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Relative Efficiency of Major Cities in Nepal

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Abstract – This study aims to measure the relative efficiency of six Metropolitan and six sub-metropolitan cities of Nepal. The major cities represent by metropolitan cities and sub-metropolitan cities. Data Envelopment Analysis (DEA) method has been used to measure the efficiency from both CRS and VRS model. In addition to this scale efficiency and Malmquist Index have also been studied. Three variables i.e. recurrent/operational expenditure, Local Governance and Community Development Program (LGCDP) expenditure and capital/development expenditure have been treated as input variables and two variables i.e. Own Source Revenue (OSR) and performance measurement score have been used as output variables. The types of municipalities/cities and family size are used as contextual variables in the study. Output oriented approach has been used in the study. On an average, out of the 12 cities two have been observed to be most efficient under CRS model and 3 have been observed to be efficient under VRS during study period (2011/12 to 2015/16). On an average, over all outputs of municipalities should have been augmented by 20.08% under CRSTE and that of 11.08% under VRSTE. On an average of five fiscal years, only Pokhara metropolitan city has achieved 1.8% positive TFP growth.

Keywords – Major cities , Scale efficiency, Data Envelopment Analysis (DEA), Malmquist Index, operational expenditure , development expenditure , own source revenue.

I. INTRODUCTION

Data Envelopment Analysis (DEA) is a methodology based upon an interpreting application of linear programming. It was originally developed for performance measurement but later it has been successfully employed for assessing the relative performance of the set of firm that use a variety of identical inputs to produce a variety of identical outputs. The principles of DEA were first developed by [1] but the recent series of discussion on the DEA was started by [2]. Reference [3] had introduced a good example of DEA. The recent and comprehensive material on DEA was introduced by [4] and [5].

Although, performance measurement is not a new concept, the measurement of relative efficiency of the major municipalities using DEA is the first effort in Nepal. After the restructuring of local bodies in 2017, now there are altogether 753 local levels in Nepal. Out of this, there are 293 municipalities and 460 rural municipalities. Nevertheless, the major cities are selected among the old municipalities before restructuring of the local bodies in Nepal because of the data availability. Metropolitan cities and sub-metropolitan cities are considered as major cities in Nepal. That is why out of 293 only 12 municipalities are selected from which 6 are metropolitan cities and remaining 6 are sub-metropolitan cities. The others are growing cities which are not included in the study.

In this study, relative efficiency of municipalities or major cities are analyzed based on their capacity of generating own source revenue and the achieving scores of the assessment of minimum condition and performance measurement (MCPM) annually carried out by the government of Nepal. It is because measurement of efficiency is choosing the factors that may be effective on efficiency

and the indicators that are inputs and outputs. It is assumed that the selected indicators of inputs and outputs can represent to assess the relative efficiency of the major cities of Nepal.

The rest of the paper is organized as follows. The relevant literatures are reviewed in Section 2. Section 3 is about the method and data. Section 4 is empirical analysis on relative efficiency of major cities of Nepal. Section 5 is the application of MI technology. Section 6 concludes this paper and provides direction for future research.

II. Literature Review

The measurement of the efficiency of any decision making units (DMUs) is a very difficult work. However, the interest in measuring performance has been increased among the researchers (Ridley, 1927). A study is carried out on the performance measurement in Australian local government by using DEA with holistic indices of allocative and technical efficiency of 177 NSW municipals' water service from 1995/96 to 1999/2000. The results suggest that there was scope for general improvements in the 1999/2000 performance in NSW local government water services of 26.5 with scale inefficiencies accounting for 6.1% and purely technical inefficiency 20.4%. The total factor productivity (TFP) over the 3 years from 1997/98 to 1999/2000 increased only slightly by 0.2% for water supply [6].

The efficiency analysis of 25 municipalities of Turkey was carried out in 2012 using DEA and Malmquist index (MI) technique. The efficiency scores were obtained and factors which affect efficiency and the interaction among the factors were determined. The input oriented constant returns to scale (CCR or CRS) and variable returns to scale (BCC or VRS) models are used to measure the efficiencies of municipalities. The findings say that there was a decrease in the number of efficient municipalities and the level of their efficiencies from years 2006-2008. Of the total 25, 17 municipalities were totally efficient according to CCR model in 2006 but this number was declined to 13 in 2008. According to BCC model, the efficiency score of the most inefficient municipality was about 50%. As for CCR model, this value is lower and about 40% only [7].

The another study aimed to assess the expenditure efficiency of 103 Italian major municipalities using DEA to calculate an efficiency scores and investigated economies of scale. The findings suggest that there exist inefficiencies in a number of municipalities that need an in depth investigation. The average CCR and BCC efficiency scores are 85.34% and 88.13%, which are rather high rates for studies on the subject whereas minimum efficiency scores area 37.52% and 37.65% for the CCR and BCC models respectively [8].

The few studies which were earlier carried out using DEA model are presented as follows in Table 1.

Table 1: Used variables up to efficiency analysis

Authors	Sample	Method	Inputs	Outputs
Van den et al. (1993)	235 Belgium municipalities (horizontal section)	DEA	Total current expenditure	Total population, proportion of the people who are older than 65, number of people who live at the lowest life level, number of elementary school students length of roads, number of guilt
Loikkanen and Susiluoto (2006)	353 Finland municipalities (panel data)	DEA	Total current expenditure	Daily child care houses, child care houses, central tooth care, older people's home, handicapped home, school, number of libraries and their users
Prieto and Zofio (2001)	209 Spain municipalities (horizontal section)	DEA	Expected budget spending	Potable water, waste, length of roads, number of units that illuminate the roads, cultural and sports background
Ramos and Sousa (1999)	701 Brazil municipalities (horizontal section)	DEA FDH	Total current expenditure	Settled population, number of houses that use clean water, number of houses that collect wastes, uneducated population, number of elementary school students

Source: Adopted from [9]

III. METHOD AND DATA

The non-parametric approach that uses DEA which is a deterministic mathematical programming technique that extends the Farrell's efficiency measure to a multiple inputs and outputs. Reference [10] is used to analysis the relative efficiency of major cities of Nepal. The relative technical efficiency rate (TE) of municipalities is measured by the distance between the actual observation and the frontier obtained from all the municipalities under examination. A municipality is efficient if TE=1, but if TE<1 a municipality is considered technically not efficient [8]. Moreover, output oriented approach is used to analyze the relative efficiency of selected major cities of Nepal. The efficiency is measured adopting the conceptualization suggested by [11], assuming variable returns to scale (VRS) which is also known as BCC model.

The recurrent expenditure, capital expenditure and LGCDP expenditure are used as input variables and the scores of minimum condition and performance measurement of municipalities and own source revenues are used as output variables. Additionally, types of municipalities and family size are used as contextual variables. The data of five fiscal years from 2011/12 to 2015/16 is used to estimate the efficiency scores. For the data envelopment analysis PIM DEA software is used. The DEA-BCC model that is being solved can be described as follow [12];

$$\min_{\theta,\lambda^{\theta}} \tag{1}$$

$$st - y_i + Y\lambda \geq o, \quad \theta_i - X\lambda \geq 0, \quad \text{N1}'\lambda = 1\lambda \geq 0, \tag{2}$$

Where, θ is scalar, λ is a N*1 vector of constants and N1 is a N*1 vectors of ones, the value of θ obtained representing the efficiency score for the i-the municipality/city. Actually, the restriction N1$'\lambda$=1 that is put additionally into the model imposes convexity to the frontier, corresponding to the VRS DEA model, the specification that does not presume that all municipalities are operating at the optimal scale. In order to analyze the relative efficiency of the selected major cities, output oriented approach is applied because the output in assumed to be the controlled under the decision making units whereas the inputs are generally depending on the central government grant.

The MI is also known as the total factor productivity growth (TFPG), or Malmquist Productivity Index (MPI). It measures the productivity changes along with time variations and can be decomposed into changes in efficiency and technology with DEA like non-parametric approach, see [13].

IV. EMPIRICAL ANALYSIS

The Table 2 depicts the outcome of DEA analysis. The average CCR and BCC efficiency scores in 2011/12 are 77.5% and 92.4%. The minimum efficiency scores of CCR and BCC model in the same period are 23.8% and 76.2% respectively. The number of 100% efficiency municipalities in CCR model are five and BCC model are six out of 12 municipalities in 2011/12. At the same time five municipalities are scale efficient. On the other hand, the five fiscal years' average CCR and BCC efficiency scores are 79.2% and 88.2% correspondingly. On average, the overall outputs of municipalities should have been augmented by 22.50% in 2011/12 under CRS while only 7.57% argument under VRS in the same period. Moreover, the five years' average output of the municipality should have been augmented by 20.2% under CRS and 11.8% under CRS.

Table 2: Relative efficiency of major cities of Nepal

DMU	Description	2011/12			2012/13			2013/14			2014/15			2015/16			Average efficenct		
		CRSTE	VRSTE	CRSTE/VRSTE =SE	CRSTE	VRSTE	CRSTE/VRSTE =SE	CRSTE	VRSTE	CRSTE/VRSTE =SE	CRSTE	VRSTE	CRSTE/VRSTE =SE	CRSTE	VRSTE	CRSTE/VRSTE =SE	CRSTE	VRSTE	CRSTE/VRSTE =SE
1	Itahari Sub-Metro	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0
2	Biratnagar Metro	58.5	83.8	0.7	65.4	78.6	0.8	76.5	76.8	1.0	100.0	100.0	1.0	84.9	95.8	0.9	77.1	87.0	0.9
3	Janakpur Sub-Metro	92.6	100.0	0.9	50.3	73.6	0.7	39.1	40.2	1.0	50.8	51.4	1.0	41.5	55.1	0.8	54.8	64.1	0.9
4	Kathmandu Metro	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0
5	Lalitpur Metro	100.0	100.0	1.0	100.0	100.0	1.0	92.7	100.0	0.9	69.1	69.6	1.0	100.0	100.0	1.0	92.3	93.9	1.0
6	Hetauda Sub-Metro	100.0	100.0	1.0	96.2	99.3	1.0	89.0	98.1	0.9	100.0	100.0	1.0	76.5	99.8	0.8	92.4	99.4	0.9
7	Birgunj Metro	23.8	83.3	0.3	29.1	54.5	0.5	32.6	65.4	0.5	41.7	59.2	0.7	32.4	60.8	0.5	31.9	64.7	0.5
8	Bharatpur Metro	63.5	92.6	0.7	79.8	86.8	0.9	61.4	96.8	0.6	83.1	97.1	0.9	88.6	99.9	0.9	75.2	94.6	0.8
9	Pokhara Metro	86.7	86.8	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	97.3	97.4	1.0
10	Ghorahi Sub-metro	100.0	100.0	1.0	100.0	100.0	1.0	87.1	100.0	0.9	100.0	100.0	1.0	100.0	100.0	1.0	97.4	100.0	1.0
11	Nepalgunj Sub-Metro	46.6	76.2	0.6	56.2	60.9	0.9	54.0	60.5	0.9	65.6	74.3	0.9	81.2	85.1	1.0	60.7	71.4	0.9
12	Dhangadhi Sub-metro	58.3	86.3	0.7	68.9	82.9	0.8	57.1	74.6	0.8	70.1	86.2	0.8	100.0	100.0	1.0	70.9	86.0	0.8
	Average/Mean	77.5	92.4	0.8	78.8	86.4	0.9	74.1	84.4	0.9	81.7	86.5	0.9	83.8	91.4	0.9	79.2	88.2	0.9
	Minimum	23.8	76.2	0.3	29.1	54.5	0.5	32.6	40.2	0.5	41.7	51.4	0.7	32.4	55.1	0.5	31.9	64.1	0.5
	Maximum	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0	100.0	100.0	1.0
	Average % of output augement	22.5	7.6	17.7	21.2	13.6	10.9	25.9	15.6	12.8	18.3	13.5	6.4	16.2	8.6	10.2	20.8	11.8	11.6

Note: VRS= Variable return to scale or BCC model, CRS = Constant return to scale or CCR model, SE = Scale efficiency, TE=Technical efficiency

4.1 Average efficiency

The average efficiency scores across cities and across fiscal years are presented in figure 1. The average efficiency score under both CRS and VRS models of Birgujn Metropolitan city is drastically fallen down as compare to other cities. It is due to the low score obtained in the MCPM assessment and less collection of own source revenue. The average efficiecny scores across fiscal years under CRS and VRS models have slightly been gone down from 2011/12 to 2013/14 and started increasing in 2014/15 and 2015/16 (Figure 1).

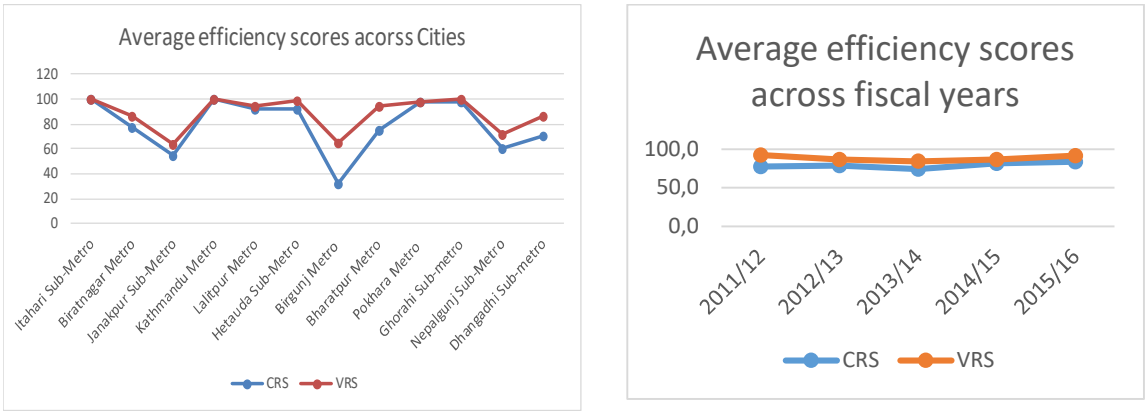

Figure 1: Average efficiency scores across cities and fiscl years

4.2 Scale efficiency

Of the total 12 municipalities/cities, Itahari sub-metropolitan city, Kathmandu metropolitan city and Pokhara metropolitan city are 100% scale effiicent through out five years. The eight municipalities are scale efficient in 2014/15 whereas the number of scale effiecient municipalities reduced in 2015/16 (Figure 2).

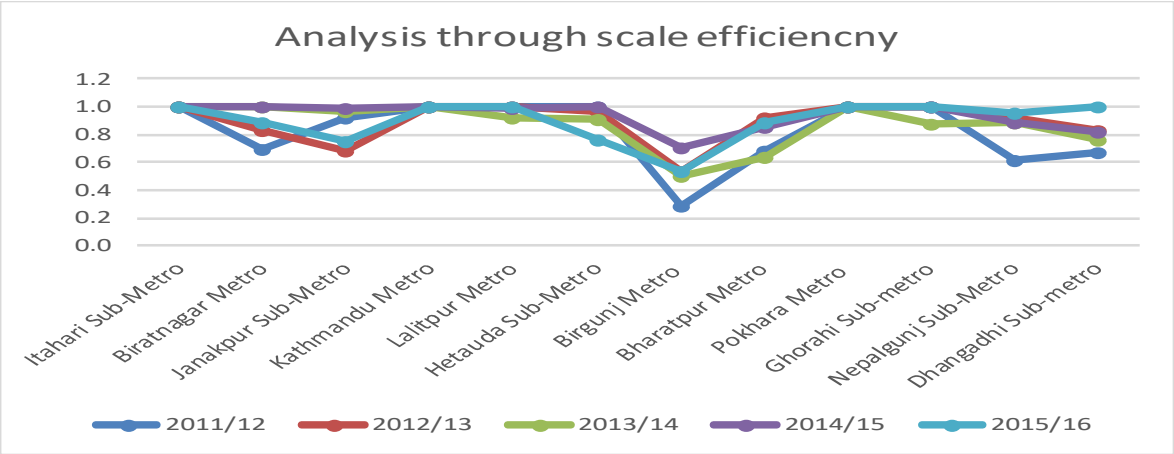

Figure 2: Scale efficiency of the major cities

4.3 Correlation coefficient

Correlation coefficient is high degree positive throughout study period implying both CRS and VRS model yield almost same score.

Table 3: Coefficient correlation of efficiency scores

Fiscal Year	2011/12	2012/13	2013/14	2014/15	2015/16
Correlation Coefficient	0.866706	0.972934	0.858887	0.949855	0.939001

4.4 ANOVA analysis

ANOVA found that P=0.041< 0.05 indicating that at least one of the contextual variables explains efficiency scores. Table 4 shows that the effect of type of municipalities is not significant as p value =0.232734>0.05 while the effect of family size on efficiency scores is significant as p value=0.015148<0.05.

Table 4: Factors Impacting on Efficiency Scores of CRS Model

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	242.2136	54.27468	4.462737	0.001571
Type	-15.4149	12.04795	-1.27946	0.232734
Family Size	-32.0269	10.70364	-2.99215	0.015148

ANOVA found that P< 0.01 indicating that at least one of the contextual variables explains efficiency scores. The same result was observed in case of VRS model regarding the factors impacting on efficiency scores. The effect of family size is found to be significant.

Table 5: Factors Impacting on Efficiency Scores of VRS Model

	Coefficients	Standard Error	t Stat	P-value
Intercept	191.246929	17.19286942	11.12362	1.47E-06

City Type	-3.14450797	3.816489807	-0.82393	0.431273
Family Size	-22.4309161	3.390647603	-6.61553	9.75E-05

4.5. The Application of Malmquist Index (MI)

Using MI technology, the five years' average TFPG shows that Pokhara metropolitan city has achieved a positive productivity growth which is 1.8% while the Itahari Sub-metropolitan city has achieved constant productivity change between 2011/12 to 2015/15 but the remaining cities have experienced productivity decline (value less than 1). Suppose, the average productivity of Biratnager metropolitan city has been decreased by 6.7% (100-93.3). The remaining TFPG can be interpreted accordingly.

Table 6: Total factor productivity growth (TFPG)

DMU	Description	2011/12 to 2012/13			2012/13 to 2013/14			2013/14 to 2014/15			2014/15 to 2015/16			Average
		TC	EC	TFPG/MI	TC	EC	TFPG/MI	TC	EC	TFPG/MI	TC	EC	TFPG/MI	TFPG/MI
1	Itahari Sub-Metro	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	Biratnagar Metro	0.890	1.120	0.990	0.740	1.170	0.870	0.750	1.310	0.980	1.050	0.850	0.890	0.933
3	Janakpur Sub-Metro	0.950	0.540	0.520	0.640	0.780	0.500	0.800	1.300	1.040	0.830	0.820	0.670	0.683
4	Kathmandu Metro	1.000	1.000	1.000	1.000	1.000	1.000	0.910	1.000	0.910	1.000	1.000	1.000	0.978
5	Lalitpur Metro	1.000	1.000	1.000	1.040	0.930	0.960	0.980	0.750	0.730	0.860	1.450	1.240	0.983
6	Hetauda Sub-Metro	1.020	0.960	0.980	0.830	0.930	0.770	0.940	1.120	1.060	0.910	0.770	0.700	0.878
7	Birgunj Metro	0.760	1.220	0.920	0.670	1.120	0.750	0.580	1.280	0.750	0.940	0.780	0.730	0.788
8	Bharatpur Metro	0.890	1.260	1.120	0.830	0.770	0.640	0.760	1.350	1.030	1.000	1.070	1.070	0.965
9	Pokhara Metro	0.930	1.150	1.070	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.018
10	Ghorahi Sub-metro	1.000	1.000	1.000	0.800	0.870	0.700	0.930	1.150	1.070	1.000	1.000	1.000	0.943
11	Nepalgunj Sub-Metro	0.620	1.210	0.750	0.600	0.960	0.570	0.820	1.210	0.990	0.780	1.240	0.960	0.818
12	Dhangadhi Sub-metro	0.840	1.180	0.990	0.780	0.830	0.650	0.710	1.230	0.880	0.840	1.430	1.190	0.928
	Average/Mean	0.908	1.053	0.945	0.828	0.947	0.784	0.848	1.142	0.953	0.934	1.034	0.954	0.909
	Minimum	0.620	0.540	0.520	0.600	0.770	0.500	0.580	0.750	0.730	0.780	0.770	0.670	0.683
	SD	0.120	0.193	0.160	0.153	0.123	0.179	0.133	0.176	0.114	0.088	0.232	0.181	0.100
	Note: efficiency change (EC), technical change (TC), total factor productivity growth (PFPG), and Malmquist Index (MI)													

V. Conclusion

This paper has measured the relative efficiency of six Metropolitan and six sub-metropolitan cities of Nepal. Data Envelopment Analysis (DEA) method has been used to measure the efficiency from both CRS and VRS model. In addition to this scale efficiency and Malmquist Index have also been studied.

On an average, out of 12 DMU's two (Itahari and Kathmandu) have been observed to be most efficient under CRS model and 3 (Itahari, Kathmandu and Ghorahi) have been observed to be efficient under VRS during study period (2011/12 to 2015/16). Over the five years, on an average, over all outputs of municipalities should have been augmented by 20.08% under CRSTE and that of 11.08% under VRSTE.

Under the VRS model, Itahari sub-metropolitan city, Janakpur sub-metropolitan city, Kathmandu metropolitan city, Lalitpur metropolitan city, Hetauda sub-metropolitancity and Ghorahi sub-metropolitan city and under CRS model, Itahari, Kathmandu, Lalitpur, Hetauda and Ghorahiare are found 100% efficient in 2011/12. Itahari, Kathmandu, Lalitpur, Pokhara, Ghorahi and Dhangadhi are found 100% efficient in 2015/16 under both CRS and VRS models (See Table 1). Moreover, Itahari sub-metropolitan city, Kathmandu metropolitan city, and Ghorahi sub-metropolitan city are found 100% efficient under VRS model throughout the periods (five years). On an average, Ithari and Kathmandu under CRS and Itahari, Kathmandu and Ghorahi under VRS model are found 100% efficient.

The TFPG of Bharatpur metropolitan city have achieved a positive productivity growth which is 12% and there are 7% growth of Pokhara metropolitan city from 2011/12 to 2012/13. However, from 2013/14 to 2014/15, Janakpur, Hetauda, Bharatpur and Ghorahi have achieved a positive productivity growth which are 4%, 6%, 3%, and 7%, respectively. On an average of five fiscal years, only Pokhara metropolitan city has achieved 1.8% positive growth (See Table 5).

The efficiency of municipalities under study has been found to be affected significantly by family size which leads to conclude that the municipalities should plan their annual budget according to family sizes those are prevalent in their respective

municipalities.

Further work could be investigation of the economic efficiency and TFPG of the whole cities of Nepal if data are available. Other DEA models and MI technology could be used.

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