



EFFECTIVENESS OF POWER SECTOR REFORMS ON SOCIAL ASPECT OF CORPORATE SUSTAINABILITY OF ELECTRICITY GENERATION IN SRI LANKA

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Abstract

Sri Lanka has monopolistic electricity sector, which has no competition within the business. Hence, the introduction of power sector reforms (PSR) to the electricity sector was very important to improve the efficiency of the sector. With the enactment of the Sri Lanka Electricity Act, PSR was introduced in 2009 and subsequent amendment in 2013. However, it has not clearly identified or recognized the effectiveness of the PSR on social aspect of corporate sustainability (SACS) of electricity generation. Since reforms were introduced way back in 2009, it is vital to understand its effectiveness to identify the necessary amendments to reshape it. The effectiveness of PSR is measured with the electricity customers' opinions using the data collected through scale with trained artificial neural network (ANN) model. According to the findings present, PSR has less effectiveness on SACS in Sri Lankan context. However, some of the dimensions of SACS have been improved with some of the

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dimensions of PSR. Further, it has been revealed that possibility is there to enhance SACS with further PSR. Hence, it is vital to consider by policy making authorities on PSR initiatives which can enhance the SACS.

1. Background

Sri Lanka Electricity Act No. 20 of 2009 was enacted to introduce independent regulatory mechanism to monopolistic electricity sector of Sri Lanka and some amendments were introduced in 2013. PSR often focuses on aspects such as cost, incentives, market structure but service quality, achieving social objectives is vital (Jensen and Berg [6]). As such, special focus has to be driven to improve the SACS of the electricity generation. According to Lyimo [8], availability and reliability of energy services are vital for the proper functioning and development of all other sectors of the economy. Hence, the introduction of effective reforms to the electricity sector is very important as it allows competition, regulation of the sector and improves the overall efficiency of the sector. However, it has not clearly identified or recognized effectiveness of the reforms on the social aspect of the electricity generation in order to modify or reshape the PSR. Amarawickrama and Hunt [1] reiterated the implementation of reforms of the electricity supply industry in an efficient and effective way to ensure the full benefits of the PSR.

Opinion of stakeholders is very important on the implementation of the PSR as it is a fact that most of the time majority of stakeholders are opposing the PSR as they have different viewpoints on PSR. Mullins [9] emphasized the requirement of identification and consideration of stakeholders' views to transform into the regulations. Hence, measurement of the effectiveness of the PSR is to be timely as PSR was introduced way back in 2009 and no study has been performed in this regard. This kind of study would help policy makers to consider enhanced reforms for achievement of SACS as social acceptance for any business is a key to its continuation (López et al. [7]).

2. Methodology to Measure the Effectiveness of the PSR on SACS

Initially, a pre-test was carried out in two ways: the first draft was sent to six experts in power sector to ascertain the face and content validity of the questionnaire; and confirmatory factor analysis was done to evaluate the questionnaire to determine the factors and it was ended with four factors of PSR and three factors with SACS. The conceptual framework developed with the literature survey has been rearranged as follows:

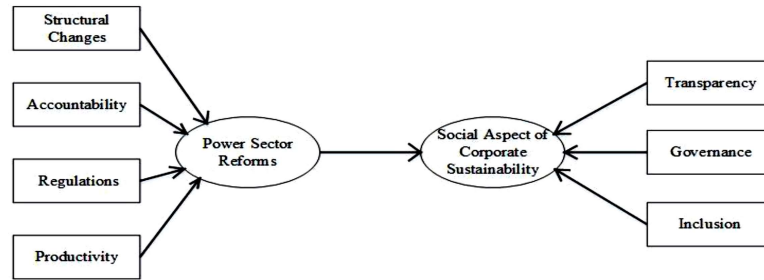


Figure 1. Conceptual framework.

The data were collected from 381 domestic electricity customers selected through random sampling. The ANN model is trained for analyzing the effectiveness of the SACS and PSR. The ANN is able to detect both linear and non-linear relationships (Anouze and Alamro [2]). Phillips et al. [11] explained that an artificial neural network analysis is more appropriate to do the analysis as Likert scale numbers used in the analysis were indicators of perceptions rather than exact observed values and overall pattern is best to define equations among inputs to output. Under the study, the data were collected through the 7 point Likert scale questionnaire from domestic electricity customers. There are four measuring dimensions of the PSR namely, the accountability of the regulator, structural changes, productivity of the sector and regulation and there are three output parameters measuring the SACS namely, transparency, governance, and inclusion. Therefore, the model eventually becomes a six input three output system. The questionnaire circulated among the algorithm has been used to train the proposed model is the Levenberg-Marquardt backpropagation

(Siddique and Tokhi [12]) algorithm with the mean squared normalized error performance function. The activation function used for the neurons in the proposed model is TanSig function. According to Baneshi et al. [4], the vital objective in designing a model is to develop a model that is capable of solving the problem under investigation with a reliable accuracy.

An artificial neural network developed in the MATLAB environment is as shown in Figure 2.

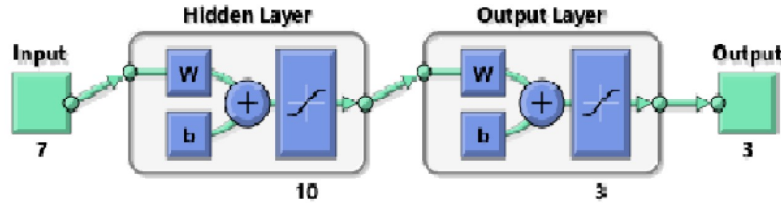


Figure 2. ANN developed in the MATLAB.

Figure 2 is the topology of the proposed ANN, with seven input cells, three output cells and ten hidden cells, all using TanSig as the activation function.

The complete set of responses to the questionnaire comprising of 198 data sets is used as the training set of the model. The model is trained with the parameters as shown in Table 1. There are numerous training algorithms in training ANN. Gershenson [5] discussed the goal of the training as getting desired output with the given inputs.

Table 1. Training parameters and values of ANN model

Training parameter	Epochs	Goal	Minimum gradient	Maximum fails	Limit of μ	μ decrement limit	μ increment limit
Value	1,000	0	1e-7	1,000	0.001	0.1	10

The network was trained with 1,000 iterations in 4 seconds in the MATLAB environment. The training performance is as shown in Figure 3. It is seen that at epoch 0, the network has achieved complete convergence. The due convergence of the network is further evident once the training state is observed as shown in Figure 3.

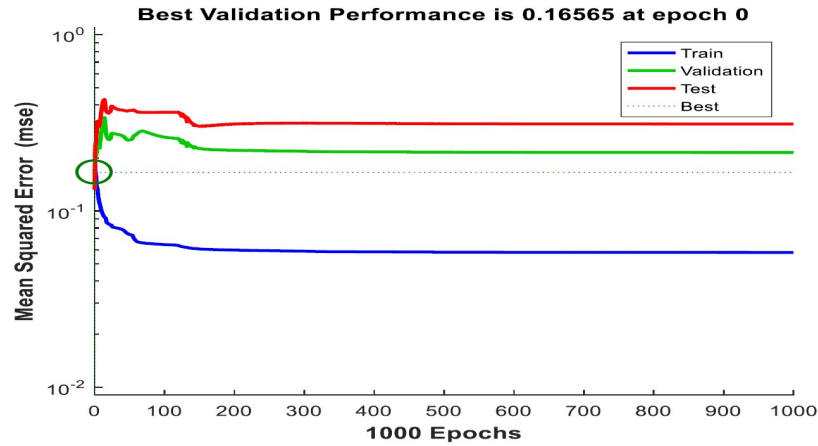


Figure 3. Training performance of the network.

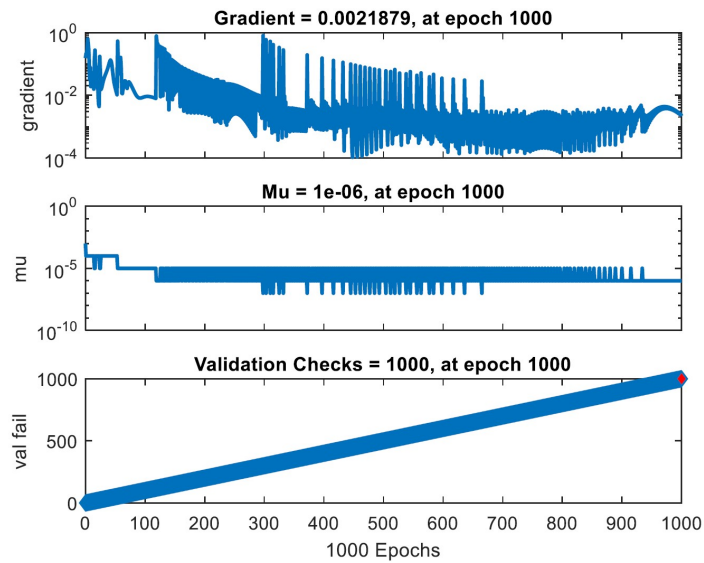


Figure 4. Training state analysis.

It is seen by the observation of Figure 4 that at the point of training, the momentum index μ and the gradient have reduced almost to zero indicating the convergence.

The error histogram of the data set in convergence is as shown in Figure 5.

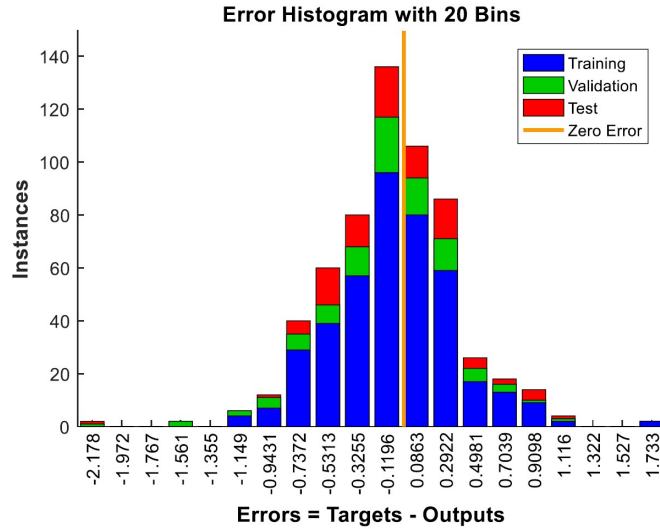


Figure 5. Error histogram.

The developed model is analyzed for the output variance in the axis of freedom. In order to do this, the base data set is taken as the first set of data as shown in Table 2.

Table 2. Baseline data set for the analysis of variance

Power sector reforms					Social aspect of corporate sustainability		
Accountability	Financial status	Structural changes	Regulatory independency	Productivity	Governance	Inclusion	Institutional values
2.0	2.0	2.4	2.3	3.0	2.8	3.0	2.0

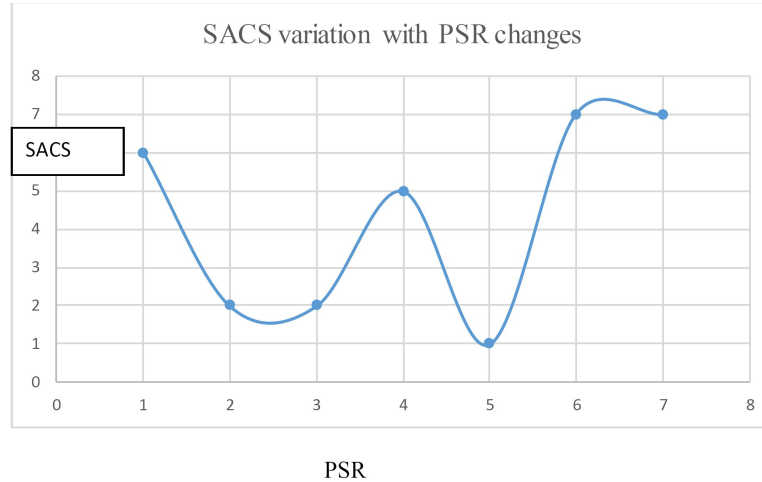
Each parameter related to power sector reforms varied from 0 to 7 while holding the other three input parameters constant and the three output parameters are plotted against the varying parameter.

3. Pattern Identification on Dimensions of SACS with PSR

In this section, the effectiveness of the PSR and SACS is discussed with the change of output due to the variation of the Likert scale of PSR and output variation of SACS results and change of the dimensions of the PSR variable. The effectiveness of the PSR on SACS was analyzed with the ANN to check the pattern variation with the change of input figures of PSR.

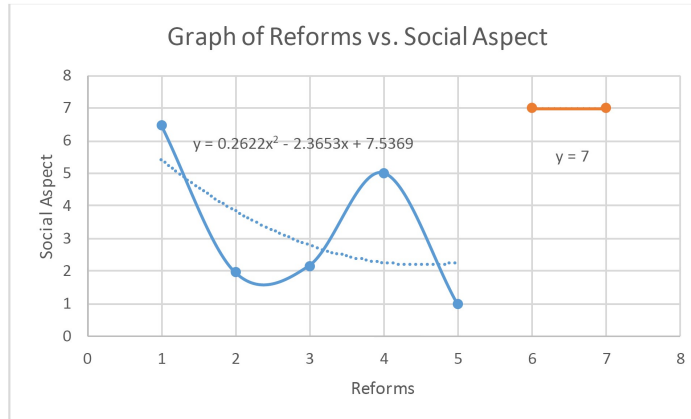
3.1. Pattern design of PSR and SACS

After the ANN model is trained, the graph was plotted with the change of Likert scale of PSR with SACS. The results are as in Graph 1.



Graph 1. Variation of SACS with PSR.

According to Graph 1, the pattern of the variation of SACS is depicted with the change of Likert scale value of PSR. According to the graph, the customers who believe the existing PSR impacts agree that there is no improvement of SACS with the present PSR initiatives. However, perception of the customers who agree with the PSR initiatives is that there is an effectiveness with existing PSR on SACS. However, customers who responded the questionnaire in a safe position that is neutral have indicated that there is no impact or effectiveness with the SACS. This is central tendency biasness as most of the respondents are reluctant to go for any extreme to express their opinion. An interesting observation is that the customers who are in extreme end have responded in a similar manner. It seems that there is abnormal pattern with extreme thinking electricity customers. Hence, to make it clear, trend graph has been plotted in Graph 2. The trend graph splits into two as extreme cases which show abnormal behavior.



Graph 2. Trend graphs of PSR and SACS.

Accordingly, the trend lines show the effectiveness of PSR on SACS with the existing reforms and SACS with the customers' point of view. However, according to the customers' point of view, the effectiveness is very low with the existing PSR.

Hence, more reforms or enhancement of PSR are needed for improved SACS which leads to achieve corporate sustainability of the sector. Accordingly, to check the effectiveness of each dimension of PSR, graphs with the strategy of change in one dimension of PSR have been plotted. The graph is drawn to see the change of one dimension of PSR to the dimensions of the SACS.

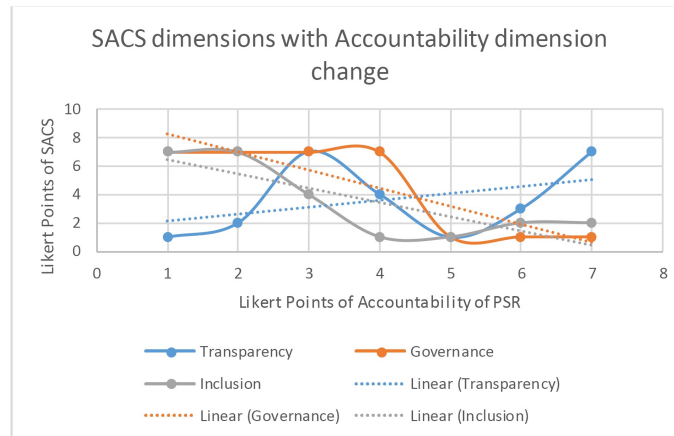
3.2. Behavior of SACS dimensions with the changes of PSR dimensions

There is complex relationship between variables in terms of pattern and models, on one hand, and, interpretations, on the other hand (Pertti et al. [10]). Since this is a type of complex relationship with the variables, different dimensions need proper interpretations. The ANN analysis graphs were developed based on following key assumptions. All the participants' responses were considered as neutral for all the dimensions to check the behavior with SACS while changing one dimension responses as 1 - 7 in numerical figures as the Likert scale and check the behavior of three dimensions of SACS.

Accordingly, the graphs are drawn with the trained ANN. The findings are as follows.

3.2.1. Behavioral change of accountability with the SACS

Accountability factor changes and results are as in Graph 3.



Graph 3. Behavior of dimensions of SACS with the change of accountability dimension of PSR and trending line.

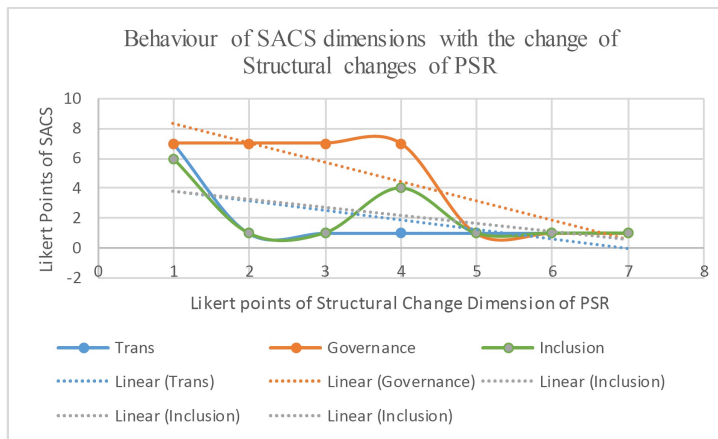
The dotted lines show the trending pattern of the dimension behavior. Accordingly, the opinion of domestic customers is inclusion. Governance dimensions have less impact due to accountability aspect of PSR. However, domestic customers believe that transparency is high under the prevailing PSR. Further, with increase of the accountability, the dimensions of inclusion and governance would improve. The behavior of the dimension of transparency is quite interesting. However, their perception is that if existing accountability reduces, the transparency would reduce. To depict more precise behavior, a trending graph has been plotted.

According to the trending graph, it can be observed that customers' opinion is that the effectiveness of the dimension of accountability of existing PSR is positive only for the transparency aspect and there is low effectiveness on governance and inclusion aspects. Thus, the existing PSR has to be enhanced to achieve the enhancement of governance and inclusion.

3.2.2. Behavior of the dimensions of SACS with the changes of dimension of structural changes of PSR

In Graph 4, behavior of the three dimensions of SACS can be seen with the change of the Likert scale of the structural changes dimension of PSR. Domestic customers’ opinion can be explained as with the prevailing structural changes, aspect of PSR is in the effective level as transparency, governance and inclusion dimensions are improved with the existing PSR initiatives. This could be because of the existing regulations. However, domestic customers believe that inclusion is high under the prevailing PSR. Further with increase of the structural changes dimension, the transparency, governance and inclusion would improve. To explain the effectiveness of the structural changes, the trending lines are plotted for 3 dimensions of SACS.

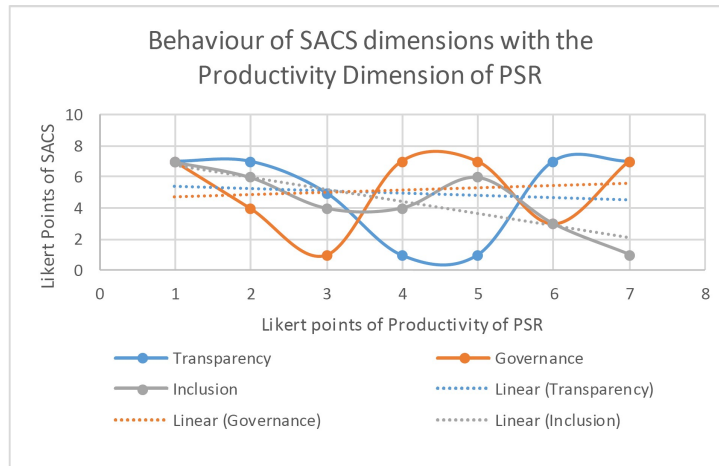
According to Graph 4, trending lines give evidence that the domestic customers are considering that existing structural changes do not help to achieve the SACS. It means that the present structural changes have less effectiveness with the SACS. However, trending lines explained that if further reforms are done, this can be changed.



Graph 4. Behavior of dimensions of SACS with the change of structural changes dimension of PSR and trending graph.

3.2.3. Behavior of the dimensions of SACS with the changes of dimension of productivity improvement of PSR

In this subsection, it had been discussed the changes of three dimensions of SACS with the change of productivity dimension of PSR while keeping other dimensions as the constant.



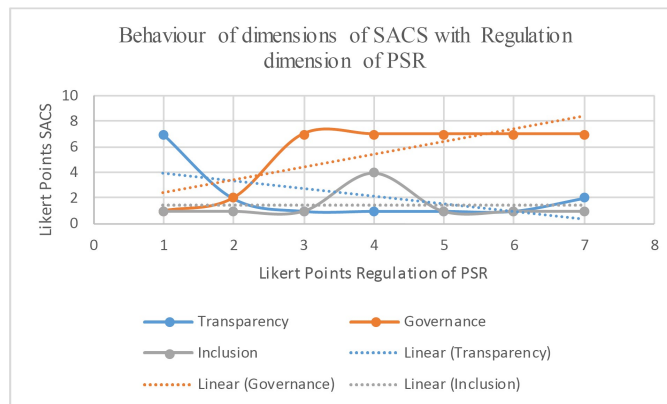
Graph 5. Behavior of the dimensions of SACS with the changes of dimension of productivity improvement of PSR.

It can be noted that with the PSR to achieve CS, the transparency, governance and inclusion have low impact as people believe that the prevailing productivity of PSR is not in the effective level. Further increase of the productivity of PSR, dimensions of SACS, transparency, governance and inclusion would improve. However, it is very interesting to note the behavior of the inclusion, which will enhance the productivity through the PSR. However, the results show that even with the further enhancement of the productivity, the transparency and governance aspects will not be improved. This provides evidence that even further improvement of productivity aspect will not improve the SACS after some point. The behavior of three dimensions with the change of the productivity was plotted with trending line of each dimension.

It can be observed that existing productivity dimension has no effectiveness on present values of transparency, governance and inclusion. However, no significant improvement could be identified with the productivity through the PSR on transparency and governance. This could be basically customers to see the productivity improvement as a utility performance. Hence, they cannot give their opinion on the aspects of SACS.

3.2.4. Behavior of the dimensions of SACS with the changes of dimension of regulation of PSR

As per Graph 6, it can be explained that with the opinion of PSR where it has been implemented to achieve CS, the governance and inclusion have effectiveness as domestic customers believe that the prevailing regulation of PSR is in the effective level. They believe that the existing regulation enhanced the governance and inclusion dimensions of SACS. However, domestic customers believe that transparency is low under the prevailing PSR in terms of regulation aspect. Further increase of the regulation of PSR, dimensions of SACS, transparency, governance and inclusion would improve the situation. The trending line of the changes of the aspects of SACS has been plotted to depict the behavior of the dimensions with the regulation dimension of PSR.



Graph 6. Behavior of the dimensions of SACS with the changes of dimension of regulation of PSR.

4. Discussion and Conclusion

The findings of the effectiveness of the PSR on each dimension of SACS and overall impact on CS have been summarized in Table 3.

Table 3. Summarization of the findings

PSR dimension	ANN behavior pattern with existing PSR			Trending pattern with the enhancement of PSR			Overall corporate sustainability
	Governance	Transparency	Inclusion	Governance	Transparency	Inclusion	
Accountability	Improved	Low	Low	Possible	Possible	No	Can improve
Structural changes	Low	Low	Low	Possible	Possible	Possible	
Productivity	Low	Low	Low	No	No	Possible	

According to the opinion of the respondents, the existing PSR has very low effectiveness on the SACS and the overall impact on the corporate sustainability. It means the present reforms introduced to the electricity sector of Sri Lanka in 2009 have not been that effective on the SACS. According to the sector experts, basically, the PSR considered the efficiency improvement of the sector. According to the ANN model, the possibility is there to enhance SACS by introducing further reforms. However, it is utmost important to select the reforms initiatives which can enhance SACS to achieve overall corporate sustainability. According to Table 3, accountability dimension of PSR has enhanced the governance of the sector. Further regulation has enhanced the dimensions of transparency and inclusion. This could be the reason of selection of the PSR initiatives based on the improvement of efficiency, financial situation (ADB [3]) and economical inefficiencies (Amarawickrama and Hunt [1]) at the PSR commencing stage. However, it can be concluded that the policy makers have to think about the substantial PSR initiatives which can enhance the dimensions of SACS of the electricity generation of Sri Lanka.

References

- [1] H. A. Amarawickrama and L. C. Hunt, The Sri Lankan Electricity Supply Industry: a critique of proposed reforms, *The Journal of Energy and Development* 30(2) (2005), 239-278.
- [2] A. L. M. Anouze and A. S. Alamro, Factors affecting intention to use e-banking in Jordan, *International Journal of Bank Marketing* 38(1) (2019), 86-112.
- [3] Asian Development Bank Assessment of Power Sector Reforms in Sri Lanka: Country Report, Asian Development Bank, Mandaluyong City, Philippines, 2015.
- [4] M. Baneshi, M. Behzadijo, M. Schaffie and H. Nezamabadi-Pour, Predicting log data by using artificial neural networks to approximate petrophysical parameters of formation, *Petroleum Science and Technology* 31(12) (2013), 1238-1248.
- [5] C. Gershenson, Artificial neural networks for beginners, 2003. arXiv: preprint cs/0308031.
- [6] J. C. Jensen and N. Berg, Determinants of traditional sustainability reporting versus integrated reporting. An institutionalist approach, *Business Strategy and the Environment* 21(5) (2012), 299-316.
- [7] M. V. López, A. Garcia and L. Rodriguez, Sustainable development and corporate performance: a study based on the Dow Jones sustainability index, *Journal of Business Ethics* 75(3) (2007), 285-300.
- [8] B. M. Lyimo, Improving Energy Resilience in Tanzania, *Helio International*, 2007.
- [9] D. Mullins, From regulatory capture to regulated competition: an interest group analysis of the regulation of housing associations in England, *Housing Studies* 12(3) (1997), 301-319.
- [10] A. Pertti, B. Leonard and B. Julia, *The SAGE Handbook of Social Research Methods*, 2008.
- [11] P. A. Phillips, F. M. Davies and L. Moutinho, The interactive effects of strategic marketing planning and performance: a neural network analysis, *Journal of Marketing Management* 17(1-2) (2001), 159-182.
- [12] M. N. H. Siddique and M. O. Tokhi, Training neural networks: backpropagation vs. genetic algorithms, *IJCNN'01, International Joint Conference on Neural Networks, Proceedings (Cat. No. 01CH37222)*, IEEE, Vol. 4, 2001, pp. 2673-2678.