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ORIGINAL PAPER

Is size an input in the mutual fund performance evaluation with DEA?

Sevgi Eda Tuzcu[1] · **Emrah Ertugay**[1]

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Abstract

It has been a common practice to evaluate the performance of mutual funds with data envelopment analysis (DEA). However, DEA itself is a "black box", since there are no pre-determined inputs or outputs. This paper aims to add clarification to the "black box" nature of DEA by investigating whether fund size has to be included among DEA inputs in the Turkish mutual fund performance evaluation. Fund managers receive a proportion of fund size as compensation. Therefore, besides the traditional risk and expense inputs, economies or diseconomies of scale may also be effective in the fund's performance. For these reasons, the evaluation of fund performance by using DEA may require fund size as an input. Yet, few international study adds size as an input to the DEA. The evidence is even scarcer for developing country fund markets. To the extent of our knowledge, size has not been utilized in the Turkish mutual fund performance evaluations. This paper aims to contribute to the literature by examining the linear and nonlinear relations between DEA scores and fund size for the Turkish mutual fund industry. For this aim, linear correlation, and Kendall and Spearman rank correlation coefficients are employed as well as a regression specification. The correlations and the regression results reveal a linear relationship between the efficiency scores and fund size. In general, this study presents stronger evidence for the fund size and fund efficiency relation than Basso and Funari (Eur J Finance 23:457–473, 2017) for the Turkish mutual fund market.

Keywords Data envelopment analysis (DEA) · DEA inputs and outputs selection · Mutual fund performance · Size

JEL Classification G11 · G23 · C67

✉ Sevgi Eda Tuzcu
stuzcu@politics.ankara.edu.tr

[1] İşletme Bölümü, Ankara Üniversitesi, Siyasal Bilgiler Fakültesi, Cebeci Kampüsü, Cemal Gürsel Bulvarı, Cebeci, Ankara, Turkey

1 Introduction

Basílio et al. (2016) and Azad et al. (2017) note that banks act as intermediaries between investors and savers. Likewise, mutual funds play an important role in the allocation of scarce resources among the agents of the economy. They are also used as a long term savings tool for retirement purposes. In the last two decades, this industry has experienced strong growth worldwide. The total assets of mutual funds, exchange traded funds, and institutional funds have been more than $49.3 trillion at the end of 2017 (Investment Company Institute 2018). It is observed that most studies concentrate on liquid and larger sized fund markets, particularly on the US funds. However, the US markets are not always representatives of global markets (Ferreira et al. 2012). This paper focuses on evaluating the Turkish mutual funds which operate in a mostly small and bank dominated market. Unlike the others, Turkish mutual fund markets exhibit an interesting structure between new cash flows to fund and funds' past performance (Tuzcu 2015). In this market, when funds show a good performance in the past period, fund investors tend to liquidate their positions in the fund and disinvest. This behavior is completely opposite to the existing literature which finds a positive association between past performance and new cash flows to the fund (Chevalier and Ellison 1997). In this paper, we evaluate the Turkish mutual funds by using Data Envelopment Analysis (DEA) where we consider fund performance as a function of size, in addition to traditional cost, risk and managerial skill variables as in Choi and Murthi (2001). For this aim, we investigate the efficiency of three categories of funds, namely variable, mixed and equity funds, in the Turkish mutual fund industry for the years between 2015 and 2017.

As the demand for mutual funds increases, funds' performance evaluation becomes even more significant. However, this process is not straightforward. Besides macroeconomic conditions, different fund characteristics have a significant role (Galagedera et al. 2018). DEA has the advantage of working many inputs and outputs at the same time without a need for a benchmark, therefore it considers various fund features altogether. This makes DEA a popular tool for mutual fund performance evaluation. Yet, DEA itself is a black box. It does not indicate which characteristics must be added to the analysis. In this study, we also attempt to clarify whether to use size as a mutual fund feature in the performance evaluations of the Turkish mutual funds with DEA.

For the DEA studies, previous literature sheds light on which characteristics to add. Risk proxies and transaction costs are the common inputs in those analyses, while various definitions of return are usually used as output. In addition to these inputs, fund size might be another fund characteristic that should be included in the analyses. The literature notes that larger funds may have an advantage over smaller ones due to the economies of scale of transaction costs (Margaritis et al. 2007; Murthi et al. 1997). A different line of research in the mutual funds, however, suggests that fund managers' compensation is based on assets under management, so fund managers are eager to boost funds' total assets in an attempt to increase their own return. The aim of increasing fund size may not always serve to the best interests of the investors, since fund managers may take unnecessary

risks to reach their goal (Brown et al. 1996; Chevalier and Ellison 1997; Sirri and Tufano 1998). The risk of agency problem will be even higher when the economies of scale exist (Babalos et al. 2012). Others, on the other hand, indicate that smaller funds may perform better than the larger ones because their trading does not affect the security prices (Grinblatt and Titman 1989). Considering these arguments as a whole, we add fund size as an input in DEA besides the risk and cost variables.

It is known that fund size grows in two ways: cash inflows and asset appreciation, both depend on fund performance. Given the nature of the negative effect of past performance on the cash flows to the fund, adding size into DEA turns out to be even more interesting because these two forces will contradict to each other in the Turkish mutual fund industry. In this case, the research question of our study becomes whether the fund managers can determine the fund size efficiently even when they act with an incentive to increase their own compensation. This is the rationale behind adding size as an input into the DEA evaluations for the Turkish mutual fund performance evaluations. Gregoriou (2007) notes that DEA has the potential to reveal hidden relations in the data, because it does not require a central line like regression but offers an efficient frontier. This feature of DEA helps include information that is already taken into account in the fund managers' decision-making process as noted by Andreu et al. (2019). DEA will be an appropriate model to understand whether size can be a useful variable to consider in fund evaluations, therefore it will be helpful for the mutual fund investors.

In fact, size has been considered before in the mutual fund evaluations with DEA as in Andreu et al. (2019), Babalos et al. (2012) and Basso and Funari (2017). The evidence from these studies is mixed. This may be due to the specific conditions of the fund market that is under investigation. The contribution of this study comes from the unique nature of the Turkish mutual fund market. In this analysis, we specifically ask whether fund managers can efficiently manage the size of their portfolios to produce higher fund returns, or they try to exploit their fund size no matter what happens to fund return. This question becomes particularly interesting when we observe cash outflows, in other words, shrinking portfolio size, when the fund shows good performance in the previous period. To the extent of our knowledge, a study from this point of view has not been done before, particularly for the Turkish mutual fund market. We hope that the results of this study will illuminate other fund markets as well, especially the ones that are bank dominated and smaller in size.

We conduct an output-oriented DEA where the standard deviation of annual returns, fund beta, and fund expenses are the inputs, and fund excess return is the only output. In the second part of the analysis, we also add total net assets of funds as a proxy for size among the inputs.

The findings of this study mainly show a linear and positive association between fund size and fund efficiency scores. No logarithmic or log-quadratic relation between DEA scores and fund size can be detected. In general, larger funds are more efficient than smaller ones. These results are contrary to Babalos et al. (2012) who find a significant but negative relation in a small fund market like the Turkish mutual fund market. This finding supports the managerial concerns for their own compensation.

When the marginal impacts are examined through a slack analysis, the biggest source of inefficiency comes from the systematic risk of the portfolio. This situation is even more visible in 2016, where Turkey faced an unexpected political crisis. When the DEA is repeated with size as an input, we observe that the number of efficient funds has changed, so does the efficient frontier itself. It seems that in general, funds are on the efficient frontier in terms of fund size and their expenses because the number of funds with zero slack with respect to this input is high. However, fund size is still a source of inefficiency. Particularly in 2016, a dramatic decline is observed in the number of funds with zero slack with respect to size. Even in the recovery period, it does not reach its previous level. It suggests that fund managers have hitches while determining fund size in the crisis periods.

Contrary to the previous literature, cash outflow from the funds with good performance in the previous periods is the case for the Turkish mutual fund market. Even under these conditions, it seems that fund managers determine the fund size efficiently at large.

The next section provides a brief literature review both about the size impact and the studies previously carried out on the Turkish mutual fund evaluation. We will explain our sample and methodology in detail and provide a brief background for the Turkish mutual fund industry in the third section. Next, we present our findings and conclusions.

2 Literature review for size as a part of DEA

Gregoriou (2007) explains the inputs and outputs in the DEA as such: An input can be defined as a resource that a decision-making unit uses for producing its outputs, while outputs represent how a decision-making unit has reached its goal by processing the inputs. However, the input/output selection process for DEA evaluations is not explicit. Not many studies consider size as an input or output in the mutual fund evaluation researches. This section briefly examines the papers that use fund size as a part of different mutual fund evaluations with DEA.

The study of Murthi et al. (1997) is among the first papers applying DEA for fund performance evaluation. They examine different fund categories in the US market by employing fund return, loads and turnover, expenses and standard deviation. They also compute the correlation coefficients for the fund size and the mean efficiency scores. Then they repeat the same analysis for each fund category. The overall scores and fund size cannot demonstrate a significant correlation coefficient. However, in 10 fund categories out of 33, the correlation is found to be positive. They conclude that there is evidence that larger funds operate more efficiently mostly due to the lower transaction costs that they are exposed to. In a similar study, Choi and Murthi (2001) can only show a weak relation between fund size and efficiency. The only significant and positive association comes from the growth and income fund category. Therefore, they point out that there is no need to add size as an input.

Haslem and Scheraga (2003, 2006) investigate the financial variables that differentiate across efficient and inefficient funds for large-cap and small-cap funds. Among other variables, they also use funds' total assets in the DEA evaluations.

They note that using funds' total assets explains the differences in the efficiency scores due to economies of scale and it reflects the production theory itself. Both studies show that there are important differences in the efficient and inefficient funds' financial variables including fund size and the relations between them. Haslem and Scheraga (2006) specifically use fund size as the only output in the evaluations of small-cap funds with DEA because they note that many fund managers take this input as a target for growth. The inputs in the DEA are selected accordingly to reflect the total assets in a production function. Their results show that for the efficient funds, fund size is significantly larger than the inefficient ones. Smaller ones are more open to being managed inefficiently, and the funds with the largest asset size are the ones with the highest efficiency.

Margaritis et al. (2007) conduct a study to reflect the efficiencies of New Zeland (NZ) mutual funds. This fund market is one of the smallest in the world in which the number of funds and the size of the funds are well below the averages of international markets. They indicate that NZ investors have the advantage to reach the well developed Australian fund market. They also divide their sample into two, based on the funds' regional focus. They use an input-oriented DEA for the 1998 and 2003 period to evaluate the NZ equity mutual funds. Next, they try to explain the variation of the DEA scores by the fund's size, age and national versus international objectives by employing a TOBIT regression. Their findings show that funds that invest in local markets and have a larger asset size have a higher chance to be efficient.

Babalos et al. (2012) use an input-oriented Charnes, Cooper and Rhodes (CCR) DEA model for the assessment of the equity funds in the Greek mutual fund market (Cooper et al. 2006). They argue that due to economies of scale advantage, fund size and persistence in the funds' performance are directly associated. This association may affect the fund managers' decisions because of the ties between managerial compensation and funds' total net assets. Since mutual funds have delegated nature, this positive association is important from the point of view of investors as well and it determines the funds' efficiency and their long term success in the implementation of investment strategies. For these reasons, they examine whether fund size is a determinant in the success of a fund's investment strategy while the stock market is illiquid and small capitalized. In particular, they ask if fund size increases the probability of being efficient. This question becomes especially important for the Greek fund market where domestic funds have been exposed to a high level of outflows in the past. They employ a DEA model where the inputs are funds' total expenses, risk proxies and capital invested and the output is the terminal value of the investment. Next, by the aid of a panel logit regression analysis, the relation between the funds' efficiency scores and fund size is investigated. The results show that size is the source of inefficiency for Greek domestic equity funds. This negative relation might be a result of a microstructure of the Greek stock market, namely illiquidity and small-capitalization of stocks. In fact, Lehnert (2019) state that the selling or buying decisions of mutual funds in large amounts may cause temporary price changes. This situation might be even more influential in the small-capitalized markets like Greek stock market.

Hu et al. (2012) examine the recently well developed Taiwanese mutual fund market with a four-staged DEA methodology. They, first, conduct an input-oriented

Banker, Charnes and Cooper (BCC) type DEA where the inputs are expense ratio and standard deviation and the only output is fund return (Cooper et al. 2006). In the second stage, they evaluate the effects of various fund attributes including fund size on the slacks obtained through DEA and funds' underperformance by using a truncated regression. Next, by the aid of parameter estimation from the truncated regression, they predict the total input slack and adjust the output. Finally, they re-evaluate the original DEA by employing the adjusted output found in the previous stage. Contrary to the previous papers such as Babalos et al. (2012), their results show a positive relation between fund performance and fund size. They explain this evidence as such: it is possible that in the larger funds, the risk taking and managing abilities are better, therefore they may beat the smaller ones.

Similarly, Baghdadabad Tavakoli and Noori Houshyar (2014) examine the relative efficiency of the US mutual funds using DEA with an input-oriented CCR method and their total productivity using a Tornqvist Productivity Index. In particular, they aim to investigate the effects of 2008 financial crisis on US funds' efficiency and productivity. After obtaining the efficiency and productivity scores, they look at the impact of several fund characteristics on these scores. As in Babalos et al. (2012), they argue that fund size and its potential to create economies of scale become important for the fund investors especially in times of significant cash outflows from the funds as in the crisis period. It is found that fund size negatively affects both the relative efficiency and productivity of funds. As in the small and illiquid Greek market, size becomes a limitation for the developed and liquid US fund market.

Premachandra et al. (2012) employ a two-stage DEA methodology to assess the US mutual fund family performances, and they break the overall efficiency down into two parts, namely operational and portfolio level efficiencies. By doing so, they attempt to understand which efficiency type is more prominent on the funds' overall efficiency. In the first stage, fund expenses and management fees are used as inputs while net assets value is the output. The aim of the first stage is to observe how efficiently the inputs are used in the production of net asset value. In the second stage, where the portfolio management efficiency is determined, they discuss how efficiently the inputs of net asset value, the standard deviation of the returns, turnover ratio, expense ratio, and fund size are employed in the creation of average return. As a result, net asset value becomes the intermediate variable, which is the output in the first stage, but input in the second stage. They use an input-oriented approach. Therefore, in the second stage, the funds with smaller fund sizes are accepted as the more efficient ones. However, the literature provides conflicting evidence for the effects of size on efficiency for different markets. Galagedera et al. (2018) next improve their original model proposed in Premachandra et al. (2012) and consider the mutual fund management as a multistage process. They state that mutual fund performance may be related to size besides other fund characteristics. In this study, they discuss whether to use fund size as an input and output in DEA assessments. They conclude that fund size can better serve as a performance criterion when it is used in the intermediate stages as both input and output.

A similar study to our paper is conducted by Basso and Funari (2017). They explicitly investigate the role of fund size in the performance evaluations with DEA

models on a variable return to scale. They argue that mutual fund investors may overlook the fund size when they allocate their money across funds mostly depending on the funds' prior performance and risk level. According to the fund investors, two funds with the same performance, risk and expense levels are considered equivalents. However, fund size has the potential to reflect the fund managers' ability since larger funds are more successful to attract cash inflows. Thus, fund size becomes important particularly from the investors' point of view. The results of Basso and Funari (2017) show that there is no linear relation between efficiency scores obtained through DEA and fund size in the European mutual funds. However, there might be a quadratic or logarithmic association. They also find significant ranking correlations for fund size and efficiency scores. The small and large funds show significantly different efficiency scores. On average, larger funds are more efficiently managed.

Although we follow the paper from Basso and Funari (2017) closely in this study, our motivation is different from theirs in the following ways: First, we argue that since the fund managers' compensation is based on fund size, fund size is also of interest from their point of view. In the Turkish mutual fund market, where good performance in the previous period results in cash outflows, fund managers may have conflicting motivations to manage the fund size and fund performance altogether. In such a situation, adding fund size among the DEA inputs may help reveal the fund managers' incentives and their decision-making process to the fund investors as well. Second, Basso and Funari (2017) and many others such as Choi and Murthi (2001) use developed fund markets in which a large number of funds and liquidity exist. The market conditions and the managerial motivations may change in smaller sized and illiquid markets. There is evidence that fund managers pay more attention to the fund performance in the previous period and are more prone to engage in tournament behavior when the market size is small (Ferreira et al. 2012; Kempf and Ruenzi 2008). Although there are those fundamental differences between developed and developing markets, the research on developing markets is scarce. This paper will add to this line of research as well.

The main argument behind adding size as an input or output is that either small-sized funds can have more flexibility in realizing their investment ideas (Ammann and Moerth 2005) or larger funds have economies of scale advantage [as in Babalos et al. (2012) and Sánchez-González et al. (2017)]. Besides these two rationales, the performance evaluation of mutual funds is vital for fund managers as well as for fund investors. Investors seek better-performed funds, and their cash flows to funds reveal their decisions. Fund managers, on the other hand, are eager to attract new cash flows to the fund which increases the fund's size. Since the managerial compensation is directly linked to the fund size, a high fund performance becomes an important challenge (Chevalier and Ellison 1997; Sirri and Tufano 1998). This process eventually creates a tournament like situation in the market (Brown et al. 1996). From this line of research, winning the fund tournament and attracting new investors to the fund may be linked to the fund size. Choi and Murthi (2001) also state that the same manager may show different performance results based on different fund characteristics.

Favoring the larger sized funds, Sánchez-González et al. (2017) argue that the aim of a mutual fund company is to enhance the fund size, therefore to obtain the highest compensation from fees and bear the lowest marketing and management expenses. However, fund investors have an asymmetric view on the fund operations, and their decisions are mostly based on the funds' past performance. This study notes that besides a good past performance, to allocate their money to the best option, fund investors should consider the fund's operational efficiency which is directly linked to the fund size. For this aim, they evaluate the Spanish mutual fund companies with a network slacks-based model in which the mutual fund's operations are considered into portfolio management and marketing stages. The results of this paper suggest that mutual fund company size adds positively to the operational efficiency, so managers must increase the funds' total assets to operate more efficiently.

Likewise, Andreu et al. (2019) propose a slacks based DEA model to assess the fund managers in the Spanish mutual fund market. They note that funds with larger size are more efficiently managed due to lower transaction costs. Therefore, the returns to the fund may be related to assets under management. This is particularly important when the management fees are a function of total assets. The first input of this paper is the risk to reflect the different investment choices of managers. A manager may foresee the risk level as a result of his/her investment strategies. The second input is the portfolio turnover to represent the manager's ability for market timing. However, high turnover may also increase transaction costs. The last input is labor cost. In this paper, Andreu et al. (2019) extend the fund investors' return maximization with a given level of risk problem through a different managerial perspective. Therefore, they include total assets under management as a second output alongside the fund return. As a result, the expectation from an efficient fund manager is to maximize the returns to the greatest assets under management as much as possible while risk, transaction costs, and labor costs are low. They choose the Spanish mutual fund market because both small and independent mutual funds and bank-based larger funds operate at the same time. The results demonstrate that besides the personal education/experience of the manager, total assets under management are significantly effective on the individual manager's survival in the market. That is, managers of larger funds are more likely to keep their jobs. The fund risk, turnover or return are not significant determinants of this likelihood.

As the global markets, there have been studies evaluating the Turkish mutual fund market with DEA as well, such as Gökgöz (2009) and Yıldız (2006). However, very few of them include fund size as a determinant in the DEA evaluations. One of the early studies in the Turkish mutual fund industry belongs to Çıtak (2008). This study assesses the closed-end securities investment trusts in the Turkish mutual fund market for the 2005–2007 period and they compare two different types of DEA, namely CCR and BCC methods and different efficiency types. The inputs of this study are expense ratios, management fees, and capital; whereas the net asset value, total assets and total market value of the securities mutual fund are the outputs. Their results indicate that securities mutual funds are inefficient in their input usage, and their main problem is to operate in a suboptimal fund scale. Still, larger funds in terms of market value are more efficient than smaller ones. The motivation

and decision-making units of our paper, however, differ from Çıtak (2008) considerably. We try to understand how efficiently the managers of open-end Turkish mutual funds decide on the fund size and performance altogether, therefore we use both of these variables as inputs.

In another study, Karakaya et al. (2014) assess the efficiency of 14 individual retirement companies with DEA in which the fund size and collected premiums are used as the outputs. The inputs are the number of employees and total assets. The results show that at the end of the year 2011, 21.4% of the individual retirement companies are operating efficiently. Again, individual retirement funds have different characteristics, performance measures, and managerial motivations than open-end mutual funds. Although Karakaya et al. (2014) and our study share a common variable, exploring the role of fund size in the open-end mutual funds' DEA evaluations will add to the literature.

3 Sample and methodology

3.1 Background for the Turkish mutual fund market

Table 1 presents the number of asset management companies and total assets managed in the European countries between 2015 and 2017, which were analyzed within the scope of this paper. From this perspective, when compared to the other emerging economies in Europe, Turkey is located in the upper row. In fact, Turkey gained the emerging market status in 1989, earlier than the other emerging economies located in Europe (https://www.msci.com/emerging-markets).

In Turkey, approximately 85% of the asset management companies (EFAMA 2017, 2018, 2019) operate within bank groups. This means that although they are legally separated firms, the Turkish mutual fund industry is mostly bank-based. 60–65% of the asset management companies consist of institutional clients (EFAMA 2017, 2018, 2019). These clients include pension funds, insurance companies, banks, and other institutions. In mutual funds, however, individual investors gain weight. Most of the Turkish mutual funds are held by domestic investors.

When one examines the portfolio holdings of mutual funds, it is seen that only a small part of the mutual funds is composed of equity assets, but almost half of the fund portfolios consists of funds investing in fixed income securities.

The most significant development in Europe during the sample period is the European Central Bank's gradual reduction in its asset purchase program, which was initiated in 2015. This decision provided liquidity for fund markets in developing countries. With the recovery of global trade and increasing risk appetite since 2016, capital inflows started again in developing countries (Türkiye Sermaye Piyasaları Birliği (Turkish Capital Markets Association) 2018). However, the Turkish mutual funds began to experience cash inflows in 2017, in the recovery period after the political problems observed in the country in 2016.

Table 1 Assets under management in selected countries

Country	Asset under management (billion)			Number of asset management companies		
	End of 2015	End of 2016	End of 2017	2015	2016	2017
United Kingdom	2673	2560	3365	1000	1050	1100
France	202	2167	2355	627	630	630
Germany	1697	1755	1884	309	325	380
Switzerland	975	1044	1078	180	190	210
Netherlands	861	876	844	254	224	236
Italy	377	402	452	278	261	256
Spain	n.a.	269	309	96	101	109
Denmark	231	238	258	49	50	53
Belgium	130	146	172	64	64	64
Austria	104	132	141	29	26	24
Portugal[a]	19	22	23	72	72	66
Turkey[a]	15 (12[b])	18 (14[b])	23 (13[b])	47 (17[b])	50 (17[b])	49 (17[b])
Hungary[a]	18	19	20	36	27	24
Greece[a]	7	6	6	51	52	50
Bulgaria[a]	n.a.	1	1	30	31	31
Czech Republic[a]	14	19	n.a.	29	22	23
Finland	n.a.	n.a.	110	28	25	26
Romania[a]	n.a.	n.a.	9	21	21	22
Croatia[a]	n.a.	n.a.	3	20	21	21
Slovakia	n.a.	9	n.a.	8	9	10
Slovenia[a]	n.a.	2	2	9	7	7

Source: efama.org Asset Management Report 2017, 2018, 2019

[a]Emerging Markets

[b]Turkey's ranking among the European countries

3.2 Sample selection and the DEA model

In this paper, we investigate the performance of the Turkish mutual fund industry by applying an output-oriented DEA method on a variable return to scale. As noted by Choi and Murthi (2001), this analysis extends the mean–variance efficiency concept to a return-cost efficiency for mutual funds. It is a very common linear programming method to examine the relative efficiencies of decision-making units. Since DEA provides a relative assessment, the decision-making units must be similar in nature. Therefore, we limit our sample by only using variable, mixed and equity funds. In addition, this paper also seeks to understand whether fund managers can manage fund size efficiently or they involve in a tournament like behavior. Chevalier and Ellison (1997) and Brown et al. (1996) indicate that this behavior is observed in equity funds. In the Turkish mutual fund market, these three types of funds are the only ones investing highly in equity. Therefore, we limit our dataset with those funds.

There are 62 funds in 2015, 65 funds in 2016 and 66 funds in 2017 in our dataset. Data period selection is subject to data limitations. The daily data of these funds are used for the years from 2015 to 2017. The main data sources are the Capital Markets Board (CMB) and Financial Information News Network (FINNET) Databases. The CMB database contains total net asset values, the number of shares, share price, and the broad asset classes that a fund invests, namely equity, T-Bills and bonds, reverse repo, money market, foreign market, private sector, and other. FINNET provides us the funds' expense ratios for these years.

The first step of DEA is to determine the inputs and outputs. Cooper et al. (2006) recommend to begin with a small number of inputs and outputs, then gradually add the new items to observe its effects. Therefore, as in Murthi et al. (1997), Babalos et al. (2012) and Baghdadabad Tavakoli and Noori Houshyar (2014), we start with the mean–variance efficiency analysis of domestic Turkish mutual funds in which for a given level of risk and expenses, the maximization of fund returns is expected. For portfolio risk, we employ the standard deviation of annual returns (as in Babalos et al. 2012) and funds' beta (as in Basso and Funari 2017) to reflect the total and systematic risks of the portfolio. Andreu et al. (2019) indicate that the selected risk measures should reflect the overall risk and the positive impacts of portfolio diversification. Our choice of standard deviation and beta are in line with this argument. Funds' expense ratio is the third input (as in Murthi et al. 1997). This input reflects the overall costs that consist of management and other fees.

In the mutual fund performance assessment literature, various return definitions, such as excess return or net return, are employed as the output (Basso and Funari 2017; Choi and Murthi 2001; Gökgöz 2009; Sánchez-González et al. 2017). Our paper is based on the rationale that a fund manager wants to maximize the fund return (Andreu et al. 2019). Therefore, we use the funds' excess return, defined as the linear difference between the fund's return and the risk-free rate as the only output. To avoid the negative values, the excess return is normalized as in Gökgöz (2009).

The next step is to determine the orientation. Input orientation employed by many studies such as Babalos et al. (2012), Choi and Murthi (2001), Gökgöz (2009) and Yıldız (2006) indicates that the decision-making units that minimize the levels of input for a given level of output are the efficient ones. For example, Choi and Murthi (2001) note that in an input-oriented model, the fund manager tries to minimize the combination of risk and transaction costs for a given return. In contrast to the other inputs that represent fund costs and risks, a fund manager might not choose to minimize the fund size to operate efficiently. To be able to add this variable into the analysis and to compare the results, input orientation would not be adequate. Instead, following Basso and Funari (2017), we apply an output orientation. By doing so, we question whether the fund manager has provided the best portfolio combination to produce the highest returns (Margaritis et al. 2007). Mutual funds can operate on different scales of efficiency (Choi and Murthi 2001; Gökgöz 2009). Therefore, the variable returns to scale, namely the BCC model, is chosen for evaluating the fund performances.

After obtaining the DEA scores and slacks, possible linear and nonlinear relations between efficiency and fund size are examined through Pearson correlation and

Spearman Rank and Kendall Rank correlations. The entire sample is also divided into two according to median. The funds over the median are considered as large funds, while the ones below the median are small funds. Mann–Whitney U, Median Test, and Kolmogorov–Smirnov tests are applied to compare the mean of DEA scores of small and large funds, the equality of the medians and the distributions respectively. To deepen the analysis, we investigate the effect of size on the funds' efficiency scores by the aid of regression analysis. Following Basso and Funari (2017), we examine the impact of quadratic, logarithmic and log-quadratic functions of size definition on DEA scores.

We argue that the compensation of fund managers also depends on the fund size. Therefore, they would like to maximize the assets under management to boost their own performance fees. The growth in total assets under management depends on both asset appreciation and cash inflows. These two sources are both associated with fund performance. However, unlike the previously documented funds' past performance-new cash flow relationship, we observe a cash outflow from the well-performed funds of the previous period. In this situation, the fund manager would like to manage the conflicting fund size and fund performance at the same time. As a result, we use the funds' total net asset values as one of the inputs in a second BCC type output-oriented DEA. The DEA scores with and without size as an input are compared. For these two DEA models, to conduct a more profound investigation for the source of inefficiency, we compute relative mean slacks as proposed by Murthi et al. (1997). Relative mean slacks are computed by dividing the absolute mean slack of each input by the mean value of the input.

4 Findings

4.1 Overview of the results

The main aim of this study is to add clarification to the black-box nature of DEA when it is used for the mutual fund evaluation. To do so, we investigate whether size can be an input when managers try to manage the fund size among the other inputs to boost their own compensation. The summary statistics of the funds for each year and for the entire sample are presented in Table 2:

Table 2 shows the general outline of the mutual funds in the analysis period. Apart from 2015, we observe positive mean returns in the Turkish mutual fund market which indicate the existence of a relative up market. This is especially the case in 2017. The highest efficiency scores (0.877) are observed in 2015. Despite the lowest fund returns in 2015, it seems that fund managers achieved efficient portfolio management this year. The lowest efficiency scores (0.486), on the other hand, belong to the year 2016. Since this is an output-oriented DEA, for the low levels of efficiency scores, there must be a significant increase in the inputs and/or decrease in the output. In 2016, there was an attempted coup against the current government. This unexpected political situation may increase severely the systematic risk of the market. This situation is visible in the descriptive statistics for beta as well. The highest mean beta belongs to 2016.

Table 2 Summary statistics. Source: Dataset computations

Variable	Obs.	Mean	Std. Dev.	Min	Max
2015					
Net asset value	62	24,400,000	70,600,000	107,759	504,000,000
Share price	62	6.0675	15.9661	0.0121	84.5041
Number of shares	62	855,000,000	3,260,000,000	46,911	18,700,000,000
Size	62	15.5916	1.6679	11.5877	20.0385
Fund excess return	62	−0.1847	0.9682	−4.2552	4.3679
DEA scores	62	0.8777	0.0716	0.7661	1.0000
Beta	62	0.5354	0.3284	0.0113	1.1856
2016					
Net asset value	65	18,700,000	36,300,000	36,035	195,000,000
Share price	65	6.2550	16.8338	0.0113	91.1002
Number of shares	65	613,000,000	1,960,000,000	47,594	12,000,000,000
Size	65	15.5141	1.6801	10.4923	19.0867
Fund excess return	65	0.3769	1.2939	−0.0899	6.5059
DEA scores	65	0.4861	0.2824	0.0565	1.0000
Beta	65	0.5686	0.3397	0.0182	1.1736
2017					
Net asset value	66	15,800,000	20,200,000	269,580	103,000,000
Share price	66	7.6819	20.2956	0.0135	102.6990
Number of shares	66	339,000,000	994,000,000	40,755	6,200,000,000
Size	66	15.7356	1.4383	12.5046	18.4502
Fund excess return	66	1.4048	4.0930	−0.1148	18.4277
DEA scores	66	0.7572	0.1704	0.3104	1.0000
Beta	66	0.5242	0.3227	0.0223	1.0161
Entire sample					
Net asset value	193	19,500,000	46,600,000	36,035	504,000,000
Share price	193	6.6827	17.7602	0.0113	102.6990
Number of shares	193	597,000,000	2,240,000,000	40,755	18,700,000,000
Size	193	15.6147	1.5917	10.4923	20.0385
Fund excess return	193	0.5480	2.6388	−4.2552	18.4277
DEA scores	193	0.7046	0.2546	0.0565	1.0000
Beta	193	0.542729	0.329184	0.011276	1.185563

The lowest efficiency scores may be due to the increase in the number of less efficiently managed fund portfolios. Among the years in the analysis period, the lowest efficiency score and the highest standard deviation for this statistic belong to 2016 as well. Babalos et al. (2012) and Baghdadabad Tavakoli and Noori Houshyar (2014) similarly report a decrease in the DEA scores in the 2008 global crisis period for the Greek and the US fund markets respectively.

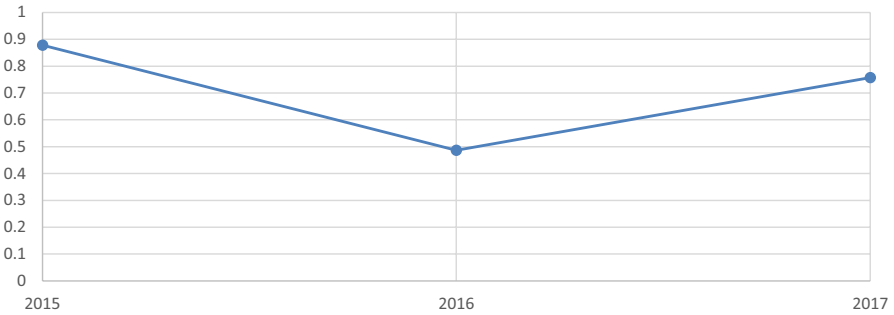

Fig. 1 Mean efficiency scores for the years 2015–2017

Table 3 An overlook for the funds from 2015 to 2017

	2015	2016	2017
Number of funds	62	65	66
Efficient funds	6	8	14
Percentage of efficient funds	0.10	0.12	0.21
Zero slacks wrt. Std. Dev.	11	33	50
Zero slacks wrt. beta	16	15	30
Zero slacks wrt. Expense Ratio	47	34	33

In 2017, we can observe a recovery on the portfolio efficiencies. Both the mean and the lowest efficiency scores increase in this year. The mean efficiency scores for each year are presented in Fig. 1.

From Fig. 1, one can observe that in 2015, funds operate very efficiently with a mean efficiency level of 0.88. A significant decrease is observed (0.49) in 2016 due to the political problems that Turkey faced during this year. A recovery in the average efficiency levels (0.76) can be observed in 2017. The number of efficient funds, however, constantly increases from 2015 to 2017. There are 6 efficiently operating funds in 2015; while 8 and 14 funds are found efficient in 2016 and 2017 respectively. From these statistics and the recovery in 2017, we can conclude that the low scores in 2016 are not signals of a continuous long-term downward trend.

Exploring slacks found by the DEA also shows the potential improvements in the inputs and outputs to reach the efficient frontier for the inefficient mutual funds. Table 3 reflects the number of total funds, efficient funds and the number of funds with zero slacks for each input. It is interesting to note that although the mean efficiency scores are the lowest in 2016, there is a continuous increase in the number of efficient funds from 2015 to 2017. It means that the funds with the lowest scores have a greater influence on the mean than those efficiently managed. In other words, funds that are not operated on the efficiency scale are affected the most from the political challenges in 2016.

Standard deviation represents the total risk of the portfolio. Zero slack with respect to standard deviation indicates that no improvement in this input is

necessary; in other words, the fund operates on the efficient frontier with respect to this variable. From 2015 to 2017, there is a significant increase in the number of mean–variance efficient funds, but their percentage in the overall sample is still not very high. It means that more and more funds are efficient to create portfolios that offer the highest return with the lowest risk possible delegated by the standard deviation as suggested in Choi and Murthi (2001). There is a decrease in the number of funds with zero slacks with respect to the expense ratio input, but most funds still efficiently manage their expenses. It seems that the main source of the fund inefficiency is fund beta. In comparison to the other inputs, less funds operate efficiently in terms of beta. This input reflects the systematic risk of the portfolios. The lowest number of funds with zero slacks with respect to this input belongs to 2016. As we mentioned before, Turkey faced political problems this year, which increased the systematic risk significantly. Alexakis and Tsolas (2011) point out that fund managers may attempt to time the market by changing the fund's beta. In this sense, it is possible to say that the fund managers are not equally successful especially in 2016 in distributing their resources across different investment options when they aim to time the market.

It is interesting to note that throughout the years, there has been an increased efficiency in the beta management and better market timing since the number of funds with zero slack with respect to beta increased. However, the same proxy has worsened with respect to the expense ratio. It is possible to conclude that funds had to bear more transaction costs as the market timing efforts increased. Babalos et al. (2012) note that such a pattern might demonstrate that funds' expenses consume fund performance.

4.2 Fund size and fund performance relation

As observed in the previous section, the efficiency scores vary across funds. In the explanation of this variation, fund size and fund performance might be relevant. Basso and Funari (2017) indicate that fund size might be an indicator of managerial skill especially in the comparison of funds that are otherwise equivalent. Brown et al. (1996) and Chevalier and Ellison (1997) also show that fund managers may attempt to boost the total fund assets in order to obtain higher personal compensation. This relation becomes particularly difficult to manage for the Turkish mutual funds where funds with good past performance experience cash outflows. In the previous literature, the evidence is scarce for developing country markets as well. In this section, we aim to examine the relationship between efficiency scores and size for one of the developing country markets, namely the Turkish mutual fund market. Following Basso and Funari (2017), we first visually inspect this relation. Figure 2 represents the relation between DEA scores and the natural logarithm of fund size over the years of 2015–2017. From Fig. 2, one might expect a positive linear relation to the fund size. However, the visual investigation will not be conclusive, hence, a deeper analysis is needed to detect possible associations.

Apart from the visual examination, linear and nonlinear relations between efficiency scores and fund size are investigated by using parametric and non-parametric

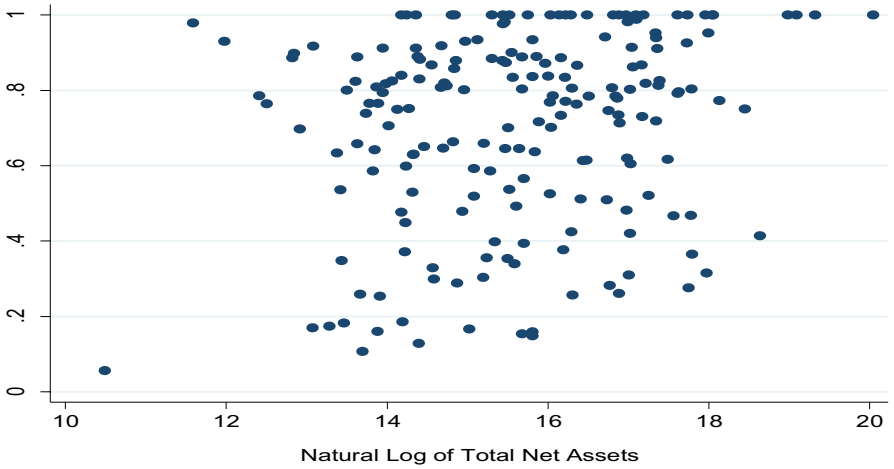

Fig. 2 DEA scores and fund size relation

Table 4 Size vs DEA scores

	Size vs DEA scores (overall sample)	Small funds	Large funds
Correlation	0.1768	0.1385	0.2014
	(0.0139)	(0.1762)	(0.0492)
Spearman rank correlation	0.2017	0.1322	0.2094
	(0.0049)	(0.1967)	(0.0406)
Kendall Rank Correlation	895.755	320.755	314.425
	(0.0052)	(0.1731)	(0.0468)

The values in parentheses indicate the probabilities

tests, and by regression analyses.[1] In addition to the overall analysis, the sample is divided into two according to the funds' size. The funds over the median size are considered as large funds, and the ones below the median are considered as small funds. The mean of the DEA scores of large and small funds, the equality of their medians and their distributions are compared by employing Mann–Whitney U, Median Test, and Kolmogorov–Smirnov tests respectively. The results of these tests are given in Tables 4 and 5.

The results presented in Table 4 show that for the overall sample there is a linear and significant relation between size and DEA scores. Both the Pearson correlation and the other two tests based on rankings verify this relation. These findings for the Turkish mutual fund industry are in contrast with Basso and Funari (2017) and

[1] All of the analyses mentioned above are repeated by eliminating the largest fund which is determined as an outlier in order to understand whether the efficient frontier is under the outlier's influence. The results are virtually the same. To conserve space, they are not given in the paper, but available on request.

Table 5 Comparisons of DEA scores for small and large funds

	Comparisons of DEA scores
Mann–Whitney U	2.008
	(0.0446)
Median	1.4984
	(0.221)
Kolmogorov–Smirnov test	0.1575
	(0.182)

The values in parentheses indicate the probabilities

Choi and Murthi (2001) but in line with the findings of Margaritis et al. (2007). It is observed that larger funds are more efficiently managed in terms of DEA scores. This finding is, in fact, consistent with the compensation concerns of fund managers.

When the sample is divided into two based on fund size, the significance levels become higher than any acceptable level for the small funds' sample. In other words, no significant correlation can be detected for the small fund group. The correlation coefficients for large funds, on the other hand, are significant at 5% level. In fact, this finding is contrary to Babalos et al. (2012). They show a significant but negative impact of size on the fund efficiencies in the small capitalized and illiquid Greek fund market. Although the Turkish fund market is not deep, once more, a positive size effect is observed on the efficiency scores. This may be a result of lower transaction costs that larger funds face due to the economies of scale (Choi and Murthi 2001). Larger funds are usually bank based in Turkey, although fund management must be legally separated. It is possible that these funds are more institutionally managed and have better organizational structures. Apart from these explanations, obtaining higher managerial compensation as suggested by Brown et al. (1996) and Chevalier and Ellison (1997) might also motivate fund managers to boost the total assets even in a market that fund investors tend to liquidate their positions once they are on the profit side, so cash outflows are observed from better managed funds.

Table 5 presents the size effect comprehensively by dividing the sample into two and comparing the means, medians, and the distributions of DEA scores of these groups. To make these comparisons, the multiplicative inverse of DEA scores is calculated as suggested in Basso and Funari (2017). They note that the following tests are nonparametric and order based. Therefore, they do not require a statistical distribution for the comparisons.

Table 6 Regression results for different functions of size

Variables	(1) Quadratic function	(2) Log function	(3) Log quadratic function
Size	1.86e−09**		
	(8.76e−10)		
$Size^2$	−0.000		
	(0.000)		
Ln(Size)		0.0334***	−0.0375
		(0.0113)	(0.162)
$(Ln(Size))^2$			0.00228
			(0.00520)
Constant	0.674***	0.183	0.728
	(0.0220)	(0.178)	(1.255)
Observations	193	193	193
Adjusted R-squared	0.028	0.039	0.034

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5 shows that although there is a significant difference between the means of small and large funds, the medians and the distributions of these two subsamples are not different. The previous findings that larger funds have higher DEA scores are verified again.

The last part of the analysis conducts a regression analysis to show the possible relation between fund size and efficiency. Since the shape of this relationship is not clear, following Basso and Funari (2017), we investigate the effects of quadratic, logarithmic and log quadratic functions of fund size on DEA scores.[2] The findings are presented in Table 6.

The regression results demonstrate that fund size defined as the total net assets and its logarithm are significant and positive. The squares of these values, on the other hand, are not significant. These findings indicate a linear relation between size and funds' efficiency scores. Unlike Basso and Funari (2017), the size effect does not show a concave parabolic relation; hence no optimal fund size can be obtained from these results.

Babalos et al. (2012) point out that large funds might be forced to allocate their resources to the sub-optimal stock portfolios due to the illiquidity in the small fund markets. This would result in lower efficiency values. Contrary to their findings,

[2] In a similar study, Babalos et al. (2012) add fund age with fund size among the explanatory variables in their regression analysis. Baghdadabad Tavakoli and Noori Houshyar (2014) use management and incentive fees besides fund size. Margaritis et al. (2007) only include the national vs international orientation of funds with fund size while investigating the possible factors affecting the fund efficiency. Since the aim of this study is to primarily detect the relation between fund size and efficiency and its exact shape is unknown, as in Basso and Funari (2017) we limit our regression analysis with only including size variable.

Table 7 DEA with size input

	2015	2016	2017
Number of Funds	62	65	66
Efficient Funds	8	14	23
Percentage of Efficient Funds	0.13	0.22	0.35
Zero Slacks wrt. Std. Dev.	13	33	54
Zero Slacks wrt. Beta	17	28	33
Zero Slacks wrt. Expense Ratio	42	45	45
Zero Slacks wrt. Size	54	47	50

we have demonstrated that fund size significantly and positively contributes to the funds' efficiencies, although the Turkish fund market is also small capitalized and illiquid. Along with Baghdadabad Tavakoli and Noori Houshyar (2014), Babalos et al. (2012) also note that the negative effect of size on the possibility of being efficient acts as a constraint in the fund market. Such an impact, however, is not observed in the Turkish mutual fund industry. It appears that fund size enhances the DEA scores. As mentioned before, in Turkey, most large funds are bank based. Besides the lower transaction costs that they face, the managers of these funds are more likely to involve in a tournament like behavior and try to attract more cash inflows as in Chevalier and Ellison (1997) and Brown et al. (1996). Despite the observed cash outflows from the previously well performed funds, this positive impact might be a result of their higher managerial efforts to be a winner fund and to increase the funds' total assets.

4.3 Size as an input in DEA

The previous sections show that in the Turkish mutual fund industry, size and efficiency are positively related. Therefore, besides other factors, one might question the fund's efficiency relative to the fund size as well. In this part of the study, we add size as an input to the DEA and evaluate its relative importance based on the methodology proposed in Murthi et al. (1997) and used in many others, namely Babalos et al. (2012), Baghdadabad Tavakoli and Noori Houshyar (2014), Daraio and Simar (2006) and Derviz and Podpiera (2008). The effect of size, in this sense, is a hidden relation. As mentioned in Gregoriou (2007), DEA is an appropriate technique to reveal these hidden relationships.

In Table 7, the number of efficient funds and zero slacks with respect to each input are given for the years of 2015–2017.

When the size of the funds is controlled, we observe that the number of efficient funds increases each year. The number of mean–variance efficient funds, that is zero slacks with respect to standard deviation, in this analysis is higher than the DEA without size input. Particularly in 2017, 54 of 66 funds are on the mean–variance efficient frontier. It is also seen that most funds do not have to make improvements in their expense ratios and sizes since the slacks obtained from DEA are zero. The number of funds with zero slacks with respect to expense ratio increased in Table 7

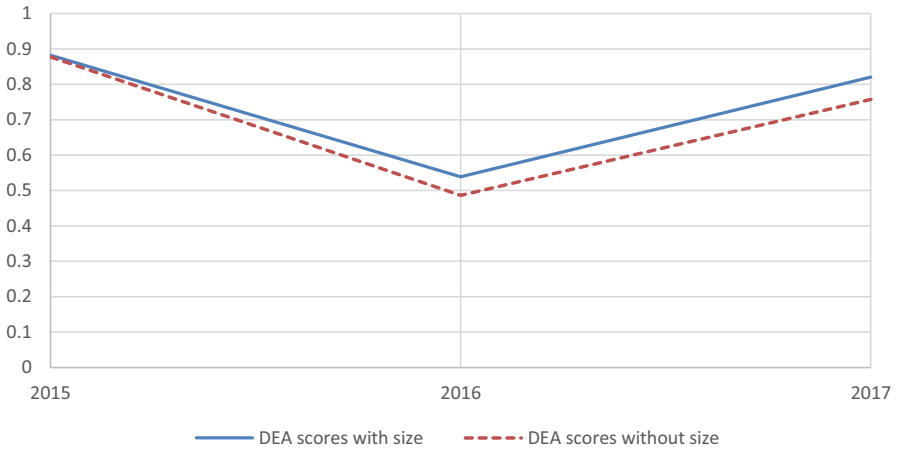

Fig. 3 Mean efficiency scores for the years 2015–2017 with and without size as an input in DEA

when compared to the results provided in Table 3. Using fund size in the DEA as another input might improve the efficiency of transaction costs as well. However, the number of funds with zero slacks with respect to size drops significantly in 2016. Even in the recovery period of 2017, it is not the same level as it was in 2015. In fact, it is the only input in which the number of funds with zero slacks decreases. Fund size seems to be one of the reasons that adds the inefficiency observed in 2016. It appears that fund managers had difficulties in 2016 regarding the management of fund size. The cash outflows from the funds and the tendency to liquidate once entering in the profit zone among the fund investors might be the explanation. The concerns and this tendency are especially visible in the crisis period. Indeed, the average holding period for the domestic investors[3] of Turkish capital markets fell down as low as to 35 days in this period (TSPB 2017).

According to Table 7, fund managers are aware of the increased political risks in the fund market and they paid attention to fund betas. Based on the number of funds with slacks, although the main source of inefficiency is again the fund betas, the number of funds with zero slacks with respect to this input increased from 2015 to 2017. In addition, the previously observed relation between market timing efforts and expense ratio disappears in Table 7.

In order to explain better the market timing ability of mutual funds, one may compare the performance of actively managed funds with passively managed ones. This paper employs actively managed mixed, equity and variable type mutual funds as a sample. According to the reports of the Turkish Capital Markets Association (TSPB 2015, 2016, 2017), the portfolio size of these funds shows either a significant decrease or a very low amount of growth especially in 2016. Only in 2017,

[3] Domestic investors are the main investor group in the Turkish mutual fund market. 96% of the Turkish mutual funds are held by domestic investors (TSPB 2015).

Table 8 Relative mean slacks

	Std. Dev.	Beta	Expense ratio	Size
2015	0.683136	0.452738	0.090199	0.006442
2016	0.299107	0.285458	0.103340	0.016550
2017	0.118145	0.080638	0.088667	0.010617

they demonstrated an important amount of growth in terms of portfolio size (TSPB 2017). In contrast, the index funds continued their growth in 2015 and 2016; but significantly shrank in size in 2017 (TSPB 2015, 2016, 2017). This situation in the Turkish mutual fund industry is reflected in the above discussed findings as well. It appears that market timing efforts become more important and bring results in 2017 in which the highest number of funds have zero slacks.

We can compare the relative efficiency scores obtained through DEAs with and without size used as an input for the period of 2015–2017 in Fig. 3, from which, it is seen that although they are very close in 2015, the mean efficiency scores are higher each year when fund size is added into the input set. This difference is particularly visible in the recovery period. It seems that managing fund size correctly mostly adds to the funds' efficiency level in the crisis and post crisis terms.

Table 8 represents the relative mean slacks of the inputs computed based on the paper by Murthi et al. (1997). Relative mean slacks are equal to the absolute mean slack of each input divided by the mean value of the input. This computation indicates the marginal influence of each input on the output, which is fund excess return (Derviz and Podpiera 2008; Murthi et al. 1997).

Relative mean slack computation provided in Table 8 offers a detailed examination of the source of inefficiency. It is observed that the marginal effect of standard deviation, that is the total risk of the fund, has decreased from 2015 to 2017. Funds have become more mean–variance efficient over time. The same pattern is valid for the beta as well. Fund risk, in terms of either total or systematic risk, has diminished noticeably. This finding is consistent with Alexakis and Tsolas (2011) and Murthi et al. (1997). In the year by year analysis, however, the highest relative mean slack scores belong particularly to standard deviation and beta inputs. The other two inputs, namely fund expenses and size, seem to be relatively stable over the period, and more efficient in comparison to the risk variables. In particular, funds' relative mean slack is low with respect to size input, although a slight increase can be observed from 2015 to 2017. In 2016, where a particular drop is observed in the overall efficiency scores, the slacks for portfolio risk measures maintain a downward trend, whereas there is a slight increase in the slacks for expense ratio and size. Therefore, one may conclude that the lowest efficiency scores in this year are not a result of overly consumed input to produce a higher output. It is a result of not generating higher returns. In 2017, the continuous decrease in the slacks of all inputs and the increase in the fund returns add significantly for the funds' recovery.

It seems that fund managers have to give priority to funds' risk, both systematic and total risks, to generate higher returns. In general, funds operate efficiently with respect to their transaction costs and size. However, the relative importance of size has increased over time, which is also consistent with the escalating distance between two DEA scores shown in Fig. 3 including size input changes the overall efficient frontier. Larger funds are more open to act efficiently.

5 Conclusion

Mutual fund literature links fund efficiency mostly with managerial skill, cost that reflects the price of additional information, and risk (Choi and Murthi 2001). Basso and Funari (2017) also note that fund investors are likely to consider two funds are equivalent if these fund features are the same, but to ignore fund size. However, fund size may bring its own advantages such as economies of scale or disadvantages such as difficulties in management and flexibility problems. It is also well known that fund managers may be prone to increase the total fund assets to improve their own compensation at the expense of investors' benefits (Chevalier and Ellison 1997). Based on this prior literature, one might expect a difference between the efficiencies of small and large funds. Following Babalos et al. (2012) and Choi and Murthi (2001), we aim to investigate the relation between fund efficiency and fund size in a relatively small and bank dominated market. Since most studies in the literature investigate the US or the other developed markets, we expect that the findings of this study might be a guide for other international markets with similar characteristics as well.

To explore the relation between efficiency and size, we first calculate the fund efficiencies of Turkish mutual funds in three categories by the aid of an output-oriented DEA with a variable scale. These funds heavily invest in equities, hence, a tournament like behavior might be possible for these funds. The results mainly indicate that in the analyzed period, there is a relative up market because the mean of the fund returns is positive. The mean efficiency scores of funds declined drastically in 2016 due to the political problems Turkey faced that year, but they recovered quickly in the next year. It is apparent that in 2016, the number of less efficiently managed funds increased, but the quick recovery in the next year indicates no long term downward tendency in the efficiency scores. Based on the slack analysis, one may conclude that most funds are on the mean-variance efficient frontier which is consistent with Choi and Murthi (2001). The main reason for the low efficiency levels in 2016 is the increase in the number of funds with slacks in beta. This suggests a higher systematic risk in the market and more market timing efforts. According to the slack analysis, the same efforts bring more transaction costs with itself as well.

Exploring fund size and the DEA scores by Pearson correlation and two other rank correlations reveals that there is a linear relation between these two. Dividing the sample into two based on the fund size demonstrates that there is an association between efficiency scores and the size of larger funds. It means that larger

funds are more efficiently operated than smaller ones. This finding is also consistent with the managers' compensation consideration arguments.

A linear regression verifies the above mentioned finding but does not show a nonlinear association. On the other hand, nonparametric tests cannot find a difference in the medians and distributions of small and large sub-samples. In general, we find stronger evidence for the fund size and efficiency relation than Basso and Funari (2017) who conclude a weak association between these two for the European markets and that there is no need to add size as an input to the DEA method.

The existence of a positive and significant size impact may be attributed to the Turkish fund market specifics. Most large funds are bank-based, although they are legally separated entities. Such a market structure may lead to lower transaction costs for large funds due to the economies of scale and better managerial techniques. One more argument to explain this relation is the fund managers' tendency to exploit the fund assets. More specifically, Chevalier and Ellison (1997) and Brown et al. (1996) state that fund managers are eager to be among winners in the market in order to attract more cash inflows because their compensation is based on the fund's total assets. This positive size effect might be attributed to those efforts. This situation is even valid for the Turkish mutual fund market where cash outflows are observed from well performed funds of the previous period.

The addition of size input into the DEA provides an analysis that considers mutual fund efficiency as a function of managerial skill, cost, risk, and fund size. The results exhibit a different efficiency frontier and a higher number of funds operating on the frontier. Larger funds are generally more efficient.

Evaluating relative mean slacks shows that although the number of funds with zero slacks with respect to size is high, particularly in 2016 it decreases significantly. It cannot rise to its previous level even in the recovery period. The intense cash outflows and the tendency to liquidate when in the profit zone among the fund investors might explain this situation. This suggests that fund managers have difficulties managing fund size in the crisis periods. Especially in these periods, fund size might add to the fund efficiencies. The visual comparison of DEA scores throughout the years with and without size as an input verifies this finding. Last, fund managers need to pay attention to the risk of the portfolio, most especially to fund beta.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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