Annex-II: Stochastic Frontier Analysis – Methodology

Following the standard stochastic frontier model for cross section analysis (Aigner *et al.*, 1977) later extended to panel data (Battese and Coelli, 1995), let

$$Y_{it} = \exp(X_{it}\beta + v_{it} - u_{it}) \quad \text{..... (1)}$$

where Y_{it} denotes own tax revenue (OTR)/ taxes on commodities and services (TaxCom), X_{it} denotes vector of inputs (*viz.*, Log Per capita GSDP, Square of Log Per capita GSDP and Log share of Agriculture in GSDP) affecting tax revenue for the *i* th state in the *t* th period and β is a vector of unknown parameters. Error component is decomposed into two parts v_{it} and u_{it}; v_{it} is statistical noise term with symmetric distribution while u_{it} is a non-negative error component representing the time varying technical inefficiency. The inefficiency effects are expressed as an explicit function of state-specific variables and a random error to identify the reasons for differences in predicted efficiencies between states as given below

$$u_{it} = Z_{it}\delta + W_{it} \quad \text{..... (2)}$$

where W_{it} is a random variable defined by truncation of normal distribution with zero mean and variance σ^2 and Z_{it} denotes vector of variables predicting inefficiency (*viz.*, Ratio of transfers in revenue receipts, Aggregate Expenditure to GSDP, Debt-GSDP ratio and VAT Dummy). The estimates of efficiency can be derived once the point estimates of u_{it} are obtained by the following expression;

$$Efficiency = \exp(-\hat{u}_{it}) \quad \text{..... (3)}$$

Table 1: Stochastic Frontier and Technical Inefficiency – Estimates

	SFA Model 1	SFA Model 2
	Log OTR-GSDP	Log TaxCom-GSDP
Stochastic Frontier		
Log Per capita GSDP	0.299* (0.032)	0.281* (0.021)
Square of Log Per capita GSDP	-0.0148* (0.031)	-0.0143* (0.015)
Log share of Agriculture in GSDP	-0.0579** (0.006)	-0.0564** (0.004)
Constant	0.644 (0.365)	0.67 (0.294)
Inefficiency Equation		
Ratio of transfers in revenue receipts	0.0222*** (0.000)	0.0228*** (0.000)
Aggregate Expenditure to GSDP	-0.0557*** (0.000)	-0.0619*** (0.000)
Debt-GSDP ratio	0.00279* (0.024)	0.00472*** (0.000)
VAT Dummy	-0.126*** (0.000)	-0.105** (0.002)
Constant	0.189** (0.001)	0.256*** (0.000)
Usigma Constant	-6.868*** (0.000)	-6.135*** (0.000)
Vsigma Constant	-4.320*** (0.000)	-4.357*** (0.000)
Observations	363	401
Log-Likelihood	262.7	288.7

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Sigma Convergence Test

	SD Model 1	SD Model 2
Year	0.792* (0.035)	1.155*** (0.000)
Year sq.	-0.000198* (0.035)	-0.000289*** (0.000)
Constant	-790.6* (0.035)	-1153.7*** (0.000)
Observations	23	25
Log-Likelihood	63.45	70.19

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$