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Some New Thoughts on Performance Evaluation of Governments: An Application to Indian Cities

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*Some New Thoughts on Performance Evaluation of Governments: An Application to Indian Cities**

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Abstract

The present paper is an attempt to build up a framework which can holistically analyse the performance of governments bringing in the financial parameters as well as service delivery. We propose a three step methodology capturing different aspects of performance, integrated in the same framework. We generate the expenditure efficiency scores of governments based on expenditure and service delivery, applying non parametric Data Envelopment Analysis in the first step. This also enables us to identify the possible sources of mis-utilisation of resources on different expenditure heads. The second step consists of a detailed assessment of fiscal patterns of governments with Principal Component Analysis based on revenue, demand, cost, socio-demographic, expenditure-adequacy and service-adequacy indicators. The components generated in the second step can also explain the differences in efficiency scores in resource utilization generated in the first step. Also, each step can generate ranks for the governments. A composite rank from both the steps can act as an index of overall performance of the governments. The methodology is applied to the urban local governments of the state of Tamil Nadu to get some insightful results.

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1. Introduction

Analysis of fiscal health of governments is one of the most complex challenges faced by public finance specialists. Irrespective of the political or constitutional definition of a nation, subnational governments are almost never self-sufficient financially. Their revenue-raising capacities fall short of their expenditure responsibilities which can force them to rely on financial transfers from the upper tiers of government. Fiscal decentralization leaves states and municipalities with different financial abilities to provide public services to their citizens. Different jurisdictions will have different needs and costs of providing public services and different revenue-raising capacities with which to finance them. As a consequence, intergovernmental transfers usually have an equalizing element to them, with higher per capita transfers going to jurisdictions with lower fiscal capacities. The extent of equalization differs considerably across nations. However, economic principles alone cannot suffice to determine the ideal system of intergovernmental transfers. Literature suggests that there is no "optimal" set of intergovernmental transfers that suits all circumstances. Instead, grants have to be tailored in each case depending on the objectives sought, the initial conditions, and resource constraints.

Intergovernmental transfers can be designed on the basis of fiscal gaps which measure the difference between the expenditure needs and revenue capacities of a government. In this approach, service delivery is considered implicitly through expenditure needs and the emphasis is on the financial parameters explicitly. The extent of accuracy of estimation of fiscal gap can determine the extent of optimality in allocation of grants. However, there are methodological hurdles in estimating the fiscal gaps as they have to be estimated as the difference between two *ideals.* Correct expenditure needs estimations depend upon the availability of *ideal standards* of services for a jurisdiction which is rarelyavailable. For revenue raising capacities, accurate estimations can be made only if we have information on the revenue base, with the desired levels of bifurcations. These problems become more complex at the city level as we have a very heterogeneous revenue base and differences in service delivery assignments across cities. For Indian cities, the expenditure needs estimation becomes particularly difficult due to the presence of considerable shares of expenditures apart from those in services for which norms cannot be defined.

Literature has also proposed the practice of achieving result-based accountability through performance oriented transfers. The objective of this kind of grant is to ensure quality and access to public services in a simple yet transparent and incentive compatible manner. It links the grant finance with service delivery performance. These transfers are subject to satisfying a set of conditions providing full flexibility in the design of performance. These conditions are designed to make policy, administration and governance effective so that it can ensurethat the necessary financial abilities are generated to achieve the performance goals. The manager of the programs faces greater incentive as the grant is based on the output. In this approach, the financial parameters are implicit and come through the conditions put forward for allocation of grants. It can preserve autonomy, encourage competition and innovation and bring accountability for results to residents. But the problem with this approach is that the economics of the service provision is not spelt out clearly.

The present paper is an attempt to build up a framework which can holistically analyse the performance of governments bringing in the financial parameters as well as service delivery. We do not go via the fiscal gap route, nor do we consider service delivery levels as independent measures to assess performance, with certain conditions on reforms met to ensure that the necessary governance, administrative and fiscal parameters are in place. Instead, we propose a three step methodology capturing different aspects of performance, integrated in the same framework.

The paper is organized as follows. Section 2 gives a brief review of literature to contextualize the problem, relating it to theory in public finance in general and practice in Indian sub nationalpolicy in particular and justifies why we need to think about an alternative framework of performance evaluation of governments. Section 3 elaborates on the new methodology of performance assessment. Section 4 offers the results of application of this methodology to the urban local bodies (ULBs) of the state of Tamil Nadu in India. Section 5 gives the policy implications and concluding remarks. The results are tabulated in a separate Annexure. The technical notes are given in an Appendix.

2. The Context: Theory and Practice

Traditional public finance theory identifies fiscal gap as an indicator of performance of a government unit which is widely used for all practical purposes. Expenditure need is the expenditure needed to provide the minimum acceptable levels of services which the government is responsible to provide for the citizens.For measuring expenditure needs, the two methods mainly used are the representative expenditure system using direct imputation method and theory based representative expenditure system. The former is done by dividing sub national expenditures into various functions, determining expenditure by each jurisdiction for each function, identifying relative need, assigning relative weights using direct imputation methods or regression analysis and allocating total expenditures of each jurisdiction for each function and across jurisdictions. The latter uses a conceptual framework that embodies an appropriately defined concept of fiscal need and properly specified expenditure function, estimated using objective quantitative analysis. Sometimes, simple summation of expenditure norms on different service delivery functions is also done to calculate expenditure need, norms being based on expert opinion.

Fiscal capacity of a government can be measured by representative tax system approach which measures the fiscal capacityof a state by the revenue that could be raisedif the government employed all the standard sources at the nation-wide average intensity of use.The method involves three major steps. First, for each tax, an appropriate base has to be identified. This base should not be the base which is recorded in official tax statistics, rather it should be the base that can be taken to be the representative of relative taxable capacity.Second, a set of representative tax rate which can be constituted as representative tax system need to be generated. This representative of the tax may be derived as the average of the effective rates of that tax, where the effective rates are defined as the ratio of actual collection to the potential base.Third, the average effective rate (AER) is calculated as the weighted average of the effective rates, weights being the respective shares of taxes.

The products of AER and the potential base of a tax will indicate the revenue which the concerned government could raise from that source if its potential is used to the average extent.So the sum of the product over all revenue sources will be the estimated revenue capacity of the government.

In Regression or stochastic approach the relation between tax ratio capacity factors and effort factors are estimated from data. The actual tax ratio depends on the ability of the people to pay taxes, the ability of the administration to collect taxes and the willingness of the government to tax. The factors affecting first two components are termed as tax capacity factors and the factors affecting the third component are tax effort factors.So the variation of tax ratio can be explained by a regression analysis where tax ratio is taken as the dependent variable and indicators of tax capacity and tax effort factors as dependent variables.

Alternatively, an attempt can be made to quantify and isolate the tax capacity factors on the tax ratio, so that the measure of the tax effort of the government will be derived on the basis of residuals. The average degree of the relationship between the tax ratio and what are identified as the taxable capacity factors may be derived through multiple regression analysis. The difference between the actual tax ratio in a jurisdiction and that estimated on the basis of tax capacity equation would be the unexplained variance component and may be attributed to tax efforts. But getting robust estimates are hard in reality.

From the above discussion it is clear that fiscal gap estimation requires huge information for accuracy in calculation. Both revenue capacity and expenditure needs are conceptually interesting but very hard to estimate without a substantial amount of data and information, which is generally neitheravailable,nor can be collected at the levels of dis-aggregation required. The other alternative which assesses the performance through levels of services can prove to be incentive incompatible once the 'inputs' are taken into account to achieve these outputs. Recent changes in outlook in Indian policies are tilted more towards performance based methods and stresses on the point of incentive-compatibility, somewhat ignoring the link between the potential role of inputs to produce these outcomes

Let us take the case for grants to urban local bodies. In India, the Thirteenth Central Finance Commission (13th FC) for the first time proposed performance based grants to ULBs.The 13th FC for the first time also recommended that the grant should come from the central taxes by creating a divisible pool.Earlier, in the 10th, 11th and in the 12th Finance Commission, the ULBs used to get "ad-hoc" grants.

The 13th FC has recommended three types of grants for the ULBs-general basic grant (which would be 1.5 per cent of the divisible pool in the previous year); general performance grant (which would be upto 1 per cent of the divisible pool) and the special area grant (where Rs. 20 per capita per year has been allotted for the first four years).

The performance based grant would only be allowed if certain conditions are met. These are:

1. Constituting the property tax board which in states will assist the ULBs in having transparent practices for property tax levies.
2. All ULBs should be fully empowered to levy property tax.
3. Constitution of the local ombudsman who would take care of complaints regarding improper administration.
4. Benchmarks should be put for four major services-water supply, sewerage, storm water drains and solid waste management

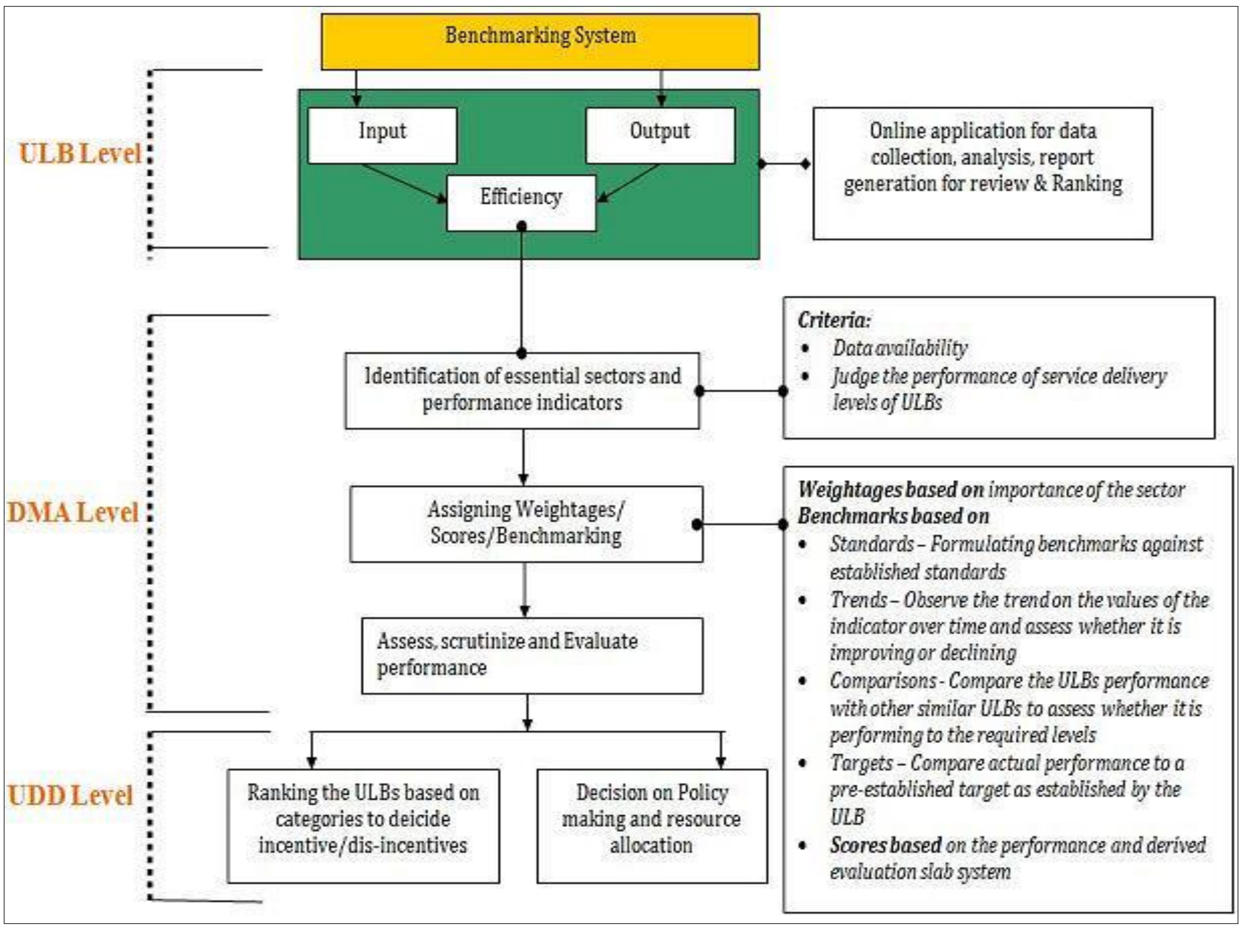
5. State government should put audit system in ULB.
6. State governments should ensure electronic transfer of grants for ensuring transparency in the system.
7. Introduction of supplement to budget document
8. Prescribing qualifications to SFC members through an ACT
9. Putting in place fire hazard response and mitigation plan

If we analyse these conditions carefully we find that they aim to strengthen the revenue base of ULBs and put checks and measures on issues related to audit and governance for an efficient system of service delivery. The financial aspect which was not explicitly taken care of in the performance based measures of governments through service delivery is incorporated through a set of conditions on the basis of which grants are to be allocated. However, mere satisfaction of these conditions would not tell us anything about the financial resources used to provide services.In order to have a clear idea about the economic model behind better service delivery, we need to approach in a different way.

One point needs to be mentioned here. The Ministry of Urban Development came up with a framework for service level benchmarking to facilitate the process and make the recommendations of thirteenth finance commission workbetter. Figure 1 explains the framework in a schematic diagram.

It is interesting to note that this framework recognizes the existence of an implicit economic model associated with the framework which is based on the principles of production and cost. But this model is never addressed while policies are formulated or evaluated. This might leave a caveat in the entire process.

Figure 1 Service Level Benchmarking Framework



In what follows we deal with the caveats of the two approaches of assessing performance of governments in an intellectual framework. We pick up the loose strings from performance based policy formulations based on service level benchmarking and attempt to offer a framework to estimate a performance indicator of ULBs which can be economically justified and analysed. We alsocome up with an alternative methodology of estimating the fiscal patterns incorporating different class of variables which are likely to affect it. This methodology demands lesser information or to be more precise, can be designed by making the best use of whatever information is available. We show that performance in service delivery and that in fiscal health are not independent of each other. These two measures are complimentary and can be combined to get a better sense of performance of governments.

3. Methodological Statement

We propose a three step methodology to build up this framework with an objective of assessing efficiency in expenditure management and service delivery as well as incorporate different categories of variables in assessing fiscal health in a holistic manner.

The first step builds up the economic model behind services provision in a simple production-cost framework. We generate the resource utilization efficiency scores of government units based on expenditure and service delivery data applying non parametric Data Envelopment Analysis. This step also helps us to identify the possible sources of mis-utilisation of resources on different expenditure heads to achieve the levels of services.

However, this analysis focuses on the role of expenditures and service delivery in evaluating performance and leaves out a set of important determinants of fiscal health.

The second step consists of a detailed analysis of fiscal health of the government units with Principal Component Analysis based on resource, demand, cost, service-adequacy and expenditure-adequacy indicators which are important for the analysis of fiscal health. This step gives clear indications regarding which variables or set of variables constructed into components explain the maximum variability in the fiscal health parameters across jurisdictions. We can identify and rank a set of components in order of their explanatory powers and can use them as instruments for further analysis. We can also combine the components into scores for each jurisdiction.

A third step attempts to integrate the two facets of performance of governments and identifies a way to explore any kind of relationship between the efficiency scores in the first step and the principal determinants of fiscal health generated in the second step. This helps us to know whether the most important determinants of fiscal health are also important in explaining the resource utilization efficiency scores or not. This would guide us in understanding the relative importance of different sets of variables holistically.

This analysis can also generate ranks for government units by assigning scores from each step. We propose to take a weighted average of the two sets of scores as the indicator of fiscal health of government, weights being determined on an objective criterion depending upon the purpose of allocating intergovernmental transfers or any other task. For instance, if a grant has to be based on performance in service delivery, the first set of scores be more important and can be given more weightage than that of the second. The third step of the analysis can also guide us to assign weights to determinants of fiscal health in the second step to generate scores from Principal Component Analysis.

This methodology is fairly general and can be applied to any level of government. In the present context, it is applied to the urban local governments of the state of Tamil Nadu to get some insightful results.

Step 1 Estimating Efficiency Scores of Governments

The first step involves computation of input-oriented technical efficiency scores of ULBs with expenditures of different categories as inputs and service levels as outputs.

Our objective would be to attempt an in-depth analysis of performance taking a ULB as the decision making unit (DMU) by bringing in the expenditures on various accounts as *inputs* and provision of services as *outputs*. This analysis attempts to bring together the financial parameters and the service delivery of the ULBs in the spirits of Eeckaut et al (1993), De Borger et al (1994), Grossman et al (1999), Bandyopadhyay (2012) which analyse the efficiencies of ULBs in different countries or explain the factors affecting these efficiencies. The main objective of our analysis is to assess the performance of the ULBs in service delivery and resource utilization in an integrated manner. We also pinpoint the possible sources of resource savings by identifying the sources for mis-utilisation of resources and estimating the quantum of resources mis-utilised which was first attempted forthe municipal sector in Karnataka in Bandyopadhyay (2012).

The justification for using non parametric DEA is that it requires only behavioral assumptions on the production technology which are very basic. Also, DEA performs well even with moderate sized data. The formulation of standard DEA problem is discussed in detail in CCR (1978), BCC (1984) and in the present context in Bandyopadhyay (2012).

Both CCR (1978) and BCC(1984) models calculate only radial (in) efficiency. For radial and slack calculation together one has to use an extended formulation based on BCC (1984). Radial measures are preferred as they can be used to measure radial efficiency and can also estimate off-radial slacks in an integrated multi-stage methodology. The input version of the efficiency models is particularly useful here because the main purpose of this analysis is to focus on the expenditure management of ULBs. A note on the technique with a diagrammatic and mathematical formulation is given in the Appendix.

Step 2 Assessment of Fiscal Patterns of Governments

The second step of our methodology consists of application of Principal Component Analysis to assess the overall fiscal health of the ULBs. Before we describe the technique, we would like to spell out why at all we need this step. The analysis of performance based on efficiency scores in step one only incorporates the expenditures as inputs but there are many factors that might affect service delivery. For that matter, there are factors that can affect expenditures too which indirectly can affect service delivery. We can define variables on different aspects of revenue generation, demand, cost, socio-demographic, expenditure-adequacy and service-adequacy which affect the performance of a jurisdiction in some way or the other. Also, the efficiency scores derived in the first step are deterministic in nature. To make it amenable to statistical inferences and determine the nature of relationship between the variables which cannot be included in deriving these scores, we need to extend the analysis in the first step. If we can come up with a set of variables that represent best the factors affecting fiscal health, we can regressthe efficiency scores on these variables to get an idea about the nature of relationship between the two categories of indicators of performance formulated in the paper.

There can be too many factors which can help to study fiscal patterns of governments. Also, in a large set of variables, some of the variables may be correlated. While too many variables may lead to incorrect inferences, correlation among the variables can also lead to problems of imprecise estimations. Without dropping any of the variables, we can come up with constructs which best represent the data by explaining most of the variability. Data reduction through principal component analysis can be applied for this purpose. After the data reduction process is complete, the reduced components, devoid of high correlations, can be used to derive scores for each observation in the dataset which once normalized can be used for ranking.The weights can be assigned from the respective eigenvalues attached with the components. The components can also be used as explanatory variables to be used in regressions to explain the variability in efficiency scores. A note on the Principal Component technique is given in the Appendix.

Step 3 Integrating Efficiency and Fiscal Patterns of Governments

We can add a third step to complete the analysis. This step integrates the two measures of performance. A regression analysis can be done to check the relation between the efficiency scores derived in the first step and the components derived in the second step. This way we get to know which category of fiscal variables are statistically significant in explaining (in)efficiencies. We can rank these categories of variables according to the statistical levels of significances to find the relative strengths of each in explaining efficiencies of governments,even if they are not statistically significant .

We can also generate a composite index with the efficiency scores and the principal component scores to assess the overall performance of a government unit. This score can be used in assessing the overall performance of governments. We can adjust the weight of the index from each method according to the purpose of generating this score. For instance, if the scores are generated for allocation of grants, for a performance grant, efficiency related component can be given a higher weight whereas for other purposes the fiscal health component can be given a higher weight

4. An Application to the Urban Local Bodies in Tamil Nadu

The above methodology is applied to the municipal sector in the state of Tamil Nadu. The urban sector in the state of Tamil Nadu is huge with 10 Corporations, 149 municipalities and 559 town panchayats. We take all the 718 ULBs for our analysis. We use the data from Fourth State Finance Commission Report and work on the most recent data published there, i.e 2009-10. The results are tabulated in tables 1-12 in the Annexure.

The first step is executed as a multistage DEA with seven outputs and five inputs. Table 1 gives the description of the input and output variables used in the model. Table 2 gives the summary statistics of the variables which shows considerable variation in the data

Table1 List of variables used in Data Envelopment Analysis (DEA) Model

Name of Variable	Symbol Used
Output	
Water supplied (in litres)	Y1
Waste Collected (in million tonnes)	Y2
Roads (km)	Y3
Storm Water Drains(in Km)	Y4
Street Light (in Number)	Y5
Public Convenience (in number)	Y6
Culverts & bridges(in numbers	Y7
Input	
Wages (Rs.)	X1
Establishment Expenses (Rs.)	X2
O&M Expenses (in Rs.)	X3
Capital Expenditure (in Rs.)	X4
Labor Cost (in Rs.)	X5

Table 2 Summary Statistics of Input and Output Variables Used in the DEA Model

	Variable	No of Observations	Mean	Std. Dev.	Min	Max
OUTPUTS						56,300,000,00
	Y1	718	1,180,000,000	3,550,000,000	1,825,000	0
	Y2	718	4,327	17,269	2	269,261
	Y3	718	53	106	2	2,034
	Y4	718	45	358	0	9,298
	Y5	718	1,533	5,643	87	132,527
	Y6	718	12	34	1	728
	Y7	718	80	199	1	2,271
INPUTS	X1	718	149,082	1,667,862	0	35,000,000
	X2	718	19,000,000	174,000,000	53,000	4,420,000,000
	X3	718	9,844,788	43,400,000	218,000	968,000,000
	X4	718	24,800,000	173,000,000	193,000	4,460,000,000
	X5	718	21,000,000	177,000,000	465,000	4,510,000,000

Table3 Efficiency Scores

Summary Statistics	All	Corporation		Municipality		Town Panchayat	
		Grand	Group	Grand	Group	Grand	Group
Number of ULBs	718	10		149		559	
Average	0.66	0.75	1	0.46	0.91	0.72	0.74
Median	0.72	1	1	0.24	1	0.77	0.77

The results of the efficiency analysis are quite interesting. Table 3 shows the summary statistics of efficiency scores for all the ULBs in the state as well as those for each category of ULB. We have run four sets of programs for estimating the efficiencies, one for all the 718 ULBs, one for the 10 corporations, one for the 149 municipalities and one for the 559 town panchayats. The overall median efficiency score is 72 per cent which means the ULBs can Tamil Nadu cansave expenditures by 28 per cent and still provide the same levels of services. Corporations perform the best followed by town panchayats. Municipalities perform the worst.

For each category of ULB there are two sets of scores reported in Table 3. The scoresreported in the 'Grand' column reports the score of the particular category when all the ULBs are considered to generate the 'Grand' frontier and the scores of eachcategory are grouped separately, The scores reported under column 'Group' are generated by running the DEA program for that particular category of ULBs only. For instance, for corporations, both the Grand and Group medians are the same which means there is not much of a difference in the relative performances of the 'corporations' whether they are a part of the municipal sector as a whole or are considered separately as 'corporations'for analyzing the performance. Same holds true for the 'town panchayats'. But we observe a drastic difference in the performance scores of the 'municipalities' in the two columns. This means that the performance within the group and relative performance with ULBs outside the group vary a lot. This is indicative of the fact that the peers outside their own group perform better and this results in a lower relative efficiency of municipalities in the entire sector. This supports the growing concern for medium sized cities which fail to cope up with the ever-growing needs. The corporations are getting the benefits of scale, the town panchayats are getting the benefits of size but the municipalities are somewhat stuck.

Table Slacks in inputs (%)

Categories of ULBs	Summary Statistics	Wages	Establishment	Operations and Maintenance	Capital Expenditure	Labor cost
All	Average	43	20.5	15.6	18.8	15.3
	Median	42.8	15.5	10.1	14.4	10.2
Corporation	Average	3.79	12.28	2.59	27.42	11.63
	Median	3.79	2.39	2.59	27.42	1.48
Municipality	Average	29.56	15.11	9.61	9.48	12.27
	Median	20.42	12.05	6.8	4.92	8.92
Town Panchayat	Average	49.76	25.62	16.76	21.49	17.2
	Median	45.16	21.3	11.45	17.23	12.6

Table 4: Analysis of Slacks in DEA Model (%)

Categories of ULBs	Summary Statistics	Wages	Establishment	Operations and Maintenance	Capital Expenditure	Laborcost
All	Average	43	20.5	15.6	18.8	15.3
	Median	42.8	15.5	10.1	14.4	10.2
Corporation	Average	3.79	12.28	2.59	27.42	11.63
	Median	3.79	2.39	2.59	27.42	1.48
Municipality	Average	29.56	15.11	9.61	9.48	12.27
	Median	20.42	12.05	6.8	4.92	8.92
Town Panchayat	Average	49.76	25.62	16.76	21.49	17.2
	Median	45.16	21.3	11.45	17.23	12.6

Table 4 elaborates on the slacks in inputs which gives the quantum of additional savings on each input. This measures the off radial contractions in inputs associated with the envelope. We find that maximum cost savings can be done for the wages component (43 per cent) and minimum for the labor cost component (10 per cent). Wages component is associated with the contractual labor in which there existscope for a lot of manipulations which is reflected through the model. We also find that the magnitudes of slacks are lower in the corporations but very high in the town panchayat category. This applies to all inputs excepting capital expenditures. Thus, mis-utilisation of resources in general is higher in the smallest category of cities.

The second step for generating components to study fiscal patterns is executed taking 56 variables related to municipal finance and service delivery. We conceptualise a framework much discussed in public finance theory slightly modified for our need of the problem. We

Table 5 Variables Used in Principal Component Analysis

variable	Description	Variable	Description
v1	Population	v29	SFC as % of Transfer
v2	Percentage share of population of ULB	v30	Per Capita Transfers (in Rs.)
v3	Percentage Share of area for ULBs	v31	Residential Properties
v4	Total slum population	v32	Commercial Properties
v5	Population below poverty line	v33	Industrial Properties
v6	Slum population as percentageof total population	v34	Total assessed properties
v7	Population below poverty line as percentage of total population	v35	Own Revenues as % of Revenue Expenditure
v8	Area in (sq KMs)	v36	Total Revenues as % of Total Expenditure
v9	Density (persons per sq km)	v37	Collection efficiency of property taxes (%)
v10	Percentage of coverage of HPEC Financial (O&M) norm for water supply	v38	Collection efficiency profession tax (%)
v11*	Percentage of coverage of HPEC Financial (O&M) norm for roads	*v39*	Collection efficiency of water charges (%)
v12*	Percentage of coverage of HPEC Financial (O&M) norm for storm water drains	*v40*	Road density (in km per sq km)
v13	Percentage of coverage of HPEC Financial (O&M) norm for solid waste management	v41	Per capita road length (in meters)
v14	Percentage of coverage of HPEC Financial (O&M) norm for street lighting	v42	Percentage of TN norm coverage for roads
v15	Per Capita O&M water supply (in Rs.)	v43	Percentage of road length covered by drains
v16*	Per Capita O&M roads (in Rs.)	v44	Percentage of TN norm covered for storm water
v17*	Per Capita O&M storm water drains (in Rs.)	v45	Percentage of coverage of HPEC norms for roads
v18	Per capita O&M solid waste (in Rs)	v46	Percentage of tube light
v19	Per capita O&M street lighting (in Rs.)	v47	Percentage of sodium vapour lamps
v20	Percentage of water charges collected (for O&M cost of water supply	v48	Percentageof TN norm coverage for tube light
v21	Per Capita Tax (in Rs.)	v49	Percentage of TN norm coverage for sodium lamps
v22	Per Capita Non Tax (in Rs.)	v50	Storage Capacity as percentage of water supply
v23	Per Capita Own Rev (in Rs.)	v51	Percentage of TN norm covered for water storage
v24	Own Rev as % of Total Rev	v52	Waste Collection Ratio-Waste Collected as % of waste generated per day-HPEC & TN norm is 100% collection
v25	Per Capita Assigned Rev (in Rs.)	v53	Per Capita Water Supply
v26	Assign Rev as % of Transfer	v54	Percentage of HPEC norms coverage for water supply-135lpcd
v27	Per Capita Grants (in Rs.)	**v55***	Percentage forTN norm coverage for high mast lamps
v28	Grants as % Total Transfers	**v56***	Percentage of high mast lamps

*Variables dropped because of missing values

intend to cover as many variables as we can as determinants of fiscal health and classify them as Cost, Demand, Socio-demographic, Revenues, Service-adequacy and Expenditure-adequacy indicators. While revenues, socio-demographic, cost and demand categories are straightforward[1], we need to spell out how we define service-adequacy and expenditure-adequacy indicators. There are certain norms on services corresponding to which financial

Table 6Summary Statistics of Variables used in Principal Component Analysis

Variables	No. of Observations	Mean	SD	Range	Variables	No. of Observations	Mean	SD	Range
v1	718	42295.7	205203.1	4997372.0	v31	718	7997.7	23500.0	525925.0
v2	718	0.1	0.7	16.5	v32	718	1014.1	4015.0	96254.0
v3	718	0.1	0.2	2.0	v33	718	107.6	554.7	10265.0
v4	717	8409.7	33599.6	658546.0	v34	718	9193.4	27607.5	623332.0
v5	716	7062.1	26795.1	430440.8	v35	718	56.4	47.1	991.9
v6	718	21.6	14.1	96.5	v36	718	131.3	80.2	1583.1
v7	717	16.5	12.1	76.3	v37	718	75.1	29.0	354.0
v8	718	14.9	16.5	216.9	v38	718	90.2	17.2	136.0
v9	718	2986.1	3650.4	28649.3	v39	718	78.2	24.4	97.9
v10	718	48.3	38.9	344.0	v40	718	6.0	17.7	463.6
v13	718	27.7	29.7	267.4	v41	718	2.1	1.3	12.2
v14	718	2399.1	1797.8	23788.5	v42	718	118.7	75.1	698.6
v15	718	139.2	103.9	840.6	v43	718	62.3	530.8	14152.1
v18	718	31.8	34.4	302.1	v44	718	41.5	353.9	9434.7
v19	718	75.5	52.6	713.3	v45	718	82.8	251.7	6622.5
v20	718	47.2	51.4	1192.9	v46	718	75.9	15.3	96.7
v21	718	204.6	248.9	3237.0	v47	718	15.2	11.8	95.0
v22	718	233.3	319.5	7018.9	v48	718	19.0	14.8	118.7
v23	718	437.9	514.2	9953.9	v49	718	117.1	91.1	730.8
v24	718	30.5	13.2	72.1	v50	718	194.2	914.2	15330.4
v25	718	97.4	152.2	2081.1	v51	718	588.4	2770.4	46455.8
v26	718	12.4	11.1	82.6	v52	718	95.4	69.2	950.7
v27	718	377.4	455.3	8136.2	v53	718	95.5	86.5	705.6
v28	718	39.4	19.3	91.5	v54	718	70.8	64.1	522.7
v29	718	49.0	17.8	90.4	v53	718	95.5	86.5	705.6
v30	718	474.8	510.9	9655.4	v54	718	70.8	64.1	522.7

Socio-demographic/Cost/Demand Variables: v1-v9
Service Adequacy Variables:v10-v20
Revenue related Variables: v21-v39
Expenditure Adequacy Variables: v40-v54

[1] These classes of variables which are considered to estimate expenditure needs and revenue capacities in the literature. See Bandyopadhyay and Rao (2009)

norms are designed for different services according to size class of cities in India (HPEC2011). The government of Tamil Nadu also has designed some state level norms on similar lines. In the category of service-adequacy we have included those variables which are related to levels of services and also the coverage of norms on physical levels of services. Similarly, for expenditure-adequacy category we include variables on service wise expenditures and the coverage of financial norms for these services. The details of these variables are given in table 5.The summary statistics are presented in table 6.

Table 7 Composition of Components*

Components	Variables
1	V1, v2, v4, v5, v31, v32, v34
2	V14, v19
3	V37, v38, v39
4	V27, v28,v29, v30
5	V46, V47, v48, v49
6	V53, v54
7	V21, v22, v23, v35
8	V43, v44
9	V40, v45
10	V50, v51
11	V10, v15
12	V3, v8
13	V13, v18
14	V41, v42
15	V6, v7
16	V25, v26

* Variables which are not a part of any component are: v9, v20, v24, v33, v36, v52

Our problem is one with 718 observations on 56 variables. We can look at it as 718 observations in R^{56} space or 56 variables in R^{718} space. We could successfully construct 16 components combining different subsets of 44 out of the 50 variables ultimately involved in the analysis explaining 84.12 per cent of the total variance in the data. We set the lower limit of eigenvalue to be 1 for selecting the components. The details of the 16 components for which eigenvalues are greater than one are given in table 7. The variances explained by each of these components are given in table 8.

Table8: Variance Explained by the Principal Components

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.567	17.134	17.134	8.567	17.134	17.134	7.868
2	6.488	12.977	30.111	6.488	12.977	30.111	3.195
3	3.400	6.800	36.911	3.400	6.800	36.911	3.204
4	2.963	5.926	42.837	2.963	5.926	42.837	3.711
5	2.804	5.608	48.445	2.804	5.608	48.445	4.284
6	2.356	4.711	53.156	2.356	4.711	53.156	2.255
7	2.162	4.324	57.48	2.162	4.324	57.48	4.208
8	2.009	4.017	61.498	2.009	4.017	61.498	2.017
9	1.961	3.921	65.419	1.961	3.921	65.419	2.111
10	1.693	3.385	68.804	1.693	3.385	68.804	2.109
11	1.534	3.067	71.872	1.534	3.067	71.872	2.392
12	1.344	2.688	74.559	1.344	2.688	74.559	2.855
13	1.286	2.571	77.13	1.286	2.571	77.13	3.386
14	1.248	2.495	79.626	1.248	2.495	79.626	2.682
15	1.182	2.365	81.99	1.182	2.365	81.99	1.375
16	1.079	2.158	84.149	1.079	2.158	84.149	2.497

It is interesting to find that the variables belonging to the revenue category explains the maximum variance (25 per cent) followed by those in the expenditure adequacy category (24 per cent), service adequacy category (23 per cent) and Cost/demand/socio-demographic category (12 per cent). It is clear that the revenue components are most prominent in explaining variances in fiscal health parameters. After revenues indicators, service-adequacy and expenditure-adequacy indicators are also more or less equally important.

Our next task is to integrate the analysis in the first step and that in the second step. We would like to synthesize two approaches, one based on expenditure management and service delivery and the other based on a comprehensive set of aspects related to fiscal patterns. We have looked at the same problem from two different angles. The first step derives fiscal health indices as expenditure efficiency scores in a non parametric framework. The second step derives the principal components as determinants of fiscal patterns out of variables apart from those which are included in the first step.

We would first need to know whether the components can explain the differences in expenditure efficiency scores. If so, which set of variables plays the most important role in explaining them? We have done some preliminary OLS and Tobit regressions to see the relationships. We have reported the results of four models. Two sets of OLS regressions are attempted, one with the 16 components and the other with the 16 components and the 6 excluded variables which are not a part of any of these 16 components but were considered in the principal component analysis. In a similar manner, two sets of Tobit regressions are also attempted. The results are reported below (table 9-table12).

Table 9 OLS Regression Model 1

Source	SS	df	MS
Model	662.937059	16	41.4335662
Residual	3024.77818	701	4.31494747
Total	3687.71524	717	5.14325696

Number of obs =	718
F(16, 701) =	9.60
Prob> F =	0.0000
R-squared =	0.1798
Adj R-squared =	0.1610
Root MSE =	2.0772

eeffi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
FAC1_1	.1359365	.0890773	1.53	0.127	-.0389537	.3108268
FAC2_1	-.1286641	.0819158	-1.57	0.117	-.2894938	.0321656
FAC3_1	.71069	.0854379	*8.32*	0.000	.5429451	.8784348
FAC4_1	.0283999	.0795669	0.36	0.721	-.1278181	.1846178
FAC5_1	.1349812	.0825419	1.64	0.102	-.0270777	.2970401
FAC6_1	-.1728753	.079995	*-2.16*	0.031	-.3299339	-.0158168
FAC7_1	.1391205	.0827945	1.68	0.093	-.0234344	.3016754
FAC8_1	.0391849	.0776768	0.50	0.614	-.113322	.1916919
FAC9_1	.0198251	.0786196	0.25	0.801	-.1345331	.1741832
FAC10_1	.0561764	.0787604	0.71	0.476	-.0984581	.2108109
FAC11_1	.0258028	.079993	0.32	0.747	-.1312517	.1828573
FAC12_1	.0518306	.0835832	0.62	0.535	-.1122728	.2159339
FAC13_1	-.267513	.0842099	*-3.18*	0.002	-.4328468	-.1021792
FAC14_1	-.2788497	.0831877	*-3.35*	0.001	-.4421766	-.1155228
FAC15_1	.0393098	.0790865	0.50	0.619	-.115965	.1945846
FAC16_1	.0699974	.081174	0.86	0.389	-.0893758	.2293706
_cons	7.844704	.0775221	101.19	0.000	7.692501	7.996908

Table 10 OLS Regression Model 2

Source	SS	df	MS
Model	776.188821	22	35.28131
Residual	2911.52642	695	4.18924664
Total	3687.71524	717	5.14325696

Number of obs =	718
F(22, 695) =	8.42
Prob> F =	0.0000
R-squared =	0.2105
Adj R-squared =	0.1855
Root MSE =	2.0468

eeffi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
v9	-.0001174	.0000424	*-2.77*	0.006	-.0002006	-.0000342
v24	.0254749	.0131816	1.93	0.054	-.0004056	.0513553
v33	.0002807	.0001861	1.51	0.132	-.0000848	.0006461
v36	.0059213	.0020691	*2.86*	0.004	.0018589	.0099836
v52	-.0025117	.0013932	-1.80	0.072	-.0052472	.0002237
v20	-.0014351	.0018828	-0.76	0.446	-.0051318	.0022615
FAC1_1	.3670314	.1254263	*2.93*	0.004	.1207716	.6132913
FAC2_1	.0355803	.1082089	0.33	0.742	-.1768753	.2480359
FAC3_1	.4802347	.1229713	*3.91*	0.000	.2387948	.7216746
FAC4_1	-.0285341	.1088706	-0.26	0.793	-.2422889	.1852207
FAC5_1	.1806832	.0829338	1.*18*	0.030	-.0178524	.3435141
FAC6_1	-.1226144	.0801747	-1.53	0.127	-.2800281	.0347993
FAC7_1	.4857807	.1760532	*2.76*	0.006	.1401208	.8314406
FAC8_1	.0388165	.0766085	0.51	0.613	-.1115954	.1892283
FAC9_1	.0525258	.0784296	0.67	0.503	-.1014616	.2065132
FAC10_1	.0164558	.0786083	0.21	0.834	-.1378825	.170794
FAC11_1	.0010848	.0974765	0.01	0.991	-.190299	.1924686
FAC12_1	.2154067	.1093239	1.97	0.049	.0007621	.4300514
FAC13_1	-.3571959	.1080681	*-3.31*	0.001	-.5693749	-.1450169
FAC14_1	-.1719154	.0932845	-1.84	0.066	-.3550687	.0112379
FAC15_1	.1201747	.0852748	1.41	0.159	-.0472523	.2876018
FAC16_1	-.0988568	.105065	-0.94	0.347	-.3051397	.1074261
_cons	6.917565	.6216409	11.13	0.000	5.697046	8.138084

Table 11 Tobitregression Model 1

Number of obs = 718

LR chi2(16) = 97.36

Prob> chi2 = 0.0000

Log likelihood = -1379.4275

Pseudo R2 = 0.0341

<table>
<tr><th>eeffi</th><th>Coef.</th><th>Std. Err.</th><th>t</th><th>P>|t|</th><th>[95% Conf.</th><th>Interval]</th></tr>
<tr><td>FAC1_1</td><td>.2452917</td><td>.1612846</td><td>1.52</td><td>0.129</td><td>-.0713663</td><td>.5619497</td></tr>
<tr><td>FAC2_1</td><td>-.1790387</td><td>.1214454</td><td>-1.47</td><td>0.141</td><td>-.4174785</td><td>.059401</td></tr>
<tr><td>FAC3_1</td><td>.8721598</td><td>.1269544</td><td>6.87</td><td>0.000</td><td>.6229039</td><td>1.121416</td></tr>
<tr><td>FAC4_1</td><td>.0846084</td><td>.1159519</td><td>0.73</td><td>0.466</td><td>-.1430457</td><td>.3122624</td></tr>
<tr><td>FAC5_1</td><td>.1622337</td><td>.1204936</td><td>1.35</td><td>0.179</td><td>-.0743374</td><td>.3988048</td></tr>
<tr><td>FAC6_1</td><td>-.2674167</td><td>.1217533</td><td>-2.20</td><td>0.028</td><td>-.5064611</td><td>-.0283724</td></tr>
<tr><td>FAC7_1</td><td>.1029888</td><td>.1332658</td><td>0.77</td><td>0.440</td><td>-.1586584</td><td>.364636</td></tr>
<tr><td>FAC8_1</td><td>.1555653</td><td>.1842259</td><td>0.84</td><td>0.399</td><td>-.2061344</td><td>.517265</td></tr>
<tr><td>FAC9_1</td><td>.0873401</td><td>.1445447</td><td>0.60</td><td>0.546</td><td>-.1964516</td><td>.3711317</td></tr>
<tr><td>FAC10_1</td><td>.0765725</td><td>.1163305</td><td>0.66</td><td>0.511</td><td>-.1518249</td><td>.3049698</td></tr>
<tr><td>FAC11_1</td><td>.0540739</td><td>.1178297</td><td>0.46</td><td>0.646</td><td>-.177267</td><td>.2854148</td></tr>
<tr><td>FAC12_1</td><td>.0010973</td><td>.1220658</td><td>0.01</td><td>0.993</td><td>-.2385606</td><td>.2407551</td></tr>
<tr><td>FAC13_1</td><td>-.3025825</td><td>.1219253</td><td>-2.48</td><td>0.013</td><td>-.5419643</td><td>-.0632007</td></tr>
<tr><td>FAC14_1</td><td>-.3520149</td><td>.1240151</td><td>-2.84</td><td>0.005</td><td>-.5954998</td><td>-.10853</td></tr>
<tr><td>FAC15_1</td><td>.0865539</td><td>.1178371</td><td>0.73</td><td>0.463</td><td>-.1448014</td><td>.3179092</td></tr>
<tr><td>FAC16_1</td><td>.1227661</td><td>.1239589</td><td>0.99</td><td>0.322</td><td>-.1206084</td><td>.3661407</td></tr>
<tr><td>_cons</td><td>8.518573</td><td>.1182592</td><td>72.03</td><td>0.000</td><td>8.286389</td><td>8.750757</td></tr>
<tr><td>/sigma</td><td>2.894684</td><td>.1028509</td><td></td><td></td><td>2.692752</td><td>3.096616</td></tr>
</table>

Obs. summary: 469 uncensored observations

249 right-censored observations

.

Table 12 Tobitregression Model 2

Number of obs = 718

LR chi2(22) = 115.33

Prob> chi2 = 0.0000

Log likelihood = -1370.4441

Pseudo R2 = 0.0404

eeffi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
v9	-.0001255	.0000626	*-2.00*	0.045	-.0002485	-2.54e-06
v24	.027178	.0194566	1.40	0.163	-.0110226	.0653787
v33	.0002769	.0002727	1.02	0.310	-.0002584	.0008123
v36	.0080351	.0030575	*2.63*	0.009	.0020321	.014038
v52	-.0033727	.0020256	-1.67	0.096	-.0073497	.0006042
v20	-.0020602	.0026938	-0.76	0.445	-.0073491	.0032287
FAC1_1	.5158509	.2267894	*2.27*	0.023	.0705776	.9611242
FAC2_1	.0398456	.1576042	0.25	0.800	-.269591	.3492822
FAC3_1	.5809333	.1781987	*3.26*	0.001	.2310618	.9308047
FAC4_1	.0421464	.1603008	0.26	0.793	-.2725846	.3568775
FAC5_1	.2094967	.1204746	1.74	0.082	-.0270405	.4460338
FAC6_1	-.2033668	.1214637	-1.67	0.095	-.4418461	.0351124
FAC7_1	.5134836	.2663573	1.93	0.054	-.0094766	1.036444
FAC8_1	.1786056	.2142781	0.83	0.405	-.2421033	.5993145
FAC9_1	.1598013	.1776663	0.90	0.369	-.1890248	.5086274
FAC10_1	.0251549	.1155192	0.22	0.828	-.201653	.2519627
FAC11_1	-.0020723	.1420317	-0.01	0.988	-.2809343	.2767897
FAC12_1	.1723573	.1590199	1.08	0.279	-.139859	.4845736
FAC13_1	-.3875778	.1568318	*-2.47*	0.014	-.6954979	-.0796577
FAC14_1	-.2124811	.1400047	-1.52	0.130	-.4873632	.0624011
FAC15_1	.1871698	.1276434	1.47	0.143	-.0634425	.4377821
FAC16_1	-.1120871	.1537068	-0.73	0.466	-.4138718	.1896975
_cons	7.388837	.9060634	8.15	0.000	5.609892	9.167783
/sigma	2.840359	.1009468			2.642162	3.038555

```
Obs. summary:        469   uncensored observations
                     249 right-censored observations
```

What we find is very interesting. It is the revenue indicators in the components which play the most important role in explaining differences in efficiencies also. We have reported only four sets of regressions but we have attempted many and in all of them one or many of the revenue components were significant with a positive sign. This implies that ULBs with better revenue generating abilities have higher resource utilization efficiencies. Among the revenue components the strongest is that comprising of the collection efficiencies of different revenue heads which indicates that the administrative efficiency can drive expenditure efficiency in service delivery. Also, it is not the grants or the assigned revenues components which were significant but the components comprising of the own revenues and coverage of revenue expenditure by own revenues which were significant. It is also interesting to note that the service adequacy and the expenditure-adequacy indicators can also be significant but with a negative sign. This indicates that better indicators in terms of coverage of norms or higher service delivery or higher expenditures on services are associated with lower efficiencies. This implies that the cost component, in achieving the targets in service delivery norm, outweighs the gains through better services. Some of the cost and demand indicators are also significant with population having a positive sign and density a negative sign. This implies that while higher population is associated with higher efficiencies, cities with lower densities record higher efficiencies. This indicates that scale effect through population is active but that through population density is not active in determining higher efficiencies.

Now we areclear about the relative importance of the indicators explaining fiscal health patterns and also inefficiency in expenditure management. We can attempt a set of indexation based on the analysis done so far. The efficiency scores are indices of one kind. The principal components can be combined into a single index. Here comes the question of how to choose weights. Traditional theory prescribes the use of eigenvalues as weights to be applied on the scores generated by the components to each individual.ULB. This has a rationale behind it as the eigenvalues captures the extent of variances explained by the respective component. We can follow this method and derive the scores. Also, from our analysis, we know that there is a dominant role played by the revenue indicators in both the steps. So, we can assign the highest weights to the revenue indicators, with a positive margin added to the eigenvalue method.

The last step would be to combine the efficiency indicator and the principal component analysis indicator into a composite index. Here we can assign weights according to the purpose and use of the indicator. If the emphasis is on service delivery, we give more weightage on the efficiency indicator. If that is not the case, we can give more weightage on the principal component analysis indicator[2].

5. Conclusions

The present paper is an attempt to offer a holistic approach of performance evaluation of governments. We propose a three step methodology for a thorough estimation of efficiency and fiscal parameters of governments. The advantage of this methodology is that it is less demanding as far as data requirements are concerned and can serve the same purpose of assigning ranks to governments according to their combined performance on efficiency and fiscal health.In the process, we thoroughly analyse the determinants of fiscal patterns and efficiency and also assess their interrelationships. The variables affecting both can be recognized as the most important ones for performance evaluations of governments and can be given more weightage while constructing indices of performance evaluations.

This methodology can minimize the errors in policy formulations in the sense that it assesses performance of governments from different perspectives. In performance based grant allocation, the major sources of errors come through the fact that the levels of services are overstated which cannot be cross-checked directly through the conditions put forward for

[2]We do not elaborate on the results of indexation, scoring and ranking of ULBs in this paper as that would make the paper more cumbersome. The issue of ranking and allocation of grants is dealt in another paper.

eligibility of these grants. The conditions are broad in nature, based on the steps followed to complete certain reform initiatives. They generally fail to capture the true fiscal patterns, which is crucial for allocation of grants, apart from the service indicators. For accurate estimations of fiscal gaps, the information cost is very high to collect data, particularly to estimatea representative effective rate, the correct revenue base and expenditure needs.The present methodology is somewhat an improvement over the traditional approach in the sense that it provides some checks and measures to arrive at correct assessments of overall fiscal patterns of governments.

An application of this methodology is attempted for the urban local bodies in the state of Tamil Nadu in India. The efficiency and fiscal health patterns are thoroughly analysed for all class of cities. It is interesting to find that the big cities are getting advantage of scale, small cities are getting advantage of their size but the medium sized cities are somewhat stuck. This calls for policy initiatives particularly oriented for medium sized cities in India, for creating higher revenue generation potential by attracting high value residents into their jurisdictions. The location of industrial hubs, particularly services, could be one way out. A more planned development of the medium sized cities are also called for.

We find mis-utilisation more dominant in smaller cities. These leakages call for better audit systems for municipal accounts. This has been prescribed by different central finance commissions and the second administrative reforms commission also. Generally, the audit process is not very regular in smaller cities.

A thorough analysis of the fiscal health parameters reveals that the revenue generating potential and the related variables are the most important in explaining patterns in the fiscal parameters. The collection efficiencies of different tax sources play a prominent role condensed in a component to explain fiscal patterns from data.The service adequacy and expenditure adequacy indicators also play a role.As a single component, population and certain demand side income related variables are also important in explaining variations in fiscal patterns. We also find that the revenue related components can also explainthe differences in efficiencies of ULBs better.The ULBs which have better revenue related characteristics are the ones with higher efficiencies in resource utilization and service delivery.

This calls for more attention towards the policy and administrative factors related to revenue generation and collection. The rates of different revenue sources should be revised on a regular basis. Collection efficiency of different revenue sources and coverage ratio as compared to the entire revenue base are important indicators for performance in revenue generation. The estimation of base through GIS and other procedures need to be taken more seriously. Outsourcing some of these activities to private and other public agencies can facilitate the process. The Jawaharlal Nehru National Urban Renewal Mission (JnNURM)recommendations included all of these but the implementation is yet to be completed.

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Appendix

A Note on Data Envelopment Analysis

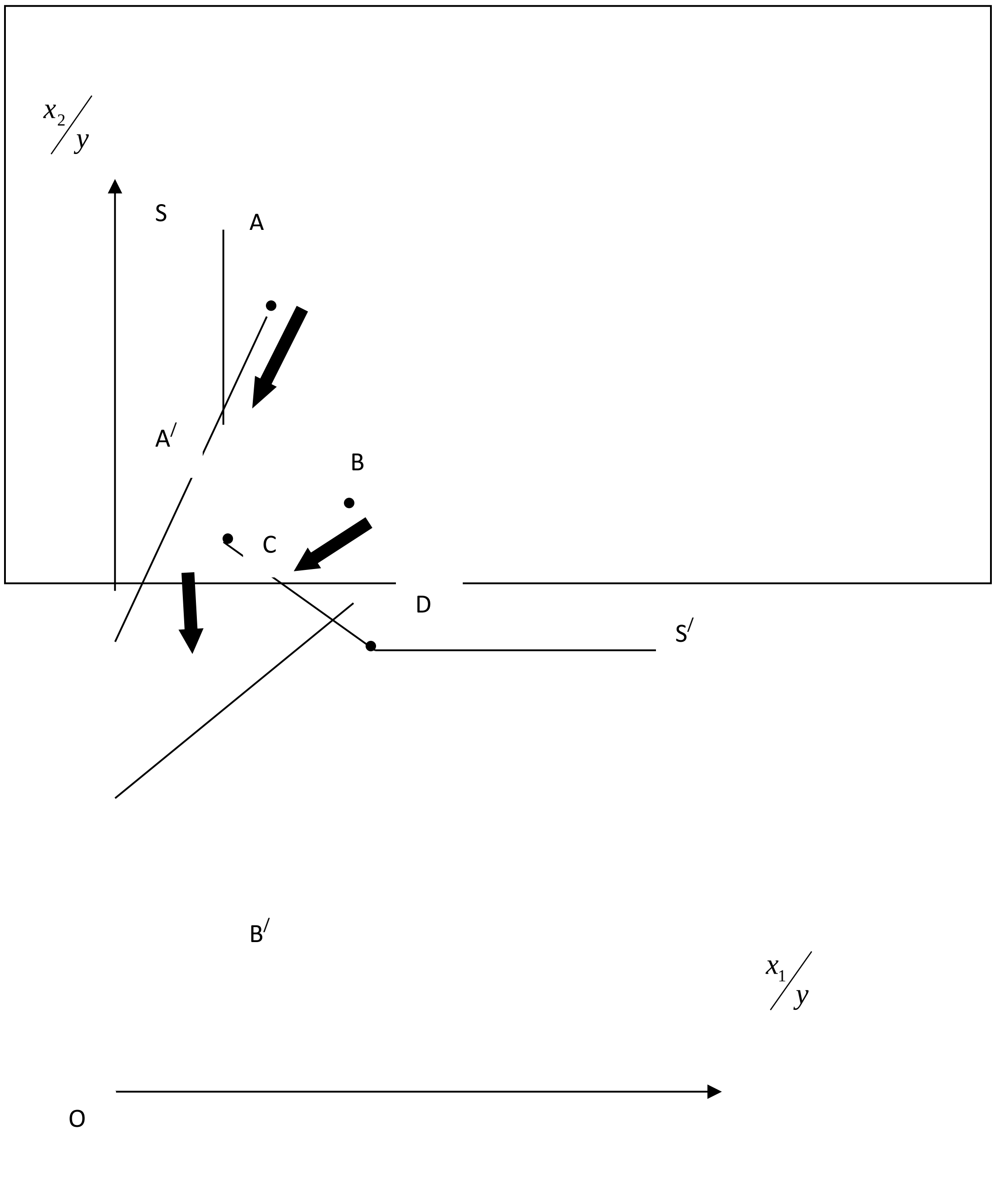
The theoretical foundation of efficiency analysis dates back to Koopmans (1951) who defined a point in the commodity space as efficient whenever an increase in the net output of one good resulted in a decrease in that of another. This definition is known as the Pareto-Koopmans condition for technical efficiency (TE). Debreu's (1951) concept of coefficient of resource utilization as a measure of TE for the economy as a whole (from the point of view of cost of resources), Farrell's (1957) notion of radial contraction of inputs/expansion of outputs from an observed point to the frontier (in axiomatic production theory), i.e., the efficiency of a DMU reflect the ability to use the inputs in optimal proportion, given their respective prices or to achieve the maximum level of output attainable by the state of technology, are all on similar lines. Hoffman (1957) suggested that the dual simplex method could be applied to obtain Farrell's measure of efficiency. This was used in Farrell and Fieldhouse (1962). But the main problem was to cast the fractional program into a linear program so that it is solvable. In principle, it maximizes the ratio of total value of outputs to total value of inputs subject to the constraint that for each DMU this ratio cannot exceed unity. Charnes, Cooper and Rhodes (1978) completed the task of conversion of the fractional program into a linear program by selecting suitable weights (which are nothing but the virtual prices of inputs and outputs). A more generalized variable returns to scale (VRS) model was developed by Banker, Charnes and Cooper (1984).

The basic principle of measurement of technical efficiency is the distance of the point of operation of a decision making unit from that projected on the frontier. Two factors viz. the way the frontier is constructed and the way the distance is measured, make one method of estimation different from the other. The parametric approach requires the imposition of a specific functional form for a production frontier and some assumptions like independently and identically normally distributed errors which have to be uncorrelated with the independent variables. In contrast the non parametric approach does not require any functional form. It is based on a set of behavioral assumptions regarding production. Taking information from data on inputs and outputs the Data Envelopment Analysis (DEA) method generates a discrete piecewise frontier by optimizing on *each* individual observation given the set of Pareto efficient DMUs or the peers. The technical efficiency scores are derived as the ratio of the actual output to the ideal output specified by the generated frontier.

For each family of parametric or non parametric specifications, the estimation can be done through mathematical programming or econometric techniques. The distance between the point on which a decision making unit *actually* operates and the point on the frontier on which it *should have* operated can be measured as a radial or a non radial characterization. In this discussion we would consider radial measures. We would consider the nonparametric method of DEA which uses a linear programming principle for estimating technical efficiency and is deterministic in nature.

Figure 1A gives a diagram to show input efficiency graphically. Suppose we have four firms A, B, C and D of which C and D are the efficient firms operating on the frontier.

Figure-A1: Input- Oriented Radial and Slack Efficiency



With the help of observed input-output data the piecewise linear isoquant (SS′) can be constructed (FigureA.1)[3] Firms A and B represent two inefficient firms. So, the extent of their technical inefficiency will be $\frac{OA'}{OA}$ and $\frac{OB'}{OB}$ respectively. But it is not the ultimate efficient point because one could reduce the input x_2 by the amount CA′ and still produce the same output. Therefore, this movement along isoquant is known as the input slack. On the other hand in case of firm B only radial movement is enough to ensure efficient input-output combination. No slack movement is required here. Similarly the concept of output slack can be described.

Model 1 is the input version of the efficiency with slacks given as:

Min: $\tilde{\theta} = \theta - \varepsilon\left(\sum_{j=1}^{m} s_j^{+} + \sum_{i=1}^{n} s_i^{-}\right)$

Subject to: $\sum_{t=1}^{N} \lambda_t y_{jt} - s_j^{+} = y_{jt}; \forall j = 1,2,\ldots\ldots\ldots\ldots\ldots, m$

$\sum_{t=1}^{N} \lambda_t x_{it} + s_i^{-} = \theta x_{it}; \forall i = 1,2,\ldots\ldots\ldots\ldots\ldots, n$ **Model-1**

$\sum_{t=1}^{N} \lambda_t = 1$

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[3] Here x_1 & x_2 indicate two inputs and y represents one output.

$$\lambda_t, s_j^+, s_i^- \geq 0; \forall t = 1,2,..............., N; \forall j = 1,2,.............., m; \forall i = 1,2,..............., n.$$

Where: θ is free.

s_j^+, s_i^- , indicates the output and input slack and ε is any pre-assigned positive number, however small. Positive sign means output should be increased and negative sign means input should be decreased.

It is the treatment of slacks that motivates the extension of the basic model to different stages. A single stage DEA we can solve a linear program in model 1 and calculate slacks residually.

Model 1 can be executed as a two stage or a multi stage model. In a two stage DEA, first, the input efficiency scores are derived and then a stage follows where corresponding to these efficiency scores the optimal slacks are estimated for each ULB. This is done by estimating $\tilde{\theta}$ in eq 1.1 in the first stage. In the second stage the non radial movement on the efficient frontier is achieved by optimising the slack variables in eq 1.2.

However, the presence or absence of weakly efficient DMUs makes the procedure a little different.

A DMU is efficient iff

$\tilde{\theta}$ =1 and $s_i^-{}^\star$ = 0; and (or) $s_j^+{}^\star$=0 for all i and j;

A DMU is weakly efficient iff

$\tilde{\theta}$ =1 and $s_i^-{}^\star$ = $s_j^+{}^\star$=0 for some i and j;

We do not know before the calculations whether weakly efficient DMUs are present. In the absence of weakly efficient DMUs, we can estimate the optimal slacks using eq 1.3 in the second stage.

Min: $\theta = \tilde{\theta}$

Subject to: $\sum_{t=1}^{N} \lambda_t y_{jt} \geq y_{jt}; \forall j = 1,2,...............,m$

$$\sum_{t=1}^{N} \lambda_t x_{it} \leq \theta x_{it}; \forall i = 1,2,...............,n \qquad \textbf{....................1.1}$$

$$\sum_{t=1}^{N} \lambda_t = 1$$

$$\lambda_t, \geq 0; \forall t = 1,2,................,N; \forall j = 1,2,..............,m; \forall i = 1,2,...............,n.$$

Where: θ **is free.**

Max: $\left(\sum_{j=1}^{m} s_j^+ + \sum_{i=1}^{n} s_i^- \right)$

Subject to: $\sum_{t=1}^{N} \lambda_t y_{jt} - s_j^+ = y_{jt}; \forall j = 1,2,...............,m$

$$\sum_{t=1}^{N} \lambda_t x_{it} + s_i^- = \tilde{\theta} x_{it}; \forall i = 1,2,...............,n \qquad \textbf{....................1.2}$$

$$\sum_{t=1}^{N} \lambda_t = 1$$

$$\lambda_t, \geq 0; \forall t = 1,2,................,N; \forall j = 1,2,..............,m; \forall i = 1,2,...............,n.$$

Where: θ **is free.**

$$s_j^+ = \sum_{t=1}^{N} \lambda_t y_{jt} - y_{jt}; \forall j = 1,2,..............., m$$

$$s_i^- = \tilde{\theta} x_{it} - \sum_{t=1}^{N} \lambda_t x_{it}; \forall i = 1,2,..............., n \qquad \text{....................1.3}$$

A two-stage procedure can suffer from two shortcomings depending upon the dataset and the nature of the problem to solve. Optimisation of slacks in the second stage can lead to maximization instead of minimization of slacks in this procedure. Also, the solutions are sensitive to the units in which the data is expressed. To overcome these difficulties, a multi-stage procedure is preferred which conduct a sequence of radial linear programs to make the necessary corrections. However, whether we need to go beyond the two stage procedure could be a matter of choice or an empirical question, which depends on the structure of the dataset and the problem to be addressed. In our case, the solution of a multi-stage model and a two stage model does not differ as the dataset does not permit us to run the program beyond the second stage.

A Note on Principal Component Analysis

The concept of generating components through data reduction is simple yet elegant. If we have a data matrix X with n observations and p variables, the entire structure can be looked at from two different spaces, the sample space or the variable space, ie to say there can be n observations/points in R^p or p variables/points in R^n. Reduction of dimensionality is achieved by an algorithm which searches for the axis used to project the samples that minimizes the loss of information or variability of the cloud of points. The variability is captured by the vector length and the correlation by the angle between two vectors for standardized variables. All the variability in the data can be considered for analysis. The components are generated in order of the degree of explanatory factor of variations by them. For instance, the first component explains the biggest share of variation. An iterative process is run by repeating this, leaving out each component after its performance. Theoretically, the number of components derived can be equal to the number of variables but the components explaining the highest shares of variations are chosen and those explaining considerably lesser proportions are ignored. The components are retained by ranking them according to the eigenvalues attached to them. A rule of thumb for retaining components is setting a cut-off for eigenvalues at 1, i.e we consider those components whose eigenvalues are greater than or equal to 1.

Principal components are derived in two steps. The components generated in the first set of iterations, with orthogonal transformation of the variables into components, might not give interpretable results. Herein comes the concept of rotation. This is a fine tuning process in order to make the results more interpretable without changing the fundamental relations in the data. The rotation of the constructed components in the second stage can be orthogonal or oblique depending upon the nature of the problem. In social science we find oblique rotations more practical as there is always some correlation between a set of variables used in these problems. After deriving the components we can derive the scores as weighted averages of these components, weights being the respective eigenvalues or the measures of variance associated with each component