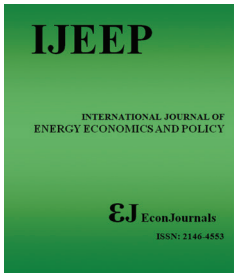

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An Analytical Study of Cross Subsidy Impact on Electricity Demand from Industries: Case of Electricity Distribution Utilities in India

Naveen Agarwal[1,2]*, Naqui Anwer[3]

[1]TERI School of Advanced Studies, Delhi, India, [2]Great Lakes Institute of Management, Gurgaon, Haryana, India, [3]Department of Energy and Environment, TERI School of Advanced Studies, Delhi, India. *Email: naveen140611@gmail.com

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ABSTRACT

In India, because of socio-economic constraints, there is cross subsidy (CS) regime in electricity sector under that industrial consumers cross subsidize agricultural and residential consumers. This paper attempts to analyze the impact of CS on the industrial demand from the state distribution units. To measure the impact, elasticity of electricity demand in context of CS is estimated and to estimate CS elasticity, panel data techniques are used. The main finding of the paper is that the impact of CS on the Discom's industrial load in is limited. The elasticity value of CS is −0.54, which is significantly lower than 1 (the perfectly elastic value), which means that change in CS does not have any meaningful influence on the electricity demand of the industrial consumers.

Keywords: Cross Subsidy, Open Access, Electricity Demand
JEL Classifications: H2, Q41, Q48

1. INTRODUCTION

One of the key issues which Indian electricity sector has been facing is very high inefficiency in the sector especially in the distribution area. Before enactment of the electricity act (EA 03) 2003, there was no choice or alternate for consumers who were not satisfied with the service of the utility of his area, whether it is tariff or quality and reliability of power supply. They were forced to purchase power only from the utility of their respective area within that state. Utilities were enjoying this monopolistic regime and there was no encouragement to improve efficiency in their system. In 2003, with the objective of bringing competition and improving efficiency of the power sector, policy makers brought in the concept of "open access" in the EA 03. As per EA 03, "*open access" means the non-discriminatory provision for the use of transmission lines or distribution system or associated facilities with such lines or system by any licensee or consumer or a person engaged in generation in accordance with the regulations specified by the Appropriate Commission*[1]. Using this act, any person or consumer who is not satisfied can procure power from any generator and can use transmission lines and distribution system in accordance with the appropriate commission. This act has brought choices to consumers of power suppliers.

The act also specify that any consumer who is availing open access for getting power supply from alternate source, will have to pay transmission charges and cross subsidy (CS) surcharge to the concerned utility[2]. The industrial or commercial consumers cross subsidize the agricultural consumers and if that consumer leaves the utility and use open access, utility will have to bear that loss. The purpose of CS surcharge is to compensate the utility for the loss of the CS due to migration of its consumers.

1 See Section 2 of Electricity Act 2003.
2 See Section 38 of Electricity Act 2003.

CS is "if one group of people is paying higher price for a commodity to subsidize the other group of people." Heald (1996), defined CS as "some consumers are asked to pay less at the expense of some other consumers for the same kind of goods." The main objective of CS is to provide social benefits to the poor class and needy people with maintaining financial viability by charging higher price to customers who can afford to be charged more. Baumol (2001) defined that with social responsibility, regulators supply product at lower price than cost to customers who are impoverished and can't afford that price. At the same time, some customers get same product at higher price ensuring their financial viability. Sinha (2005) explained CS as the difference between the "cost to serve" and the tariff charged.

As per definition, in CS structure, price for one category of consumer is higher than average price and for other category which is cross subsidized, the price is lower than the average price. In the context of electricity, in India, Industrial category of consumers subsidize the agricultural category of consumers, so price or electricity tariff for industrial consumers is generally higher than average cost of electricity, whereas for agricultural consumers it is lower than the average price. By economics concept, demand of a commodity is determinant of the price of that commodity. In this context, any change in price of electricity may impact demand of electricity. For any utility, it is important to have a reasonably correct estimation of future demand so they can accordingly plan for power supply and expansion of distribution network infrastructure. Any major deviation in estimation of electricity demand may distort the planning of the utility and that may result in significant financial losses. As CS, may encourage industrial consumers to leave the utility and opt other options of power supply using open access, so it is important for the utility to assess the impact of CS on electricity demand of its industrial consumers. Considering these important factors, this paper proposes the following research question.

1.1. Research Question

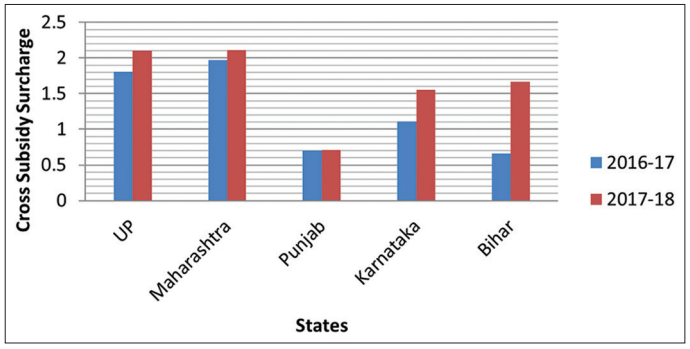
How does CS in electricity tariff impact electricity demand for industrial consumers of an electricity distribution utility in India?

Based on this research question, following hypothesizes are framed:

- Alternate hypothesis (H_1) – There is no impact of CS on electricity demand from utility's industrial consumers
- Null hypothesis (H_0) – CS has negative impact on electricity demand from utility's Industrial consumers.

To answer the research question, this paper estimates the elasticity of electricity demand for Industrial consumers in context of CS, so that the impact of change in CS on utility's electricity demand can be estimated more accurately. There are mainly two categories of consumers - industrial and agricultural - whose tariff structures have effective percentage of CS (subsidizing and subsidized). Commercial or non –domestic category of consumers also cross subsidize the agricultural category of consumers, but generally the percentage of total consumption of this category is relatively much lesser than the other two categories of consumers and so this category is not included in the estimation of elasticity in this paper.

Figure 1: Cross subsidy surcharge in different states



Source: State tariff orders

Agricultural category is also not included in analysis, because the tariff structure for this category includes both subsidy and CS and the agricultural consumers would react not only to CS but also to the general subsidy. Therefore, the measurement of impact of CS on agriculture demand would not give appropriate results.

Overall this paper has been organized in following sections. Section 2 gives literature review to synthesize the existing knowledge about CS in electricity sector in India and as well as other countries. It also highlights regulations related to CS. Section 3 provides the methodology for estimation of elasticity and data presentation. Section 4 provides an analysis of outcomes in view of research question. Section 5 provides the recommendations and concluding remarks.

2. LITERATURE REVIEW

Open access which was enacted in the EA 03, has been widely recognized as the soul of the EA. This is so, because open access is the mechanism crafted to usher in competition and choice, and in turn facilitate investment and protect the interests of the consumers. A consumer, who is availing open access, has to pay different charges like CS surcharge, transmission and wheeling charges, and stand by support charges. CS surcharge is the most significant and contentious of all. Open access was introduced to bring competition in the electricity distribution sector, but CS surcharge discourages the consumers to use open access (Singh, 2005). It means that CS surcharge neutralize the objective of forcing competition through open access (Ranganathan, 2004).

Though the tariff policy required a reduction of the CS surcharge at a linear rate of 20%, there is a general reluctance to reduce surcharge without matching it with a reduction in cross subsidies. In spite of National Tariff Policy (NTP) guidelines to bring tariff level ±20% of the average cost of electricity supply, there are many states where CS surcharge is still increasing (ICRA, 2016). Figure 1 clearly shows that cross subsidy surcharge level of few states has been increased in recent years.

The methodology for computing surcharge has been the subject of much debate. The tariff policy has given a formula, which is based on marginal power purchase costs. Additionally, there have been suggestions to adopt the average cost of supply or the cost of supply at applicable voltage level. Implementing these

suggestions would have led to lower CS surcharge. There is study which analyses financial impact of different CS surcharge calculation methods like long-run incremental cost, marginal unit cost, and average cost of supply, and finds that average cost of supply method has highest impact on Discom's financials because under this method, the cross-subsidy surcharge is least among all the methods (Singh, 2005).

The foundation of subsidy is to provide basic necessary goods or services to the needy people at affordable price, but it has become a political tool in elections where parties announce free power to a category of consumers to get votes (Bhattacharyya, 2005). To make it financial viable to utilities, in EA 03, the law added that if any government announces any subsidy to consumers, it will have to pay subsidy amount to the utility in advance (Bhattacharyya, 2005). The other major concern with subsidy and cross-subsidy is that it can create discrimination among farmers as only farmers who are connected to the grid (which are relatively richer farmers), will enjoy the subsidy (Dash, 2006).

If a consumer leaves the utility using open access, consumer has to pay cross-subsidy surcharge to the utility and it's not financially inimical to the utility (AF-MERCADOS EMI, 2014). But if consumer is setting up captive power (CP) plant for his own use or procuring power from renewable energy sources, CS surcharge would not be levied on him (FoR Pwc, 2015; CII and Pwc, 2015). In this case utility has to bear that loss of cross-subsidy and one of the major consequences of this is that it will distort demand planning of utility, which will affect its estimated revenue for that year (IEX AF Mercados EMI, 2014). Exemption of CS surcharge, in case of power procurement from renewable energy sources is an attempt to attract consumers to invest in renewable energy (Singh, 2005; MYTRAH Pwc, 2015). On positive side, high CS can lure industries to invest in renewable energy.

In view of above discussion, it is necessary to assess the impact of CS on the industrial demand of the utility, so that utilities can make better planning of their expenditure in generation, power purchase and network planning. Utility can also incorporate empirically estimated elasticity of industrial consumers while planning for their long term electricity demand, supply and subsidy analysis.

3. DATA AND METHODOLOGY

To estimate the impact of CS on industrial demand from discoms, we need to analyse the relationship between CS and industrial demand. To find this relationship, we estimate elasticity to see the responsiveness of electricity demand to the change in CS. The CS elasticity η for electricity demand from discoms is

$$\eta = \frac{\text{Percentage change in electricity demand}}{\text{Percentage change in cross subsidy}} \quad (1)$$

3.1. Data

The present research is based on the secondary data of the selected states. The top 15 states in the list of highest electricity demand were selected for the research. A final sample of 14 states was taken based on availability of the data. The period of study is from 2009-2010 to 2015-2016.

Based on the review of the literature done in the literature review section, following determinants were identified.

3.1.1. Electricity demand

In this study electricity demand of utility's industrial consumers is measured. This data is taken from the power finance corporation (PFC) reports ("the performance of state power utilities for the years 2009-2010 to 2011-2012, 2012-2013 to 2014-2015, and 2013-2014 to 2015-2016), where category wise electricity consumption for the state utilities is available.

3.1.2. Cross-subsidy

This is main variable of interest and is calculated by subtracting industrial tariff to the average tariff of electricity of the respective state utility. Data for this variable is also collected from the PFC reports ("the performance of state power utilities for the years 2009-2010 to 2011-2012, 2012-2013 to 2014-2015, and 2013-2014 to 2015-2016) only. Chattopadhyay (2004) estimated industrial electricity demand and found that cross-subsidy in electricity tariff is prone to inefficiency.

3.1.3. Control variables

Based on the literature review, we include other control variables in our regression equation. Variables like state – GDP for industries (SGDPI) has been used by Bose and Shukla (1999) to estimate elasticity of electricity demand and showed that there is positive effect on electricity demand. We make equation more robust by including variables like CP plant, spot market price, and bilateral market price.

3.2. Methodology

In this study, sample contains data across states over a period. As per Guha-Khasnobis and Bhaduri (2002), estimates from panel data are expected to be more robust. In another paper by Baltagi (2011), it is mentioned that using panel data, allows the estimation of parameter in a more efficient way. Also in panel data, impact of multicollinearity reduces as both time and cross sectional dimensions are present in the data. To understand and estimate the impact of CS surcharge on electricity demand, two panel data estimation have been used, namely pooled ordinary least square, and fixed effects panel model.

The equation for the panel data will estimate in the form given below:

$$ED_{it} = \beta_0+\beta_1 LogP_{Iit}+\beta_2 LogCS_{it}+\beta_3 LogSGDP_{Iit}+\beta_4 LogCP_{it}+\beta_5 LogBP_{it}+\beta_5 LogEP_{it}+e_{it}$$

Where
i = Number of cross-sections
t = Period of study
k = Type of market (spot market and bilateral market)
e_{it} = Error-term of the equation

Here, the electricity demand of the utility from the industrial consumers of state I in period t (edit) depends on a states'

electricity tariff for industrial consumers (P_I), CS which is the key regressor of our analysis, state gross domestic product of industries ($SGDP_I$), CP plant capacity (CP), average price of electricity in bilateral market (BP), and average price of electricity in spot market (EP). Coefficient of each independent variable measures the elasticity of electricity demand in context of that respective variable.

4. EMPIRICAL FINDINGS AND DISCUSSION

4.1. Correlation Analysis

The correlation between independent variable is measured in this study. The Table 1 shows the measured value of correlation and it is found that there is not any high degree of correlation among the independent variables. It proves that the equation formulated earlier will not be effected by problem of multi-collinearity.

4.2. Regression Analysis

The regression results (Table 2) from the pooled OLS method show that out of six independent variables, cross-subsidy, GDP, and CP plant are significant determinants of electricity demand at 5% level for the selected Indian states. Cross-subsidy, the main variable of interest, has value of −0.2, meaning electricity demand is inelastic to our main variable. In results of pooled OLS estimation, tariff, bilateral price and spot price are not significant. R^2 value is 0.56 which is considerably lower.

Our data sample contains data from across states over a period of time, which may lead to cross-sectional effects. To correct it, fixed effect panel model is used. The result of fixed effect panel regression (Table 3) shows that out of six determinants, tariff, cross-subsidy, GDP, CP, and bilateral price are significant determinants for electricity demand from industrial consumers. In this result, coefficient value of cross-subsidy has increased to −0.54. The R-squared value also has increased to 0.79.

In the process of doing regression step-by-step to understand the contribution of independent variables which were found to be insignificant, in case of pooled OLS regression, it is seen that in fixed effect model most of the variables are significant. Also R-square value has increased significantly compared to R-square value in pooled OLS regression.

4.3. Discussion

Our results from the regression suggest that Industrial tariff (P_I), CS, State GDP ($SGDP_I$), CP, and bilateral price (BP) are significant determinants of industrial electricity demand. Based on p value, exchange price (EP) is the only variable which does not have significant relationship with electricity demand. Out of five significant variables, P_I, CS, and BP have negative correlation with the electricity demand, whereas $SGDP_I$ and CP have positive.

Regarding our main variable of interest 'cross-subsidy,' the value of coefficient of this variable is −0.54 which suggest a negative relationship with electricity demand. It means that electricity demand is moderately elastic to cross-subsidy and 1% increase in cross-subsidy will reduce the electricity demand by 0.54%. As elasticity value is not high, it is possible that revenue of utility will not have any impact due to change in CS. This result forces us to think that while there are other options for industries to get power like electricity market using open access and setting up their own CP plant, why industries are not opting those options. Open access which was enacted to introduce competition in the power sector, seems has not been successful in achieving its objective. It's possible that because of this inelastic situation, yet there is no adverse impact of CS on the revenue of the industries. Presently it may be good news for discoms but for them it is necessary to go deeper to analyze the cause of this inelastic demand to CS to make assure that their future revenue also get not affected because of CS. For that it is imperative to understand the perspective of industries regarding CS.

One of the main factor which we can think about is the cross-subsidy surcharge which they (industries) have to pay to the respective utility while going for open access. This increases the overall cost of power and takes away all the benefit. Industries can bypass this CS surcharge by setting up their own CP plant as most of the states give exemption of CS surcharge in this case. But question arises that why industries are not opting this option. One could be high upfront cost of setting up new CP plant. The other possible reason of inelastic demand is that some industries are even not aware about the CS components in the electricity

Table 1: Correlation matrix independent variables

Independent variable	P_I	CS	$SGDP_I$	CP	BP	EP
P_I	1	0.42	0.23	0.05	−0.66	−0.59
CS		1	−0.15	−0.18	−0.2	−0.2
$SGDP_I$			1	0.24	−0.07	−0.07
CP				1	−0.1	−0.08
BP					1	0.83
EP						1

Table 2: Effect of explanatory variables on electricity demand in using pooled OLS estimation model

Independent variable	Estimate	Standard error	T-value	Pr. (>ItI)
P_I	−0.22	0.25	−0.89	0.37
CS	−0.2	0.062	−3.2	0
SGDPI	0.74	0.045	16.38	0
CP	0.12	0.039	3.13	0
BP	−0.27	0.86	−0.32	0.74
EP	−0.18	0.36	0.52	0.6

R^2=0.56

Table 3: Effect of explanatory variables on electricity demand using fixed effects estimation model

Independent variable	Estimate	Standard error	T-value	Pr. (>ItI)
P_I	−0.46	0.19	−0.89	0.02
CS	−0.54	0.032	−16.875	0
$SGDP_I$	0.62	0.039	15.89	0
CP	0.16	0.035	4.57	0
BP	−0.78	0.23	−3.39	0
EP	−0.34	0.22	−1.54	0.11

R^2=0.79

tariff as well as other possible options of power supply other than utility. There can be some other constraints which can be known only after doing a survey of industries. Survey can also reveal that how much percentages of industries are affected with these constraints.

5. CONCLUSION

This paper measures the relationship between CS and electricity demand of utility's industrial consumers which corresponds to a significant share of utility's total revenue. Any fall in demand from this section could significant impact utility's earnings. CS, which has been a debatable issue for policy makers, has not been decreased even after directions as per the EA 03 and NTP 2006. Considering possibility of negative impact of CS on electricity demand of the industrial consumers due to available alternate options of power supply like electricity market and setting up CP plant, this paper has attempted to measure the impact of CS on industrial demand. In the empirical estimation of elasticity of electricity demand for CS, as per results, in present scenario CS does not impact the electricity demand of industrial consumers. This gives a signal to policymakers that though CS is an unwanted component in tariff structure for subsidizing category of consumers, but so far they are not reacting on that. For policymakers it should be a matter of concern regarding success of open access policy which was enacted to create competition in the sector. For a utility this can be a satisfactory situation as industries are not moving out. It is recommended to utilities that they should properly analyze industry's perspective regarding CS that whether they are really satisfied with the utility or there are some constraints which are obstructing them to move out. If those factors are relaxed in future, there would be an impact on utility's revenue.

In India, an electricity distribution utility play a very important role in providing last mile connection of electricity, leaving of large or bulk consumers will put a question on its future viability. A financially crunch utility would not be able to serve its consumers properly.

This research work can be extended by doing a proper survey of industries to understand their perspective regarding CS which may help to analyze the outcomes of this empirical estimation of elasticity.

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