paper. As a nonparametric method DEA does not require any assumptions about the behaviour of banks, the functional form of the technology or efficiency distribution. However, DEA makes no allowance for statistical noise; therefore interpretation requires caution[9].

O'Donnell (2008, 2010b) measured the overall productive efficiency of a firm (TFP efficiency) as the ratio of observed TFP to the maximum TFP that is possible using the technology available in period *t*. Hence, the TFP efficiency of firm *n* in period *t* is presented as:

$$TFPE_t = \frac{TFP_{nt}}{TFP_t^*} = \frac{\frac{Y_{nt}}{X_{nt}}}{\frac{Y_{nt}^*}{X_{nt}^*}} \tag{2}$$

where TFP_t^* represents the maximum TFP, and Y_{nt}^* and X_{nt}^* symbolize aggregate output and aggregate input at the TFP–maximizing point.

O'Donnell (2008, 2010b) showed that equation (2) can be decomposed in several ways using various efficiency measures, and defined an output-oriented decomposition of the TFP efficiency as:

$$TFPE_t = \frac{TFP_{nt}}{TFP_t^*} = OTE_{nt} \times OME_{nt} \times ROSE_{nt} \tag{3}$$

where OTE_{nt}, OME_{nt}, $ROSE_{nt}$ denote measures of output-oriented pure technical efficiency, mix efficiency and residual scale efficiency, respectively[10]. The OTE_{nt} is the well-known measure of technical efficiency proposed by Farrell (1957), while the OME_{nt} is a measure of the increase in TFP that can be achieved by holding inputs fixed and relaxing restrictions on output mix. $ROSE_{nt}$ measures the increase in TFP as the firm moves around an unrestricted production frontier from a technically efficient point on this frontier to the point of maximum productivity (where a straight line through the origin is tangential to the unrestricted production possibilities frontier).

This decomposition in equation (3) can be used as a foundation of an output-oriented decomposition of a multiplicatively complete TFP index, and can be defined as:

$$TFP_{nt} = TFP_t^* \times (OTE_{nt} \times OME_{nt} \times ROSE_{nt}). \tag{4}$$

A similar equation can be written for any other firm like *m* in period *s*. Accordingly, the index number that compares the TFP of firm *n* in period *t* with the TFP of firm *m* in period *s* is defined as:

$$TFP_{ms,nt} = \frac{TFP_{nt}}{TFP_{ms}} = \underbrace{\left(\frac{TFP_t^*}{TFP_s^*}\right)}_{Technical\ change} \times \underbrace{\left(\frac{OTE_{nt}}{OTE_{ms}} \times \frac{OME_{nt}}{OME_{ms}} \times \frac{ROSE_{nt}}{ROSE_{ms}}\right)}_{Efficiency\ change}. \tag{5}$$

The first parenthesis on the right-hand side of this equation is a measure of technical changes, since it measures the difference between the maximum TFP possible using the technology feasible in period *t* and the maximum TFP possible using the technology feasible in period *s*. Thus, the industry experiences technical improvement or decline as TFP_t^* / TFP_s^* is greater than or less than 1, respectively[11]. The other ratios in parentheses on the right-hand side are measures of technical-efficiency change, mix-efficiency change and (residual) scale-efficiency change. Equation (5) is applied in this study to analyse different components of technical-efficiency change. This approach has also been used by Hoang (2011) and O'Donnell (2010b) to investigate changes in the agricultural productivity of OECD countries and Australia, respectively.

IV. Data description

There being no consensus as to how to specify inputs and outputs for financial institutions, in this study we employed the popular intermediation approach which focuses on bank services. Under this approach banks are viewed as financial intermediaries with outputs measured in local currency, and with labour, capital and different funding sources as inputs. This approach is suggested by Sealey and Lindley (1977) and has been used in many studies such as Berger et al. (1987), Aly et al. (1990), Hancock (1991), Wheelock and Wilson (1999) and Burgess and Wilson (1995). We included three inputs: labour (x_1), measured by the number of full-time equivalent employees on the payroll at the end of each period; physical capital (x_2), measured by the book value of premises and fixed assets; and purchased funds (x_3), including all time and savings deposits and other borrowed funds (not including demand deposits). We included three outputs: total demand deposits (y_1); state-owned sector loans (y_2), including loans for agriculture, manufacturing, mining and services; and non-state-owned loans (y_3). All data were obtained from Iran's Central Bank archives (CBI, 2005, 2008). We considered all but three banks operating in the Iranian banking industry, as these three were not homogenous in input and output mixes. In all, we used balanced panel data for 14 banks over six years (2003-2008). All estimates were attained using the DPIN software written by O'Donnell (2010a).

V. Empirical results

As the Hicks–Moorsteen is a distance-based index, the DEA methodology developed by O'Donnell (2010b) is applied for estimating the distances under VRS. The interpretation is straightforward. A technical efficiency estimate equal to unity indicates that the bank lies on the boundary of the production set, and, accordingly, is (relatively) efficient. An estimate below unity indicates that the bank is positioned under the frontier and is technically inefficient. A firm that has technical efficiency equal to 1 and has scale and mix efficiency less than 1 is still on the frontier, but at a relatively unproductive point on the frontier. The estimates of output-oriented efficiency levels are reported in Table I, and categorised into four groups: commercial banks, specialised banks, private banks and mean efficiency for the banking industry over the period 2003–2008[12]. Columns 1 and 2 of Table I show the different categories of banks and years 2003 through 2008, respectively. Columns 3-5 list the measures of pure technical efficiency, scale efficiency and mix efficiency, respectively, for each year[13].

Table I shows that, as a whole, the industry's output-oriented technical efficiency (OTE) improved over 2003–2006, and worsened over 2006–2008. The reduction of overall OTE after 2006 was mainly attributable to the performance of private banks, as their technical efficiency levels decreased from 98 per cent in 2006 to 89 per cent in 2007 and to 88 per cent in 2008. Table I also reveals that, on average, all the groups of Iranian banks became highly scale inefficient after 2006. It seems that scale inefficiency became a major problem for the Iranian banking industry over this period, changing from 90 per cent in 2006 to 77 per cent in 2007 and to 86 per cent in 2008. The industry also experienced relatively lower levels of mix efficiency after 2006. This level declined from 95 per cent to 91 per cent in 2007 (although it returned to 95 per cent in 2008).

However, concentrating only on efficiency estimates can provide an incomplete view of banks' performance over time. Changes in distance function values over time could be caused by either movement of banks within the input-output space (efficiency changes), or progress or regress of the boundary of the production set over time (technological changes). The decomposition of the TFP index, as provided in Table II, makes it possible to distinguish changes in productivity, efficiency and technology.

[Tables I and II about here]

Table II lists measures of the banks' total factor productivity changes (ΔTFP) and its components, technical change (ΔTech) and efficiency change (ΔEff), in the four groups over five pairs of years between 2004 and 2008. The table also presents components of the ΔEff: changes in output-oriented pure technical efficiency (ΔOTE), residual scale efficiency (ΔROSE) and mix efficiency (ΔOME). Estimated values greater than unity indicate an improvement in the measures, and estimated values less than unity indicate a deterioration.

As predicted by the theory, Table II shows that technical changes (ΔTech) are the same for each group of banks in any period since the measure of ΔTech is the change in the point of maximum productivity and that is the same for all firms. A change in the production possibilities set (ΔTech) can be attributable to any changes in the environment. Thus, it will capture the effect of technological change as well as the effects of government regulations and central bank policies. In 2004–2005, 2005–2006 and 2006–2007 the industry's estimated ΔTech was greater than unity, suggesting overall technological progress in the industry. These changes coincided with technological advances in the banking industry starting in 2004, such as increased numbers of automated teller machines, credit cards, debit cards and online-branches, as well as increased pressure on commercial banks to expand credit in 2006. This rate was 42 per cent, 6 per cent and 127 per cent in 2004–2005, 2005–2006 and 2006–2007, respectively. Despite the significant positive technical change in 2006–2007, the industry showed a large decrease in technical change, -16 per cent, for the period 2007–2008, which coincided with the substantial rise in the state-owned banks' non-performing loans and, consequently, a substantial decrease of the banks' intermediation services.

A general comparison of the different indices in Table II reveals that the most important component of the TFP changes (ΔTFP) for Iranian banking was technical changes (ΔTech). As a result of these changes the industry experienced improvement of TFP over 2004–2005, 2005–2006 and 2006–2007, and deterioration of ΔTFP over 2003–2004 and 2007–2008. ΔROSE (scale-efficiency changes) was the second most important component of the TFP changes. For example, in 2006–2007, commercial banks, specialised banks and private banks experienced an extensive technology advance of 127 per cent (see the fourth column in Table II, where ΔTech=2.27 for all banks). However, a considerable deterioration of scale efficiency (ΔROSE) negated significant positive changes of ΔTech, limiting the extent of TFP growth over this period: TFP changes for commercial banks, specialised banks and private banks showed net changes of 14 per cent (commercial banks), 87 per cent (specialised banks), and -5 per cent (private banks). Overall, the industry witnessed its highest negative scale efficiency rate, 38 per cent (ΔROSE=0.62), and consequently its highest negative efficiency growth, 43 per cent (ΔEff=0.57), during 2006–2007. In general, the results in Tables I and II indicate that, while government regulations may have resulted in large advances in the production possibilities set over time, state regulatory measures exacerbated scale inefficiencies.

Although mix-efficiency (ΔOME) and technical-efficiency changes (ΔOTE) did not have a strong effect on ΔTFP, their estimated values showed that the industry has became relatively more mix and technically inefficient after the regulatory changes. It reflects the banks' problems with resource allocation in the post-regulation era, when interest rates and the allocation of direct lending facilities were regulated. For example, while the sector showed some positive changes in OME and OTE before 2005, in 2006–2007 OME fell about 4 per cent and OTE about 5 per cent.

VI. Conclusions

This paper has employed a new decomposition of the Hicks–Moorsteen TFP index developed by O'Donnell (2010b), to analyse efficiency and productivity changes in a banking context for the first time. We investigated the efficiency and productivity growth of the Iranian banking industry over the period 2003–2008, which encompasses years before and after the reforms of 2005.

Based on our results it appears that the industry's technical efficiency, which was improving in the years before the regulation, deteriorated considerably soon after the regulatory changes. This reduction of overall technical efficiency after 2006 was mainly attributable to the performance of private banks which became technically inefficient (the worst bank-group) and more scale and mix inefficient over this period, particularly in 2008. It may be argued that due to the expansion of state-owned banks' advances to the non-public sector after 2006, state-owned banks became more technically efficient than private banks under the intermediation approach. The considerably lower technical efficiency of private banks over this period can also be attributed to their poor management of increasing deposits caused by the different interest rates, increased public confidence in private banks and the low attractiveness of investment in other markets. Also, given the small size of the private banks, their performance may be more efficient through institutional growth and an increased number of branches.

According to our findings the industry became largely scale inefficient and relatively more mix inefficient after 2006. These deteriorations were more attributable to the performance of state-owned banks, particularly specialised banks, during this period. One may relate these changes to the suboptimal usage of inputs by the financial institutions, and more importantly to the government regulatory intervention in their management of inputs and outputs. Hence, the government may need to rethink and redesign the reform measures with the objective of increasing the independence of state-owned banks. Expanding privatisation of state-owned banks would be the best way to decrease direct facilities and increase management's ability to control risk factors. Since all the commercial banks (except the National Bank and Bank Sepah) are already scheduled for privatisation, they will need significant restructuring and the establishment of clear criteria for privatisation before being sold. Specialized banks that are not scheduled for privatisation, have a strong need to be more independent of government and more exposed to the latest management practices.

In terms of TFP changes, our results show that technological changes and government regulations could largely increase the banks' TFP by shifting the production possibility frontiers upwards during 2004–2005 and 2006–2007. However, sizable falls in scale efficiency dramatically contributed to the diminishing efficiency and TFP growth of Iranian banks during these periods. We also find that the TFP rate deteriorated significantly for all the bank-groups over 2007–2008 which could be due to the unprecedented rise of the sector's NPLs after 2006. Thus, it can be argued that not only the banks must be more independent from government, but they may also need to improve their monitoring mechanisms to assess loans more precisely.

Overall, it can be concluded that the technical efficiency, mix efficiency and productivity of the industry have been affected considerably since the introduction of regulations, and scale inefficiency has become a major problem for Iranian banks. Our findings, *inter alia*, suggest that central-bank independence and limited government-regulatory power in the banking industry could boost the efficiency and stability of the banking system.

Table I. Measures of output-oriented technical efficiency (OTE), scale efficiency (OSE) and mix efficiency (OME) assuming VRS

Banks	Year	OTE	OSE	OME
Commercial banks (state-owned)	2003	0.8905	0.9454	0.9379
	2004	0.9821	0.9736	0.9896
	2005	0.9820	0.9775	0.9804
	2006	0.9928	0.9397	0.9650
	2007	0.9950	0.6366	0.9532
	2008	0.9349	0.8806	0.9629
Specialised banks (state-owned)	2003	1.0000	1.0000	0.9648
	2004	0.9263	0.9194	0.9078
	2005	0.9548	0.8851	0.9211
	2006	0.9911	0.8351	0.9105
	2007	0.9846	0.7420	0.8844
	2008	1.0000	0.8386	0.9030
Private banks	2003	0.7949	0.9876	0.9502
	2004	0.9364	0.9383	0.9681
	2005	1.0000	0.9333	1.0000
	2006	0.9897	0.9527	0.9831
	2007	0.8971	0.9336	0.9016
	2008	0.8806	0.8684	0.9122
The banking industry	2003	0.8951	0.9777	0.9510
	2004	0.9482	0.9438	0.9552
	2005	0.9789	0.9319	0.9671
	2006	0.9912	0.9091	0.9528
	2007	0.9589	0.7707	0.9130
	2008	0.9385	0.8625	0.9260

Note: Efficiency estimates equal to unity indicate that the bank-group is (relatively) efficient, and estimates below unity indicate that the bank-group is relatively less efficient

Table II. Changes in total factor productivity and its components assuming VRS

Banks	Period	ΔTFP	ΔTech	ΔEff	ΔOTE	ΔROSE	ΔOME
Commercial banks (state-owned)	2003/2004	0.7656	0.8252	0.9209	1.1259	0.7734	1.0576
	2004/2005	1.0206	1.4253	0.7133	0.9999	0.7201	0.9908
	2005/2006	1.1901	1.0605	1.1234	1.0130	1.1266	0.9843
	2006/2007	1.1417	2.2734	0.5039	1.0023	0.5093	0.9870
	2007/2008	0.8179	0.8432	0.9765	0.9387	1.0254	1.0146
Specialised banks (state-owned)	2003/2004	0.8762	0.8252	1.0597	0.9263	1.2225	0.9358
	2004/2005	1.1186	1.4253	0.7820	1.0404	0.7362	1.0209
	2005/2006	0.9110	1.0605	0.8553	1.0443	0.8319	0.9846
	2006/2007	1.8700	2.2734	0.8104	0.9934	0.8464	0.9638
	2007/2008	0.9682	0.8432	1.1448	1.0162	1.0971	1.0269
Private banks	2003/2004	0.9065	0.8252	1.1298	1.2447	0.8877	1.0226
	2004/2005	1.0733	1.4253	0.7830	1.0854	0.6959	1.0366
	2005/2006	1.1838	1.0605	1.1107	0.9897	1.1417	0.9831
	2006/2007	0.9530	2.2734	0.4290	0.9078	0.5147	0.9182
	2007/2008	0.9633	0.8432	1.1437	0.9720	1.1582	1.0159
The banking industry	2003/2004	0.8494	0.8252	1.0619	1.0989	0.9612	1.0053
	2004/2005	1.0708	1.4253	0.7595	1.0419	0.7174	1.0161
	2005/2006	1.0950	1.0605	1.0327	1.0157	1.0334	0.9840
	2006/2007	1.3215	2.2734	0.5771	0.9678	0.6235	0.9563
	2007/2008	0.9164	0.8432	1.0873	0.9756	1.0935	1.0191

Notes: $\Delta TFP = \Delta Tech \times \Delta Eff$, and $\Delta Eff = \Delta OTE \times \Delta ROSE \times \Delta OME$

Notes

1. Specialised banks focus more on special services in their area of interest such as mining, agriculture, dwelling construction, etc.

2. The Malmquist productivity index was initially introduced by Caves et al. (1982) as a theoretical index. Färe et al. (1992) merged Farrell's (1957) measurement of efficiency with Caves et al.'s (1982) measurement of productivity to develop a new Malmquist index of productivity change. Then, Färe et al. (1989, 1992) proved that the resulting total factor productivity (TFP) indices could be decomposed into efficiency-change and technical-change components. Färe et al. (1994) further decomposed the efficiency change into a pure technical efficiency change and changes in scale efficiency, a development that made the Malmquist index widely popular as an empirical index of productivity changes.

3. Using a similar data-set to that of Coelli et al. (2005), O'Donnell (2008) showed that the estimated Malmquist index numbers differed from the estimated Hicks–Moorsteen index numbers, even though both were computed under the assumption of constant returns to scale. Estimated components of TFP change were also found to differ under different approaches. Hence, in this study we were not able to provide a comparison between the results of the Malmquist index and the Hicks–Moorsteen index. See Färe et al. (1996, 1998) for the necessary and sufficient conditions for the Malmquist index to be equal to the Hicks–Moorsteen index.

4. O'Donnell (2008, p. 22) states that "It is ironic that the Malmquist index has achieved much greater popularity than the [Hicks–Moorsteen] index partly because it decomposes into various sources of productivity change (Lovell, 2003, p. 438) and yet, unless the technology is inversely homothetic and exhibits constant returns to scale, it is the latter index, not the former, that can be decomposed in an economically-meaningful way".

5. For a comprehensive review of the literature on the TFP index and its decomposition, see O'Donnell (2008).

6. That idea was first raised seriously by Bjurek (1996).

7. See Grifell-Tatje and Lovell (1995) for a detailed explanation.

8. Briec and Kerstens (2004) also introduced a new difference-based variation of the Malmquist TFP index which is known as the Luenberger–Hicks–Moorsteen indicator in the literature. For recent theoretical contributions on the Hicks–Moorsteen index see also Briec and Kerstens (2011) and Briec et al. (2011).

9. One possible solution for quantifying the magnitude of these possible errors would be to estimate the technology using an econometric methodology that allows for statistical noise (e.g., stochastic frontier analysis). However, not only does this type of

analysis require a larger sample size than we use here, it goes beyond the scope of this paper.

10. To avoid repetition attention is focused on the decomposition of a multiplicatively complete TFP index, and the definitions of the efficiency measures in terms of quantity aggregates have not been presented. For an extensive explanation of these aggregates see O'Donnell (2008, 2010b).

11. For more explanation regarding the difference between this measure of technical change and the Färe et al. (1994) measure of technical change, see (O'Donnell 2008, 2010b).

12. Results for all years are available from the authors upon request.

13. A method for estimating residual scale efficiency is not currently available; hence, only estimates of pure technical efficiency, scale efficiency and mix efficiency are provided.

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