

## Time-Varying Stochastic Frontier Model Approach for Measuring Female Parliamentarian Efficiency of Selected Countries in Asia

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**Abstract:** The study considers stochastic frontier model to investigate the technical efficiency of randomly selected eight Asian countries namely Pakistan, China, India, Bangladesh, Indonesia, Thailand, Philippine and Malaysia applied to unbalanced panel data sets for the period 2002-2010. A half-normal distribution assumption with a simple specification of the time-varying inefficiencies was incorporated to the model. A Cobb-Douglas stochastic frontier production function with time-varying technical inefficiency effects was estimated. Year wise mean technical efficiency of the parliament of eight Asian countries during the reference period decreased from 46.8-42.8%. Among the selected Asian countries, China and Pakistan were experienced highest (87.58%) and lowest (33.40%) parliament mean efficiencies, respectively. In case of time-invariant inefficiency effect model, the estimated overall average technical efficiency was found 54.96% for the parliament of selected Asian countries and it is of potential output for the half-normal distribution.

**Key words:** Time varying inefficiency effects, Cobb-Douglas Stochastic Frontier Production Model, female parliament, Asian countries, Malaysia

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### INTRODUCTION

The representation of women in most of the developing countries is about 10.1% in Arabs, 13.2% in Pacific, 18.4% in Sub Saharan Africa and 18.7% in Asian countries. This impressive growth of women representation in the parliament during the past three decades has attracted the attention of the researchers of both developed and developing societies to analyze substantive representation (the role of women in the parliament) to female related issues (Celis *et al.*, 2008). Considerable attention has been given to the issue of women under-representation all over the world following United Nation Fourth National Conference at Beijing 1995 and Millennium Development Goal 2000. Consequently, the representation of women in parliament rose from 12.1% in 1997 to 48.75% in July 2010 (Matland, 1998; Devlin and Elgie, 2008) and Inter Parliamentary Union (Inter-Parliamentary Union, 2010). The highest representation of women (48.75%) is in Nordic countries, 19.9% in the Organization for Security and Co-operation in Europe (OSCE) member countries (excluding Nordic countries) and 22.2% in American societies (Inter-Parliamentary Union, 2010).

There is a growing body of literature that seeks to explain substantive representation of women (the role of women in the parliament). Some studies found positive links between women representation and women related issues while many others found little or no difference in the attitude and behavior of the male and female parliamentarians. For example, Gargarella (1998) conceded that the presence of women in the parliament is necessary because women compared to men representatives can be trusted more to promote women's interests in the parliament. In addition, female representatives have different political priorities and policy concerns as compared to male parliamentarians (Phillips, 2000). Bratton (2005) is of the view that in United State of America (USA) women representatives' concentrates more on issues and the bills related to women matters. Similarly many other researchers argued that higher numbers of women in the parliament promote higher values of external efficacy for women, strengthen the position of women's interests exert due pressure on the parliament to promote legislation on women related issues (Atkeson and Carrillo, 2007; Wangnerud, 2009; Childs and Krook, 2009). While several studies have analyzed substantive women representation and the impacts of factors thereupon

(Sainsbury, 2004; Norris, 2006; Tremblay, 2007; Whitford *et al.*, 2007; Stockemer, 2008; Franceschet and Jennifer, 2008; Chaney, 2008; Waylen, 2008; Celis, 2009; Bano, 2009; Krook, 2010). The central concern of research is whether who hold office (descriptive representation) affects the type of policies passed (substantive representation). Researchers explored this link through questions such as Do women in politics make any difference? Do women act for women?

In order to measure the (in) efficiency of parliament in Asian countries, in this study researchers propose a stochastic frontier production function for unbalanced panel data (Battese and Coelli, 1992) assumed to be distributed as a half normal random variables. This type of frontier and the computation method present advantages with respect other alternatives, for example the deterministic frontiers (Forsund *et al.*, 1980; Kalijaran and Shand, 1999). First, the deterministic frontiers are based on the assumption that the only type of explanation for the deviation between the observed output and its frontier output is due to its own inefficiency. This idea is difficult to maintain at the empirical level due to it ignores the possibility that the observed output can differ from the potential because of two other factors: stochastic shocks and measurement error in the variables.

The present study focuses on women parliamentarian's technical efficiency of selected countries in Asia and seeks to obtain the empirical results by employing the stochastic frontier model. To identify the determinants of technical efficiencies to improve existing level of Asian countries and at the same time, to see whether their efficiencies are time-varying or time-invariant is also of the interest.

## MATERIALS AND METHODS

**Data description:** Researchers used panel data for the period 2002 to 2010 from randomly selected eight Asian countries namely Pakistan, China, India, Bangladesh, Indonesia, Thailand, Philippine and Malaysia. The data were collected from Inter Parliamentary Union PARLINE database (IPU) 2010 And Freedom house 2010.

**Dependent variable:** Percentage of women in lower house of the parliament (Y): percentage of women representation in lower house of the parliament is the dependent variable of the study. Data were obtained from Inter-Parliamentary Union (2010). Inter-Parliament Union's PARLINE data base was used to get figures of the percentage of women representation in the parliament of eight Asian countries for 9 years from 2002-2010.

**Independent variables (Total membership of lower house of the parliament ( $X_1$ )):** Total membership of lower house of the parliament is the first input variable of the study as it plays significant role in the determination of size of women representation in parliament. Data for this input variable was obtained from Inter-Parliamentary Union (2010). Inter-Parliament Union's PARLINE data base was used to get figures of membership of lower house of the Parliament of eight Asian countries for 9 years from 2002-2010.

**Election system type ( $X_2$ ):** Election system type is a second important input variable used in this study. For this variable, researchers used three categories exists in Europe such as (proportional, semi proportional and plurality-system) and coded 1-3, respectively. Data was obtained from the data base of electoral system design provided by the International Institute for Democracy and Electoral Assistance (IDEA), 2010 and Inter Parliamentary Union PARLINE data base on National Parliament 2010.

**Political rights ( $X_3$ ):** Political rights of citizens are the third input variable used in this study. Data for this variable were obtained from the freedom house. Freedom in the world is the standard-setting comparative assessment of global political rights, civil liberties and status of the government, published annually since 1972. The survey ratings and narrative reports are widely used by policymakers, media analysts, civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide.

**Civil liberty ( $X_4$ ):** Civil liberty is the fourth input variable of this study. Several studies found positive links between civil liberty level of a country and the percentage of women representation in parliament. Data for civil liberty were obtained from freedom house. Freedom in the world is the standard-setting comparative assessment of global political rights, civil liberties and status of the government, published annually since 1972. The survey ratings and narrative reports are widely used by policymakers, media analysts, civic activists and human rights defenders to monitor trends in democracy and track improvements and setbacks in freedom worldwide.

**Life expectancy at birth, female (years) ( $X_5$ ):** Life expectancy at birth, female (years) is fifth explanatory variable used in this study. Life expectancy at birth indicates that number of years the newborn infant would leave if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Researchers found positive link between life expectancy at birth of female and political representation. Researchers tested this proposition and found significant positive impact of life expectancy at birth on female political representation. Data for this variable were obtained from World Development Indicator (WDI) 2010.

**GDP per capita (Curreant US\$) (X<sub>6</sub>):** GDP per capita is another useful input variable used in this study. It is a gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data of this variable were obtained from World Development Indicator 2010 and Penn World Table 3.6.

**Theoretical Stochastic Frontier Model:** This study assumes that the data are available for a sample of N Asian countries over T time periods. The general stochastic frontier production function followed by Battese and Coelli (1992) for panel data is defined as:

$$Y_{it} = \exp (X_{it}\beta + V_{it} - U_{it}) \quad i = 1, 2, \dots, N; t = 1, 2, \dots, T \quad (1)$$

Where:

- Y<sub>it</sub> = The output for the ith country in the tth time period
- X<sub>it</sub> = The vector whose values are functions of inputs for the ith country in the tth time period
- β = A vector of unknown parameters to be estimated
- V<sub>it</sub> = Independent and identically distributed random errors which have normal distribution with mean zero and variance σ<sup>2</sup> and independent from U<sub>it</sub>
- U<sub>it</sub> = Non-negative random variables associated with the technical inefficiency of production

The model used here incorporates a simple specification of the time-varying inefficiencies following (Battese and Coelli, 1992) as:

$$U_{it} = \{ \exp [ -\eta (t-T) ] \} U_i \quad (2)$$

where, η is an unknown scalar parameter to be estimated which determines whether inefficiencies are time varying or time invariant. The U<sub>it</sub> term can have different specifications and the most popular are the independent and identically distributed non-negative random variables of a truncated normal with an average μ and a constant

variance (U<sub>i</sub>~iid|N(μ, σ<sub>v</sub><sup>2</sup>)|) and the half-normal distribution (U<sub>i</sub>~iid|N(0, σ<sub>v</sub><sup>2</sup>)|). However, in this study, the half-normal distribution was assumed in the context of stochastic frontier production model.

In Stochastic Frontier Model (1) using the composed error terms we utilize the parameterization of Battese and Corra (1977) who replace σ<sub>v</sub><sup>2</sup> and σ<sub>u</sub><sup>2</sup> with σ<sup>2</sup> = σ<sub>v</sub><sup>2</sup> + σ<sub>u</sub><sup>2</sup> and γ = σ<sub>u</sub><sup>2</sup> / (σ<sub>v</sub><sup>2</sup> + σ<sub>u</sub><sup>2</sup>). In a half-normal distribution, the ratio of country specific variability to total variability, γ is positive and significant implying that country specific technical efficiency is important in explaining the total variability of output produced.

**Empirical Cobb-Douglas Stochastic Frontier Model:** The proposed functional form of Cobb-Douglas stochastic frontier production function has country effects that are assumed to be distributed as half normal random variables and also are permitted to vary systematically with time. The model can be expressed as:

$$Y_{it} = \beta_0 + \sum_{j=1}^6 \beta_j X_{jit} + (V_{it} - U_{it}) \quad i = 1, 2, \dots, 8; t = 1, 2, \dots, 9 \quad (3)$$

Where:

- Y<sub>it</sub> = The logarithm of the total membership of lower house of the parliament of the ith country in the tth time period
- X<sub>j</sub> = The jth input quantities (the logarithm of) percentage of women in the lower house of the parliament, election system type, status of government
- β<sub>j</sub> (j = 1-6) = The output elasticity with respect to the jth input
- V<sub>it</sub>-U<sub>it</sub> = The random variables

Given the specifications of the stochastic frontier production function, defined by Eq. 1, the technical efficiency of ith country in the tth year is defined as:

$$TE_{it} = \exp(-U_{it}) \quad (4)$$

where, U<sub>it</sub> denotes the specifications of the inefficiency model in Eq. 1 and 2. The technical efficiency of a country is between zero and one and is inversely related to the level of the technical inefficiency effect.

## RESULTS AND DISCUSSION

In this study, the results of the estimation of technical efficiency of women in parliament of eight Asian

Table 1: OLS estimates of Cobb-Douglas Stochastic Production Frontier Model with time-varying inefficiency effects for half-normal distribution

Variables	Parameters	Coefficient	SE	t-values
Constant	$\beta_0$	-4.4560***	2.417	-1.843
Total membership of lower house of the parliament	$\beta_1$	0.1720***	0.115	1.495
Election system type	$\beta_2$	-0.2910***	0.227	-1.127
Political rights	$\beta_3$	0.5610***	0.386	1.452
Civil liberty	$\beta_4$	-0.4530***	0.786	0.576
Life expectancy at birth, female (years)	$\beta_5$	3.0130***	1.463	2.059
GDP per capita (UD\$)	$\beta_6$	-0.1130***	0.104	-1.084
Sigma-squared	$\sigma^2$	0.0714***	-	-
Log likelihood function	-	-3.4850*	-	-

\*\*\*Means insignificant; SE = Standard Error

countries are presented. The parameters of Ordinary Least Square (OLS) estimates and Maximum Likelihood Estimates (MLE) were computed using Cobb-Douglas Stochastic Production Frontier Model to measure the technical efficiency of parliament for a randomly selected eight Asian countries. A two step process was used to find out the technical efficiency using maximum likelihood method. In the first step using frontier 4.1 by grid search the ordinary least square estimates of parameters were obtained and these estimates were used in the second step to estimate the maximum likelihood estimates of the parameters using Cobb-Douglas frontier production function.

**Results of Cobb-Douglas Stochastic Frontier Model**

**Ordinary least square estimates:** The ordinary least square estimates of the parameters of Cobb-Douglas production function showed an average performance of the sample female parliamentarians. The OLS estimates of the parameters are used as initial values for the maximum likelihood estimates of the parameters. The results of OLS estimates of time-varying inefficiency effects are presented in Table 1. From the results, researchers observed that in time varying one coefficient is statistically significant in the production process which indicated that life expectancy at birth, female (years) has significant positive impacts on the efficiency of female parliamentarians.

**Maximum likelihood estimate of Cobb-Douglas Stochastic Frontier Model:**

The maximum likelihood estimates for the parameters for time-varying and time-invariant inefficiencies of Cobb-Douglas stochastic frontier production function with half normal distributional assumption were obtained and presented in Table 2 and 3, respectively. From the results of MLE analysis in time varying model presented in Table 2, researchers observed that the coefficients of election system type and GDP per capita (US\$) are statistically

Table 2: MLE estimates of Cobb-Douglas Stochastic Production Frontier Model with time-varying inefficiency effects for half-normal distribution

Variables	Parameters	Coefficient	SE	t-values
Constant	$\beta_0$	0.777***	1.566	0.496
Total membership in lower house of the parliament	$\beta_1$	0.054***	0.128	0.425
Election system type	$\beta_2$	-0.821**	0.360	-2.279
Political rights	$\beta_3$	0.221***	0.205	1.079
Civil liberty	$\beta_4$	0.472***	0.582	0.809
Life expectancy at birth, female (years)	$\beta_5$	0.603***	0.880	0.685
GDP per capita (US\$)	$\beta_6$	-0.246**	0.096	-2.559
Sigma-squared	$\sigma^2$	0.044**	0.019	2.267
Gamma	$\gamma$	0.645*	0.157	4.086
Eta	$\eta$	0.154*	0.023	6.647
Log likelihood function	-	35.213	-	-

Table 3: MLE estimates of Cobb-Douglas Stochastic Production Frontier Model with time-in varying inefficiency effects for half-normal distribution

Variables	Parameters	Coefficient	SE	t-values
Constant	$\beta_0$	-4.129***	2.713	1.521
Total membership in lower house of the parliament	$\beta_1$	0.542***	0.411	1.318
Election system type	$\beta_2$	0.834**	0.540	1.543
Political rights	$\beta_3$	0.381***	0.281	1.354
Civil liberty	$\beta_4$	-0.778***	0.723	-1.074
Life expectancy at birth, female (years)	$\beta_5$	1.619	1.236	1.309
GDP per capita (US\$)	$\beta_6$	0.378	0.150	2.508
Sigma-squared	$\sigma^2$	0.361**	0.187	1.925
Gamma	$\gamma$	0.929	0.042	21.933
Mu	$\mu$	0.000	0.000	0.000
Eta	$\eta$	0.000	0.000	0.000
Log likelihood function	-	15.843	-	-

\*, \*\*Significance level at 1, 5, 10% consecutively; \*\*\*means insignificant; SE = Standard Error

significant at 5% level. On the other hand, the coefficient of total membership of lower house of the parliament, political rights, civil liberty and life expectancy at birth, female (years) (input variables) are insignificant. So, there is an overall indirect impact on election system type and GDP per capita (US\$) due to their technical inefficiencies to parliament in their respective countries. All the variance parameters are significant at different level and the variance parameter ( $\gamma$ ) was found significantly different from zero for a half normal distribution. The ratio of country specific variability to total variability ( $\gamma$ ) was positive and significant, implying that country specific technical efficiency is an important in explaining the total variability of the female parliamentarians of the lower house of parliament produced. In addition, the ( $\gamma$ ) estimate associated with the sigma-squared of the technical inefficiency effects is relatively large. Since, the estimate of the ( $\eta$ ) parameter is positive, indicated that the technical efficiency effects of the sample country increases over time.

From the results given in Table 3, researchers observed that maximum likelihood estimates of time-invariant inefficiency effect for the election system type was statistically highly significant (0.834) for half

Table 4: Year-wise technical efficiency of parliament with time-variant in Asian countries

Years	Pakistan	China	Bangladesh	India	Indonesia	Thailand	Philippine	Malaysia	Mean efficiency
2002	0.90925	0.83242	0.27872	0.68076	0.44401	0.82450	0.88918	0.69075	0.69370
2003	0.92157	0.85439	0.33470	0.71918	0.49873	0.84742	0.90409	0.72821	0.72604
2004	0.93231	0.87373	0.39154	0.75386	0.55097	0.86762	0.91712	0.76196	0.75614
2005	0.94164	0.89069	0.44785	0.78493	0.60007	0.88535	0.92846	0.79215	0.78389
2006	0.94972	0.90551	0.50250	0.81260	0.64562	0.90086	0.93832	0.81899	0.80927
2007	0.95673	0.91843	0.55461	0.83709	0.68740	0.91438	0.94687	0.84273	0.83228
2008	0.96278	0.92966	0.60352	0.85867	0.72534	0.92615	0.95427	0.86362	0.85300
2009	0.96800	0.93940	0.64884	0.87761	0.75950	0.93636	0.96067	0.88194	0.87154
2010	0.97251	0.94783	0.69036	0.89418	0.79005	0.94521	0.96619	0.89796	0.88803
Mean	0.94606	0.90562	0.49474	0.80210	0.63352	0.89421	0.93392	0.80870	0.80154

Table 5: Country-wise parliament mean technical efficiencies in time variant model

Country	Mean efficiency
Pakistan	0.94606
China	0.90562
Bangladesh	0.49474
India	0.80210
Indonesia	0.63352
Thailand	0.89421
Philippine	0.93392
Malaysia	0.80870

normal distribution. These results confirmed the findings of the study conducted by Paxton *et al.* (2009) that women representation is higher in countries using proportional electoral system as compared to semi-proportional and plurality system of election. The coefficients of estimated parameters for GDP per capita (US\$) is 0.378 and found to be statistically highly significant. This means that GDP per capita is a vital causal variable in enhancing the efficiency of female parliamentarians of the respective. In addition, the value of ( $\gamma$ ) is positive and highly significant which demonstrated that there exists technical inefficiency in the Asian countries.

In case of both time-varying and time-invariant inefficiency effects models ( $\gamma$ ) was estimated at 0.645 and 0.929, respectively implying that about 64-92% of random variation for half-normal distribution around in country's female parliamentarian contribution or output due to their inefficiency. These can be interpreted also that about 964-92% of the variation in contribution among the countries are due to the differences in technical efficiency for half-normal distribution.

**Average parliament efficiency over time:** Table 4 and Fig. 1 illustrated year wise average parliament technical efficiency. The results indicated that mean technical efficiency of female parliamentarians of eight Asian countries during the period 2002-2010 increased from 69.3-88.8%.

**Country-specific parliament technical efficiency (Results from Half-Normal Model):** Country wise parliament technical efficiency in case a half normal distributional assumption model displayed in Table 5 and Fig. 2. The

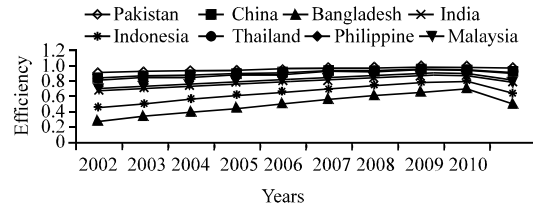


Fig. 1: Year-wise mean time varying technical efficiency

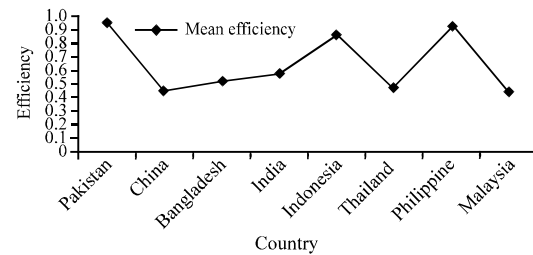


Fig. 2: Country wise mean technical efficiency in time in varying

results indicated that Pakistan is leading with highest average technical efficiency at 0.94606 and 0.94368 in both the time-variant and time-invariant models, respectively. These findings are supporting the plea of the study conducted by Aurat Foundation. The study has dispelled the widely held notion that woman parliamentarians in Pakistan are no more than silent spectators. On the contrary, it says they play a significant role in legislative functioning through their interventions on issues like violence, health, education and environment. Furthermore, it is find that women parliamentarians have actually excelled in several areas of legislative functioning as compared to their male colleagues (Ebrahim, 2009).

Philippine is the next leading country with second highest average technical female parliamentarian's efficiency (0.93392 and 0.92565) in both time-variant and time-invariant models. These results may be due to mega steps taken by the government to meet the target set by the UNO in shape of Millennium Development Goal in 2000.

Table 6: Country-wise parliament mean technical efficiencies in time in-varying situation

Country	Mean efficiency
Pakistan	0.94368
China	0.44795
Bangladesh	0.52357
India	0.56880
Indonesia	0.85595
Thailand	0.46797
Philippine	0.92565
Malaysia	0.44131

These findings are contradicting the results of Sobhan when he argues that in parliamentarians of South East Asian states including Philippine tends to be an arena of rhetorical exchange rather than a vehicle for political consensus building and due to the destruction of political institutions of governance during Martial law and authoritarianism the performance of Parliamentarians are low (Table 6).

China's is third leading country with average technical efficiency at 0.90562 and 0.44790 in both the time-variant and time-invariant models, respectively. Despite leading economy the China's female parliamentarians technical efficiency is less than Pakistan and Philippine which may be due to the non-existence of quota for female in China. Most surprisingly the technical efficiency of the female parliamentarians in China is the second lowest in time in-varying situation which may be alarming for them. However, these results are in consistent with the findings of Zhu (2004) that the parliamentarians in China are playing significant role in maintaining political accountability in a country. However, it is evident from the results that efficiency of China's female parliamentarians is considerably in time in varying model than time varying model.

Technical mean efficiency of female parliamentarians in Thailand is 89.4% and 46.7 in time variant and time in-varying situation, respectively. Whereas India attained their female parliamentarians technical mean efficiency at 80 and 56% in both the time-variant and time-invariant models. So, it implied that they were performing well in time varying model as compared to time in-varying model. Over time efficiency of both the countries increased although slowly as compared to Indonesia and Bangladesh. Big difference in an efficiency scores between the time-variant and time-invariant models is the most striking feature of both the countries. These results showed that female Parliamentarians of both the countries reacted well to the impact of time and they tried their level best to improve their efficiency. But the findings are negating the arguments of Rahman (2007) "that Indian

parliamentary committees do not perform as successfully as their counterparts in western world in controlling the government and holding it to account".

Technical efficiency of female parliamentarians of Indonesia and Bangladesh is 0.63352; 0.49474 and 0.85559; 0.44790 in both time variant and time in variant situation, respectively which are at the bottom of the table with Bangladesh is on the tail of the table. This is pertinent to note that female parliamentarians technical mean efficiency of both the countries is good in time varying situation bur worst in time in-variant model. These results are supporting the finding of the Sherlock (2007) that "the Parliamentarians continues to grapple with the effects of having been a rubber-stamp legislature for so long. It is still in the process of developing its institutional strengths and the procedures and practices of a democratic and accountable body" and the findings of Ahmed and Aftab (1996) when he argues that "due to poor performance Bangladeshi parliament is considered mere a house of controversy and irrelevant speeches."

### CONCLUSION

In this study, researchers analyzed the Cobb-Douglas Stochastic Frontier Production Model with a half-normal distributional assumption using panel data sets of female parliamentarians in the selected Asian countries. The estimated value of ( $\gamma$ ) associated with the sigma-squared of the technical inefficiency effects was observed positively large and highly significant which demonstrated that there exists technical inefficiency in the Asian countries. The estimates for parameters of the time varying inefficiencies model indicated that the technical inefficiency effects tend to increase over time since the parameter  $\eta$  was estimated to be positive (0.6452) for the half-normal distribution. The mean technical efficiency of the female parliamentarians during the reference period also increased from 69.3-88.8% which indicated that the mean technical efficiency improved through the years in female parliamentarians of each country. From the results, it was also observed that Pakistan attained the highest technical efficiency with 0.94606 and 0.94368 whereas Bangladeshi and Malaysians women parliamentarians experienced the lowest technical efficiency with 0.49474 and 0.44131 in time-variant and time-invariant models, respectively. The overall mean efficiency according to half normal distribution was found to be 0.80154 in case of time-variant and 0.64685 in time invariant inefficiency effect model. The time-variant inefficiency effects model was found to be an adequate representation than time-invariant inefficiency effects model.

## IMPLICATIONS

Research implications of the study are as follows:

- Causes of an increase in technical efficiency of female Parliamentarians in every country: since, model shows that the 'nature and tempo' of increase in the technical efficiency of different countries differs from country to country therefore it is indicative of a variety of causes operating behind the problems of every state. This needs further exploration
- Solutions of the problems for different countries. Connected with the preceding point, if researchers succeed in unearthing the causes of increase in the perspective of every single state, a domesticated solution model is possible to be sorted out exactly in consonance with the typical conditions of a country

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