
**Electronic Journal of Applied Statistical Analysis**
**EJASA, Electron. J. App. Stat. Anal.**
http://siba-ese.unisalento.it/index.php/ejasa/index
e-ISSN: 2070-5948
DOI: 10.1285/i20705948v11n1p58

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Published: 26 April 2018

*Electronic Journal of Applied Statistical Analysis*
Vol. 11, Issue 01, April 2018, 58-73
DOI: 10.1285/i20705948v11n1p58

# Productivity growth of the Australian real estate investment trusts

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Published: 26 April 2018

This study aims to evaluate the productivity change of the Australian Real Estate Investment Trust (REITs) by using a Balance panel data set which cover 10 AREITs operating in the Australian market from 2004 to 2011. The study use a non-parametric approach Data Envelopment Analysis based analysis to investigate the productivity change. Input-oriented Malmquist indices of productivity change are estimated to measure total factor productivity (TFP) change. The TFP changes are decomposed into the product of technological change and technical efficiency change (catch-up). Three inputs are utilized which are operating expenses, administrative expenses, and interest expenses. Meanwhile, outputs used are total assets, enterprise value. Variable Return to Scale Data Envelopment Analysis (VRS-DEA model) is used for the entire sample using the DEAP version 2.1 (Coelli, 1996). The results indicate that the average productivity declined and technology regressed during this decade. It appears that the typical REIT has failed to improve technically, but exerted substantial effort to catch up with the best practice ones relying mainly on aggressive growth strategies. Results indicate that AREITs experienced a 2.4% TFP regress, a 2.6% technological regress, a 0.1% efficiency progress, a 0.5% pure efficiency fall and a 0.6% scale efficiency increase on average between 2004–2011.

**keywords:** Data Envelopment Analysis, Malmquist Index, Productivity, TFPC, Real Estate, AREITs)

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ISSN: 2070-5948
http://siba-ese.unisalento.it/index.php/ejasa/index

# 1 Introduction

Australia Real Estate Investment Trusts (AREIT) one of the largest sectors on the Australian Stock Exchange. The total market capitalization of the sector rivals the banks and resource stocks. There are 47 Australian Real Estate Investment Trust (Listed Property Trusts). For most investors it is unfeasible to own commercial assets by itself or it would not be efficient from a portfolio diversification perspective. REITs allows individual investors to gain exposure to direct real estate assets in their portfolio. While Australian investors love invest in property. REITs is one of the most accessible means for individual investors to gain exposure to Commercial Real Estate. It is also tax efficient. REIT Distributions does not have franking credits because the income is not taxed if it's paid out to investors.

Significant structural changes occurred during the decade in Australian Real Estate Investment Trust (REITs), this industry experienced remarkable asset growth during the decade, with a large number of initial public offerings and substantial increases in market capitalization. In addition, REITs are real estate securities that sell like a stock on the major exchanges and invest in real estate directly, either through properties or mortgages. Employing the Data Envelopment Analysis-type Malmquist index approach, this paper explores the changes on productivity growth, efficiency change, and technological progress of REITs.

Real state mutual funds that invest money (obtained through the sale of its shares to investors) in residential or commercial properties and earn primarily rent revenue (equity REITs), invest in property mortgages and earn principally interest revenue (mortgage REITs) or combine both investment strategies for shareholders (hybrid REITs). REITs have provided small investors with an opportunity to buy skyscrapers, shopping malls, hotels, restaurants and apartment buildings, without incurring the hassles of direct property ownership. With the all right essential consistent and remarkable profits, low volatility, impressive dividends, enhanced liquidity, low correlation with other investment classes, and most importantly professional management, REITs have become a part of every serious investor's diversified portfolio in recent years (Topuz, 2005).

The productivity can be measured simply as a scalar ratio of outputs to inputs that the RIETs uses. RIET's productivity may vary based on differences in the quality of inputs used. However, efficiency can be measured by associating the observed and optimal values of the bank's outputs and inputs. The question of whether RIETs outperform or underperform other RIETs has received considerable attention in the literature. There is a large body of literature dealing with the measurement of banking efficiency and productivity growth in the developed economies, but studies on RIETs efficiency and productivity growth are few. To the best of my knowledge, no empirical work has studied and examined the productivity, technology and efficiency growth of the REITs in Australia. The purpose of this study, is to examine the developments in the productivity growth of the REITs using the non-parametric Malmquist Index method.

This study aim to investigate whether the Australian REITs have experienced any improvement in their productivity during the period 2004-2011. Hence, the objective to investigate whether there has been an increase of efficiency levels through the years for AREITs for a balanced panel data which covers 10 companies operating in Australia, by estimating a non-parametric approach Data Envelopment Analysis. This study applied input-oriented Malmquist productivity indices to measure total factor productivity (TFP) change (Coelli, 1996). The TFP changes are decomposed into the product of technological change and technical efficiency change (catch-up). Applying DEA model using the software package, DEAP Version.2.1.

The study organized as follows. Section 2 presents a brief overview of existing literature on productivity changes in REITs. This is followed by Section 3, which provide a brief review on data and research methodology. The results of productivity change are presented in Section 4. Sections 5 summarizes and brings together the main findings.

## 2 Literature Review of REIT Efficiency using DEA

There are few researchers' measure productivity growth using DEA in REITs sector worldwide. However, various studies applied same methods for measuring banking efficiency and productivity. There is a paper done by Emrouznejad and G (2008) presented a survey and analysis of the first 30 years of literature in DEA, covering research developments and outcomes from the pioneering years of DEA to 2007. The survey is the most comprehensive source of references on DEA application in measuring the efficiency and productivity of DMUs. It covers 4015 publications, serving as an important source for obtaining references.

For the REITs efficiency measurement using the DEA method to find the most efficient REITs. The inefficient REITs may be due to the poor utilisation of input and failure to operate at constant to scale (Anderson and Springer, 2003; Topuz, 2005; Lewis and Anderson, 2003; Topuz, 2002. Topuz (2002) measured the allocating and technical efficiency of REITs in the USA using both SFA and DEA, suggests that the REIT has an average to low efficiency contributed by technical inefficiencies more than allocating inefficiencies.

Other researchers applying DEA for measuring REITs efficiency are Anderson and Springer (Anderson, 2002, Anderson and Mcleod, 2004, and Nanka-Bruce, 2006). Anderson and Springer (2003) had found portfolio of REITs constructed had superior performance in 1st, 2nd and 3rd year when using DEA technique for the 1995-1999. Another study done by Anderson and Mcleod (2004) examine the performance seven Real Estate Mutual Funds (RMFs) from 1997-2001. There results reveal, that discover the superior performance along five years (1997 – 2001), seven in 1997, three in 1998, three in 1999, four in 2000 and six in 2001, operating on the efficient frontier.

Jreisat (2012) has investigated the efficiency and productivity growth of the Jordanian banking sector, during the period of financial deregulation, 1996-2007. It begins with analysis of technical efficiency based on DEA, followed by measuring cost efficiency, finally, the Malmquist productivity indices are computed to examine the total factor productivity change.

More recently, Bhatia and Mahendru (Bhatia and Mahendru, 2016), they evaluate technical efficiency scores of public sector banks (PSBs) in India. Their study also determines the nature of return to scale (RTS) of individual banks and thereby identifies the leaders and laggards in the PSBs. Non-parametric approach, that is, data envelopment analysis (DEA) is used to determine the causes of inefficiency. Their sample of the study includes 26 PSBs operating in India during the time period from 2007–2008 to 2011–2012. Their results show that although the PSBs have more or less similar efficiency scores, that is, higher than 0.900, still out of 22 banks falling in the category of efficient banks in 2007–2008, only 7 of them were left by the year 2011–2012. Overall analysis of PSBs during the time period of the study explains that a greater part of inefficiency among PSBs is attributed to scale inefficiency. In addition, the number of banks operating at constant return to scale (CRS) came down to 9 in 2011–2012 from 23 in 2007–2008. In addition, there was a reduction in leaders and increase in laggards. It is suggested that banks must optimize their scale of operations and adopt technological innovations.

As recognized by Berger AN (1997), who surveyed 130 efficiency studies on different financial institutions from 21 countries, earlier research has not dealt directly or indirectly with the productivity or efficiency performance of REITs despite the significant changes in their regulatory apparatus and phenomenal growth. However, a few static studies emerged in recent years that explore the determinants of the efficiency level for REITs (e.g., Anderson, 2002 and Topuz, 2005). However, none of these papers has dwelled on efficiency growth (catching up or falling behind effect) or technological progress (outward shift or regress in AREITs technological frontier) or productivity gains (rise in the ability of the REITs to generate more outputs from the same inputs), in the REIT's industry during this remarkable growth period. Besides, as discussed below and in the methodology section, productivity and efficiency concepts refer to different aspects of firm production.

To the best of our knowledge, there are no single research articles related directly to the productivity growth of RIETs, The aim of this paper is to fill the gap in the existing literature on efficiency and productivity growth in the RIETs industry of Australia. The primary objective of this paper is to undertake and in-depth evaluation and examination of the productivity growth in the ARIETs. Input-oriented Malmquist indices of productivity change are estimated with DEA to measure total factor productivity (TFP) change. The empirical results are obtained by running an input-oriented DEA model using the software package, DEAP Version 2.1 (Coelli, 1996).

## 3 The Malmquist Total Factor Productivity Index: Decomposition and Measurement

The Malmquist TFP index was first introduced in two very influential papers by Caves DW and Diewert (1982). These authors define TFP index using Malmquist distance functions; hence the resulting index is known as Malmquist TFP index. One of the important features of these distance functions is that they allow description of a multi-input, multi-output production technology without the need to specifying a behavioural objective htb

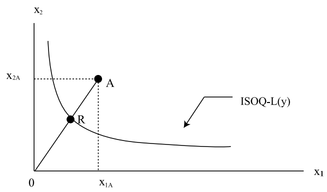


Figure 1: Source: Coelli and Battese (2005)

such as cost minimisation or profit maximization.

Distance functions are of two types: the input distance functions and the output distance functions. Input distance functions look for a minimal proportional contraction of an input vector, given an output vector; and output distance functions consider the maximum proportional expansion of output with a given set of inputs. Since the banks have better control over the inputs, we adopt an input-orientated approach for computing TFP.

Let $y_t \in R_+^M$ denotes an (Mx1) output vector, $x_t \in R_+^N$ an (Nx1) input vector, and L(y) denote the input requirement set representing the set of all input vectors, x, which can produce the output vector, y. Then the input distance function, which involves the scaling of input vector, is defined on input set, L(y), as:

$$d_i^t\ (y_t,\ x_t) = \max\{\, \rho_t : (x_t/\rho_t) \in L\,(y)\} \tag{1}$$

where the subscript 'i' indicates 'input-oriented' measure. The notation $d_i^t\,(y_t, x_t)$ stands for the distance from the period t observation to the period t technological frontier. In other words, this distance function represents the largest factor,$\rho_t$ by which an input vector($x_t$)is deflated to produce the output vector under period t technology. Similarly, $d_i^s\,(y_t, x_t)$ would indicate distance from period t observation to period s technology. An input distance function can be illustrated using an example where two inputs, $x_1$ and $x_{2,}$ are used to produce a given output vector, y. For a given output vector, the production technology is represented by the isoquant, L(y) in figure 1. The value of the distance function for the point, A, which defines the production point where the firm uses $x_1$ of input 1 and $x_2$ of input 2, to produce the output vector y, is equal to the ratio $\rho$= OA/OB.

Based on input distance functions, the Malmquist TFP index can be constructed to measure productivity change between periods s and t, based on period t technology,

$$m_i^t\,(y_s, x_s, y_t, x_t) = \frac{d_i^t\,(y_t, x_t)}{d_i^t\,(y_s, x_s)}. \tag{2}$$

A similar input- oriented Malmquist index can be obtained based on period s technology as follows,

$$m_i^s\left(y_s,x_s,y_t,x_t\right)=\frac{d_i^s\left(y_t,x_t\right)}{d_i^s\left(y_s,x_s\right)}. \tag{3}$$

Clearly, equations 2 and 3 imply that estimation of TFP change between the two periods could depend on the choice of technology. In order to avoid the effect of any arbitrarily chosen technology, Färe et al (1994) suggest to estimate the input- oriented TFP as the geometric mean of the indices based on periods t and s technologies as given by equations 2 and 3, respectively. Hence we have

$$m_i\left(y_s,x_s,y_t,x_t\right)=\left[\left\{\frac{d_i^s\left(y_t,x_t\right)}{d_i^s\left(y_s,x_s\right)}\right\}\left\{\frac{d_i^t\left(y_t,x_t\right)}{d_i^t\left(y_s,x_s\right)}\right\}\right]^{\frac{1}{2}}. \tag{4}$$

When the value of $m_i$ exceeds unity this indicates a positive TFP growth from period s to period t and a value of the index less than one indicates a decline in TFP growth. The Equation 4 can be re-written as

$$m_i\left(y_s,x_s,y_t,x_t\right)=\frac{d_i^t\left(y_t,x_t\right)}{d_i^s\left(y_s,x_s\right)}\left[\left\{\frac{d_i^s\left(y_t,x_t\right)}{d_i^t\left(y_t,x_t\right)}\right\}\left\{\frac{d_i^s\left(y_s,x_s\right)}{d_i^t\left(y_s,x_s\right)}\right\}\right]^{\frac{1}{2}}. \tag{5}$$

The ratio outside the square brackets measures the change in the input-oriented measure of technical efficiency between periods, s and t. This efficiency change is equivalent to the ratio of the Farrell technical efficiency in period t to the technical efficiency in period s. The remaining part of the index indicates the shift in technology between the two periods. Thus, the Malmquist TFP index shows that productivity change is the product of technical efficiency change (called 'catch-up') and technological change ('shift in frontier'). The figure 2 below illustrates the decomposition.

The technologies for period t and period s (t >s) are represented by St and Ss showing technological progress from period s to t. Both observations (yt, xt) and (ys, xs) are inefficient with respect to their own frontier and (yt, xt) does not belong to (ys, xs). Our formula 5 of the Malmquist index can be expressed in terms of distances along the x-axis. Thus we have:

$$m_i\left(y_s,x_s,y_t,x_t\right)=\frac{oe/of}{oa/ob}\left[\left\{\frac{of}{od}\right\}\left\{\frac{oc}{ob}\right\}\right]^{\frac{1}{2}} \tag{6}$$

To measure Malmquist TFP change between any two periods as defined in equation 5, four distance functions have to be calculated.

The technical efficiency change can be further decomposed into changes in scale efficiency and pure technical efficiency components. This requires the calculation of the distance functions with VRS technology. The values obtained with CRS and VRS technology can be used to calculate the scale efficiency change residually. The mathematics underlying the estimation procedure is outlined in Coelli and Battese (2005) and Färe and Wang (1990).

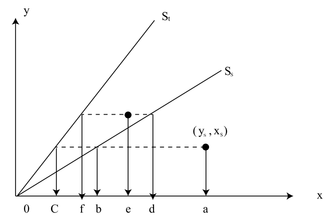


Figure 2: Source: Färe and Wang (1990)

### 3.1 Data Sample and the choices of variables

The primary objective of this paper is to undertake and in-depth evaluation and examination of the productivity growth in the Australian Real Estate Investment Trust (REITs). Input-oriented Malmquist indices of productivity change are estimated with DEA to measure total factor productivity (TFP) change using a balanced panel data containing 10 companies operating in Australia for the period 2004-2011. The study compares the productivity change between the Australian Real Estate Investment Trust (REITs) during the sample period. The empirical results are obtained by running an input-oriented MPI - DEA model using the software package, DEAP Version 2.1 (Coelli, 1996). A value of the index greater than one indicates positive productivity growth or productivity progress, while a value less than one indicates productivity decline or productivity regress. Percentage change in productivity is given by (Productivity Change – 1) x 100.

This study examined Australian REITs 2004-2011 (see Table 1 for the list of AREITs). The financial data was obtained from various annual reports, DEA program version 2.1 (Coelli, 1996) is used to calculate the efficiency scores. The study excluded other REITs which was unbalance data due to missing data for the other companies operating in Australian market for the period.

Since the empirical results based on DEA often depend or are influenced by the choice and/ or number of inputs and outputs entering into the model, this study discuss below the variables that are often used in deriving the efficiency results. The banking literature has not come to a consensus yet on the definition of bank inputs/outputs although there were over 130 frontier efficiency and productivity studies as of 1997 (Berger AN, 1997). Not surprisingly, rather limited number of the REITs frontier studies also does not provide a consensus as to what really signifies the production of REITs, or how to measure their outputs.

Measuring REITs by utilizing DEA are essential to have the suitable inputs in order to have an efficient output. The most common input selected by researchers is the total number of expenses, such as study done by Yusof (2009), Miller, Topuz (2005) and Anderson (2002). There are also other inputs utilized. This can be found in research done by Springer and Miller (2007), Coelli and Battese (2005) and Anderson and Elder (1998), where price variable is selected as input variable in their study. Meanwhile, Isik and Topuz (2010) chose interest expenses and property operating expenses as input

Table 1: REITs in Australia 2004-2011

| | |
|---|---|
| 1 | STOCKLAND |
| 2 | THAKRAL HOLDINGS GROUP |
| 3 | CFS RETAIL PR.TST. |
| 4 | ASPEN GROUP |
| 5 | BWP TRUST |
| 6 | ARDENT LEISURE GROUP |
| 7 | MIRVAC GROUP |
| 8 | INVESTA OFFICE FUND |
| 9 | ABACUS PROPERTY GROUP |
| 10 | ALE PROPERTY GROUP |

**Source:** Annual Report of REIT

variable. On the other hand, common output selected is the total assets, where can be found in Yusof (2009), Springer and Miller (2007), Anderson and Mcleod (2004), Anderson (2002). For other researchers, instead of using total assets as output variables, (Ambrose and Pennington-Cross, 2000, Springer and Miller, 2007, Coelli and Battese, 2005 and Anderson and Elder, 1998) select total revenue as an output in their study.

Based on the past studies, few studies are applying DEA models with different inputs and outputs, which inputs and outputs selection are based on study's objective. Therefore, in this research, DEA models which similar to Anderson and Springer (2003), Anderson and Mcleod (2004), Sham and Tsai (2009) and Nanka-Bruce (2006) are implemented to measure efficiency of REITs in Australia focusing only to input-oriented measurement. For this paper, 10 companies were chose based on the data availability and accessibility when this research is carried out.

This study follow same methodology done by JC and I. (2008). By applying input-oriented DEA model is to compute Malmquist indices of productivity change. For finding TFP the variables this study employ two inputs, see Table 2 which provide three inputs and two outputs, respectively that are used in this study. These inputs and outputs are then utilized to measure the of AREITs efficiency. Our total expenses are used as input variables, whereby, these inputs include (i) operating expenses, (ii) administrative expenses and (iii) interest expenses. Meanwhile, two output measures are total assets and enterprise value.

Table 2: List of Inputs and Outputs

| | |
|---|---|
| Inputs | Operating expenses (X1) |
| | Administrative expenses (X2) |
| | Interest expenses (X3) |
| Outputs | Total assets (Y1) |
| | Enterprise value (Y2) |

## 4 Results Of The Malmquits Productivity Inddexes

In order to determine absolute improvement in productive performance across time, the Malmquist productivity index is commonly preferred to traditional efficiency measures in time-series analyses (Berger AN, 1997; Canhoto A, 2003; Isik I, 2003). In Malmquist methodology, the data set remains the same but time periods change, making it possible to compare REITs against a common frontier. Second, as Coelli T (2003) note, the DEA efficiency scores tend to increase upward as the sample size decreases. Given the constantly increasing number of REITs throughout the sample period, using a balanced panel data set is critical to control for such an upward bias for earlier years (and downward bias for later years) of the decade.

To provide an overview of the productivity growth of AREITs. DEA was implemented to measure the productivity change of REITs for 10 companies in Australia. DEA is useful in identifying MREITs companies that minimizes the costs to produce optimal outputs. This study have used non-parametric data envelope approach to compute the input oriented Malmquist indices of productivity change based on the panel data which cover 10 AREITs operating in the Australia from 2004 to 2011.

The computer software DEAP (Coelli, 1996) is used to calculate these indices. The Malmquist index requires that a REIT exist in two successive years. Hence, this study use a balance panel data set to examine the productivity change of the same set of 10 REITs continuously during the period from 2004-2011. The value of the Malmquist productivity indices (MPI) greater than one indicates positive productivity growth or productivity progress while a value less than one productivity decline or productivity regress. Percentage change in productivity is given by (productivity change – 1) x 100. Where mean aggregate indices are reported for the different groups of banks, these are weighted geometric means using the shares of individual banks in the group output as weights. Similarly, the indices aggregated over the period are also weighted geometric means, where shares of yearly outputs in the total output for the period are used as weights.

The sample period mean of TFP change and its components of technical efficiency change, pure technical efficiency change, scale efficiency change and technological change indices for each bank are presented in Table 3. The results reveal that three AREITs have shown productivity improvements and for the remaining companies (seven) productivity has declined over the years. The highest mean TFP growth has been shown by company eight with progress of TFPC 6.8% and lowest by company four with 11.8%. The observed improvement in mean TFP for company eight is largely attributable to technological progress.

Table 3: Mean MPI Estimates of Productivity Change and its Components, 2004–2011

| Firm Number | TEC | TC | PTEC | SEC | TFPC |
|---|---|---|---|---|---|
| 1 | 1.007 | 1.015 | 1.000 | 1.007 | 1.022 |
| 2 | 0.968 | 0.956 | 0.983 | 0.985 | 0.925 |
| 3 | 1.000 | 0.984 | 1.000 | 1.000 | 0.984 |
| 4 | 0.972 | 0.908 | 0.985 | 0.987 | 0.882 |
| 5 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 6 | 1.003 | 0.922 | 1.000 | 1.003 | 0.925 |
| 7 | 1.038 | 1.011 | 0.965 | 1.076 | 1.049 |
| 8 | 1.043 | 1.025 | 1.022 | 1.020 | 1.068 |
| 9 | 0.985 | 0.931 | 1.000 | 0.985 | 0.917 |
| 10 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Mean | 1.001 | 0.974 | 0.995 | 1.006 | 0.976 |

**Source:** author's calculations.

**Note:** TFP: total factor productivity; TEC: technical efficiency change; PTEC: pure technical efficiency change; SE: scale efficiency change; TC: technological change.

With respect to the changing reference technology (Table 4), we observe that the REITs in our sample experienced a 2.4% TFP regress, a 2.6% technological regress, a 0.1% efficiency progress, a 0.5% pure efficiency fall and a 0.6% scale efficiency increase on average between 2004–2011. It is clear that the productivity fall of the sector in this period would have been worse had it not been for the impact of efficiency increases—catching up effect. For the entire period, our results presents a similar picture with respect to fixed reference technology (see Table 4), with falling productivity and a contracting technological frontier. These results indicate that the main cause of the productivity decline for the Australian REITs during the decade was the contraction in their technology. Despite the disappointment in technological performance, the REITs appear to have slightly efficiency gains, partly owing to the contraction of the frontier. Likewise, scale efficiency increase was always positive during the sample period. It appears that the cardinal driver behind the REITs' stunning efficiency performance was scale efficiency increases (movement of the REITs towards the optimum scale where there are constant returns to scale, CRS). Importantly, we can observed from the results, in 2008 the AREITs have been worse which appeared that all TFPC, TC, TEC, PTE and SE declined which could be due to the global financial crisis (GFC).

Table 4: Yearly Malmquist Indices of Productivity Change for AREITs, 2005–2011

| Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mean |
|---|---|---|---|---|---|---|---|---|
| TEC | 1.147 | 0.951 | 1.059 | 0.937 | 0.99 | 0.975 | 0.966 | 1.001 |
| TC | 0.982 | 1.002 | 0.979 | 0.848 | 0.975 | 1.124 | 0.931 | 0.974 |
| PEC | 1.037 | 0.979 | 1.037 | 0.96 | 0.989 | 0.977 | 0.991 | 0.995 |
| SEC | 1.106 | 0.971 | 1.021 | 0.976 | 1.001 | 0.998 | 0.974 | 1.006 |
| TFPC | 1.127 | 0.953 | 1.036 | 0.794 | 0.965 | 1.096 | 0.9 | 0.976 |

**Source:** author's calculations.
**Note:** TFP: total factor productivity; TEC: technical efficiency change; PTEC: pure technical efficiency change; SE: scale efficiency change; TC: technological change.

The annual estimates of productivity change and its components of technical efficiency change, pure technical efficiency change, scale efficiency change and technological change indices for each company are presented in Table 5, results show yearly fluctuations in efficiency and technological levels. In the early phase of the period and before 2008, TFP growth of most AREITs showed accelerated TFP growth, largely due to technological improvement. In 2008, results showed TFP regress for nine companies out of ten and a decline in technological efficiencies for all companies. The TFP growth across all companies except the three companies effected from 2008 and have TFP regress in 2011.

## 5 Concluding Remarks

This study has used the DEA approach to estimate input-oriented Malmquist indices to examine TFP changes in the AREITs during the period, 2004–2011. The TFP changes were decomposed into the product of technological change and technical efficiency change (catch-up). The technical efficiency change was further decomposed into the product of pure technical efficiency change and the product of scale efficiency change. This is the first known attempt to investigate TFP change in both the Australian real estate investment trust sector. The results reveal that three AREITs have shown productivity improvements and for the remaining companies (seven) productivity has declined over the years. The highest mean TFP growth has been shown by company eight with progress of TFPC 6.8% and lowest by company four with 11.8%. The observed improvement in mean TFP for company eight is largely attributable to technological progress.

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Table 5: MPI Estimates of Productivity Change and its Components, 2004–2011

| Banks | Prod | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| STOCKLAND | TEC | 1.000 | 0.819 | 1.280 | 1.000 | 1.000 | 0.887 | 1.127 | 1.000 | 1.014 |
| | TC | 1.000 | 1.307 | 0.792 | 1.038 | 0.806 | 1.063 | 1.279 | 0.943 | 1.029 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | SEC | 1.000 | 0.819 | 1.280 | 1.000 | 1.000 | 0.887 | 1.127 | 1.000 | 1.014 |
| | TFPC | 1.000 | 1.070 | 1.013 | 1.038 | 0.806 | 0.944 | 1.442 | 0.943 | 1.032 |
| THAKRAL HOLDINGS GROUP | TEC | 1.000 | 1.290 | 0.794 | 1.601 | 0.633 | 1.580 | 0.528 | 0.920 | 1.043 |
| | TC | 1.000 | 1.055 | 1.075 | 1.016 | 0.826 | 1.152 | 0.818 | 0.812 | 0.969 |
| | PTEC | 1.000 | 1.231 | 0.813 | 1.558 | 0.683 | 1.465 | 0.594 | 0.955 | 1.037 |
| | SEC | 1.000 | 1.048 | 0.977 | 1.028 | 0.927 | 1.078 | 0.889 | 0.963 | 0.989 |
| | TFPC | 1.000 | 1.360 | 0.853 | 1.627 | 0.523 | 1.819 | 0.432 | 0.747 | 1.045 |
| CFS RETAIL PR.TST. | TEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TC | 1.000 | 1.124 | 0.771 | 0.975 | 0.873 | 1.104 | 1.166 | 0.941 | 0.994 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | SEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TFPC | 1.000 | 1.124 | 0.771 | 0.975 | 0.873 | 1.104 | 1.166 | 0.941 | 0.994 |
| ASPEN GROUP | TEC | 1.000 | 1.456 | 1.000 | 1.000 | 1.000 | 0.816 | 1.225 | 0.563 | 1.008 |
| | TC | 1.000 | 0.935 | 0.973 | 1.109 | 0.799 | 0.840 | 0.776 | 0.965 | 0.925 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.898 | 0.987 |
| | SEC | 1.000 | 1.456 | 1.000 | 1.000 | 1.000 | 0.816 | 1.225 | 0.627 | 1.016 |
| | TFPC | 1.000 | 1.360 | 0.973 | 1.109 | 0.799 | 0.685 | 0.951 | 0.543 | 0.928 |
| BWP TRUST | TEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TC | 1.000 | 0.949 | 1.843 | 0.635 | 0.798 | 0.933 | 1.046 | 1.156 | 1.045 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | SEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TFPC | 1.000 | 0.949 | 1.843 | 0.635 | 0.798 | 0.933 | 1.046 | 1.156 | 1.045 |
| ARDENT LEISURE GROUP | TEC | 1.000 | 1.216 | 1.000 | 1.000 | 0.807 | 0.878 | 0.896 | 1.326 | 1.015 |
| | TC | 1.000 | 1.137 | 0.840 | 1.045 | 0.773 | 0.978 | 0.968 | 0.778 | 0.940 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 0.960 | 1.034 | 1.007 | 1.000 | 1.000 |
| | SEC | 1.000 | 1.216 | 1.000 | 1.000 | 0.840 | 0.849 | 0.890 | 1.326 | 1.015 |
| | TFPC | 1.000 | 1.382 | 0.840 | 1.045 | 0.624 | 0.858 | 0.867 | 1.031 | 0.956 |
| MIRVAC GROUP | TEC | 1.000 | 1.800 | 0.521 | 1.105 | 1.020 | 0.902 | 1.187 | 1.150 | 1.086 |
| | TC | 1.000 | 1.178 | 1.118 | 0.963 | 0.880 | 1.103 | 1.105 | 0.792 | 1.017 |
| | PTEC | 1.000 | 1.000 | 1.000 | 0.920 | 1.011 | 0.591 | 1.320 | 1.071 | 0.989 |
| | SEC | 1.000 | 1.800 | 0.521 | 1.201 | 1.009 | 1.526 | 0.899 | 1.073 | 1.129 |
| | TFPC | 1.000 | 2.121 | 0.583 | 1.064 | 0.898 | 0.994 | 1.311 | 0.911 | 1.110 |
| INVESTA OFFICE FUND | TEC | 1.000 | 1.340 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.043 |
| | TC | 1.000 | 0.968 | 1.272 | 0.825 | 0.960 | 0.882 | 1.080 | 1.279 | 1.033 |
| | PTEC | 1.000 | 1.166 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.021 |
| | SEC | 1.000 | 1.149 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.019 |
| | TFPC | 1.000 | 1.296 | 1.272 | 0.825 | 0.960 | 0.882 | 1.080 | 1.279 | 1.074 |
| ABACUS PROPERTY GROUP | TEC | 1.000 | 0.874 | 1.145 | 1.000 | 1.000 | 1.000 | 1.000 | 0.898 | 0.990 |
| | TC | 1.000 | 0.736 | 1.053 | 0.756 | 0.688 | 0.946 | 1.922 | 0.827 | 0.991 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.998 | 1.000 |
| | SEC | 1.000 | 0.874 | 1.145 | 1.000 | 1.000 | 1.000 | 1.000 | 0.900 | 0.990 |
| | TFPC | 1.000 | 0.643 | 1.205 | 0.756 | 0.688 | 0.946 | 1.922 | 0.742 | 0.988 |

| Banks | Prod | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| ALE PROPERTY GROUP | TEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TC | 1.000 | 0.639 | 0.686 | 1.775 | 1.149 | 0.815 | 1.465 | 0.937 | 1.058 |
| | PTEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | SEC | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | TFPC | 1.000 | 0.639 | 0.686 | 1.775 | 1.149 | 0.815 | 1.465 | 0.937 | 1.058 |

**Source:** author's calculations.

**Note:** TFP: total factor productivity; TEC: technical efficiency change; PTEC: pure technical efficiency change; SE: scale efficiency change; TC: technological change.