Mapping Perceptions of Universities of Higher Education in India: A Comparative Analysis using DEA and Quantile Regression

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The Background

- According to a recent report published by EY, India has remarkably transformed its educational landscape with one in four graduates in the world being a product of her system.

- India is also among top 5 countries globally in cited research output, with 23 Universities in global top 200.

- The Government of India (GoI) has undertaken massive structural and systemic changes in higher education like reforms in
  - governance,
  - intensive use of technology,
  - transition to a student-centric paradigm of education,
  - expansion of access and
  - qualitative improvement.

  - Despite these efforts by the GoI, India's GER is much lower (26.3%) than the global average of (36.7%) in addition to many Indian students choosing to study abroad.

- There are 50,000 higher educational institutions operational in India.

- 907 Universities currently exist in India. These include 399 state Universities, 126 deemed to be Universities, 48 central Universities and 334 private Universities.

- Nearly 300 million students are pursuing education in India and the value of the education market in India in FY 19 is pegged at $101bn.

- Most importantly, MHRD, India announced a new education policy on July 29, 2020 after three decades(NEP-2020) and it is expected set the pace for the sector which caters to 25% of the country’s population.

- Headed by the Krishnaswamy Kasturirangan, a committee of nine experts had drafted the National Education Policy, 2019 and shared the draft for seeking inputs and suggestions on June 10, 2019 from citizens of the country.

Perceptions

- Perceptions - the process or result of becoming aware of objects, relationships, and events by means of the senses, which includes such activities as recognizing, observing, and discriminating. These activities enable organisms to organize and interpret the stimuli received into meaningful knowledge and to act in a coordinated manner.
- Source: https://dictionary.apa.org/perception

- Research suggests that consumers act and react on the basis of their perceptions, not on the basis of objective reality (Schiffman, Kanuk, Kumar & Wisenblit, 2010). Thus, the reality of a University might be different from its perceptions and vice-versa. However, perceptions form the basis of selection of a University by its stakeholders.

Literature Review

- Not much evidence of literature on ***perceptions*** of Universities of higher education in India.

- Agrawal (2006) studied the Higher education system in India and

  - suggested that it needs to change so as to provide affordable and accessible education to all.

- Potluri et al. (2015) studied student perceptions on Quality of Indian Higher Education system

  - found the positive and negative facets of quality viz.,

  - tangible facilities, competence, attitudes, content, delivery in terms of students' perceptions at Institutes in Andhra Pradesh, South India.

- Except for National Institutes Ranking Framework (NIRF) framework
  - which was approved by the MHRD and
  - launched by Honourable Minister of Human Resource Development on 29th September 2015 and
  - which developed metrics to measure efficiency and released the first set of rankings in April, 2016,
  - the researcher could not find evidence of metrics used to map and rank Institutions of Higher education across the country.

Research Objectives

Given the background, the purpose of this research is to:

- explore the relationship between perceptions and other variables considered by NIRF for ranking of Universities of Higher Education in India
- provide a novel behavioural operational research approach for:
  - assessing the relative input-output efficiency of Universities of Higher education in India based on perceptions
  - using Data Envelopment Analysis (DEA) and
  - quantile regression
- To find out the major factors and their relative importance in contributing to the perceptions of Universities
- compare and contrast the results obtained through DEA and quantile regression.

The Method

- The input and output measures for performing DEA and Quantile regression are:
  - pseudo measures derived from the National Institutional Ranking Framework (NIRF), 2020
  - published by the Department of Higher Education, Ministry of Human Resource Development, Government of India.
- The NIRF framework ranks various Institutions across India based on five parameters viz.:
  - Teaching, Learning and Resources (TLR)
  - Research and Professional Practice (RP),
  - Graduation outcomes (GO),
  - Outreach and Inclusivity (OI), and
  - Perceptions (PR).

NIRF Ranking Methodology

Summary of Ranking Parameters and Weightages- 2020 (Overall)

Sr. No.	Parameter	Marks	Weightage
1	Teaching, Learning & Resources	100	0.30
2	Research and Professional Practice	100	0.30
3	Graduation Outcomes	100	0.20
4	Outreach and Inclusivity	100	0.10
5	Perception	100	0.10

Source: NIRF Ranking Methodology, 2020, MHRD, GoI

Detailed break-up of the parameters

S.No.	Parameters	Marks
1.	**Teaching, Learning & Resources (TLR)** **Ranking weight: 0.30**	**100**
	A. Student Strength including Doctoral Students(SS): 20 marks B. Faculty-student ratio with emphasis on permanent faculty (FSR): 30 marks C. Combined metric for Faculty with PhD (or equivalent) and Experience (FQE): 20 marks D. Financial Resources and their Utilisation (FRU): 30 marks	
2.	**Research and Professional Practice (RP)** **Ranking weight: 0.30**	**100**
	A. Combined metric for Publications (PU): 35 marks B. Combined metric for Quality of Publications (QP): 35 marks C. IPR and Patents: Published and Granted (IPR): 15 marks D. Footprint of Projects and Professional Practice (FPPP): 15 marks	

Source: NIRF Ranking Methodology, 2020, MHRD, GoI

3.	**Graduation Outcomes (GO)** **Ranking weight: 0.20**	**100**
	A. Metric for University Examinations(GUE): 60 marks B. Metric for Number of Ph.D. Students Graduated (GPHD): 40 marks	
4.	**Outreach and Inclusivity (OI)** **Ranking weight: 0.10**	**100**
	A. Percentage of Students from Other States/Countries (Region Diversity RD): 30 marks B. Percentage of Women (Women Diversity WD): 30 marks C. Economically and Socially Challenged Students (ESCS): 20 marks D. Facilities for Physically Challenged Students (PCS): 20 marks	

Source: NIRF Ranking Methodology, 2020, MHRD, GoI

5.	**Perception (PR)* Ranking weight: 0.10**	**100**
	A. Peer Perception: Academic Peers and Employers (PR): 100 marks	

*However for universities in the PR parameter, 70% weight was given to Peer Perception and 30% to Accreditation.

Source: NIRF Ranking Methodology, 2020, MHRD, GoI

About this research

- Output variable
  - Perceptions (PR)
- Input variables
  - Teaching, Learning and Resources (TLR),
  - Research and Professional Practice (RPC),
  - Graduation Outcomes (GO) and
  - Outreach and Inclusivity (OI)
- Assumption:
  - Aggregate Perceptions are a function of TLR, RPC, GO and OI.
- Only the top 50 of the 100 universities according to the NIRF framework.

Data Envelopment Analysis (DEA)

- Is an Linear Programming(LP) based optimization methodology
- Determines how efficiently an operating unit converts inputs to outputs when compared with other units.
- The problem in DEA is to determine values for the weights assigned to inputs and outputs.

The Decision Variables (DVs)

- The efficiency of an arbitrary unit *i* is defined as follows:

- $Efficiency\ of\ unit\ i = \frac{\sum_{j=1}^{n_o} O_{ij} w_j}{\sum_{j=1}^{n_I} I_{ij} v_j} = \frac{Weighted\ sum\ of\ unit\ i's\ outputs}{Weighted\ sum\ of\ unit\ i's\ inputs}$

- *Where*
- O_{ij} *represents the value of unit i on output j*
- I_{ij} *represents the value of unit i on input j*
- w_j *is a non-negative weight assigned to output j*
- v_j *is a non-negative weight assigned to input j*
- n_o *is the number of output variables*
- n_I *is the number of input variables*

- The problem in DEA is to determine the weights w_j and v_j.

- Thus, w_j and v_j represent the decision variables in a DEA problem

The objective function

- A separate LP problem is solved for each unit in a DEA problem
- For each unit, the objective is the same:
  - to maximize the weighted sum of that unit's outputs.
- For an arbitrary unit *i*, the objective is stated as:
- Max: $\sum_{j=1}^{n_o} O_{ij} w_j$
- As each LP is solved, the unit under investigation is given the opportunity to select the best possible weights for itself (or the weights that maximize the weighted sum of its output)

The Constraints

- Any unit under investigation cannot select weights for itself that would cause the efficiency for any unit (including itself) to be greater than 100%.

- Thus, for each individual unit, the weighted sum of the unit's outputs are required to be less than or equal to the weighted sum of its inputs

- This will imply that the ratio of weighted outputs to weighted inputs does not exceed 100%

$$\sum_{j=1}^{no} O_{kj} w_j \leq \sum_{j=1}^{n_I} I_{kj} v_j \ , for\ k = 1\ to\ the\ number\ of\ units$$

- or equivalently

$$\sum_{j=1}^{no} O_{kj} w_j - \sum_{j=1}^{n_I} I_{kj} v_j \leq 0, for\ k = 1\ to\ the\ number\ of\ units$$

- To prevent unbounded solutions, we also require the sum of weighted inputs for the unit under investigation (unit *i*) to equal one.

$$\sum_{j=1}^{n_I} I_{ij} v_j = 1$$

- Because the sum of weighted inputs for the unit under investigation must equal one and its sum of weighted outputs (being maximized) cannot exceed this value, the maximum efficiency score for the unit under investigation is also one (or 100%).

- Thus, units that are efficient will have a DEA efficiency score of 100%

Results & Analysis

- Units 2,4,9 and 20 are operating at 100% efficiency (in the sense of DEA)

- while the remaining units are operating less efficiently

- For units that are DEA inefficient, there exists a linear combination of efficient units that results in a composite unit that produces at least as much output using the same or less input than the inefficient unit

- The idea in DEA is that an inefficient unit should be able to operate as efficiently as this composite unit formed from a linear combination of the efficient units

- For instance, unit 1 has an efficiency score of 96.44%.

- Now, the output shows that:

  - a weighted average of 82.93% of unit 2,

  - 2.14% of unit 4 and

  - 18.86% of unit 20

  - produces a composite unit with outputs greater than or equal to those of unit 1 and requiring less input than unit 1.

DEA optimal weights and Target values

- DEA\DEA output.xlsx

Inferences from the DEA output

- DEA efficient units and their Optimal Weights

NIRF Rank	Name of the Institute	DEA Efficiency	Perception	TLR	RPC	GO	OI
2	Indian Institute of Science	1.0000	0.0100	0.0000	0.0090	0.0021	0.0000
4	Indian Institute of Technology Bombay	1.0000	0.0110	0.0019	0.0114	0.0000	0.0000
9	Indian Institute of Technology Roorkee	1.0000	0.0128	0.0007	0.0111	0.0024	0.0000
20	Anna University	1.0000	0.0167	0.0029	0.0173	0.0000	0.0000

- As anticipated, there are disparities between NIRF ranks and DEA efficiency scores.
- This explains that aggregate perceptions are bound to be different from the rankings.
- RPC contributes the highest to the DEA efficient units.
- OI does not contribute anything to the DEA efficient units.

- OI contributes to the formation of perception of only two Universities.

- Of the 50, there are only 7 Institutions where 3 inputs contribute to the perceptions.

- The highest optimal weight of perception that of Kerala University at 0.0427 and interestingly it also has a corresponding highest contributing value of RPC at 0.525

- Target values indicate the amount of inputs that need to be expended to produce the current outputs to be as efficient as the efficient units.

- Perceptions are different from reality as reflected from the following optimal weights table:

Top 5 DEA optimal weights for Perceptions	Column1	Column2
Institution	DEA optimal weight	NIRF Rank
Kerala University	0.0427	42
Mysore University	0.0415	47
Siksha `O` Anusandhan	0.0316	38
Andhra University	0.0313	36
King George`s Medical University	0.0307	50

- For 49 out of the 50 Institutes,
  - Research and Professional Practice (RPC) contributes the maximum to form perceptions.

- For 40 out of the 50 Institutes,
  - Teaching and Learning Resources (TLR) do not contribute to the formation of perceptions and hence to the efficiency

- Maximum DEA optimal weights of input variables

Input	Optimal weight	Institution
TLR	0.00287	Anna University
RPC	0.05255	Kerala University
GO	0.01296	Indian Institute of Technology Delhi
OI	0.00451	Institute of Chemical Technology

Variable	NIRF assigned weight (2020)
Perception	0.1
TLR	0.3
RPC	0.3
GO	0.2
OI	0.1

- NIRF assigned weights are different from the maximum weights obtained through DEA

- Implies that different Universities are perceived differently. i.e. different factors influence the perceptions of Universities differently.

- NIRF uses standard weights across all Universities. However, if Indian Universities want to improve their perceptions they need to work on TLR, RPC, GO and OI scores differently.

Quantile Regression

- Used to describe the distribution of a dependent variable

- models the relationship between a set of predictor (independent) variables and specific percentiles (or "quantiles") of a target (dependent) variable, most often the median

- Models the relationship between x and conditional quantiles of y rather than just the conditional mean of y unlike OLS.

- Quantile regression makes no assumptions about the distribution of the target variable.

- Quantile regression tends to resist the influence of outlying observations

Quantile regression model

- Is described by the following equation:

$$y_i = x_i{}'\beta_q + ei$$

where βq is the vector of unknown parameters associated with the qth quantile

- OLS minimizes $\sum_i e_i^2$, the sum of squares of the model prediction e_i

- The quantile regression minimizes $\sum_i q|e_i| + \sum_i (1-q)|e_i|$, a sum that gives asymmetric penalties $q|e_i|$ for under prediction and $(1-q)|e_i|$ for over prediction.

- The qth quantile regression estimator $\widehat{\beta_q}$ minimizes over β_q the objective function:

$$Q(\beta_q) = \sum_{i:yi \geq xi\prime\beta}^{N} q|y_i - x_i{}'\beta_q| + \sum_{i:yi \leq xi\prime\beta}^{N}(1-q)|y_i - x_i{}'\beta_q|$$

where 0 < q < 1

- QR computation uses LP methods unlike OLS which uses maximum likelihood

Quantile regression coefficients and marginal effects

- The standard conditional quantile is specified to be linear:

$$Qq(y_i|x_i) = x_i{}'\beta_q$$

- For the jth regressor, the marginal effect is the coefficient for the qth quantile

$$\frac{\partial Qq(y|x)}{\partial xj} = \beta_{qj}$$

β_{qj} estimates the change in a specified quantile q of the dependent variable *y* produced by a one unit change in the independent variable x_j

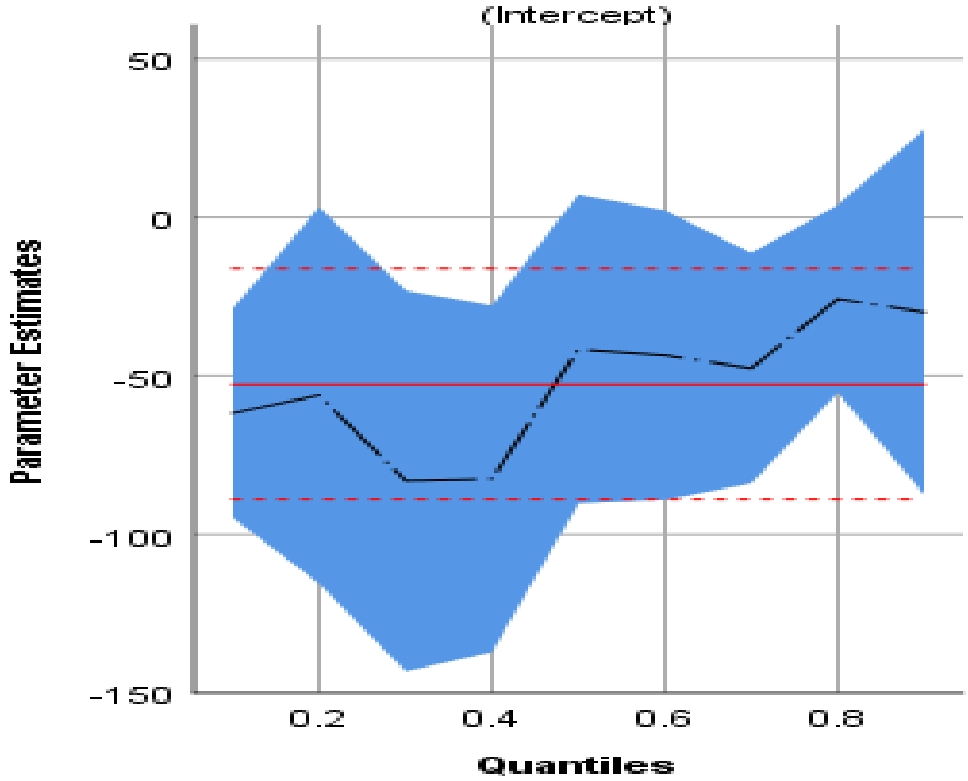
Quantile regression for this research

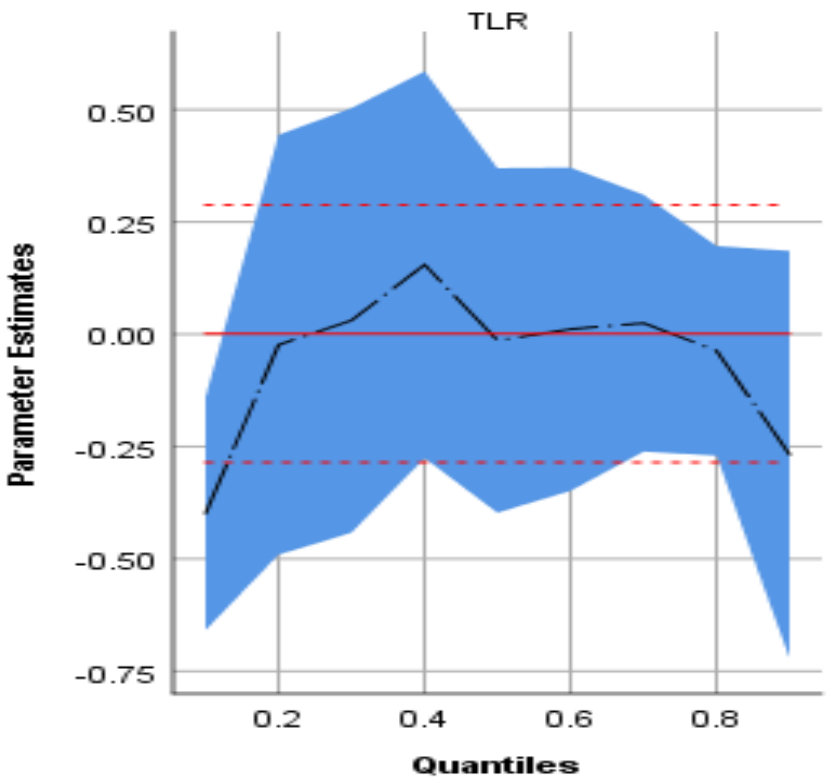
- Dependent variable – perception
- Independent variables – TLR, RPC, GO, and OI

Parameter	OLS	q=0.1	q=0.2	q=0.3	q=0.4	q=0.5	q=0.6	q=0.7	q=0.8	q=0.9
(Intercept)	-52.554	-61.749	-56.129	-83.102	-82.430	-41.566	-43.458	-47.579	-25.720	-29.856
TLR	0.001	-0.399	-0.024	0.031	0.155	-0.014	0.011	0.025	-0.037	-0.268
RPC	1.193	0.744	0.806	1.014	1.215	1.275	1.269	1.268	1.204	1.266
GO	0.426	0.805	0.437	0.680	0.528	0.372	0.378	0.290	0.300	0.276
OI	-0.028	0.136	0.165	0.157	0.146	-0.152	-0.122	0.088	-0.135	0.234

a. Dependent Variable: Perception

b. Model: (Intercept), TLR, RPC, GO, OI



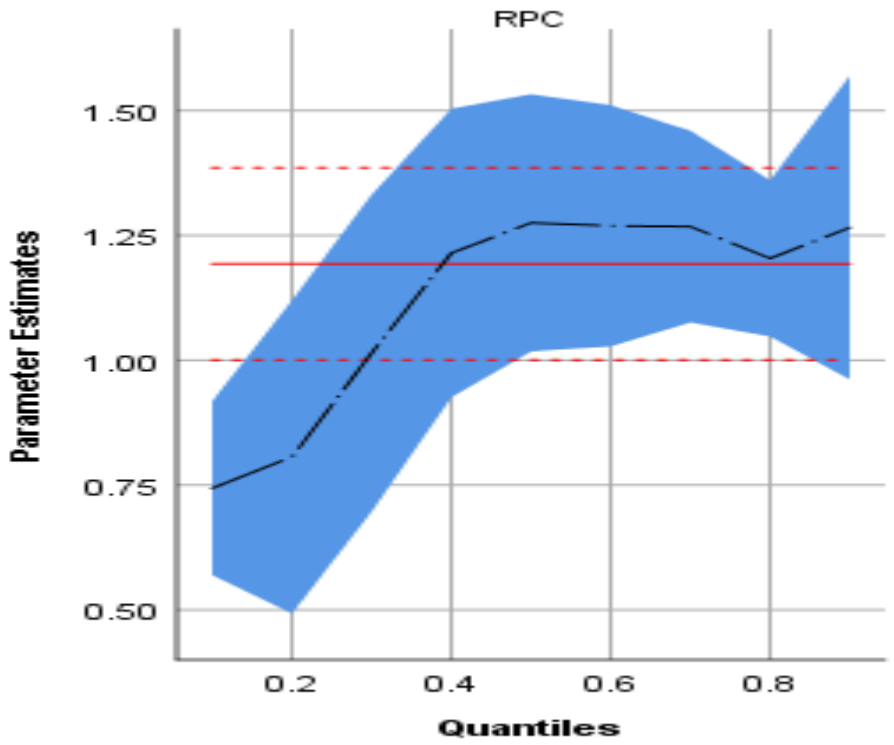


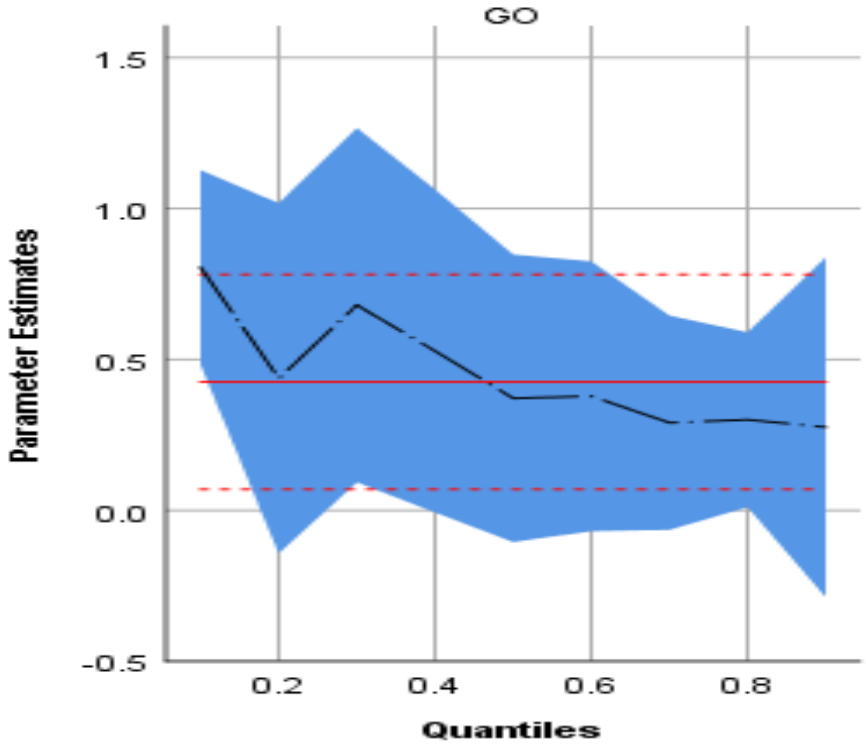
Confidence intervals of the parameter estimates

Parameter estimates at the different regression quantiles

Parameter estimates for the ordinary linear regression with the same predictors

Confidence interval bounds for the ordinary linear regression with the same predictors





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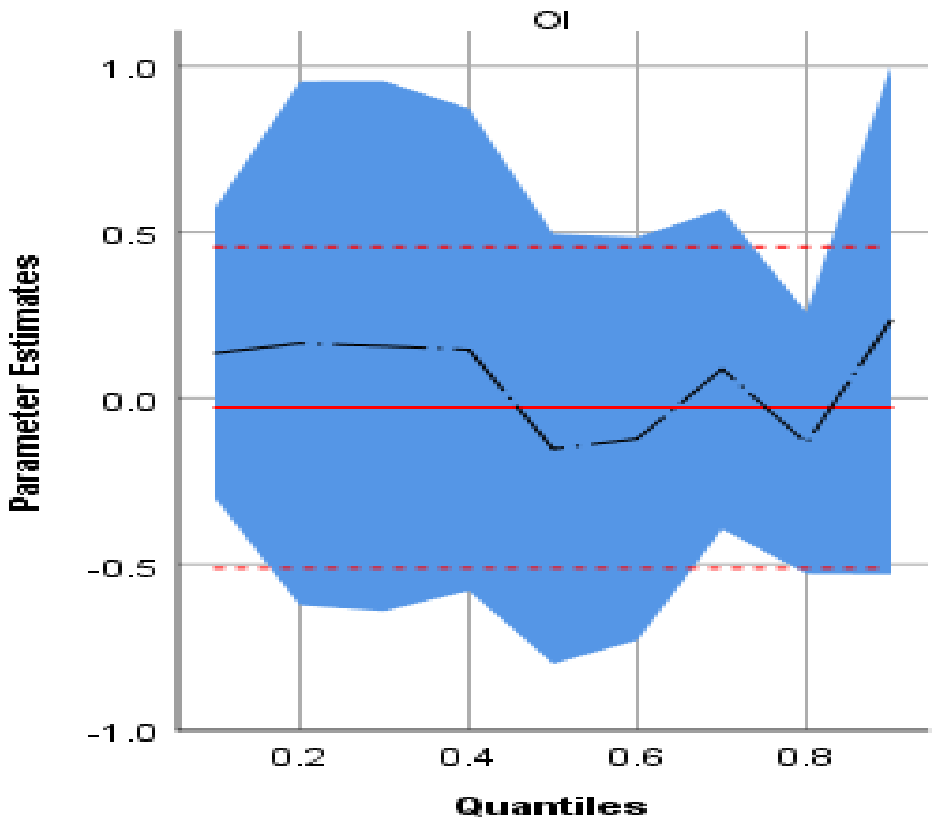

Confidence intervals of the parameter estimates
Parameter estimates at the different regression quantiles
Parameter estimates for the ordinary linear regression with the same predictors
Confidence interval bounds for the ordinary linear regression with the same predictors

Inferences from OLS regression

- Intercept is significant at 0.006 level and has a value equal to -52.544 which means for a University to have a zero perception score it needs to have certain threshold level/s of TLR, RPC, GO and OI.

- Only RPC and GO are significant at 0.000 and 0.020 levels of significance respectively.

- RPC and GO with weights equal to 1.193 and 0.426 are relatively more important than other variables in explaining perception.

- 82.1% of variance in perception is explained by TLR, RPC, GO and OI respectively.

Inferences from Quantile Regression

- The values of intercepts at every 10th quantile are skewed. All the intercept valu es are negative which indicates that for an institute to have even a zero percepti on score, there need to be certain minimum threshold values for either or all of the predictor variables.

- RPC values are consistently increasing at every 10th quantile till the median quantile after which they are consistently decreasing. This shows its fluctuating impact on the perceptions of the Universities.

- Graduation outcomes create a bigger impact on perceptions at Universities ranging from 10th quantile to 50th quantile. This indicates that this variable creates a greater impact for Universities ranging in the lower quantiles.

- TLR and OI have fluctuating values implying their fluctuating impact on perceptions.

Comparison of results obtained through DEA and Quantile Regression

- The results obtained from Quantile Regression corroborate the results obtained from DEA

- Different Universities are perceived differently and

- the factors that influence the perceptions of these Universities also differ.

Implications

- Perceptions form the basis for reality.

- The analysis of perceptions of Universities may be used by Universities themselves to benchmark and streamline their processes by strengthening the inputs that form the basis for positive stakeholder perceptions.

- At the national level, the analysis can serve as a base to indicate the inputs which contribute to Universities to be perceived better vis-à-vis others.

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