An Empirical Study on Measuring Operating Efficiency and Revenue of Real Estate Assets in the UAE Using Data Envelopment Analysis

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Abstract

Purpose- This paper examines the performance efficiency of 56 real estate assets within the rental sector in the UAE to evaluate the relative operation efficiency in relation to revenue generation.

Method- The Data Envelopment Analysis (DEA) Approach was used to measure the relative operational efficiency of the studied assets in relation to the revenue performance. This method could produce a more informed and balanced approach to performance measurement.

Findings- The outcomes show that scores of efficiencies ranging from 7% to 99% in some of the models. The results showed that on average buildings are 75 percent relatively less efficient in maintenance, in term of revenue generation, than the benchmark set. Likewise, on average, the inefficient buildings are 60 percent relatively less efficient in insurance. Result also shows that 95% of the building assets in the sample are by and large operating at decreasing returns to scale. This implies that managers need to considerably reduce the operational resources (input) to improve the levels of revenue.

Research limitations/ implications- The study recommends that the FM operational variables that were found to inefficiently contribute to the revue should be re-examined to test the validity of the findings. This is necessary before generalising or interpolating the results that are presented in this study.

Practical implications- The information obtained about operational performance can help FM managers to understand which improvements in the productivity of inefficient FM resources are required, providing insight into how to reduce operating costs and increase revenue.

Originality/value- The paper adds value in using new FM operational parameters to evaluate the efficiency of the performance of built assets.

Keywords: Operating efficiency, envelopment analysis, asset performance measurement, facilities management, operational performance.

Introduction

Real estate management refers to all the activities that involve funding, development, control, monitoring, and operation aspects of real estate. Investment in real estate is one of the most lucrative investments globally due to its diversified impact and potential revenue (Osagie, 2018). There is a significant surge of interest in real estate worldwide from both individuals and corporate businesses. Real estate performance is of paramount importance to investors and operators. Several authors have used portfolio theory and discounted cash flow to assess the efficiency of investments in real estate. It is reported that the Capital Asset Pricing Model is deficient and inadequate to study the efficiency of real estate (Osagie, 2018, Christersson et al. , 2015 and Sengupta, 2003). This could probably be because, in the past, most real estate portfolios were generally built on a small scale. Studies covering real estate markets like Germany (Schaefers, 2009), Singapore (Chiang et al., 2016), India (Roy and Kohli, 2016) and Taiwan (Hai-feng and Shuang, 2015) reach different conclusions with regard to CAPEX efficiency. For instance, CAPEX efficiency for real estate assets in Europe is moderately high (Hartmann, 2015). This is confirmed by Ge and Guo (2014) to some extent, since European market management has very mature financing infrastructure. These studies focused on the financial instruments related to real estate CAPEX and OPEX rather than the operational efficiency of the building assets. Furthermore, these types of empirical analyses are normally ex-post analyses, which may only confirm the ex-ante investment decisions (Chiang et al., 2016). However, as a result of special property characteristics (heterogeneous), there are a variety of problems in selecting the appropriate asset for investment. Thus, this may require a different form of analysis (Virginia & Richard, 2009). The modern market has become increasingly competitive, and that has given rise to the need to constantly evolve and improve real estate performance (Stein et al., 2017). The performance paradigm that follows an input-output oriented methodology is associated with efficiency theory. The theory states that (Osagie, 2018) "an organization is cost efficient if it is able to use its allotted resources (input) to achieve a higher-level of output without incurring incremental cost of operation or if such a firm uses the least possible cost to generate the same level of output."

The efficiency of real estate management was discussed from an operational perspective in (Ge & Guo, 2014; Hai-feng & Shuang, 2015; Lins et al., 2005; Anderson et al., 2000; Arribas et al., 2016). Real estate performance is also analysed from a development and construction point of view (Jin et al., 2015). There is also an increased amount of research in real estate management from the perspective of financial investment and portfolio construction (Chiang et al., 2016). Ge and Guo (2014) pointed out that there is an increased number of real estate companies that are listed on the stock market. The authors claimed that these companies' aim is to demonstrate their operational efficiencies so that they can raise capital. The authors went on to highlight that most of the inefficiency in Chinese real estate management is due to operation funding problems. On a similar note, Hai-feng and Shuang (2015) performed a comparative efficiency study between listed real estate companies in China and Taiwan. They concluded that the technical efficiency of Chinese companies is lower than their counterparts in Taiwan. Lins et al. (2005) used DEA to analyse the price efficiency of real estate units. The authors claimed that DEA methodology is superior to traditional techniques such as regression analysis. Anderson et al. (2000) performed an efficiency analysis of real estate management based on Bayesian Stochastic Analysis. Their findings pointed out that the inefficiency of real estate companies is mostly due to a failure to increase profit instead of reducing costs. Arribas et al. (2016) used Hierarchal Linear Models to identify variables that are most affecting efficiency in real estate management. Many of these studies suffer from serious limitations. For example, most of the real estate studies focused on the capital expenditure, as a reliable measure to account for the profitability, instead of the actual operation efficiency evaluation (Zheng et al., 2014). CAPEX performance indicators are highly volatile to the market condition, which is usually beyond the control of the management (Arribas et al., 2016). Most of the prior studies on real estate used the return on investment as a proxy for the financial performance and did not use all the OPEX, CAPEX and real estate physical characterises determinants as standard metrics for real estimate operation competitiveness and efficiency. The efficiency measurement diverts the focus of the evaluator from the inputs that have been invested in the real estate and the resulting outputs (Stein et al., 2017). Moreover, the majority of the existing literature on real estate has been conducted in developed economies (Hartmann, 2015). These markets are very mature compared to emerging economies such as the UAE. The laws governing performance efficiency in these markets may not apply to local real estate markets. Thus, this study aims to extend the knowledge of real estate management performance efficiency by taking into consideration OPEX, CAPEX, performance (revenue and churn) and real estate physical characteristics. The present study makes a noteworthy contribution regarding the scope of performance metrics. Most existing research focuses on a few performance metrics to measure real estate management efficiency. This study takes 26 metrics into consideration in its analysis. These efficiency indicators allow the real estate FM managers and investors to effectively allocate and manage resources to maximise possible output in the form of an increased value of the asset.

Findings from this research bear practical implications for both real estate management and owners, as well as the economy in general. Firstly, the world's population is growing, which leads to an expansion in global investable real estate. Non-financial indicators, such as technology innovation and sustainability, will be key drivers for building asset value. Thus, in order to prepare for these implications, the real estate managers and the organizations will need to make sure that they understand the value drivers that propel real estate's operational efficiency. Secondly, high energy prices, climate change, government regulation, and technology disrupting real estate economics will reshape the entire investment in the sector. Thus, providing understanding of the risks for real estate investment opportunity for real estate investors and asset managers. Thirdly, from the general economic point of view, it's necessary to improve the operating efficiency of investable assets because efficiency is a central problem in economics, and consequently, finding indictors that contribute to efficiency will help to develop and identify prime assets.

The logical structure of this paper is built in the following way, the first part introduces the theoretical background into the operation and management real estate assets, the second part describes the performance indicators of measurement and evaluation of efficiency in the real estate industry. The third part presents the issues of methodology, including the description of the DEA method and the research process. The fourth part contains analyses of data and results descriptions.

Research background

The real estate operations model operates under the principles of productivity, maintenance efficiency, cost-reduction, and satisfaction of the tenants (Korngold, 2015). Under this model, facility managers must constantly balance the cost of service against the benefits and quality being received by the tenants. Real estate operation management also involves plant operations, energy management, and environmental compliance (Stein et al., 2017, Mahadevan, 2015). This is in line with the view expressed by Dawidowicz et al. (2014) that real estate's efficiency evaluation should be based on the selection of functions, management and operation methods, valuation, and evaluations of real estate operation efficiency. Accordingly, existing literature fails to resolve the issue of building assets' operational efficiency in this comprehensive manner. Most existing literature analyses the efficiency of real estate management in terms of specific metrics. For instance, Nappi-Choulet and Decamps (2013) were concerned about the capitalization of energy efficiency in asset value and rent cost. They utilized (rent or asset value of the building, energy consumption of the building, building type, building size, number of stories, age of the building, and employment level of buildings). On a similar note, Christersson et al. (2015) used the discounted cash flow method to analyse the influence of energy conservation on the actual property value. Findings showed the advantages of energy efficiency investments at the building portfolio level. Roy and Kohli (2016) used DAE to point out areas of inefficiency in real estate, which are a result of turnover inventory and excess manufacturing expenses. Pinder and Price (2005) used DEA to benchmark office buildings using satisfaction ratings. The authors used full-time equivalent occupancy and total FM costs along with satisfaction ratings to study the efficiency of office buildings. Their study suggests "a combination of high user satisfaction and better than average accommodation efficiency can be obtained." Kolbe et al. (2012) pointed out that capital expenditures affect the rate of return. This is in line with Ghosh and Petrova’s (2017) findings that the rate of return from real estate is associated with the characteristics of building assets. Thus, one might argue that the effectiveness of building facility management may be identified by analyzing the effectiveness of all the determinates described in these studies. However, most of these studies used financial indicators and a limited number of building characteristics to measure the operating efficiency of real estate assets. Thus, these previous studies have not dealt with some of the latent non-financial indicators, in a detailed or distributive manner, which may have an influence on efficiency results. Since the objective of every real estate owner or investor is to obtain a profit on their investment. Thus, the performance efficiency of real estate ought to revolve around analytical solutions that lead to maximising gains, lowering operating costs, and furthering the performance of their assets. Findings within the empirical literature on these efficiencies of indicators' relative contribution to real estate's performance efficiency are by no means conclusive. Therefore, the present paper performs a DEA analysis to find out whether some of the financial and non-financial indicators make the conclusion of an efficient real estate performance more (or less) likely.

Real Estates Operational Indicators of efficiency

Real estate businesses, like other businesses, are expected to utilize their resources efficiently to accumulate higher earnings. Performance measurement is a set of well-designed processes that assist an organization in analysing, measuring, monitoring, and identifying key competencies, systems, and processes (Taylor, 2013). Many companies use financial measures to evaluate their costs and revenues. In the long run, these two metrics are proven to be inadequate in identifying key indicators that an organization can use to improve its overall efficiency (Ohsato & Takahashi, 2015). This is consistent with the view that commercial companies that focus on their profit margins will have short-term decision-making. The short-term also discounts the importance of internal and external environmental factors that may be essential for the long-term survival of companies (Yin et al., 2016). Performance measurement with regard to real estate poses different kinds of challenges. The customer base for real estate is very diverse. Real estate companies have a variety of objectives that vary from social investment to private equity funds. Different qualitative factors also take central stage when analysing the overall picture of the performance measurement in real estate facility management.

The existing literature provides several metrics to evaluate efficiency. The main metrics are shown in Table 1. The performance indicators are categorised into three clusters of inputs and one output performance. These are used as input and output in the DEA model.

Capital Expenditures (CAPEX)

The first input is capital expenditure (CAPEX), which is associated with the acquisition, construction, or enhancement of significant fixed assets, including land, buildings, and equipment. It is selected as an input because of its influence on the operational aspects of building assets. This expenditure is indispensable for acquiring and upgrading the property. Variables such as age, location, and property type can influence how much CAPEX is required to acquire and operate an asset. This in turn will determine the level of the yield from the investment (Crosby et al., 2012). Studies indicated that CAPEX can be measured as a function of property characteristics (age, square footage, occupancy rate, leverage, leasing commissions, lagged returns and property type, etc. (Ghosh and Petrova, 2017). The authors showed that CAPEXs are "mostly idiosyncratic and related to unique property characteristics; they are a significant determinant of property returns." Others state that capital expenditures can affect the rate of return (Kolbe et al, 2012). Thus, cost, utilization, and availability are used as input variables in this study to measure the efficiency performance of the buildings..

Operational Expenditures (OPEX)

Real estate owners or investors can have a better understanding of the potential return of a property in relation to how much it would cost to operate it. Lynch (2001) postulated that shareholder value can be increased by improving the operation expenditures (such as debt, cost, and leasing) process for fixed building assets. The author went on to suggest reducing the risk of capital expenditures and increasing asset performance to increase the value. It is also pointed out that the most challenging aspect of real estate operations is determining the appropriate operational budget (Klein, 2016). The operational budget is the backbone of maintenance and repair (Masalskyte et al., 2014). Thus, the second selected input is operating expenditures (OPEX), that is, an expense that is incurred in the normal course of running a real estate business (Gibler & Lindholm, 2012). This includes (but is not limited to) expenses such as payroll, rent, equipment, insurance, software services, utilities, office expenses, and operating leases (Lynch, 2001; Pinder and Price, 2005). The yield from real estate is highly correlated with OPEX (Zheng et al., 2014). As demonstrated in the previous section, if the goal of real estate investment is to maximize net income or profit, then minimizing OPEX is a crucial part of real estate management. Thus, understanding the contributing factors to OPEX and improving their efficiency will maximise the revenue. Studies have shown that repair and maintenance levels have an impact on the depreciation rate of the asset and can significantly influence the operation cost (Masalskyte et al., 2014).

Cleaning and environmental factors are used as major input variables in the studies of building facility management performance (Lynch, 2001). Growing environmental regulations and cleaning standards have made it essential for real estate operation practitioners to devise effective recycling and waste reduction strategies (Guerrero et al., 2013). It was claimed that recycling has higher costs per tenant (Wu et al., 2016). This problem is particularly persistent in urban areas. This creates an additional operational expense, which reduces the revenue or alternatively increases the rent. The AC systems and air quality management are of paramount importance for the well-being of the tenants. AC and air quality regulations have several legal and safety consequences in commercial as well as residential buildings (Kumar et al., 2015). Better air quality can lead to better productivity and lower health and safety-related costs (Zheng et al., 2014). This is a critical area where the real estate operation cost may increase if climate change scenario and pollution carry on increasing. Facility management is used as a major input variable in the studies of building operation management (Pinder and Price, 2005). The function of the real estate manager, largely, involves dealing with the inventory of the furniture, fittings, and their procurement and disposal (Geman & Tunaru, 2013). Moreover, it is reported that nearly 50% of real estate management has to deal with information technology management (Mahadevan, 2015). In the digital era, telecommunication has become a necessity without which a commercial or residential premise cannot function properly. If the IT infrastructure is not managed properly, it can cause a substantial hike in maintenance costs

(Mahadevan, 2015). Staffing is also one of the key elements in the efficient operation of real estate (Azmi et al., 2015). The right combination of contract and in-house workforce is crucial in real estate operations efficiency (Azmi et al., 2015).

Building Characteristics

The third input category is building asset characteristics like location, age, sustainability features, technological innovation (e.g., smart building management systems), environmental performance, fabric etc. While assets' sale prices do reflect building quality ratings, poor characteristics also undermine value and return from building assets (Bernheim et al., 2013). Pinder and Price (2005) recommended that building net internal area should be considered in performance measurement. Ashuri et al. (2019) advocated the selection of building characteristics, such as building conditions, floor area, number of apartments, number of parking lots, and type of AC systems, for benchmarking building energy consumption. These characteristics can be considered to represent the scale of the building, or "the scale efficiency in terms of the economies of scale" (Ashuri et al., 2019). Available rentable area, percentage of rentable area to gross area, number of units and average unit size are also used as a major input variables in the studies of the building facility management benchmarking (Lynch, 2001; Pinder and Price, 2005; Ashuri et al., 2019). These indicators are significantly related to efficient utilisation of the asset. A high level of efficiency is significantly related to the level of return from the investment (Lynch, 2001).

Performance

The last category is output performance measures, which are related to income from rent and vacancy rates (Plazzi et al. 2011). Both vacancy rates and the length of time to rent are indicators of real estate's expected returns and can also be used as proxies for supply and demand. This is in line with Pinder and Price (2005), who suggested occupancy characteristics data, such as occupancy rate, ought to be used as indicators to assess investment performance. The authors went on to suggest that to also include occupancy cost data, including net income and total income. Rental revenue is an appropriate variable to represent the primary source of income for owners (Lynch, 2001). The percentage of vacant units is also used as a major output variable for asset usage efficiency. The number of vacant units is significantly related to the level of return from the investment (Plazzi et al., 2011). Similarly, the length of time to re-let is also an important consideration for property owners (Zheng et al., 2014). Property owners and investors continuously look at these variables in the assessment of real estate efficiency (Lynch, 2001).

Insert table 1 here

Data and Methods

This research adopts the DEA method to evaluate the efficiency of building rental operations. The first model of DEA was introduced in 1978 (Searle et al., 2014). It is a non-parametric approach that requires no parameters to be optimized (Yao & Pretorius, 2014). The DEA method assumes that any proportional change in every input variable would result in the same proportional change in every output variable (Searle et al., 2014). The DEA is used to measure the efficiency of operations and management (Dawidowicz et al., 2014). The DEA was used in hospital FM (Boussabaine and Kirkham, 2006), the banking sector (Eriki & Osifo, 2014), the manufacturing sector (Ahmadi & Ahmadi, 2012), and the insurance sector (Ogieva, 2017; Faruk & Rahaman, 2015). Ashuri et al. (2019) used DEA to benchmark the energy performance of buildings. The authors' DEA output consists of six variables: total floor area, the number of occupants, number of apartments, number of bedrooms, number of washing machines, and number of parking spaces. Other studies used four output variables for benchmarking energy efficiency (Yun and Steemers, 2009).

There has been little quantitative analysis or no attempt has been made to use DEA in evaluating building performance efficiency operations in the UAE. Furthermore, most of the studies that adopted the use of DEA methodology in real estate performance efficiency evaluation did not attempt to use the determinates of CAPEX, OPEX, and asset characteristics together. This study is based on the DEA multi-output/multi-input-oriented model as per (Searle et al., 2014; Osagie, 2018; Ashuri et al., 2019). The rationale behind the model is to optimise the outputs to inputs by estimating a group of weights that satisfy the conditions assumed in the linear equations as demonstrated next. This study provides an opportunity to advance our knowledge of the relative importance of the input and output determinates shown in table 1.

In the current paper, it is assumed that there are n rental buildings (DMUs). Let assume that each building in the data set consumes a set of resources inputs, (x_{jk} = X_{1k}; x_{2k}; . . . ; $x_{jk)}$) to produce a set of outputs, (y_{ik} = y_{1k}; y_{2k}; . . . ; y_{ik}). Then the efficiency score is obtained by the following linear programming optimisation problem (Bieszk et al., 2017).

Max $E_k = \sum_{j=1} \lambda_j y_{jk}$

Subject to:

$$\sum_{i==1}^{I} \alpha_i x_{ik} = 1$$

$$\sum_{j=1}^{J} \lambda_j y_{jm} - \sum_{i=1}^{I} \alpha_i x_{im} \leq 0 \quad m = 1, \ldots, n$$

$$\lambda_j \geq 0 \quad j = 1, \ldots, J$$

$$\alpha_i \geq 0 \quad j = 1, \ldots, I$$

Where the α‘s and λ’s represent the variables of the building rental operation problem and are constrained to avoid any input or output being ignored in determining the efficiency of each building in the data set. Thus, the input/output variables of the building rental operation problem are the weights, and the solution produces the weights (Baronin et al., 2014), the most favourable measure of efficiency. The solution to the above problem produces the efficiency of a building k, and weights lead to that efficiency. The resulting formulation has an optimal technical efficiency value (E_k) that is at most equal to unity. If $K_k = 1$, then no other building is more efficient than building k for its selected weights. This means that building k lies on the optimal frontier and is not dominated by any other building in the data set. However, if $E_k<1$, then building k does not lie on the optimal frontier and there is at least one other building that is more efficient for the optimal set of weights estimated from the above equations.

The efficiency scores, or weights, are calculated using the above formulation. These scores are then used to rank buildings in the data set in terms of their FM operational efficiency in using infrastructure resources to generate revenue for the operators. The DEA method consists of the following steps:

- Define and select the units of assessment (DMU) and associated input and output decision variables. In this work, 56 DMU (buildings) were selected.
- Data collection of inputs and outputs (see table 1)
- Data pre-analysis to deal with outliers and missing data (see table 2)
- The calculation of efficiency scores for each unit (DMU)
- The generation of the efficiency metrics
- The interpretation of the efficiency scores.

In order to compare the efficiency of building FM management, a DEA output-oriented model under the assumption of constant returns to scale was used, as formulated in Giannakis (2007). Using the above steps, several DEA models were established for the sampled building assets in this study. The above algorithm generates several efficiency scores (Coelli, Rao, and Battese, 1998) that are used to interpret the results from DEA.

Data

The data used in this study was collected from real estate accounts of 56 assets in Abu Dhabi, UAE. Table 2 shows the input and output variables used in this study. The data was based on annual reports and accounts. The output and output variables for this study are based on the suggestions advanced by Bieszk et al. (2017) and others (see table 1). All the figures for the data from different decision units were converted to cost per square meter. This was necessary to normalise data for comparison purposes (Boussabaine and Kirkham, 2006). This is necessary to eliminate the effect of externalities on the analysis of building assets rental efficiency, which may skew the results.

The study utilised 21 input variables and 4 output variables to evaluate and analyse the relative efficiency of the sampled 56 rented buildings. Table 2 shows the descriptive statics of the 56 investigated buildings for the period of the 2012-2016 fiscal year. The table is composed of descriptive statistics that include means and standard deviations of costs included in the research. The analysis reveals the significant variation, and range, and standard deviation for all building assets. In light of this variation shown in Table 2, it would be problematic to ascertain the efficiency of these assets in terms of how well they have used their resources and equity input to generate revenue output. Therefore, this issue required the need for DEA analysis since descriptive statistics cannot show their relative performance in the context of weighted inputs and outputs.

Insert table 2 here

Efficiency Distribution results

The purpose of this efficiency metric is to show the level of efficiency of the DMUs (buildings) in the analysis. The results will demonstrate if the building assets in the analysis are performing well or perhaps need improvement. The results indicate how inefficient each building's assets are in a particular FM provision compared to the best reference buildings. The reference set indicates the buildings that are used by the models as a benchmark for a particular building in the cluster. Whereas, the percentage of improvements in FM inputs and outputs indicate the relative increase or decrease of FM resources a building needs to achieve in order to gain a comparable FM efficiency (compared to the best performing buildings in the data set).

In observing the results, a total of three buildings were found to lie on the efficiency frontier (Ek =100) in all the studied models. Thus, these three buildings within the data set have a DEA score equal to 100 across all FM inputs and revenue performance indicators, and therefore, can be considered relatively efficient (best in class). These efficient buildings do not need any improvements (relative to other buildings in the data set) as they lie on the efficient frontier. Furthermore, no input/output gain is required for these assets. This indicates that the managers of these assets were able to optimise the FM input resources to maximise the rental revenue. In contrast, the majority of the other buildings in the data set show that through some decrease in FM resources, potential revenue increase exists (see figures 1 and 2).

Table 3 summarises the average efficiency score and changes in input/output levels that would lead inefficient building units to achieve efficiency. The efficiency averages were calculated by obtaining the mean value of the efficiency improvement score across all the 12 models.

What is noticeable from the descriptive statistics shown in Table 3, is the large differences in the relative efficiency scores. The scores of the inefficient FM operation parameters range from 7 to 99.9 depending on the input variable used to generate the relative efficiency index. This shows that while some building assets are very efficient in the allocation of resources, others need considerable improvement in the management of FM resources. It is also very perceptible that the reference set for the non-efficient assets is only dominated by three buildings. The FM operation performance of these assets should be at least subjected to further analysis in order to derive any best practices that can be used to ameliorate the FM management of the inefficient buildings.

The results in Table 3 illustrate that the studied assets performed badly in maintenance, insurance, and operational characteristics (e.g., available rentable area). The results showed that on average the inefficient buildings are 75 percent relatively less efficient in maintenance, in term of revenue generation, than the benchmark building. Likewise, on average, the inefficient buildings are 60 percent relatively less efficient in insurance. This anomaly in performance might be attributed to the fact that the rent revenue from these assets is very low, as indicated by the large percentage gains (here the gain is related to output increase and input decrease) shown in figures 2 and 3. Equally, one might argue that the FM operation management in the reference set buildings is uniquely different.

Insert table 3 here

The projection shown in Fig. 1, entails a reduction of the FM input resources and an increase in the level of revenue. The increase in revenue or decrease in FM input resources is expressed as a percentage of the original inputs and outputs data for each respective building asset. The results from the capital expenditures input showed 16 real estate assets with 100% efficiency. It shows that the level of CAPEX spending is not translated into inputs to produce superior outputs. This is clearly demonstrated in Fig. 2., where most building assets were unable to translate capital spending up front into efficient revenue. The repair and maintenance cost examination revealed that only 18 real estate assets were efficient. This demonstrated that, in general, the investigated buildings performed poorly in terms of repair and maintenance. This may indicate that the maintenance management regime is inefficient.

The cleaning services indicator showed that the average value of efficiency scores is 92.72. Further, the results demonstrated that, on average, only 18 out of 56 real estate assets were 100% efficient. The average score might signal that cleaning costs are being optimised and managed efficiently. However, the lower number of efficient assets might suggest the opposite. Notably, the electricity consumption indicator showed that just 13 out of 56 buildings were efficient. This could be directly related to the local environment and air-conditioning usage. The average performance of the studied stock indicated that 12.5% of the assets were efficient in churn as measured by the percentage of new tenancies. This might imply that marketing to attract new occupants is necessary. Based on the insurance indicator results, on average, around 50% of studied assets have less than 80% efficiency. This suggests that insurance costs are high in the UAE.

The management overall cost indicator exhibited no more than 12 real estate assets that were 100% efficient. This is around 21% of the stock. The results demonstrated that a huge improvement is required in optimising the management costs. This means that the assets are over-managed. This is surprisingly low; one expected the efficiency to be high because the staff wages in the UAE are very low compared to the developed world. The efficiency results based on rent indicator revealed that just 22 out of 56 real estate assets that were 100% efficient rent management as measured by (Average Rent Per Building, Rent per square meter, income per building, and Percentage of rent collection rate). Occupancy cost and leasing score were 90.35, as demonstrated by 18 assets that were efficient. Whereas the efficiency results-based debt indicator showed only 10 real estate assets were efficient. This reveals nearly one in six of the stocks are inefficient. This suggests that there is an issue with debt servicing. If this is not managed well, the debt service will increase the overall OPEX cost, leading to a lower return on investment. The analysis showed that on average, 50% of the studied assets were efficient based on available rentable area and percentage of rentable area to gross area parameters. The results demonstrate that 50% of the studied assets are underutilised. Similarly, to the operational characteristics, just 50% of the assets in this study were 100% efficient based on their physical characteristics. This might mean the design, layout, and value of units per asset play a major role in rental efficiency.

Insert figure 1 here

In some of the assets (as shown in figure 1), the projection of savings in repair and maintenance (planned maintenance requests, unplanned repairs, and percentage of planned maintenance completed on time) is considerable. Similarity, it appears that a huge reduction in insurance, churn, and leasing costs is also required to bring the assets to the benchmark building level.

Insert figure 2 here

Potential Improvements results

Figure 3 shows the average percentage of improvements in output in the DEA model. The figure shows the percentage improvement required relative to the reference set (or benchmark sets). The results demonstrated that the revenues needed to be increased by over 20% over all the inputs. One key finding is that the capital spent up front to build assets appears not to tally with the revenue. Similarly, leasing costs must be substantially reduced to improve the revenue. In terms of cleaning, churn, security, insurance, and electricity consumption, models reveal that the percentage of vacant units needs to be reduced substantially more than the increase in revenue relative to the refence sets. Results appear to indicate that the repair and maintenance and both the length of time to re-let and percentage of vacant units' indicators need to be lowered more than revenue to achieve relative optimum performance.

Insert figure 3 here

Figure 4 shows the improvement required for the model's inputs. It shows that CR3, OR1, OI1 and OI2 are the most inefficient parameters in the study. These inputs need to be reduced by between 35 and 40% to achieve the relative efficiency required. Similarly, OR2, OR3, and OO1 need to be decreased by around 20% to attain the required relative comparative efficiency. All other inputs need to be cut down by at least 5% to accomplish comparability with the refence building sets.

Insert figure 4 here

Interpreting and implication

The overall improvement summary indicates that real estate owners have the greatest potential to raise their revenue if the operational aspects can be managed well (see Figs. 3 and 4). Therefore, asset managers should expect to gear their efforts towards the FM areas that are deficient. The efficiencies discovered in this study would usually be taken as indicative of the fact that building assets that are in the benchmark set are using management practices that, if less efficient building managers were to adopt them, would enable them to improve the performance of their assets. The results clearly demonstrated the presence of specific areas of inefficiency by giving data on the comparative reduction in specific inputs and the proportional increase in specific revenue parameters. The results of this study are in line with the view that life-cycle costing is an essential element of CAPEX and OPEX management of real estate assets (Ristimaki et al., 2013). The results demonstrate that the capital spent per square meter to build the asset has a direct influence on the efficiency of OPEX and revenue outcomes. The inefficiency discovered in this study confirms the findings by Apgar (1995) and Mahadevan (2015). The authors pointed out that in the UAE, general real estate consumption of electricity and water accounts for over 50% of the total budget available for real estate management. A creative and consistent general consumption management system can save nearly 30 to 33% of the energy costs in a building (Mahadevan, 2015). Others suggest that energy usage can be reduced by effective energy management practices (Ashuri et al., 2019). The results of this study are consistent with findings in Masalskyte et al. (2014); Queena et al. (2013); Roy and Kohli (2016); Schaefers (2009); Wang et al. (2015); and Yin et al. (2016). Researchers of these works argued that most of inefficiencies can be eliminated by reducing FM services cost. The results presented in this paper are along the lines of Kenton's (2019) findings. The author pointed out that decreasing the utilisation of FM resources results in an increase in the efficiency of the revenue. This research provides value through the identification of FM indicators for benchmarking for facility managers and asset owners to improve the efficiency of FM resource utilisation. The work will also assist them to identify the low-performing assets as improvement targets to enhance FM resource utilisation, leading to better financial efficiency.

Almost all the assets in the sample suffered from deficiencies in maintenance and repair, probably due to bad construction methods in the first place or huge turnover between occupants. Case studies have shown that problems with building defects have an influence on the building quality and customer satisfaction (Zalejska-Jonsson, 2020). Thus, cost saving in maintenance services may have the effect of lowering the quality of asset function, leading to further revenue loss. Facility managers should be in a position to influence the maintenance strategies. Some studies point out that the level of maintenance services is a good predictor for FM service performance (Zalejska-Jonsson, 2020). Thus, the maintenance regime in the study of properties needs to establish this self-inspection process and conduct spot checks on an annual or more frequent basis. The results have also indicated that efficiency is required in cleaning and security services. This is in line with Hui and Zheng's (2010) assertion that cleaning services, safety, and security had the greatest effect on FM service efficiency. Another finding that is important to note is that building assets in the sample were not able to manage insurance expenses. The cost of premium and insurance cover might be managed through better FM services to minimise the effect of negligence or breach of duty on health and safety.

In general, the results show that FM managers have not been able to use their FM operational resource input effectively to generate higher revenue outputs. This, in the long run, implies that the building sample in this study used more inputs to produce relatively less income for the owners. The three buildings that have shown complete efficiency indicate that their managers were busy minimising inputs to achieve a proportionally better yield when equated to other sampled buildings. This means that the management of these real estates was successful in using their relative FM input resources to generate income relatively better than peer real estate in the sample, therefore, forming slacks or under-utilization problems. This type of information will help FM managers to work towards improving the performance of their assets towards the efficiency frontier in relation to revenue performance. A fully integrated performance management framework is essential to provide corporate visibility of the activities that directly deliver growth and a clear framework for determining how to continuously allocate resources to support the management of the building assets (Masalskyte et al., 2014).

Following the above analysis, one could suggest that investigated buildings are technically inefficient under a constant check of the scale's assumptions. This research contributes to the identification of FM indicators that are responsible for low-performing buildings that can be used as targets for the improvement of the FM services to increase the financial return efficiency of these assets. Further work should take into consideration the size, in terms of asset base, of the real estate companies.

Conclusion

The research contributes to the body of knowledge of building FM operation benchmarking through the identification of the FM input resources that contribute inefficiently to revenue generation. The DEA approach provided justification for efficiency indicators that need to be used to improve building asset facility management. The efficiency revenue from rent largely reflects the general consumption of the input resources and the state of the economy. This study investigated the efficiency of a sample of 56 real estate assets for the years 2012–2016. DEA was used for operational inefficiency, i.e., inputs are not managed properly, or inefficiency is due to the level of revenue. Only three buildings were found to be efficient among the sampled set.

Scores of efficiency ranged from 7% to 99% in some of the models. This implies that managers need to considerably reduce the operational resources of their inputs. The results also showed that 95% of the building assets in the sample are by and large operating at decreasing returns to scale (if output increases by less than the proportional change in inputs). This phenomenon is attributed to the managerial inefficiency caused by rises in input expenses (operational costs) that were not converted into adequate revenue. Thus, the study demonstrated that building assets underperform in the utilization of inputs to create optimum revenue.

This study therefore recommends that the managers of the inefficient building assets should bench mark their operational aspects with the management of the efficient in the sampled data set. Further research is required to study the managerial causes behind underperforming assets.

The sole purpose of this work was to compare the FM operation efficiency in relation to the revenue. Consequently, any change in the sample under consideration would modify the relative efficiency measures and the consequences associated with them. In other words, interpolation and extrapolation of information is only valid within this set of building assets.

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Table 1 Metrics to evaluate efficiency from literature

PTER 1: Input variables	**PTER 2:**Reference
PTER 3:Capital Expenditures (CAPEX) **PTER 4:**Cost per square meter CR 1 **PTER 5:**Total cost/ total rentable area CR 2 **PTER 6:**Current income/estimate income CR3 **PTER 7:**Rented time/down time CR4	**PTER 8:**Crosby et al., (2012), Li, L. (2016), Sun et al., 2015, Baucells & Bodily, 2018, **PTER 9:**Bieszk et al., 2017
TER 10: Operational Expenditures (OPEX)	**TER 23:** Gibler & Lindholm, 2012, Boussabaine and Kirkham 2005, Bieszk et al., 2017

TER 11: Repair and maintenance OR, **TER 12:** Cleaning OC, **TER 13:** Energy OE, **TER 14:** Water OW, **TER 15:** General Consumption OG, **TER 16:** Churn OH, **TER 17:** Security OS, **TER 18:** Insurance OI, **TER 19:** Management and overall costs OM, **TER 20:** Rent OT, **TER 21:** Occupation Cost and Leasing OO **TER 22:** Debt OD	
TER 24: **Building Characteristics** **TER 25:** Available rentable area BO1, **TER 26:** Average Unit Cost Per Building BO2, **TER 27:** Percentage of rentable area to gross area BO3, **TER 28:** Number of all units BP1, **TER 29:** Average unit size BP2 **TER 30:**	**TER 31:** Bernheim et al., 2013, Plazzi, A., Torous, W., and Valkanov, R., (2011) **TER 32:** Boussabaine and Kirkham 2005
TER 33: **Performance** **TER 34:** Rental Revenue PR1, **TER 35:** Percentage of vacant units PR2, **TER 36:** Average rent lost due to vacant units PC1, **TER 37:** Length of Time to re-let, PC2	**TER 38:** Plazzi, A., Torous, W., and Valkanov, R., (2011), Bieszk et al., 2017

Table 2: descriptive statistics for DEA Input and Output Variables

Input /Output Variables				Static			
	Categor	Sub-	Metrics	Mean	St.	Minimu	Maximu
Input Variables	Capital Expendit	Cost	Cost per square	3,162.60	130.84	3,000.00	3,500.00
		Global	Cost per	2,894.02	1,118.6	483.27	5,388.53
		Utilizat	Income /expected	0.85	0.15	0.59	1.19
		Availab	rented time /	0.96	0.00	0.96	0.96
	Operational Expenditures (OpEx)	Repair and maintenanc	Number of	6,363.16	3,054.65	300.21	11,485.35
			Number of	2,007.29	1,036.94	132.20	4,601.84
			Percentage of planned	1,489.96	2,598.2	0.85	9,938.97
			Percentage of unplanned	991.55	1,529.19	0.86	5,130.92
		Cleaning	Number of	6.15	2.84	0.00	13.78
			Equipment and	112,920.7	23,248.3	75,640.5	140,640.0
			Number of	365.00	0.00	365.00	365.00
		Energy	Cost of kilowatt	17.96	0.00	17.96	17.96
		Water	Cost per meter	4.04	0.00	4.04	4.04
		General	Electricity and	601,085.	264,578.	161,621.	1,111,985.
		Churn	Percentage of	0.20	0.00	0.20	0.20
		Security	Number of	1.00	0.00	1.00	1.00
			Number of	1.00	0.00	1.00	1.00
			Security	3,000.00	0.00	3,000.00	3,000.00
			Number of	17.36	3.61	11.80	24.40
		Insura	Building	48,643.56	19,112.22	20,000.00	80,000.00
			Equipment	121,500.0	63,082.9	38,931.8	239,000.0
		Manageme nt	Employees	86,564.3	10,809.9	73,600.0	106,493.
			Management	0.02	0.00	0.02	0.02
			Number of	22.13	2.99	18.40	27.40
		Rent	Average Rent	13,969,98	6,123,24	4,358,00	27,846,57
			Rent per square	899.39	190.89	566.62	1,259.07
			Income per	11,383,949	5,261,234	4,110,048	22,395,061
			Percentage of	1.00	0.00	1.00	1.00
		Occupat ion C	Number of	10.99	8.09	0.00	32.20
			Percentage of	0.08	0.01	0.06	0.11
			Percentage of	0.85	0.16	0.59	1.19
			Percentage of	0.72	0.13	0.51	0.97
		Debt	Length of time	30.00	0.00	30.00	30.00
			Percentage of	0.09	0.00	0.09	0.09
			Percentage of	0.08	0.01	0.06	0.10
	Building Characteristi	Operational C	Available	19,780.29	8,903.65	6,540.00	36,317.34
			Average Unit	96.73	34.66	27.54	152.91
			Percentage of	0.89	0.05	0.78	0.98
			Number of all	394.69	267.55	46.00	844.00

		Physical	Average unit	**194.87**	**48.95**	**116.00**	**280.00**
Outp	**Performance**	Rent	Rental	**10,804,81**	**4,815,96**	**4,110,04**	**22,368,45**
			Average rent	**1,552,766.**	**1,130,82**	**73,187.5**	**4,718,315.**
		Churn	Time to re-let	**144.93**	**7.34**	**129.60**	**156.67**
			Percentage of	**0.10**	**0.08**	**0.00**	**0.35**

Table 3: efficiency scores descriptive statistics

	capex	*repaire*	*cleaning*	*elect*	*churn*	*security*	*insurance*	*staff*	*rent*	*leasing*	*debt*	*charact*	*phy*
Mean	92	75	93	92	92	92	60	92	94	88	92	88	70
Median	93	88	93	92	92	92	55	93	95	90	93	88	69
Standard Deviation	4	30	4	4	4	4	20	4	4	8	4	7	17
Range	16	93	16	16	16	16	68	16	15	32	16	26	56
Minimum	84	7	83	84	83	83	32	83	85	68	83	73	42
Maximum	99.4	99.9	99.7	99.4	99.4	99.4	99.8	99.4	99.8	99.6	99.4	99.8	98.8

Fig.1 Compares operational inputs resources efficiency to the revenue efficiency

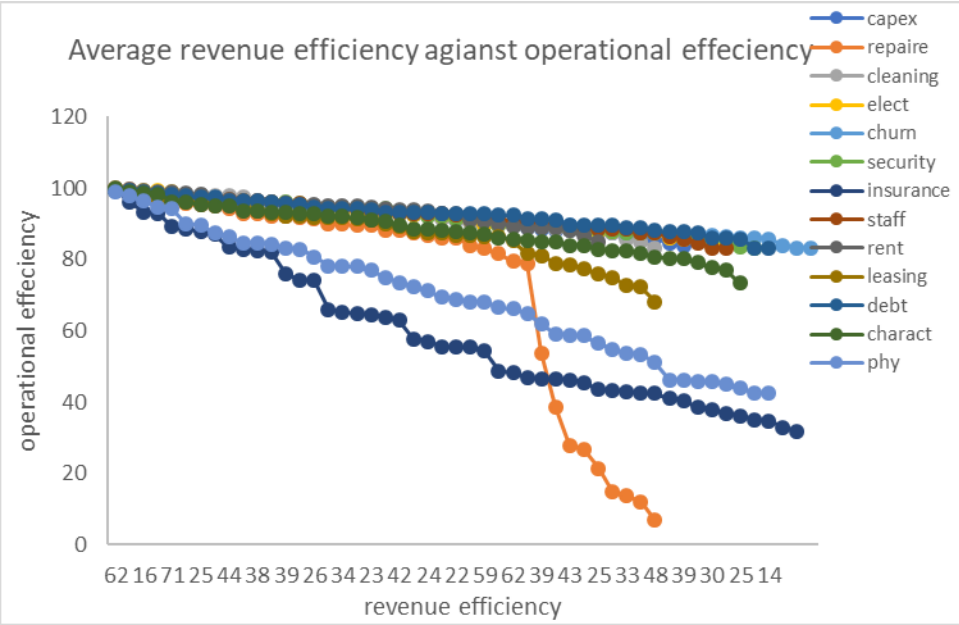

Fig. 2 Compares operational inputs resources efficiency to CAPEX efficiency

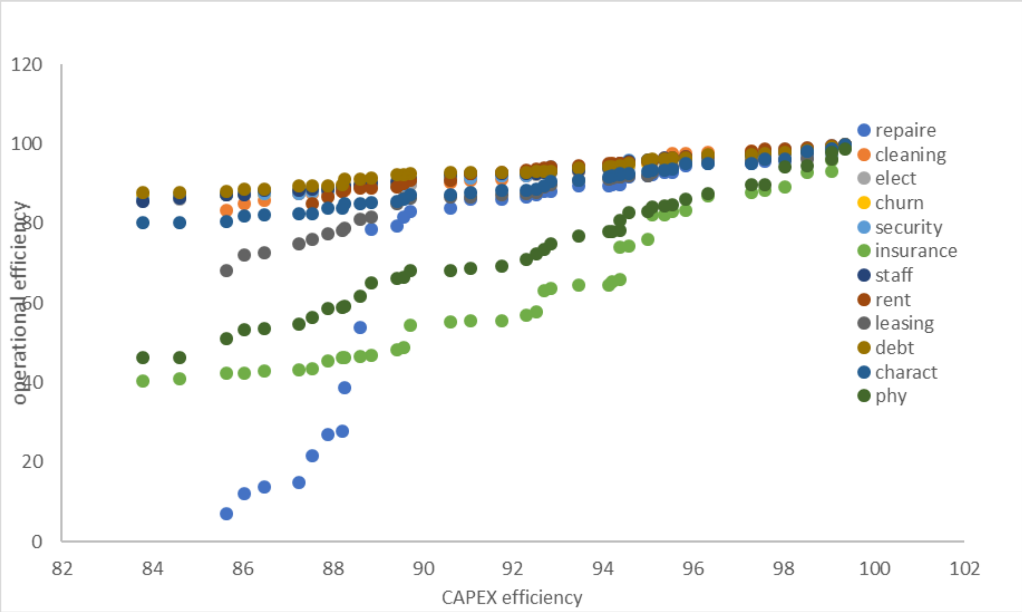

Figure 3: Revenue performance improvement

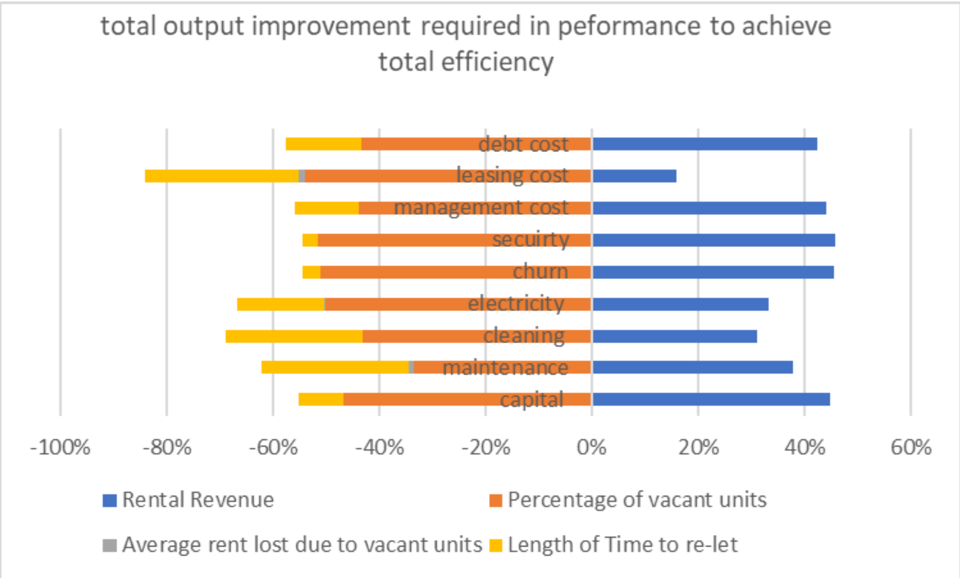

Figure 4: efficiency improvement in the FM input resources