EXAMINING EPIRA AND ITS EFFECT ON TECHNICAL AND OPERATIONAL EFFICIENCIES OF THE TOP FIVE PRIVATE DISTRIBUTION UTILITIES IN THE PHILIPPINES: SFA AND DEA APPROACHES

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Abstract

Purpose: The Electric Power Industry Reform Act (EPIRA) was implemented in 2001 to restructure the Philippine Electric Industry. After two decades of EPIRA’s enactment, it is essential to assess where in the Distribution Sector, the reform’s trajectory has stalled. The study aimed to examine and assess the technical and operational efficiencies of the top five electric private distribution utilities (PDUs) in the Philippines under the regulatory policy.

Methodology: This is a causal-comparative study using a panel data structure on technical and operational efficiencies of the top five PDUs in the Philippines from 1995 to 2014, employing quantitative measurement. This study used Data Envelopment Analysis (DEA) as the non-parametric test while Stochastic Frontier Analysis (SFA) as the parametric approach.

Main Findings: Using the Stochastic Frontier Analysis (SFA) model showed that the implementation of EPIRA (post-EPIRA: 2001 to 2014) made the top five electric private distribution utilities in the Philippines more technically efficient in their operations than without the reform (pre-EPIRA: 1995 to 2000). It was also noted that PDUs with bigger franchise areas and older in existence were technically efficient in their operations than their smaller and younger PDUs counterpart, respectively.

Applications: This study will enhance public awareness in the various assessment of regulatory policy arenas in PEI. Moreover, this study will also render useful insights into the management of DUs in the Philippines.

Novelty/Originality of this study: An up-to-date empirical analysis of the situation to substantiate the claim of the reform’s efficiency in the Philippines is lacking in the literature. This paper is thus providing a comprehensive theoretical debate by examining some indications of EPIRA’s efficiency in the Distribution Sector in the Philippines.

Keywords: DEA, Distribution Utility, Operational Efficiency, Restructure, SFA, Technical Efficiency.

INTRODUCTION

In many countries, the electric power industry services are controlled and regulated by the government to ensure that all consumers are served. However, during the 1970s, a reversal of falling prices had been observed in the electricity markets (Blumsack, 2018). These caused some countries to adopt legislation that deregulated (i.e. removing control over prices) and restructured (i.e. creation of new framework) the sector to address the needs of the economies.

According to the study of Das and Nanduri (2009), the common goal of deregulation is to reduce the electricity rates and to increase social welfare. In the Philippines, the primary reasons for overhauling the Philippine Electric Industry (PEI) in 1991 are to address the power shortage that was further confounded and heated up by the Asian financial crisis resulting in the ballooned debt portfolio of the National Power Corporation (NPC). The NPC is a government-owned corporation acting as the transmission grid operator, dominant generator, and supplier of wholesale electricity to distribution utilities. These industry concerns, along with relatively high electricity rates, highly fragmented distribution sector, non-universal access to electricity, and the lack of incentives to drive industry stakeholders to operate more efficiently compelled the government to go through a gradual restructuring (Gabo-Ratio & Tabios-Hillebrecht, 2019). This major decision lead to the enactment of the Republic Act (RA) 9136 or the Electric Power Industry Reform Act (EPIRA) on June 8, 2001. EPIRA introduced reforms in areas of regulation, market structure, and organizational efficiency (Brucal & Ancheta, 2018). It likewise provided for the unbundling of the industry to improve business efficiency and economic growth, fostering competition, and reducing the consumers’ financial burden.

With the implementation of EPIRA, PEI is segregated into four sectors, namely generation, transmission, distribution, and retail electricity supply. The generation segment had a mixed-status which is composed of NPC and private producers where the assets of NPC were sold to private sectors. On the other hand, the distribution segment is composed of private utilities, electric cooperatives, LGU-operated utilities, and other duly authorized entities. Moreover, transmission and distribution are considered natural monopolies, while generation and supply are highly competitive markets.

Among the four sectors of the PEI, this paper focuses on the Distribution Sector. The electric distribution utilities (DUs) were designed to serve the end-users regardless of their nature, size, and paying capacity located within their franchise.
areas. Thus, it can be assumed that DUs’ operational failure has a direct impact on the end-users or the community. As referred to the Distribution Development Plan 2016 – 2025 of the Department of Energy (DOE), there are currently around 151 DUs composed of 121 electric cooperatives, 21 private distribution utilities, and 8 local government unit-owned utilities. These DUs are still run by local monopolies and regulated by the Energy Regulatory Commission (ERC).

As envisioned in EPIRA for the Distribution Sector, greater accountability and operational efficiency should be attained by 2040 (Department of Energy, 2018). The PEP identified the eight “Energy Sector Strategic Directions by 2040” (ESSDs) which will serve as the guiding principle to secure the country’s energy future (Gabis, 2020). To achieve this, one of the initiatives of the government is to implement the transparency of the majority components of the operating expenses of the DUs in the electric bills which started in the June 2003 billing cycle. Having this in place, the DUs are assumed to continuously improve their operational performance thus avoiding public complaints of an unusual increase in their operating costs.

Given the current framework of the electric distribution sector, along with EPIRA’s agenda of attaining greater accountability and operational efficiency, the first general assessment of the reform's positive impact on the industry has to be confirmed. Thus, after two decades of the implementation of EPIRA, it is now the focus of this study to assess whether the reform trajectory in the Distribution Sector has progressed. It has been noted though that the reform has slowly improved with no evident impacts as compared with the pre-reform performance (Urpelainen & Yang, 2019).

As emphasized by Erdogdu (2011), it is only through empirical testing that the true value of electricity reform can be validated. It is the same in this study. To end the theoretical debates in the Philippines, this paper examined some indications of EPIRA's efficiency in the Distribution Sector by using combined Stochastic Frontier Analysis and Data Envelopment Analysis methods.

The study aimed to examine and assess the technical and operational efficiencies of the top five electric private distribution utilities (PDUs) in the Philippines under the regulatory policy, EPIRA. Since EPIRA is designed to achieve operational efficiency in the sector, this study serves as a performance yardstick if the industry reform framework has been efficient in its implementation. Five specific objectives are formulated to substantiate the aim of this study, which include: (1) to analyze and compare the operational efficiency of the top five PDUs in the Philippines under the regulation of EPIRA in terms of (a) total operating expenses; (b) purchased power; and (c) total assets; (2) to examine if total operating expenses, total assets, and purchase power affect total revenue; (3) to investigate whether technical efficiency of the PDUs is systematically affected by age, franchise area, and EPIRA in the Philippines; (4) to measure the slack of the top five PDUs in the Philippines from 1995 to 2014; and (5) to identify the best and worst performers among the top five PDUs in the Philippines.

From these perspectives, this study aims to enhance public awareness in the various assessment of regulatory policy arenas in PEI.

LITERATURE REVIEW

The changes in the electric power sector have affected the mechanical and family unit costs in creating nations in Latin America, the previous Soviet Union, and Eastern Europe. As indicated by (Stern, 2010), on-going examinations affirm that building nations have improved gradually through a clear guideline and efficient execution of management in the telecoms and electricity sector. Higher financial development and advancement of business are both achieved by following the policies of the nation (Jalilian et al., 2003). The establishment of an administrative framework depends on the components of lucidity of its jobs, freedom, and strategy for guaranteeing responsibility. Essentially, consistency, the interest of partners, and the straightforwardness of administrative procedures are said to upgrade the credibility of the organization (Laqui & An, 2014). There are several electricity-related studies in the Philippines (Antonio & Calara, 2014; Posadas & Cabanda, 2007), however, this study is the first to assess the efficiency of regulatory policy (EPIRA) in the country.

The majority of the studies existing in literature are devoted to the assessment of the efficiency level performance of various sectors in the electricity industry. Other empirical studies discussed the effects of structural reform variables such as regulation, competition, and privatization on the level of electricity performance using a qualitative research approach (Aris et al., 2020). The study of Cook (1999) emphasized that the administrative culture advancement is...
compelled due to the absence of the limitation of the government to uphold administrative principles and observing agreements. Further, cultivating conditions that empower rivalry and diminish hostile to serious conduct is an advantageous yet moderate procedure. On the other hand, the study of Dubash (2007) conducted in the administrative offices in Indonesia, Philippines, India, and Thailand, highlighted the need of legitimate thought and should be tended to while planning the changes of the institutional plan and its structure.

Stern and Holder (1999) arranged the formal and casual perspective standards in deciding the appropriate presentation of an administrative system in Asian creating nations. The conventional angle mostly identifies with the institutional plan and incorporates lucidity of jobs, independence, and responsibility while the casual viewpoint identifies with administrative practices and procedures. The casual viewpoint comprises of investment, straightforwardness, and consistency (Zeb et al., 2015). The investigation of Zeb et al. (2015) uncovered an irregularity of guidelines between the vitality sector controllers of Pakistan (e.g., NEPRA and OGRA) and the equivalent passes on a befuddled message to financial specialists. This sort of irregularity causes disharmony in evaluating techniques in the vitality sectors and presentations absence of self-governance and clearness of jobs in NEPRA and OGRA.

In an overview of change and creating economies, Gutiérrez (2003) discovered that administrative change in creating nations has not received a systematic methodology for advancement and upgrade of administration. The paper proposes to prioritize administrative strategies, instruments, and establishments. Further, deliberate endeavors are expected to incorporate the components for the development of the administration. Steiner (2000) assessed the impact on the execution of the electricity age industry in OECD brought about by progression and privatization. Results indicate that privatization, unbundling of age, open access to transmission systems, and the presentation of electricity markets have a critical effect on the exhibition and make ideal conditions for the worldwide extension of the business. On the other hand, the implication of the guideline on the development of the economy in creating nations is exhibited by Jalilian et al. (2003). The examination utilized an econometric model and investigated the impact of administrative administration on financial results. The fundamental discoveries demonstrated that there is a settled connection between monetary execution and administrative quality. The investigation further discovers that the effect of changes compelled/restricted of shortcomings in an open arrangement. Electricity and Telecommunication Regulation in Small and Developing Countries has introduced by Stern (2000). The technique employed was the overview of proof from telecom and electricity enterprises in Asia, Latin America, and Sub Saharan Africa.

The compelling and autonomous administrative offices plays a significant in the achievement and maintainability of the change procedure. Further, administrative offices can be fortified by a better instructive framework. Utility guideline in Ghana Center on Regulation and Competition (CRC) is assessed by Arreyetey & Ahene (2005). In this examination, the approach utilized was a contextual investigation of media transmission, electricity, and water utilities (e.g. three fundamental open utilities in Ghana). It is presumed that the administrative change process is hampered by inadequate administrative mastery; a non-helpful demeanour by some key industry entertained. Jarvis and Sovacool, (2011) present a calculated structure that can be utilized for assessment of administrative frameworks of water and electricity sectors. It proposes a coordinated structure that consolidates the measurements of two primary components of the administrative framework (e.g. administrative substance and administrative administration) to assess administrative viability concerning execution-based results in the arrangement of water and vitality related services. Researchers were prompted to design a study that examined and assessed the technical and operational efficiencies of the top five electric distribution utilities in the Philippines under the regulation of EPIRA. A related study of Goto and Sueyoshi (2011) measured the positive influence of regulatory reform on the operational performance of the US electric utilities using the new DEA model. However, instead of adapting only the new non-parametric DEA model of Goto and Sueyoshi (2011), the Researchers employed both parametric and non-parametric methodologies underlying the elements of benchmarking. Both parametric and non-parametric approaches are popular in benchmarking studies (Anaya & Pollitt, 2017). The absence of this kind of research in the Philippines is the reason why there is no convincing assessment of the electricity’s reform outcomes.

METHODOLOGY
This is a causal-comparative study using panel data structure on technical and operational efficiencies of the top five PDUs in the Philippines from 1995 to 2014, employing quantitative measurement. This study used Data Envelopment Analysis (DEA) as the non-parametric test while Stochastic Frontier Analysis (SFA) as the parametric approach.

Data Description of PDUs
As of 2018 in the Department of Energy (DOE) website, there are 21 private distribution utilities in the Philippines. The study did not include some of the private distribution utilities in the analysis due to a lack of sufficient data to represent the pre-EPIRA period. Based on the submitted documents in SEC i-View from 1995 to 2014, twelve (12) PDUs had an aggregate set of Audited Financial Statement (AFS) business operations under the nature of private distribution utility. Of the twelve (12) PDUs, only the top five utilities based on net revenue generation were selected on account of more than 90% of the market share. These are the Manila Electric Company (MERALCO), Visayan Electric Company (VECO), Davao Light and Power Co. Inc. (DLPC), Cagayan Electric Power and Light Company (CEPALCO), and San Fernando Electric Light and Power Co. (SFELAPCO).
Selection of Variables

While this study made use of the variables about various existing literature on efficiency studies in the electricity industry, Arcos-Vargas et al. (2017), stressed that there was no clear consensus in the literature as to what combination of variables gave the best description of efficiency performance. He suggested that most of the models were based on the orientation of variables from other studies. According to the study of Mihaiu et al. (2010), the following were the direct factors influencing efficiency:

- **Inputs.** These are the expenses incurred for the project/service. The input orientation is adapted from other studies. These variables include operating/operational expenses (Pinheiro, 2012; Zorzo et al., 2017), purchased power cost (Posadas & Cabanda, 2007), and total assets (Goto & Sueyoshi, 2011).

- **Outputs.** These are the results after the project/service has been done which is influenced by the inside factors of the firm. With the improvement of the mentioned inputs, the result affects the total revenue of the PDUs. Thus, the selected outputs are chosen as this signifies the health of a PDU and its operations.

- **Outcomes.** These are the effects covered by a project which are often accomplished in a longer period. Operational efficiency is one of the identifiable outcomes of EPIRA in 2040 as released by the DOE.

- **Environmental factors or Exogenous Shock.** This includes lifestyle, public administration reform, and various socio-economic influences. This study considered EPIRA as an exogenous variable enabling the PDUs to alter business strategies.

Further to the study of Arcos-Vargas et al. (2017), selected contextual variables were comprised of the age of the utilities and the franchise area. These were the ones selected due to the availability of data.

The aforementioned variables are shown in the research paradigm presented in Figure 1.

![Figure 1: Research Paradigm](Author Analysis)

Statistical Treatment of Data

This study is based on the panel data structure of the technical and operational efficiencies of the top five PDUs from 1995 to 2014. These data were taken into account to determine the efficiency of the top five PDUs under the regulation of EPIRA: (1) total revenue as the output, while the inputs are (2) total operating expenses (includes salaries, wages, and employee benefits, contracted services, taxes, fees and permits, provision for doubtful accounts - net, and other expenses), (3) purchased power (includes capacity fees, fixed operating and maintenance fees, and transmission line fees that are accounted for similar to a lease under Philippine Interpretation IFRIC 4, "Determining whether an arrangement contains a lease"), and (4) total assets. These variables were then processed using the statistical benchmarking methods, Stochastic Frontier Analysis and Data Envelopment Analysis, integrally.

One major component of performance is identified as efficiency (Ozcan, 2014; Yap et al., 2020). The foundation of efficiency is expressed as a ratio of output over input. As a result, improvement of efficiency depends on the
increase/decrease movement of either output or input or can be both. Efficiency attainment of EPIRA and PDUs may be the results of various factors. To realize such, this study considered two phases. The first phase is the technical efficiency measurement of EPIRA on the top five PDUs from 2001 to 2014 vis-à-vis pre-EPIRA period from 1995 to 2000. SFA was the efficiency concept to be employed. In the second phase, an input orientation DEA model was used for proportionally reducing the excessive inputs (input slacks) to improve the output (total revenue). This slack-based model or also known as the additive model was incorporated in DEA.

**Phase 1: SFA as a technical efficiency test**

As a parametric method approach, Stochastic Frontier Analysis (SFA) was utilized in this study for measuring the technical efficiency of the top five PDUs under the regulation of EPIRA. This method provides techniques for modeling the frontier concept within a regression framework measuring inefficiency (Cardona & Garcia, 2015). SFA considers the error term which represents inefficiency and statistical noise (Azadeh et al., 2009).

The stochastic frontier production model was developed simultaneously by Meeusen and van den Broeck (1977) and Aigner et al. (1977). The Cobb-Douglas function is commonly used with the following form (Rezaei et al., 2016):

\[ \ln Y_i = \beta_0 + \sum B_j X_{ij} + (V_i - U_i) \]

Where:

- \( \ln \): natural logarithm
- \( B_j \): unknown parameters to be estimated
- \( Y_i \): revenue of the i-th electric distribution utility in time t
- \( X_{ij} \): a vector of inputs for electric distribution utilities I in time t
- \( U_i \): non-negative technical inefficiency component
- \( V_i \): random error term

In this study, the preferred model is a stochastic frontier production function model based on the time-variant efficiency model of Battese and Coelli in 1995 (Amornkitvikai & Harvie, 2010). This model permits the levels of technical efficiency to change in a long span since the regulators of EPIRA expect to learn from their learning-by-doing experience. It is emphasized by Amornkitvikai and Harvie (2010) that as the observation becomes larger, the technical efficiency effects change. This model is said to comprise of two main components: (1) to estimate the time-varying stochastic frontier production function; and (2) to examine what specific variables significantly affect the EPIRA’s inefficiency.

The computer program, Frontier version 4.1 software, was used to estimate the method of maximum likelihood of a subset of the stochastic frontier production.

**Phase 2: Input oriented SBM-DEA model**

In the second stage of statistical analysis, Data Envelopment Analysis (DEA) was employed as a non-parametric method that calculates the efficiency in a given set of electric private distribution utilities (PDUs). The regulators in the electricity industry use this method as a well-known benchmarking tool (Azadeh et al., 2009).

In the context of the Philippine’s Distribution Sector, DEA can help the regulators to (1) assess the PDU’s relative performance; (2) identify the top performer among the PDUs; and (3) identify ways to improve the performance of the less efficient PDUs by amending the regulatory framework, EPIRA.

In this phase, the same sample set and variables in the SFA method’s application were applied while estimating performance indicators employing a DEA approach. According to the study of Jarzebowski (2013), this procedure eliminates the problem of accidental selection of variables.

The study used a slack-based method with input-oriented data envelopment analysis (DEA) under the variable returns to scale (VRS) model. It means that in the ratio analysis of efficiency, the emphasis is given on the reduction in inputs to improve efficiency. In the case of the PDUs being natural monopolies, electric private distribution managers have more control over the input level than over the regulated rate-setting methodology set by the ERC. The focus was to determine the efficient and inefficient PDUs through a proportional reduction in their inputs (total operating expenses, total assets, and purchasing power). Computer software called DEAP version 2.1 developed by Timothy Coelli in 1996 was used to calculate slacks.

**RESULTS AND DISCUSSION**

This paper analyzes 20 years of operation of the top 5 PDUs of the Philippines from 1995 to 2014. The data were taken from SEC i-View and the archives of DOE. Except for franchise area (sq km) and age (years), total revenue, total operating expenses, total assets, and purchasing power were measured in million Philippine pesos (PHP) to have a common measure.
Panel data of the PDUs and the average value of the variables in Table 1 showed that MERALCO (PhP163,764 million) and VECO (PhP9,244 million) were the highest average earners in the past 20 years. Both MERALCO AND VECO displayed the highest average operating expenses (PhP21,014 and PhP1,304 million, respectively), total assets (PhP158,318 and PhP6,748 million, respectively), and purchasing power (PhP132,165 and PhP7,476 million respectively). It may be mentioned that the oldest PDUs were MERALCO (86 years) and SFELAPCO (78 years). Also noted is that MERALCO and DLPC have the largest franchised areas of 9,338 sq km and 3,561 sq km, respectively.

On the other hand, the average growth rate per year of the 5 PDUs in terms of total revenue, operating expense, total assets, and purchasing power were computed to be 10.8%, 7.4%, 7.9%, and 11.3%, respectively. If the same trend would be experienced by the PDUs for another 20 years, total revenue, operating expenses, total asset, and purchasing power would be 11.4%, 7.7%, 8.2%, and 11.9%, respectively.

Table 1: Cross tabulation of PDUs and variables

| PDU       | Total Revenue (in M of PHP) | Operating Expenses (in M of PHP) | Total Assets (in M of PHP) | Purchased Power (in M of PHP) | Franchise Area (sq km) | Ave. Age (Yrs) |
|-----------|-----------------------------|----------------------------------|-----------------------------|-------------------------------|------------------------|----------------|
| MERALCO   | 163,764                     | 21,014                           | 158,318                     | 132,165                       | 9,338                  | 86             |
| VECO      | 9,244                       | 1,304                            | 6,748                       | 7,476                         | 674                    | 44             |
| DLPC      | 5,696                       | 1,093                            | 5,468                       | 3,887                         | 3,561                  | 26             |
| CEPALCO   | 2,891                       | 496                              | 4,181                       | 1,919                         | 720                    | 47             |
| SFELAPCO  | 2,033                       | 357                              | 1,233                       | 1,600                         | 204                    | 78             |
| Grand Mean| 36,725                      | 4,853                            | 35,190                      | 29,410                        | 2,899                  | 56             |

Ave. growth per year 0.108, 0.074, 0.079, 0.113
Growth rate in 20 years 0.114, 0.077, 0.082, 0.119

Source: Author Analysis

Do total operating expenses, total assets, and purchased power affect total revenue?

Table 2 showed the effects of total operating expenses, total assets, and purchased power to total revenue.

The value of constant suggests that about PhP2.43 million was the average total revenue of a PDU at the beginning of 1995. Also, the constant refers to an 89.0% contribution of technology to total revenue, without the effects of the three inputs. Parameter $b_1$ represents an 11.4% contribution of total operating expenses to total revenue. This means, total revenue increased by 11.4% for every 100% increase in total operating expenses. In the same token, parameters $b_2$ and $b_3$ indicated that total revenue grew by 4.0% and 80.6% for every 100% growth in total assets and purchased power, respectively.

The values of the parameters ($b_1$, $b_2$, and $b_3$) represent the responsiveness (elasticity) of total revenue to the proportionate increase of the predictors (total operating expenses, total assets, and purchasing power). The sum of this responsiveness indicated the return to scale (size of operation) of the private distribution utilities (PDUs). On the average, a PDU was operating at decreasing return to scale ($Drs, 0.960 < 1.00 = 0.114+0.040+0.806$).

Table 2: Effects of total operating expenses, total assets, purchased power to total revenue

| Stochastic Frontier Estimates | mle coefficient | t-ratio | t-critical | sig. |
|------------------------------|----------------|---------|------------|------|
| Parameter                    | Variable       |          |            |      |
| $b_0$                        | Constant       | 0.890    | 17.35      | 3.179| 0.001|
| $b_1$                        | Total Operating Expenses | 0.114    | 4.38       | 3.179| 0.001|
| $b_2$                        | Total Assets   | 0.040    | 2.84       | 2.367| 0.01 |
| $b_3$                        | Purchased Power| 0.806    | 33.56      | 3.179| 0.001|

Inefficiency effects

| Parameter                        | Variable                | mle coefficient | t-ratio | t-critical | sig. |
|----------------------------------|-------------------------|-----------------|---------|------------|------|
| $d_0$                            | Constant                | 1.509           | 3.69    | 3.179      | 0.001|
| $d_1$                            | Franchise Area (sq km)  | -0.118          | -4.21   | 3.179      | 0.001|
| $d_2$                            | Age                     | -0.162          | -2.57   | 2.367      | 0.01 |
| $d_3$                            | Pre-EPIRA and Post-EPIRA| -0.009          | -0.57   | 1.661      | n.s. |
| $\sigma^2$                       | sigma-squared           | 0.003           | 5.63    | 3.179      | 0.001|
Gamma

| Γ   | Gamma | 0.472 | 3.51 | 3.179 | 0.001 |
|-----|-------|-------|------|-------|-------|

dependent variable = Total Revenue (Php million)

LR test of the one-sided error = 34.043 > 19.696

with number of restrictions = 5

[note that this statistic has a mixed chi-square distribution]

Kodde & Palm (df = 5, 0.001) = 19.696

Source: Author Analysis

Since the proportion of increase of total revenue (= 0.960) was less than the desired increase in input (= 1.00) during 1995 – 2014, an average PDU has experienced decreasing returns to scale (DRS) in their operation. A DRS suggested a loss of efficiency in the operation of the PDU at the advent of production expansion or a PDU could have been too large to be operated as one single entity.

As cited in the study of Banker (2016), this result is similar to other numerous papers that showed that the largest distribution firms in Norway, Sweden, Switzerland, Philippines, and Spain were found to operate in decreasing returns to scale.

The t-ratio of the parameters ($b_0 = 17.35$, $b_1 = 4.38$, $b_2 = 2.84$, and $b_3 = 33.56$) were computed to be above the t-critical values at 5% level of significance. The significance (sig. or $\rho$) indicated that all factors or variables affect the dependent variable (total revenue). This means that the null hypothesis ($H_0$: $B_i = 0$) "no factors or predictors are affecting the dependent variable" was rejected at 5% level of significance in favour of the alternative hypothesis ($H_a$: $B_i \neq 0$) "there is at least a factor affecting the dependent variable".

Is the technical efficiency of the PDUs systematically affected by age, franchise area, and EPIRA in the Philippines?

The stochastic frontier regression (SFR) contains a decomposed element, random variation ($V_i$), and inefficiency effect ($U_i$). The random variation section as explained above and the lower portion of Table 2 explained the technical inefficiency portion. The PDUs with bigger franchise area (sq km) have better technical efficiency than those PDUs with smaller franchise area. This indicates that PDUs located in a larger area were operationally efficient than PDUs located in smaller areas.

The negative sign of Age (= -0.162) reflects a decreasing technical inefficiency. This means older PDUs have better-operating efficiency than younger PDUs. Hence, PDUs operating longer in the industry were technically efficient in their operation than those PDUs with lesser years of experience in the industry.

This result is similar to the study of Altoe et al. (2017) which revealed that size is a determinant factor for technical efficiency since larger companies could be able to negotiate finance at lower costs as a result of better management skills and greater financial flexibility. This was supported by the study of Becker-Blease et al. (2010) emphasizing industries with optimal firm size had better profitability as larger firms were able to take advantage of economies of scale than smaller ones. However, the study of de Quadros Martins et al. (2018) showed otherwise. They found out that the size of the concession area and the extent of the network were not determinant factors for determining the efficiency of the 18 electric distribution companies in Brazil.

Figure 2 reflected the improvement in the total revenue of the PDUs from 1995 to 2014. The total observation was 100 (5 PDUs x 20 years). The total revenue was in the natural log to accommodate a smooth curve. The PDUs were separated by a vertical blue line to depict the improvement in total revenue. Post-EPIRA improvement in total revenue is growing upward and continues to increase until the end of 2014. The grey line (frontier line) showed a gradual increase in total revenue during the post-EPIRA period per PDUs. The closeness of the actual total revenue to the frontier (best
practice) suggests that the PDUs improved their efficiency during the post-EPIRA period (as exhibited by the efficiency line).

**Table 3:** Comparison of pre and post-EPIRA total revenue of PDUs

| PDUs  | EPIRA | Actual  | Frontier | Efficiency |
|-------|-------|---------|----------|------------|
| MERALCO | Pre   | 76,463.73 | 76,463.73 | 100.0      |
|       | Post  | 201,178.50 | 201,178.50 | 100.0      |
| VECO  | Pre   | 3,685.49  | 4,022.23 | 91.6       |
|       | Post  | 11,625.74 | 11,898.83 | 97.7       |
| DLPC  | Pre   | 2,114.42  | 2,191.32 | 96.5       |
|       | Post  | 7,230.26  | 7,230.26 | 100.0      |
| CEPALCO | Pre | 1,141.21  | 1,241.30 | 91.9       |
|        | Post  | 3,640.23  | 3,714.06 | 98.0       |
| SFELAPCO | Pre | 666.12   | 752.83  | 88.5       |
|        | Post  | 2,619.50  | 2,780.77 | 94.2       |

**Source:** Author Analysis

Table 3 showed the comparison of pre and post-EPIRA total revenue of PDUs. MERALCO showed the best performance during the pre and post-EPIRA period with an efficiency of 100%. The actual total revenue and target revenue (frontier) was achieved during pre-EPIRA (PhP76,463.73 million) and post-EPIRA (PhP201,178.50 million) period. MERALCO experienced a 163.10% aggregate growth in total revenue from the pre-EPIRA to the post-EPIRA period indicating a very efficient operation. On the other hand, DLPC grew at about 241.95% between pre and post EPIRA periods. Said company was only at 96.5% efficiency during the pre-EPIRA period but achieved 100% efficiency during the post-EPIRA period.

The remaining three (3) PDUs were below the 100% efficiency but showed improvement in efficiency scores during the post-EPIRA period. Further, VECO improved its total revenue by 215.45% from pre-EPIRA to the post-EPIRA period. On the other hand, CEPALCO and SFELAPCO achieved growths of 218.98% and 293.45%, respectively, in total revenue after the implementation of EPIRA. Therefore, results showed that the imposition of the EPIRA improved the total revenue of the PDUs.

Similar improved efficiency result of post reforms was also noted in Pakistan and US electric utilities in the study of Mirza, et al. (2017); Goto and Sueyoshi (2011).

**Hypotheses test for selecting the full model (model 2 of Battese & Coelli 1995 specification).**

The values of sigma-squared ($\sigma^2 = 0.003, \rho = 0.001$) and gamma ($\gamma = 0.472, \rho = 0.001$) indicate that the PDUs were not efficient in its annual earning of total revenue and the distance between the best years of earning total revenue (frontier or potentials of achieving total revenue) and the actual data are due to inefficiency and not due to random variation. Critical t-values passed the 5% level of significance indicating that the parameter ($b_i$) are not equal to zero and inputs (total operating expenses, total assets, and purchasing power) affected the output (total revenue).

The value (=34,043) of the likelihood ratio test of the one-sided error is greater than the value of 19.696 at 0.001 level of significance (Kodde and Palm table) and 5 degrees of freedom (number of restrictions = 5) implying that the assumption on a general truncated (reduced) normal distribution ($\mu \neq 0$) where mean ($mu$) is not zero and the time-varying (1995 – 2014) efficiencies passed all expectations. So, the two distributions in this paper are normal for the stochastic portion ($Vi$ = random variation) and a half – normal for the technical inefficiency portion ($Ui$). Also, the likelihood ratio test implied that the SFR - mle estimated appropriately the total revenue than the ordinary least squares (OLS) of the classical statistics.

**How operationally efficient are the top five PDUs in the Philippines under the regulation of EPIRA in terms of total operating expenses, purchased power, and total assets?**

Operational efficiency refers to the ratio between output (total revenue) produced from the business and inputs (total operating expenses, total assets, and purchasing power) to run a private distribution utility (PDU) operation. Knowing PDU's operational efficiency enables a manager to measure the capability of PDUs to deliver services to their concessionaires in “the most cost-effective manner possible while still ensuring the high quality of its products, service, and support” (Coelli et al., 2005). Thus, operational efficiency deals with the technical efficiency of the PDUs in effectively using the set of inputs to generate their output.
The study used a slack-based method with input-oriented data envelopment analysis (DEA) under the variable returns to scale (VRS) model. The focus was to determine the efficient and inefficient PDUs through proportional reduction of their inputs (total operating expenses, total assets, and purchasing power).

Table 4: Efficiency summary of the PDUs

| PDUs   | crste | vrste | Scale | rts  |
|--------|-------|-------|-------|------|
| MERALCO | 1.000 | 1.000 | 1.000 | crs  |
| VECO   | 1.000 | 1.000 | 1.000 | crs  |
| DLPC   | 1.000 | 1.000 | 1.000 | crs  |
| CEPALCO | 0.996 | 1.000 | 0.996 | irs  |
| Mean   | 0.999 | 1.000 | 0.999 |      |

Source: Author Analysis

Table 4 showed the efficiency summary of the PDUs. Based on said table, MERALCO, VECO, DLPC, and CEPALCO displayed strong efficiency from 1995 to 2014. A strong efficiency as PDUs (firms) with 100% performance in overall or global technical efficiency (crate), local pure technical efficiency (vrste) or managerial efficiency, and scale efficiency (scale). The scale efficiency described the good (constant returns to scale, CRS) or bad (IRS or DRS) condition of operation of the PDUs. These PDUs that achieved 100% maximum performance was operating at the most productive scale size (mass).

On the other hand, SFELAPCO has weak efficiency as it registered a 100% efficiency only in local pure technical efficiency (vrste). This means SFELAPCO was efficient in managing its inputs (total operating expenses, total assets, and purchasing power) from 1995 to 2014. However, said company was not cost-efficient (overall or crate = 0.996 < 1.0) due to bad condition of operation (scale = 0.996 < 1.0). The bad condition suggests an increasing return scale (IRS) where the use of inputs (total operating expenses, total assets, and purchasing power) were doubled to generate total revenue at a faster rate. The scale efficiency score indicates whether a firm operates at the most productive scale size (score=1) or not. A score smaller than one indicates that the firms are over/under-dimensional.

Do the top five PDUs in the Philippines have excess in inputs and shortage in output from 1995 to 2014?

Table 5 presented the summary of the input-output slacks of the PDUs. The five PDUs namely MERALCO, VECO, DLPC, CEPALCO, and SFELAPCO, have no output shortages and input surpluses. Thus, these five PDUs were able to maintain zero levels of slacks in generating their total revenue and managing their total operating expenses, total assets, and purchasing power.

Table 5: Summary of input-output slacks of the PDUs

| PDUs    | rts | Total Revenue | Total OpEX | Total Assets | Purchased Power |
|---------|-----|---------------|------------|--------------|-----------------|
| MERALCO | crs | 0             | 0          | 0            | 0               |
| VECO    | crs | 0             | 0          | 0            | 0               |
| DLPC    | crs | 0             | 0          | 0            | 0               |
| CEPALCO | crs | 0             | 0          | 0            | 0               |
| SFELAPCO| irs | 0             | 0          | 0            | 0               |
| Mean    |     | 0             | 0          | 0            | 0               |

Source: Author Analysis

CONCLUSIONS AND RECOMMENDATIONS

As guided by the results of this study, the study concludes that the post-EPIRA made the five PDUs more technically efficient in their operation than without the reform. PDUs were able to achieve a reduction in their technical inefficiencies and improved total revenues during the post-EPIRA period. Moreover, MERALCO demonstrated the best performance (100%) during pre and post-EPIRA periods at 163.10% aggregate growth in total revenue, and PDUs with bigger franchise areas and older in existence were technically efficient in their operations than their smaller and younger PDUs counterpart, respectively. By using the slack-based method with input-oriented data envelopment analysis (DEA) under the variable returns to scale (vrs) model, MERALCO, VECO, DLPC and CEPALCO displayed strong efficiency from 1995 to 2014. This suggests that these four PDUs were managerially efficient and were operating at the most productive scale size. Meanwhile, SFELAPCO was efficient in managing its inputs during 1995 to 2014, however, it was not cost-efficient (cost = 0.996 < 1.0) due to bad condition of operation (scale = 0.996 < 1.0). Thus, for SFELAPCO to
operate at its most productive scale size, it needs about 0.4% potential improvement using the same level of inputs (total operating expenses, total assets, and purchasing power) to become efficient. This area can be looked at to enhance the operational performance management of SFELAPCO.

Researchers suggest that the Board of Directors of SFELAPCO should pay attention to how they can enhance their operational performance following achieving EPIRA objectives, resulting in revenue growth sustainability. A quarterly collaboration meeting of the PDUs to adopt best practices from the best performers should be organized by ERC. Such best practices were the contentions of Goto and Sueyoshi’s (2001) findings that an enhancement in the operational performance of electric utility firms increased financial performance. The electric distribution utilities (DUs) were designed to serve the end-users regardless of their nature, size, and paying capacity located within their franchise areas. With this role, the linkage of the EPIRA’s impact on the DUs in their operational and financial performances has seen to influence the quality of their services to the end-users. Researchers, therefore, recommend that all the DUs in the Philippines conduct future extension of the three performance measures, namely operational, financial, and service quality to obtain overall gains on the EPIRA implementations. At this point in the reform along with positive empirical results, it is not recommended to repeal the restructuring of PEI but to find ways to sustain optimal operational efficiency results until 2040.

LIMITATION AND STUDY FORWARD

The subject of this study was the top five electric private distribution utilities (PDUs) in the Philippines thus, the scope of this study was limited to a few organizations in the Philippines. A broader population and research sample covering maximum organizations in the Philippines will provide more fine-grained results and deep insights. Further, the researchers recommend that it is important to include in the next session of the Congress the thorough analysis of the complexity of all the PDUs' management structure, geographical conditions, and the connections of these areas to the design of the regulatory reform to achieve optimal and sustainable results.

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Kathrine Joyce R. Acebedo worked on data gathering, analysis, and initial drafting of the manuscript, while Nelson C. Bool and Dante R. Garcia worked on the interpretation, and final proofreading.

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