The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/2515-964X.htm

The efficiency of Jordan insurance companies and its determinants using DEA, slacks, and logit models

Mutasem Mahmoud Jaloudi
Technical, Financial and Licensing Supervision Department, Insurance Directorate, Ministry of Industry, Trade and Supply, Amman, Jordan

Received 11 October 2018
Revised 15 January 2019
14 February 2019
Accepted 4 March 2019

Abstract

Purpose – The purpose of this paper is to evaluate the technical efficiency in the Jordan insurance market and examine the internal and external determinants that appear to affect the technical efficiency of the insurance companies.

Design/methodology/approach – The study used panel data for 22 insurance companies operating inside Jordan over the period 2000–2016. The author used the data envelopment analysis to evaluate the technical efficiency scores, slacks-based and logit models to examine the efficiency determinants.

Findings – The study found that there is a slight development of technical efficiency for the Jordanian insurance companies during the study period. In addition, there is a substantial efficiency difference among insurance companies each year, and there is a variation at the level of efficiency for each company in each year. The results also showed that owners' equities are among the most important internal determinants of companies' efficiency, and there is a significant correlation between type, size and return on assets of the insurer and its efficiency.

Originality/value – This study provides insurance management with relevant indicators that would guide them to make efficient use of the resource base. The period of study also covers the period following the adoption of the insurance law and the issuance of most of the legislation related to the work of insurance companies.

Keywords Jordan, Efficiency, DEA, Insurance, Logit model

Paper type Research paper

1. Introduction

The efficiency has become an issue that has begun to take an interest in the insurance sector as efficiency helps to identify efficient and inefficient companies in the market, in order to improve competition and profitability and raise the trust of the policyholders. The efficiency of the insurer refers to insurer ability to produce a given set of outputs via the use of inputs (Diacon *et al.*, 2002).

In recent years, efficiency measurement has captured a great deal of attention. And the insurance sector, in particular, has seen extreme growth in the number of studies applying frontier efficiency methods. Frontier methodologies measure firm performance relative to best practice frontier comprised of the leading firm in the industry. Data envelopment analysis (DEA) is the most frequently applied method of frontier efficiency analysis in the insurance. DEA measures the relative performance of companies through comparing a set of inputs and outputs and developing benchmarks related to industry best practices, based

© Mutasem Mahmoud Jaloudi. Published in *Journal of Asian Business and Economic Studies*. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at http://creativecommons.org/licences/by/4.0/legalcode

Journal of Asian Business and Economic Studies
Vol. 26 No. 1, 2019
pp. 153-166
Emerald Publishing Limited
2515-964X
DOI 10.1108/JABES-10-2018-0072

on the idea that the widespread application of these can lead to improving performance throughout the whole industry (Barros *et al.*, 2005).

The insurance sector in Jordan consists of 24 insurance companies, whereof 1 is licensed as a life company, 9 are licensed as non-life companies and 14 are licensed as composite companies. Jordan insurance market is small by international standard. In 2016, gross written premiums in Jordan reached JOD582.9m, and the gross claims paid reached JOD438.9m. In the same year, the sector earned JOD35.1m in net profits before tax, the return on assets was 3.8 percent and the return on equity was 10.2 percent.

The importance of the insurance sector in Jordan increased during the period 2000–2016, where gross written premiums increased at an annual rate of 12 percent, insurance premiums per capita increased by 187 percent, which increased from JOD21 to 59 at that period. In addition, the ratio of gross premiums to the gross domestic product (insurance penetration ratio) increased from 1.7 percent in 2000 to 2.1 percent in 2016.

The purposes of this study are to partially fill the gap in existing literature by evaluating the technical efficiency for the Jordan insurance companies using DEA method, and examine the internal (managerial inefficiency) and external (characteristic of external environment) determinants that appear to affect the technical efficiency of the insurance companies using slacks-based and logit models.

The importance of the study stems from the importance of efficiency in the work of the insurance companies and their impact on their performance and results. The issue of efficiency in the insurance companies is of fundamental importance for the current time due to the challenges faced the insurance sector in Jordan represented by the low return on assets and weak contribution to GDP, in addition to the low per capita insurance. This study provides insurance management with a relevant indicator that would guide them to make efficient use of the resource base. The period of study also covers the period following the adoption of the insurance law and the issuance of most of the legislation related to the work of insurance companies.

2. Theoretical background

In microeconomic theory, the production function is defined in terms of the maximum output that can be produced from a specific input, given the existing technology to the firm involved (Battese, 1992). The term economic efficiency means that resources are used in such a way to generate maximum possible output with a given input. In insurance, efficiency refers to the ability of an insurance company to produce a specific set of outputs (such as premium or investment profits) from the use of a specific set of input, such as capital and labor. More specifically, the insurer has two main aspects of its business: the insurance side and the investment side. From the insurance side, output or services provided by an insurer constitute the range of activities an insurer undertakes as its effort to pool risk as premiums reflect the ability of the insurer to market a product, select a client and to accept carrying a risk. And for the investment side, the investment profit captures investment activities by the insurer. Input represents resources that the insurer employs in order to conduct its operation like labor, material and capital. Therefore, the insurer efficiency could also be interpreted as a measure of the insurer's ability to produce outputs from its set of inputs. The insurance company is technically efficient if it can reduce its resources usage without some corresponding reduction in output, given the current state of production technology[1] in the industry[2] (Diacon, 2001). In other words, the insurer uses the optimal amounts and mix of inputs to produce given output levels, and any reduction of input will cause a reduction in the output.

Economic efficiency consists of technical efficiency and allocative efficiency (Farrell, 1957), where technical efficiency means the ability of an organization or decision-making unit (DMU)[3] to obtain the maximum amount of production using available inputs, and the measure of technical efficiency is usually defined as the maximum reduction of all inputs allowing continual production of the same output as before. Allocative efficiency refers to the capacity of the production unit to mix optimal proportions of inputs and outputs appropriate to their current market price. Thus, economic efficiency refers to the combination of both technical efficiency and allocative efficiency. Therefore, the company cannot be 100 percent economically efficient unless it is 100 percent technically and allocative efficient (Jarraya and Bouri, 2012).

There are two approaches to calculating the efficiency indicators; the first is the input-oriented approach, which minimizes the inputs used in the production to the lowest possible level while the level of production remains constant. The other approach is the output-oriented approach, which increases the production level to the highest possible level while the input level remains constant. The two approaches can specify to the production function under the assumption of constant (CRS) or variable return to scale (VRS) (Eling and Luhnen, 2010).

Efficiency is estimated by comparing firms to the "best practice" efficient frontier formed by the most efficient firms in the industry (Farrell, 1957). The literature distinguishes two main approaches to estimating these frontiers: parametric and non-parametric approach. The parametric approach requires the specification of functional form of the production, cost and profit frontier and some distributional assumptions about the error term. On the other hand, non-parametric approach does not assume any specific functional form for evaluating efficiency, and therefore, does not take into account the error term. The most widely non-parametric or mathematical approach used is DEA introduced by Charnes *et al.* (1978). DEA is a non-parametric approach that employs linear programming technique to construct an efficient frontier that envelopes all the combination between inputs and outputs of firms in the sample. The efficient combination of input and output is in the frontier, while the inefficient combination will be less than that.

The objective of this model is to estimate the production frontier of DMUs that use the same input in the production. The relative efficiency of each unit measured for the purpose of making a comparison and efficiency score is usually standardized between 0 and 1, with the most (least) efficient firm receiving the value of 1 (0). The difference between a company's assigned value and the value of 1 can be interpreted as the company's improvement potential in terms of efficiency (Diacon *et al.*, 2002).

The efficiency of any economic entities is obtained through the maximum of the weighted ratio of outputs to the weighted ratio of inputs, provided that the ratios of similar entities are less or equal to 1 (Charnes *et al.*, 1978).

The model is generally as follows[4]:

$$\text{Max } \theta = \frac{\sum_{r=1}^{s} U_r Y_{ro}}{\sum_{i=1}^{m} V_i X_{io}},$$

subject to:

$$\frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \leqslant 1,$$

where $j=1, \ldots, n$; $U_r,\ V_i \geqslant 0\ U_r,\ V_{rj} \geqslant 0$; $r = 1, \ldots, s$; $i=1, \ldots, m$; $Y_{rj},\ X_{ij} > 0$; s is the number of output; U_r the weight of output r; Y_{ro} the amount of r produced by DMUs; m the number of input; V_i the weight of input i; and X_{io} is the amount of input I used by DMUs.

There are two types of DEA, namely the CRS and VRS. The first model was introduced by Charnes *et al.* (1978) and called DEA–CCR. This model is appropriate when the entities operate at their optimal scale of production where outputs will increase proportionally to the amount of inputs increased. The production possibilities curve can be determined under this assumption and the technical efficiency scores known as the overall technical efficiency.

The second model was developed by Banker *et al.* (1984) and called DEA–BCC. Many factors do not make the entities operate at its optimal level such as incomplete competition and some restrictions on financing and so on. Therefore, the DEA–CCR model may give inaccurate ratios of the technical efficiency of the entities. In this model, technical efficiency is decomposed to pure technical efficiency and scale efficiency.

Measurement of efficiency for insurance sector got significant consideration in recent years, where the empirical researches observed various matters concerning the efficiency of the insurance business. A study was prepared by Fecher *et al.* (1993), which included 84 life and 243 non-life insurance companies in France during the period 1984–1989. By using both parametric and non-parametric approach, the authors observed that there is a great variation in the relative efficiency levels between companies, and there is a correlation between the size, ownership, distribution, reinsurance and claims ratio of the company and its efficiency.

In order to analyze the technical efficiency of 94 insurance companies operating in Italian insurance market for the period 1985–1993 using the DEA model, Cummins *et al.* (1996) found that the result indicated that the level of efficiency during the study period remained constant despite the low productivity in the same period.

Cummins *et al.*'s (1999) study of the US market, which focuses on the life insurance companies during the period 1988–1933, found that the efficiency of insurance companies is relatively low when compared to other companies in other financial sectors in addition to the existing of significant differences in efficiency among those companies.

Diacon (2001) reviewed the efficiency of non-life insurance companies in the UK and compared their counterparts in the European Union. The study included 431 companies in six European countries. The results showed that the efficiency of insurance companies operating in the UK is medium and has the ability to be one of the most efficient companies in the EU. In a study by Diacon *et al.* (2002), which included 450 life insurance companies in 15 European countries, with the aim of identifying the best companies for reference and measuring the performance of other companies, they found significant differences in the level of efficiency between countries. In addition, there was a decrease in the average level of technical efficiency during the study period. Also by using tobit regression they found that mutual companies have higher levels of efficiency than stock companies, the most efficient insurer are those that specialized in particular market sectors and solvency ratios are associated with higher level of technical efficiency.

Hardwick *et al.* (2004) evaluated 50 life insurance companies in various organizational forms to verify the relationship between corporate governance and efficiency and found that the efficiency of companies increases as a number of board of directors increases.

Borges *et al.* (2008) used the DEA model to evaluate the performance of Greek life insurance companies during the period 1994–2003. They found that large and equated life insurance companies as well as those involved in merger and acquisition exhibit higher efficiency.

In Jordan, Ajlouni and Tobaishat (2010) studied 22 insurance companies listed in Amman Stock Exchange by using DEA during the period 2000–2016 and showed an improvement in the efficiency of companies during the study period, and the efficiency of life and non-life is nearly close.

3. Data and methodology

The study used panel data for 22 out of 24 insurance companies operating inside Jordan covering the period 2000–2016. Two companies excluded from the study due to unavailability of data covering the entire study period. The data were collected from the annual financial statements of the insurance companies.

In insurance, there are three main inputs: business, capital and business services, and there are three main approaches for measuring the output of the insurance industry: asset or intermediation approach, user-cost approach and value-added approach.

The value-added approach emphasizes the importance of outputs if they contribute significant added value based on operating cost allocations. This approach is the most used approach for studying insurance companies' efficiency (Cummins and Weiss, 2000). This approach assumes that insurers offer three main services through risk pooling and risk bearing, real financial services related to insured losses and intermediation by collecting funds and invest them.

Insurers create value added by operating a risk pool, collecting premiums from policyholders and re-distributing most of them to customers who have incurred losses. They also reduce their customers' risks by holding capital to absorb unexpected losses. The second service, "real" financial services relating to insured losses, means that insurers create value added for their policyholders by providing real services such as financial planning (life) or the design of coverage programs (non-life). The third service is intermediation, where insurers create value added by acting as financial intermediaries that invest assets, which policyholders provide by way of their.

DEA results are sensitive to the variables used (inputs and outputs), and the choice of method and variables have an important impact on the measurement and analysis of efficiency. The following variables will be used in efficiency measurement by DEA (Diacon, 2001; Yang, 2006; Alhassan *et al.*, 2015; Jaloudi and Bakir, 2019):

- Inputs: total operating expenses, debt and owner's equity and total technical provisions.
- Outputs: net earned premiums and investments income.

Details of the input and output variables are given in Table I.

Because of the many constraints that prevent companies from operating at their optimal scale of production, and produce a frontier which has increasing returns to scale at low input levels and decreasing returns to scale at high input levels, the DEA model

Variable	Description
Total operating expenses	Includes administrative, general expenses and commission paid as at the end of the year
Debt and owner's equity	Including the paid-up capital of the company in addition to the retained earnings after the issuance of both statutory and voluntary reserves and premium on paid-up capital, as well as the value of the change in the investment valuation reserve as at the beginning of the year. Plus borrowing from banks
Total technical provisions	Includes the provision for unearned premiums, outstanding claim provision and the mathematical reserve at the end of the year
Net earned premiums	Premiums written by the company after excluding reinsurers' share plus the value of the change in the unearned premium provision after excluding the reinsurer's share (for non-life insurance business) or the value of the change in the mathematical reserve after deducting reinsurers' share (for life insurance)
Investments income	Including the profits from financial investments in addition to the interest on deposits in banks and interest earned on bonds owned by the company

Table I. Input and output variables description with a VRS (DEA–BCC) is used to evaluate the level of efficiency for insurance companies in Jordan. As follows:

$$\text{Min}_{\theta,\lambda}\theta,$$

subject to:

$$-Y_j + Y\lambda \geqslant 0$$

$$\theta X_j - X\lambda \geqslant 0$$

$$Z'\lambda = 1$$

$$\lambda \geqslant 0,$$

where $[X]_{i,j}$ is the input matrix; $[Y]_{r,j}$ is the output matrix; λ is the vector of the variables weights; Z is scale constraint; and θ represents the technical efficiency of the DMUs, where $0 \leqslant \theta \leqslant 1$.

4. Data analysis and findings

DEA analysis result

Table II summaries the average technical efficiency per year for the insurance companies in Jordan during the period 2000–2016. The result of DEA analysis shows, in general, that during the period of study there is a slight development of technical efficiency for the Jordanian insurance companies, where it was 89.0 percent in 2000 and reached 92.5 percent in 2016. The year 2012 witnessed the highest level of efficiency reached by the insurance companies, i.e. 94.0 percent, while the lowest level of the efficiency of these companies was in 2001 as it was 80.1 percent.

Table III shows that DMU-1 achieved the highest level of efficiency by 100 percent and it was the benchmark for the other companies. A total of 12 companies had average efficiency

Table II. Average technical efficiency per year for the insurance companies in Jordan during the period 2000–2016

Year	Average efficiency (%)	Year	Average efficiency (%)
2000	89.0	2008	92.6
		2009	91.7
2001	80.1	2010	85.5
2002	89.8	2011	91.6
2003	85.2	2012	94.0
2004	82.5	2013	90.5
2005	92.7	2014	91.2
2006	92.9	2015	92.5
2007	92.8	2016	92.5

Table III. Average technical efficiency per company for the insurance companies in Jordan during the period 2000–2016

DMU	Efficiency score (%)	DMU	Efficiency score (%)
DMU-1	100.0	DMU-12	91.1
DMU-2	99.7	DMU-13	89.2
DMU-3	99.5	DMU-14	88.0
DMU-4	98.4	DMU-15	87.4
DMU-5	97.4	DMU-16	86.0
DMU-6	96.8	DMU-17	85.7
DMU-7	95.5	DMU-18	83.7
DMU-8	94.7	DMU-19	78.5
DMU-9	93.5	DMU-20	77.3
DMU-10	93.4	DMU-21	77.0
DMU-11	92.2	DMU-22	72.5

greater than 90 percent during the study period, while 5 companies with an average efficiency of 80–90 percent, 4 companies' efficiency was lower than 80 percent and the lowest company in terms of efficiency was DMU-22 at 72.5 percent.

If a firm is fully efficient (efficiency = 100) then it has only one peer group firm, itself. Companies that are more efficient than 90 percent are considered to perform well in comparison with their inputs in the production process; this indicates that most firms operating in Jordan were highly efficient during 2000–2016. These companies are characterized either by higher output such as DMU-1 or lower use of production inputs compared to other companies as they depend on certain types of insurance such as motor compulsory insurance, which does not require high expenses to achieve premiums. And these companies can reduce their use of inputs to reach full technical efficiency.

The second group of companies, which ranged between 80 and 90 percent, could achieve the same outputs using less input; these companies are a composite insurer (life and non-life). The third and fourth groups, which ranged between 70 and 80 percent, had large inputs and could achieve the same outputs by significantly reducing their inputs. The third and fourth groups reflect a poor management skill and did not achieve the best balance between its inputs and outputs. Also, it has a diversified portfolio without the focus on certain line of insurance, which caused an increase in its expenses and disproportionate in its premiums and investment income with the inputs used.

Table AI illustrates that there is a substantial efficiency difference among insurance companies in each year, for example in 2000, 9 companies achieved the level of efficiency 100 percent, while the other companies fell from this level. In addition, the lowest level of efficiency in that year was 60.9 percent.

In addition, there is a variation at the level of each company each year, which affects the average efficiency during the study period. For example, the fluctuation in the efficiency of DMU-120, which was in 2000 68.5 percent and increased to 97.9 percent in 2002, then reach 72.2 percent in 2004, and increased to achieve the full technical efficiency during the years 2005–2008, then decreased in 2009 to 80.8 percent and fluctuated during the years 2010–2016 and reached 91.1 percent at the end of 2016.

These results are similar to those of Ajlouni and Tobaishat (2010) in terms of the technical efficiency of the insurance companies. However, there is difference in the efficiency scores of the companies between the two studies because they calculate the efficiency scores under the assumption of a CRS, contrary to our study, which uses the assumption of a VRS.

5. Determinants of efficiency

Slacks-based model

The inefficiency is either from using inputs incorrectly, or these inputs cannot achieve the required level of output. Therefore, if companies reduce their use of inputs to achieve the same level of output, it will be possible to upgrade their efficiency to achieve full technical efficiency.

For inefficient firm, the input target will be less than actual input. The difference between actual input and target input is input slack, and it can be expressed as a percentage:

$$\text{Input slack percentage} = \frac{\text{Actual input} - \text{Input target}}{\text{Actual input}} \times 100,$$

whereas the input target can be calculated in the following form:

$$\text{Input target} = \text{Actual input} \times \text{Relative efficiency}/100.$$

Table AII shows the percentage of input that must be reduced in order to achieve the full efficiency for each company. By reviewing the ratio for each company, it is clear that the owner's equity and debt are the most important determinant of firm efficiency, followed by technical reserves. Operating expenses were the least important determinants of efficiency.

It is possible to reach the current level of output by reducing the owner's equity and debt by 6.33 percent, its technical reserves by 0.85 percent and operating expenses by 0.27 percent. Thus, the companies achieve the full technical efficiency.

Logit model

To examine how external factor affects the efficiency level for the insurance companies, this study uses the logit model to analyze the size and direction of the relative effect of the independent variable in their impact on the efficiency. One of the main advantages of logit regression is that it does not require a linear relationship between dependent and independent variables, and it can handle various types of relationships because it applies a non-linear log transformation to the predicted odds ratio. Those external variables are not decision variables that would otherwise figure in the firm's choice of the nature or level of inputs and or/outputs as that already been included in the DEA analysis.

The suggested model can be formed as follows:

$$\theta_{it} = \alpha + \beta_1 \text{Size}_{it} + \beta_2 \text{Rein}_{it} + \beta_3 \text{ROA}_{it} + \beta_4 \text{Type}_{it} + \varepsilon_i,$$

where α represents the constant; i is the insurance company; t the time period (in years); θ the technical efficiency; Size the natural logarithm of assets; Rein the reinsurance ratio; ROA the return on assets; Type the type of insurance company; βs the model parameters; and ε is the random error.

The dependent variable (efficiency) converted to a binary outcome: (0, 1) expressing that the company is efficient or not, where the variable takes the value (1) by probability (P) if the company is technically efficient, and the value (0) with probability of ($1-P$) if company is not technically efficient.

Size: size of the insurer i in time t. Large insurers expected to benefit from economies of scale and scope in the form of lower per unit cost of production derived from the large scale of production. In other hands, the inability of the larger firm to monitor and control activities of large-scale operation results in diseconomies of scale, a negative relationship. Size of the insurer is measured by natural logarithm of company assets.

Rein: reinsurance of the insurer i in time t. Reinsurance is a way of transferring the risk from the insurer to the reinsurer, in order to protect the insurer from unexpected financial losses that may expose to it. This variable is measured by dividing the total amount transferred to the reinsurers to the total premiums written by the insurer.

ROA: return on asset of the insurer i in time t. Profitability of insurer proxy by ROA to investigate if there is a relationship with technical efficiency.

TYPE is a dummy variable equal to 1 for composite (life and non-life) insurer and 0 for life or non-life insurer, aiming to capture the role of business line diversification on efficiency.

Table IV shows the results of the logit models that investigate the probability if the company is efficient employing the explanatory variables mentioned above.

Based on the maximum likelihood estimation, the result indicated that the type of insurance has a significant impact on the efficiency of the company. The coefficient is negative which means that the proportion of insurer being efficient decreased by 1.273 times in case if the insurer licensed as a composite (life and non-life).

This result can be explained as while the insurer being just life or non-life insurer, it will enhance the efficiency through concentrating the efforts and resources on the specific line of business in a way that increases the insurance efficiency. This finding is consistent with the number of previous studies such as Barros *et al.* (2005) and Diacon (2001), and contrary to what came in the study of Wasseja and Mwenda (2015).

The result supports that the size of the insurer plays a role in achieving the full technical efficiency, where the coefficient is positive and statically significant at 10 percent.

Variable	Coefficient
Size	0.270659*** (0.146413)
Rein	−0.08912 (0.816565)
Type	−1.273139* (0.270336)
ROA	2.467615** (1.163194)
C	−3.700586 (2.381742)
Log likelihood	−242.3529
LR statistic	33.72552
Cox–Snell *r*	0.086229
Nagelkerke *r*	0.114976

Notes: Standard errors in parentheses. *,**,***Significant at 1, 5 and 10 percent levels, respectively

Table IV. Regression result

Large insurer seems to have improved flexibility to arrange the best combination of inputs and outputs and benefits from the economies of scale. This finding supports Diacon *et al.* (2002), Barros *et al.* (2005) and Yao *et al.* (2007).

Return on assets variable highlight the role of profitability in enhancing the chance that insurer being efficient, where the result indicates that ROA increases the chance of being efficient by 2.46 times. The result is consistent with the findings of Gramanova and Strunz (2017) and Diacon (2001).

However, reinsurance had no statically significant impact on the insurer efficiency, which means that reinsurance does not matter to efficiency.

The log likelihood ratio for the model, which is testing whether the coefficients are simultaneously significantly different from zero, confirms the general statistical significance of the model at the 1 percent level of significance. Pseudo R^2 values are also calculated (Cox and Snell and Nagelkerke pseudo R^2). This value is an indicator of the percentage of the variance in the dependent variable explained by the model; the results considered acceptable since econometric estimation based on cross-section data usually shows low R^2, particularly logistic regression (Gujarati, 2003).

6. Conclusions and recommendations

This study aimed to evaluate the insurance companies in Jordan during the period 2000–2016 by measuring the technical efficiency of these companies and its determinants. The study uses panel data for 22 insurance companies operating in Jordan, where the technical efficiency and factor that appear to affect its efficiency were estimated by utilizing DEA, slacks-based and logit models.

The study finds that there is a slight development of technical efficiency for the Jordanian insurance companies during the study period. In addition, there is a substantial efficiency difference among insurance companies in each year, and there is a variation at the level of efficiency for each company each year.

The results also showed that owners' equity is among the most important internal determinants of companies' efficiency, followed by technical provisions and operating expenses. The external determinants identified by the logit model support that there is a significant correlation between type, size and return on assets of the insurer and its efficiency.

Based on the results, the study recommends improving the technical efficiency of low-efficiency companies by reducing the level of inputs used, reallocating the resources used to maximize efficiency and increasing the managerial skills to achieve the full efficiency, as the results showed that it is possible to reach the same current level of output by reducing on average the owner's equity and debt by 6.33 percent, technical provisions by 1.82 and operating expenses by 0.85 percent.

In addition, insurance companies should focus on specific types of insurance (life or non-life) and should increase their size through merger with each other's (specially inefficient companies) to reach economies of scale, and regulator must take action to encourage such mergers, since the results showed that these factors positively affect the efficiency of the insurer that operates in Jordan.

Notes

1. Technology in insurance related to the information processing technology. Various insurers face the same operating environment, thus, share the same technology.
2. Insurance industry comprises of all the insurance companies active in a particular country.
3. DMUs in this study refer to the insurer operating in Jordan.
4. Appendix 1 illustrates how DEA is used to evaluate the relative efficiency.

References

Ajlouni, M. and Tobaishat, S. (2010), "The effect of technical efficiency in insurance companies on stock performance: data envelopment analysis (DEA) evidence from Jordanian companies listed in Amman Stock Exchange (ASE) during the period (2000–2006)", *International Journal of Strategic Management*, Vol. 10 No. 1, pp. 67-75.

Alhassan, A., Adidsson, K.J. and Asamoah, M.F. (2015), "Market structure, efficiency and profitability of insurance companies in Ghana", *International Journal of Emerging Markets*, Vol. 10 No. 4, pp. 648-669.

Banker, R.D., Charnes, A. and Cooper, W.W. (1984), "Some models for estimating technical and scale inefficiencies in data envelopment analysis", *Management Science*, Vol. 30 No. 9, pp. 1078-1092.

Barros, C., Barroso, N. and Borges, M. (2005), "Evaluating the efficiency and productivity of insurance companies with malmquist index: a case study for Portugal", *The Geneva Papers on Risk and Insurance*, Vol. 30 No. 2, pp. 244-267.

Battese, G. (1992), "Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics", *Agriculture Economics*, Vol. 7, pp. 185-208.

Borges, M.R., Nektarios, M. and Barros, C.P. (2008), "Analyzing the efficiency of the Greek life insurance industry", *European Research Studies*, Vol. XI No. 3, pp. 648-669.

Charnes, A., Cooper, W. and Rhodes, E. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational research*, Vol. 2, pp. 429-444.

Cummins, D. and Weiss, M. (2000), "Analyzing firm performance in the insurance industry using frontier efficiency methods", working paper, The Wharton Financial Institution Center, University of Pennsylvania, PA.

Cummins, J.D., Tennyson, S. and Weiss, M.A. (1999), "Consolidation and efficiency in the US life insurance industry", *Journal of Banking and Finance*, Vol. 23 Nos 2-4, pp. 325-357.

Cummins, J.D., Turchetti, G. and Weiss, M.A. (1996), "Productivity and technical efficiency in the Italian insurance industry", working paper, Wharton Financial Institutions Center, University of Pennsylvania, Philadelphia, PA.

Diacon, S. (2001), "The efficiency of UK general insurance companies", CRIS Discussion Paper Series No. 2001III, Center for Risk & Insurance Studies, Nottingham University Business School, Nottingham.

Diacon, S.R., Starkey, K. and O'Brein, C. (2002), "Size and efficiency in European long-term insurance companies: an international comparison", *The Geneva Papers on Risk and Insurance*, Vol. 27 No. 3, pp. 444-466.

Eling, M. and Luhnen, M. (2010), "Efficiency in the international insurance industry: a cross-country comparison", *Journal of Banking & Finance*, Vol. 34 No. 7, pp. 1497-1509.

Farrell, M. (1957), "The measurement of productive efficiency", *Journal of the Royal Statistical Society. Series A (General)*, Vol. 120 No. 3, pp. 253-290.

Fecher, F., Kessler, D., Perelman, S. and Pestieau, P. (1993), "Productive performance in the French insurance industry", *Journal of Productivity Analysis*, Vol. 4 Nos 1-2, pp. 77-93.

Gramanova, E. and Strunz, H. (2017), "Efficiency of insurance companies: application of DEA and tobit analysis", *Journal of International Studies*, Vol. 10 No. 3, pp. 250-263.

Gujarati, D. (2003), *Basic Econometrics*, McGraw-Hill Book Company, New York, NY.

Hardwick, P., Adams, M. and Zou, H. (2004), "Corporate governance and cost efficiency in the United Kingdom life insurance industry", European Business Management School Working Paper No. EBMS/2003/1, Swansea.

Jaloudi, M. and Bakir, A. (2019), "Market structure, efficiency, and performance of Jordan insurance market", *International Journal of Business and Economic Research*, Vol. 8 No. 1, pp. 6-13.

Jarraya, B. and Bouri, A. (2012), "Efficiency concepts and investigations in insurance industry: a survey", *Management Science Letters*, Vol. 3 No. 1, pp. 39-54.

Wasseja, M.M. and Mwenda, S.N. (2015), "Analysis of the efficiency of life assurance companies in Kenya using the DEA model", *American Journal of Mathematics and Statics*, Vol. 5 No. 2, pp. 60-71.

Yang, Z. (2006), "A two-stage DEA model to evaluate the overall performance of Canadian life and health insurance companies and computer", *Mathematical and Computer Modelling*, Vol. 43 Nos 7-8, pp. 910-919.

Yao, S., Han, Z. and Feng, G. (2007), "On technical efficiency of China's insurance industry after WTO accession", *China Economic Review*, Vol. 18 No. 1, pp. 66-86.

Further reading

Alhassan, A. and Biekpe, N. (2016), "Competition and efficiency in the non-life insurance market in South Africa", *Journal of Economic Studies*, Vol. 43 No. 6, pp. 882-909.

Barros, P. and Obijiaku, E.L. (2007), "Technical efficiency of Nigerian insurance companies", Working Paper No. 18, Department of Economics, Institute for Economics and Business Administration, Technical University of Lisbon, Lisbon.

Eling, M. and Huang, W. (2011), "An efficiency comparison of the non-life insurance industry in the BRIC countries", Working Paper No. 94, Risk Management and Insurance, Institute of Insurance Economics, University of St Gallen, Gallen.

Appendix 1. DEA mathematical model

The linear programming technique is used to find the set of coefficients (*U*s and *V*s) that will give the highest possible efficiency ratio of outputs to inputs for the service unit being evaluated.

In this model, j is the number of decision-making units (DMUs) being compared in the DEA analysis; DMU_j is DMU number j; θ is efficiency score of the DMU being evaluated by DEA; Y_{rj} is amount of output r used by DMU_j; X_{ij} is amount of input i used by DMU_j; i is number of inputs used by the DMUs; r is number of outputs generated by the DMUs; U_r is coefficient or weight assigned by DEA to output r; and V_i is the coefficient or weight assigned by DEA to input i.

The data required to apply DEA are the actual observed outputs produced, Y_{rj}, and the actual inputs used, X_{ij}, during one time period for each DMU in the set of units being evaluated. Hence, X_{ij} is the observed amount of the ith input used by the jth DMU, and Y_{rj} is the amount of rth output produced by the jth DMU.

If the value of θ for the DMU being evaluated is less than 100 percent, then that unit is inefficient, and there is the potential for that unit to produce the same level of outputs with fewer inputs.

To illustrate the DEA mathematical model:

$$\text{Max } \theta = \frac{U_1 Y_{10} + U_2 Y_{20} + \cdots + U_r Y_{r0}}{V_1 X_{10} + V_2 X_{20} + \cdots + V_m X_{m0}} = \frac{\sum_{r=1}^{s} U_r Y_{ro}}{\sum_{i=1}^{m} V_i X_{io}}.$$

(Maximize the efficiency score θ for DMU 0).

This is subject to the constraint that when the same set of U and V coefficient is applied to all other DMUs being compared, no DMU will be more than 100 percent efficient as follows:

$$\text{DMU}_1 \ \frac{U_1 Y_{11} + U_2 Y_{21} + \cdots + U_r Y_{r1}}{V_1 X_{11} + V_2 X_{21} + \cdots + V_m X_{m1}} = \frac{\sum_{r=1}^{s} U_r Y_{r1}}{\sum_{i=1}^{m} V_i X_{i1}} \leqslant 1$$

$$\text{DMU}_2 \ \frac{U_1 Y_{12} + U_2 Y_{22} + \cdots + U_r Y_{r2}}{V_1 X_{12} + V_2 X_{22} + \cdots + V_m X_{m2}} = \frac{\sum_{r=1}^{s} U_r Y_{r2}}{\sum_{i=1}^{m} V_i X_{i2}} \leqslant 1$$

…

$$\text{DMU}_0 \ \frac{U_1 Y_{10} + U_2 Y_{20} + \cdots + U_r Y_{r0}}{V_1 X_{10} + V_2 X_{20} + \cdots + V_m X_{m0}} = \frac{\sum_{r=1}^{s} U_r Y_{r0}}{\sum_{i=1}^{m} V_i X_{i0}} \leqslant 1$$

…

$$\text{DMU}_j \ \frac{U_1 Y_{1j} + U_2 Y_{2j} + \cdots + U_r Y_{rj}}{V_1 X_{1j} + V_2 X_{2j} + \cdots + V_m X_{mj}} = \frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}} \leqslant 1$$

$$U_1, \ldots, U_s > 0 \text{ and } V_1, \ldots, V_m \geqslant 0.$$

DEA differs from a simple efficiency ratio in that it accommodates multiple inputs and outputs and provides significant additional information about where efficiency improvements can be achieved and the magnitude of these potential improvements. Moreover, it accomplishes this without the need to know the relative value of the outputs and inputs that were needed for ratio analysis.

Appendix 2

DMU	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	2005 (%)	2006 (%)	2007 (%)	2008 (%)
DMU-1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DMU-2	100.0	100.0	100.0	99.5	95.1	100.0	100.0	100.0	100.0
DMU-3	100.0	92.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DMU-4	100.0	91.6	84.3	100.0	100.0	100.0	100.0	100.0	98.4
DMU-5	90.2	96.6	100.0	85.0	89.9	100.0	100.0	100.0	100.0
DMU-6	100.0	100.0	100.0	100.0	100.0	100.0	96.8	100.0	100.0
DMU-7	100.0	79.0	90.2	53.8	100.0	100.0	100.0	100.0	100.0
DMU-8	76.1	57.7	100.0	95.5	100.0	100.0	100.0	100.0	100.0
DMU-9	85.6	100.0	93.5	100.0	98.4	95.7	96.4	100.0	91.3
DMU-10	91.5	91.7	100.0	100.0	87.5	94.4	88.1	100.0	100.0
DMU-11	100.0	79.5	74.3	82.4	67.1	100.0	100.0	94.5	98.4
DMU-12	68.5	88.6	97.7	77.8	72.2	100.0	100.0	100.0	100.0
DMU-13	100.0	100.0	100.0	100.0	100.0	100.0	100.0	69.1	75.8
DMU-14	80.0	50.3	100.0	77.4	61.5	82.6	100.0	100.0	100.0
DMU-15	90.5	100.0	99.5	100.0	100.0	100.0	56.9	87.4	100.0
DMU-16	60.9	34.8	71.7	55.5	67.3	82.3	88.7	100.0	100.0
DMU-17	85.4	85.0	100.0	100.0	71.2	100.0	56.4	100.0	68.8
DMU-18	74.4	82.6	100.0	62.5	58.4	92.8	100.0	82.1	100.0
DMU-19	84.8	50.5	73.7	44.0	51.2	78.2	98.3	75.5	76.5
DMU-20	100.0	71.3	69.0	59.0	57.0	64.4	100.0	61.3	71.6
DMU-21	72.4	52.8	69.7	82.9	85.5	75.0	100.0	100.0	100.0
DMU-22	96.8	63.1	52.5	100.0	52.2	73.0	66.2	65.3	67.1
Average	89	80	90	85	82	93	93	93	93

DMU	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	Average (%)
DMU-1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DMU-2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7
DMU-3	100.0	99.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
DMU-4	100.0	100.0	98.7	100.0	100.0	100.0	100.0	100.0	98.4
DMU-5	100.0	100.0	100.0	100.0	97.0	97.0	100.0	100.0	97.4
DMU-6	86.7	82.6	97.9	100.0	81.5	100.0	100.0	100.0	96.8
DMU-7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.5
DMU-8	95.9	94.4	89.8	100.0	100.0	100.0	100.0	100.0	94.7
DMU-9	97.5	100.0	93.5	71.8	79.9	91.4	97.5	97.5	93.5
DMU-10	100.0	100.0	100.0	100.0	96.6	82.9	77.4	77.4	93.4
DMU-11	78.9	100.0	100.0	100.0	100.0	98.5	100.0	100.0	92.6
DMU-12	80.0	91.0	96.3	98.9	98.1	97.3	91.1	91.1	91.1
DMU-13	89.2	72.5	87.9	81.5	92.7	93.6	77.4	77.4	89.2
DMU-14	100.0	87.4	79.3	100.0	88.3	89.0	100.0	100.0	88.0
DMU-15	57.2	71.5	100.0	100.0	87.0	64.7	85.4	85.4	87.4
DMU-16	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	86.0
DMU-17	100.0	61.2	62.0	81.5	100.0	84.8	100.0	100.0	85.7
DMU-18	89.7	83.0	100.0	91.7	68.9	77.0	79.4	79.4	83.7
DMU-19	100.0	67.5	97.2	100.0	93.1	96.0	73.9	73.9	78.5
DMU-20	94.5	50.1	100.0	97.7	75.0	82.3	80.3	80.3	77.3
DMU-21	59.7	51.8	55.0	63.5	62.6	77.5	100.0	100.0	77.0
DMU-22	85.1	75.4	59.6	80.6	73.8	80.6	70.9	70.9	72.5
Average	92	86	92	94	91	91	92	92	90

Table AI. Technical efficiency of insurance company in Jordan for the period 2000–2016

Appendix 3

DMU	Technical reserves (%)	Variable return to scale Operating expenses (%)	Owner's equity+debt (%)
DMU-1	0.00	0.00	0.00
DMU-2	−5.00	0.00	−1.42
DMU-3	−0.98	0.00	−4.88
DMU-4	0.00	−0.16	0.00
DMU-5	−0.43	0.00	−3.99
DMU-6	0.00	0.00	−5.84
DMU-7	−0.24	0.00	0.00
DMU-8	−0.53	−0.25	−16.32
DMU-9	−7.48	−0.05	−3.16
DMU-10	−3.07	0.00	−6.35
DMU-11	−0.70	−0.56	0.00
DMU-12	−1.69	−0.05	−8.39
DMU-13	−3.76	0.00	−16.96
DMU-14	−0.07	−0.86	−2.86
DMU-15	−2.88	0.00	−19.90
DMU-16	−0.29	−0.03	−1.73
DMU-17	−2.71	−0.01	−21.07
DMU-18	0.00	−14.49	−11.03
DMU-19	−3.25	−0.40	−5.43
DMU-20	−1.94	−1.06	−2.16
DMU-21	−3.66	−0.27	−0.46
DMU-22	−1.31	−0.61	−7.23
Average	−1.82	−0.85	−6.33

Table AII.
Input slacks

About the author
Mutasem Mahmoud Jaloudi is Head of Technical Supervision Division in the insurance directorate at the Ministry of Industry, Trade and Supply in Jordan. He has a PhD Degree in Business Economics from the University of Jordan. His research interests are economics (micro and macro), insurance economics and financial economics. Mutasem Mahmoud Jaloudi can be contacted at: m_jdi@hotmail.com

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**