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Policy considerations for limiting electricity theft in the developing countries

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ABSTRACT

The study analyzed electricity theft through a three layered principal-agent-client model. The factors that entrench corruption and theft are its beneficial features of lowering the cost of electricity for the consumers and generating private illegal incomes for the corruptible employees. We show that an individual steals electricity only if the subjective pecuniary gains are higher than the associated costs e.g. fine imposed in case of detection or dismissal from job. The study finds that efficiency wages along with higher deterrence and active consumer involvement in reporting the crime can help in combating corruption and pilferage in electricity sector.

1. Introduction

Theft and petty corruption occur frequently in the electricity distribution systems of under-developed economies. It comprises of incidents where an electricity distribution agency fails to recover its receivables either due to illegal abstraction or non-payment of electric power by consumers. Illegal abstraction generally takes place with the help of corrupt employees, where the employees commit improper recording and reporting of electricity consumption to the utility. As a result, the actual revenues do not reach the coffers of utilities. A dishonest consumer either steals electricity directly from distribution lines or colludes with utility employees for overdue consumption of electricity by paying nominal bribes in order to reduce the risk of detection and conviction (Jamil and Ahmad, 2014). Electricity theft harms the financial health of distribution companies and negatively affects future investments in the power sector. Electrical energy worth billions of dollars is stolen every year and the costs are routinely passed on to the paying customers in the form of high tariffs and poor quality of service (Smith, 2004). In poorly managed energy systems such as in the less developed countries, the chances of stealing the commodity are enormous especially in the presence of corruption and bribe exchange (Bò and Rossi, 2007; Lewis, 2015; Gaur and Gupta, 2016).

This study develops a modeling framework for the developing countries that combines the von Neuman-Morgenstern model of choice under uncertainty with a principal-agent model of corruption to study the individual behavior towards electricity theft. The electricity sectors of developing countries generally face extensive public controls that sometimes is used to pursue social, economic and political objectives (Joseph, 2010). Mostly, these countries adopt a single buyer model where multiple power producers sell to public utility(ies) responsible for distribution and retail activities. Therefore, electricity theft is essentially an issue of developing countries signifying the role of public choice theory.

The distinguishing features of electricity distribution set up is the heart of the problem in these countries. As the problem is put here, the development of separate framework for the developed economies having well-functioning electricity markets, is not in the scope of this study. Public dominance in utilities' management results in inefficiencies at both the generation and distribution levels. Due to general lack of transparency and accountability in public utilities, corruption persists from top ranked executives to lower staff of utilities like, meter reader and lineman (Smith, 2004). The consumers take advantage of the deficiencies in regulatory regimes and poor governance to avoid electricity charges. Sometimes electricity theft occurs without connivance of the utility employees while in most of the instances, utility employees facilitate electricity theft signifying the role of corruption (Jamil and Ahmad, 2014; Sharma et al., 2016).

The economics of electricity theft is concerned primarily with the cost and benefits of limiting this non-violent crime. Electric utilities may not seek complete eradication of crime since it is not economically optimal and may deduct net benefits. Resultantly, the enforcement agencies want to allocate resources to achieve the optimal level of deterrence at a least cost. The benefits of curtailing theft are associated with the increased utility revenues and improved quality of the service.

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The costs include technology and surveillance expenditures; and rewards and price incentives to monitors and consumers respectively. Theft itself is a form of corruption, albeit corruption in this study is considered as any kind of fraudulent use of electricity wherein consumer (client) and utility employee (agent) collude for their respective gains causing loss to the utility (principal). The individual considers the monetary value of unpaid electricity as benefits. Ignoring the diminishing marginal utility, we believe benefit equals stolen/un-reported units of electricity. By corruption, we refer to the following phenomena. The agent and client may collude for illegal private gains through; the agent not reporting fully the actual electricity consumption of a client, or agent may extort money from honest clients by over reporting or false detection of theft. The former case resembles the Shleifer and Vishny (1993) model of corruption with theft which is self-fulfilling and more widespread since both the employee and consumer usually gain. The factors that entrench corruption in electricity theft are its beneficial features in terms of lowering the electricity cost for the consumers as well as private illegal incomes for the corruptible employees. We study an individual's behavior towards electricity theft in the framework of expected utility maximization in the context of a three layered principal-agent-client model. The agent delivers electricity to clients and does not turn over the actual revenues to the principal.

There is vastly available literature on crimes and corruption but few studies focus specifically on identifying the determinants of electricity theft or corruption in electric utilities. To face the multi-dimensional inter-linked aspects, this study is structured to specify a general model of individual behavior under risk and explicitly identify the major policy tools for the principal to combating corruption and electricity theft. The findings of the study may be applicable in further empirical studies and of interest to most of developing countries where hefty amounts of utilities' revenues are lost due to electricity theft every year.

The paper is organized as follows. We begin in Section 2, by looking at the literature covering the wide range of issues including, electricity theft and corruption. Section 3 illustrates the anatomy of electricity theft, its extent and consequences on the volume of distribution losses of utilities. We proceed by constructing a simple theoretical model of individual behavior towards electricity theft in different settings in Section 4. The potential policy implications of the model are discussed in Section 5. Finally, Section 6 summarizes the findings and concludes the study.

2. Literature review

The literature on the topic of electricity theft mostly comprises of descriptive and empirical studies (see for example, Jamil and Ahmad, 2014; Gaur and Gupta, 2016; Jamil, 2018). In the following lines we review some studies on social problems of electricity theft and corruption. The aim is to identify theoretical basis for choosing analytical framework. Becker (1968) motivates the theoretical research on economics of crimes. It suggests that criminal is a utility maximizer who weighs the subjective costs and benefits of a crime. The study argues that the observed number of crimes in a society depends on relative return on legal and illegal activities, penalty for committing crime and the probability of being detected. The crime is committed only if the gain from offence exceeds the expected cost of crime. The economic cost-benefit analysis aims to develop optimal public and private policies to combating crimes. From enforcement point of view, the study proposes that the amount of fine may complement probability of detection and conviction in deterring individuals from committing crimes.

Irregularities in the electricity sector in a country mainly stem from the sociopolitical structure therein and the institutional governance. There is vast literature available on political and bureaucratic corruption and its consequences in different sectors of economy. These studies cover multidimensional aspects of corruption and its determinants. Polinsky and Shavell (2001) illustrates that corruption dilutes deterrence imposed by penalties; hence it has to be reduced in order to make tools of deterrence effective. Most of the studies identify corruption as a socially and economically undesirable phenomenon (see, Shleifer and Vishny, 1993; Mookherjee and Png, 1995; Bardhan, 1997; Groenendijk, 1997; Polinsky and Shavell, 2001; Jain, 2001 and Gupta et al., 2002). In so far as the beneficial corruption is concerned, it is the second best option in the presence of rigid regulation (see, for instance, Jain, 2001; Aidt, 2003; Xin and Rudel, 2004; and Silva et al., 2007).

In the economics literature, corruption is mostly analyzed either in the framework of principal-agent model with focus on resource allocation and public law enforcement or in the framework of collective action (for example, Ostrom, 1998; Ostrom, 2010; Walton and Jones, 2017). Corruption may be considered a typical collective action problem. The collective action has evolved from an academic topic to an issue with policy relevance. If corruption is norm in a setup, everybody would feel better off if a decision to not pay bribes is made but they face the dilemma of whether or not to offer bribes for personal benefits. The collective action problem has two dimensions. One, each individual leaves the burden of fighting corruption to other members of the group and to wait for materializing the benefits of reformers. Two, the problem involves trust where individuals in a group would want to get rid of corruption but giving up bribe payment is not viable due to lack of trust hence find no incentive to act honestly (Ostrom, 1998).

Recent studies, which consider corruption as a collective action problem, argue that coordinated anti-corruption measures are difficult if people consider corruption as normal behavior. Since principal-agent model motivates monitoring, transparency and penalties, we find it suitable to study electricity theft problem in the developing countries. Groenendijk (1997) illustrates that in the agency model of corruption, the interests of the principal and the agent may diverge and there is information asymmetry to the advantage of agent that enable the agent to act as a monopolist selling a public good with the objective to maximize the value of its bribes collected from sale of the public good.

In the context of crime, corruption and electricity theft, it is important to appreciate that individuals' perceptions determine their behaviors. In the framework of the principal-agent-client model, the role of agent is found critical in the literature who manages the relationship between clients and the principal. An individual's perceptions are influenced by the realities faced in the past, and these perceptions affect their current and future actions. Hence, in different regions of a country, perception of individuals about corruption may vary. Some studies attempt to identify the deterring factors of corruption such as moral, psychological and reputational costs (see, Myles and Naylor, 1996).

Corrupt utility employee facilitates electricity theft by accepting bribe from electricity consumer. Silva et al. (2007) argue that if law enforcers are dishonest but the principal can impose large fines and can employ opportunistic anti-corruption unit (monitor), the problem of monitoring the police would be solved. The underlying intuition is that the utility employee will find it advantageous not to engage in corruption since the fine in case of detection from monitor would be very high. Bardhan (1997) also suggest that the presence of many officials with overlapping jurisdictions may help prevent theft from the principal because the potential offender has to hide or persuade through bribing all individuals involved in monitoring from different departments.

Smith (2004) explicitly focus on electricity theft and compares its various forms, its consequences and measures to check it. The study finds that low transmission and distribution (T&D) losses ($\leq 6\%$) are most common in countries with low corruption perception like Belgium, Finland and Germany and while higher T&D losses ($\geq 30\%$) are most common in countries with high corruption perception like Albania, Bangladesh, Ghana, Haiti, India and Pakistan. Smith (2004) finds that electricity theft is highly correlated with all governance dimensions, such as civil rights, democratic institutions and accountability. Many recent studies discuss important aspects of electricity theft trends and technical and managerial methods for combating it (Winther, 2012;

Jamil, 2013; Min and Golden, 2014; Yurtseven, 2015; Yakubu et al., 2018).

Few studies explore the efficiency cost of corruption in electricity sector with regard to electricity sector reforms introduced in most of the countries. Bò and Rossi (2007) examine the link between efficiency and corruption using the electric utilities' data and find that corruption increases the factor requirement of firms due to diversion of the managerial efforts away from factor coordination, which essentially affect the output of electric utilities. The study observes that more corrupt countries possess more inefficient firms in the sense that they employ more inputs to produce a given level of output.

Past studies did not model the individual behavior towards the electricity theft and corruption. This paper fills the gap and develops an individual choice model under risk of conviction. As per our knowledge, this is the first attempt to model electricity theft using expected utility framework. We develop a model of crimes in the framework of choice under risk and an agency model of corruption specifically in electricity sector. The model enables us in identifying key relationships among economic, social and governance variables based on expected utility of individual and suggest some policy implications.

3. General anatomy of electricity theft

Electricity is generated at various power stations, which are generally located at distances from the load centers or end-users. It is then transported to end-users through a setup of wires, transformers and conductors. During transmission, transformation (stepping up and down of voltage) and distribution process, a part of energy is lost. These are generally termed as transmission and distribution (T&D) losses in electricity system. The T&D losses break up into technical and non-technical components (Lewis, 2015). Some energy is illegally abstracted. It becomes part of non-technical losses generally termed as electricity theft. The distribution lines of the utilities lie open and hence the chances exist of consumers' illegally abstracting electric power through by-passing or tempering the meter. Electric utilities charge electricity on the basis of readings displayed on the meters at the consumers' interface. Electricity theft can be in the form of fraud (meter tampering), stealing (illegal abstraction), billing irregularities, or unpaid bills. Any interference with proper recording of meter or diversion of electricity from the grid or any illegal act to avoid paying for electricity by violating the laws is theft.

In order to supply electricity to its consumers, an electric utility delegates to employees various activities, such as repairing and maintenance, electricity retailing and theft detection (Ahmad, 2017). A utility employee directly interacts with the consumer and hence both may collude to form an agency model of corruption. The agent may help consumers in hiding the actual electricity consumption by stipulating bribes from them. Both the corrupt employees and consumers benefit through this illicit relationship. The relationship among the utility, its employees and consumers can be illustrated in Fig. 1. Corruptible utility employees and consumers who are not detected as shown in the lower boxes in the figure, are causing a loss to the principal.

The electricity theft is an issue related to three *Rs i.e.* improper *recording* of electricity consumption or illegal abstraction of electricity, less than actual *reporting* of electricity consumption or collusion of employees with consumers for illegal private income, and low *recovery* or non-payment from consumers (Jamil and Ahmad, 2014). Less than optimal level of any of the three *Rs* may result one of the following outcome.

a) Electricity theft committed by consumers at their own risk
b) Consumers stealing electricity with the connivance of utility employees
c) Consumers not paying for their electricity charges

These outcomes may depend on different underlying socioeconomic and political factors that render the perception and behavior of an individual or some group of individuals. Non-paying behavior is an issue, which is more related to groups rather than individuals because utility can cut electricity supply off if an individual fail to pay his electricity charges. However, it is difficult to suspend electricity supply to a group on the basis of non-payment especially when defaulters have political clout or are in majority (Katiyar, 2005). The extent of non-payment among individuals or a group in a society depends critically on how many others in the same category are not paying for their consumption. The incentive for individuals or a group to be non-payers may also depend on collective reputation of the group they belong (Jamil and Ahmad, 2014). The implication of the collective reputation is that the honestly paying consumer belonging to non-paying community suffers the most. Although, non-payment behavior may be due to a number of reasons from political influence to paying inability, but when it becomes institutionalized and individuals and organizations feel they can get away with it, then deliberate non-payment for the service may be treated as electricity theft (Smith, 2004). It is important to identify the economic, political and historical factors underlying the non-paying behavior of individuals.

The deterrent measures adopted for curbing the electricity theft are mainly technical such as introduction of smart electricity meters (Ahmad, 2017). Besides, technology induced deterrence essentially requires utility officials to be committed to introduce preventive measures and reforms. But in societies with high irregularities in the electricity system, corrupt officials sometimes convert petty corruption into mega scandals through bulky purchases of technical instruments. Transparency and reduction in corruption is high on agenda of many international financial agencies like World Bank, Asian Development Bank, Transparency International and USAID. On the whole, these agencies focus on sectoral aspects of corruption and ways to combating it.

4. Model of electricity theft

Electricity theft model is developed adopting the framework of three layered principal-agent-client model of corruption. Some of the relevant dimensions of electricity theft include crime and law enforcement (see, for instance, Becker, 1968; Polinsky and Shavell, 2001), white-collar crimes or crimes against the state property (see, Besley and Mclaren, 1993) and corruption (see, for example, Shleifer and Vishny, 1993; Groenendijk, 1997; Bardhan, 1997; Jain, 2001; Aidt, 2003; Clarke and Xu, 2004; Bò and Rossi, 2007). In most of these dimensions, the individual's choice under uncertainty is considered as the starting point for model building.

Electricity theft is a crime and the choice of the offender to commit it can be viewed as other choices made by individuals, primarily by comparing the relevant cost and benefit. Thus an individual will steal electricity only if the expected benefit from theft is greater than the associated expected cost. In the following, we first model the behavior of consumers towards electricity theft with and without paying bribery. Our choice of studying individual behavior is methodological and it does not deny the importance of social and economic institutions, of which individual is a part. Later, we develop an agency model of corruption to identify the behavior of consumer or client and utility employee or agent towards electricity theft.

4.1. Individual's behavior towards electricity theft

The standard approach to model the behavior of electricity stealing consumer is based on the economics of decision-making under risk with the presumption that the individual involved is an expected-utility-maximizer. We assume that the electricity consumer is risk averse and has legal electricity connection. However, he can extract electric power from the distribution lines illegally either through meter-tempering or

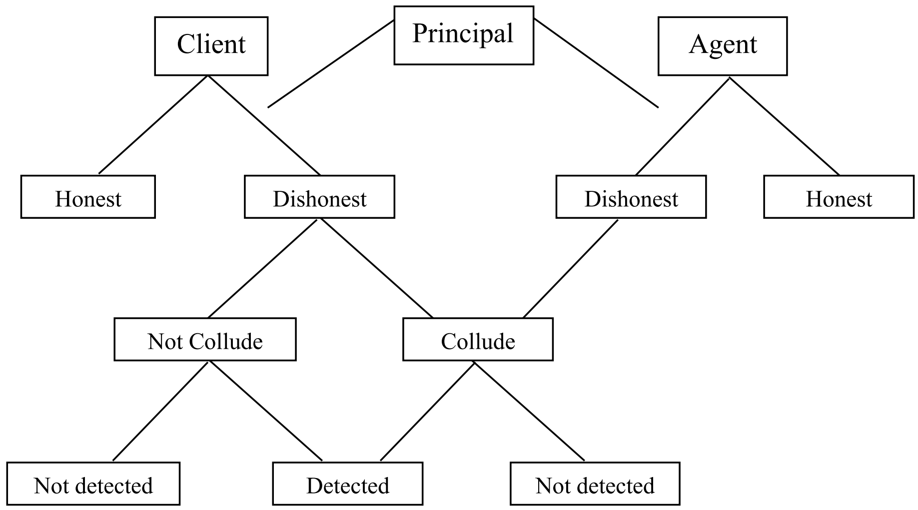

Fig. 1. Principal-agent-client linkages in electricity theft.

by-passing the electricity meter. The decision of the individual is based on comparing the associated expected benefits with the risk involved and expected costs. In particular, paying fully for electricity consumption is like purchasing a safe asset, while electricity theft is analogous to purchasing a risky asset. The electricity theft decision facing an individual then essentially becomes a portfolio selection.

A consumer faces the choice of whether or not to commit electricity theft. The decision depends on a number of random factors, some of which are assumed to be known to him before he makes the decision. Let the electricity tariff rate (λ) is assumed to be constant. Individual consumes C units of electricity whose actual value is $R = \lambda.C,$ measured at a particular point in time when he is assumed to pay. The electricity stealing consumer conceals $T = (C - X)$ units and pays only for X units whereas, T units become a part of distribution losses of utility. Hence, the utility charges an amount $r = \lambda.X$, and his pecuniary gain equals $G = \lambda.T$, which is a fraction of the total due payment.

The electricity theft (T) is endogenous and the actual gain for the stealing consumer is difficult to interpret hence, we use a constant amount of theft $\check{T}$ such that $\check{T}$ is the maximum amount of electricity that he can steal. One of the two outcomes is expected if an individual chooses to steal electricity. The consumer may be able to conceal electricity theft or be detected with probability p. The probability of detection is exogenous to the consumer and depends on the surveillance expenditures incurred by the utility. The fines or sanctions imposed on offender depend on the social loss to the society due to the offence (Becker, 1968). The consumer has to pay a fine f if detected where, $f > \lambda\check{T} > 0.$

If the stealing consumer is not detected, the value of illegally abstracted electricity is his pecuniary benefit. The cost involves risk of conviction and moral psychic cost. The non-pecuniary reputation cost in case of detection depends on the society's behavior towards the crime. Since the individuals notice how other neighboring consumers behave, the pilferage decision essentially becomes interdependent. If the consumer engaged in theft is detected and penalized, the amount of fine will add up to the cost. For the without bribery case, we specify expected utility function for the consumer as

$$E(U) = (1 - p).\ U(Y + G \ - \rho) + p.\ U(Y + G - f - d - \rho) \qquad (1)$$

where

U = Function giving utility of wealth saved through electricity theft. This function is assumed to reflect risk aversion, that is $U' > 0$ and $U'' < 0.$
Y = Wealth of the consumer
G = Pecuniary gain in the form of illicit saving through electricity theft that equals [electricity price (λ) multiplied by amount of electricity stolen (T)]
p = Probability that an individual who steal electricity is convicted. We assume the probability of being caught to be independent of amount of theft.
f = Fine collected from an individual convicted for electricity theft. It is assumed that the fine or penalty depends on the assessed illegal private benefit to the convicted consumer. It may also include the cost of obtaining new connection in case of power cut.
d = Non pecuniary reputation cost
ρ = Non pecuniary moral satisfaction loss

Akerlof (1980) specifies a reputation function that depend on individual's obedience to the code of behavior $D,$ and the portion of population who believes in that code μ. Hence, larger the number of honest consumers in a society, the more reputation would be lost if an individual commits electricity theft. The reputation function can be written as follows.

$$d = d(D, \mu), \quad \frac{\partial d}{\partial D} > 0, \ \frac{\partial d}{\partial \mu} > 0 \qquad (2)$$

An individual will engage in electricity theft if following condition holds.

$$(1 - p).\ U(Y + G - \rho) + p.\ U(Y + G - f - d - \rho) > U(Y - \lambda.\ C) \qquad (3)$$

hence, the potential control variables obtained are tariff rate, reputation cost, probability of detection and fine rate. The probability of detection depends on the monitoring and surveillance expenditures. The reputation cost for the offenders is subjective and can be increased by launching awareness campaigns through civil society and media. Although it is a non-equilibrium model since the electricity tariff is not adjusting simultaneously and solving the model with revenue target, the aforementioned assumptions may either result in agents extorting money from honest consumers or public subsidy may bridge the revenue gap.

4.2. Electricity theft in case of corruption among consumers and employees

In this section, we employ utility framework with electricity stealing consumer and corruptible employee such that the factors that entrench corruption are specifically included in the model with the presumption that corruption is endogenous. The three layered model of electricity theft with corruption involves consumer (client), utility employee (agent) and the utility (principal).[1] We basically, focus on the interaction between the agent and client. The discretionary powers of the agent in billing of electricity charges to the clients give rise to corruption. Electricity plays a vital role in the economy and hence may be a source of considerable rent-seeking for the officials. The behavior of the agent is constrained by the principal's ability to set precise rules and to closely monitor the former. The extent of imprecision in the implementation of rules and cost of monitoring the employees in a utility may determine the level of corruption (Polinsky and Shavell, 2001).

Although the principal may be fully informed about its revenue loss and the amount of electricity stolen by consumers, it cannot distinguish honest consumers from the corruptible ones unless electricity theft is detected by the agent delegated to monitor. The agent may receive bribe from consumers to give favors. Suppose a utility employee is delegated to report the electricity consumption and a consumer faces the choice of whether or not to steal electricity. Whether or not he will engage in corruption depend on the cost and benefit of doing so. Let the individual's pecuniary gain is G less bribe payment b. The bribe payment here serves to dilute the deterrence through reducing probability of detection. The consumer may be able to conceal electricity theft with probability ($1 - p$) or be detected with probability p and has to pay a fine where, $f > (G - b) > 0$.

The pecuniary benefit may lead the agent to accept bribe to waive the client's electricity charges. As a result, the agent will report X units of electricity. The model focuses on fraction of the consumers and utility employees who are dishonest. The principal can discover the electricity pilferage with probability p. If an agent is charged and proved accepting bribe from client, he will be dismissed and have to pay penalty $\eta > 0$. Similarly, the convicted client has to pay fine $f > 0$. For practically implementable deterrence, the penalty for corrupt agent η and fines for convicted consumers (f) must be less than their respective wealth. The gain from electricity theft of the client is equal to ($G - b$), while that of the agent equals b. The financial loss of the principal equals G, which is the social cost of theft. The client faces the choice of whether or not to steal electricity consumed at some given probability of being caught. We model separately the behavior of client towards electricity theft with corruption as well as the agent towards accepting bribe as explained below.

(i) Given the wealth of the client, he will offer bribery if his expected gain is greater than the honest payment for the electricity consumed. *i.e.* if $G - p.f > 0$.

$$(1-p).\,U(Y+G-b-\rho)+p.\,U(Y+G-b-f-d-\rho)>U(Y-\lambda.\,C) \tag{4}$$

Let us keep all parameters same as described in Equation (1). The bribery paid to the agent is represented by (b). If they can get away with theft, most of the electricity stealing risk-averse clients choose to pay bribery to agents. The incidence of theft essentially depends on policy variables including; tariff rate *(r),* amount of fine or penalty *(f),* probability of detection *(p),* and reputation cost associated with electricity theft.

(ii) The behavior of utility employee or agent towards corruption can be explained following Aidt (2003). We compare the expected benefit of the agent in the form of wage and bribery and cost, in case of conviction in the form of penalty and dismissal from the job. Let the wage rate in some other job is w_0 which is assumed to be lower than the wage rate w in the electric utility. In case of detection, let we assume that the agent has to pay penalty $\eta > 0$ plus dismissal from job. The expected utility of a corruptible utility employee can be given as follows.

$$E(U)=(1-p).\,U(w+b)+p.\,U(w_0-\eta) \tag{5}$$

An agent will accept bribe for facilitating electricity theft only if expected payoff is higher than his legitimate income. Assuming that the agent is risk neutral, he will accept bribe if,

$$(1-p).\,b+p(w_0-w-\eta)>0 \tag{6}$$

hence we assume that utility function of the agent is linear. The expected utility maximization is equivalent to expected income maximization. The policy variables emanating from this model include: wage rate in the utility *(w)*, penalty rate *(η)*, probability of detection *(p)* and reputation *(d)* that enable the principal to limit the corruption. These variables comprise economic, social as well as aspects related to law and governance.

5. Potential control variables

We analyze the characteristics of consumers and utility employees so as to formulate appropriate policy through identification of control variables. The primary objective of the policy should be to impair the agent-client collusion since it may help reducing electricity theft. The appropriate strategy may be a mixture of incentives and penalties for both the consumers and employees. Given the policy package (*w, f, d, η,* λ), the utility will choose optimal level of corruption and electricity theft based on the combination of incentives and deterrence or punitive measures. Below is given a brief discussion on these control variables.

Wages: Wage rate for a utility employee appears significant policy variable for combating petty corruption and consequently electricity theft. Efficient and fair wages are seen as the most effective way of combating corruption (Sosa, 2004). The underlying intuition is that when wages are high, the expected cost of being caught and penalized may undermine the net payoffs. From Equation (6), the minimum wage rate that may keep all the employees of the utility honest is given as follows.

$$w=w^0+\frac{(1-p)}{p}b-\eta \tag{7}$$

The efficiency wage equals private sector wage w^0 plus a mark-up. The mark-up or premium is proportional to effectiveness of corruption detection system *i.e.* higher the probability of detection in case of an employee accepting bribe, the lower will be the premium to make wages efficient. The higher wages in the utility portrays higher cost of dismissal for the employee if detected. Another implication of efficiency wages is that employees will demand higher bribes in order to compensate the increased cost of dismissal, thus lessen the number of occurrences of corruption. However, the problem with this option is that it may reduce monitoring efforts from the utility employees thus increase electricity theft. This can be dealt with through the payment of performance based monetary rewards for reporting theft or making recovery from non-paying consumers can in addition to efficient wages (Mookherjee and Png, 1995).

Polinsky and Shavell (2001) postulate that the payment of rewards to enforcers can reduce or eliminate the problem of bribery but they cautioned that such payments can encourage extortion. An increased implicit penalty can be imposed on employees through paying them with higher wages to increase the expected cost of corrupt behavior. An agent is likely to accept bribe if it is high enough to compensate the cost of penalty. Due to relatively low wages, agents may view bribe as a morally justified addition to wages. Besley and Mclaren (1993) described such wage structure as capitulation wages - so low wage that no one will accept unless augmented with corruption. Evidence from some countries shows that wages do have significant impact on decreasing corruption (Mookherjee and Png, 1995). In Singapore, a wage premium above private sector salaries has been found a useful tool to fight

[1] The assumed case frames the problem as a problem of public utility. It seems a plausible assumption as electricity is distributed through public utilities in most of the developing countries and utility relies on the government for most of the decisions and finance. In case of public utility, the government at large will be the principal.

corruption therefore, favoring the efficient wage.

The relationship between corruption and compensation policy to utility employees is quite complex and efficiency wages may not necessarily reduce corruption to desired levels. Furthermore, the objective of utility may not be merely to reduce corruption in the organization but at the same time to achieve many other objectives such as, capital formation, sustainable and affordable supply of electricity to consumers in all sectors. Redeeming features of corruption is the possibility for a utility to hire employees at smaller salaries and reduce cost of supply but if the utility can eradicate corruption, few would be willing to work for the utility at existing salary packages.

Tariff Rate: In order to ensure the sustainable and abundant supply of electricity in a market economy, a cost recovering tariff rate must be set. Economic theory suggests that for a risk neutral offender, utility maximization implies that theft will tend to increase with tariff rate. If the system is already exposed to high rate of electricity theft, an increase in tariff rate may affect electricity demand and revenue of utilities in two ways. The honest consumers would cut their consumption of electricity, while the proportion of dishonest consumers may increase (Jamil, 2013).

The corruptible utility employees will raise the bribe rate and monitoring efforts to detect consumers who are stealing electricity without paying bribe resulting in higher payoffs for them. The relationship between electricity price and utility revenues is type of Laffer curve where revenues would be lesser if tariff rate increase from certain high levels as theft offset the revenue raised by increased tariffs (Sanyal et al., 2000). The result may be higher electricity consumption, higher bribe earnings for corrupt employees, higher electricity theft and lower revenue collection by the utility. The higher tariffs will induce temptation among the consumers to steal electricity as in this case the net payoff will rise. The principal-client relationship is also an important factor in determining the consequences of higher tariff rates. Raising electricity price can actually reduce revenue collection unless it is accompanied with efficient surveillance and better quality of supply service in terms of lower outages and lesser consumer harassment. Recent empirical investigation suggests that increased tariff rate with prolonged outages would raise the electricity theft (Jamil, 2013).

Probability of Detection and Enforcement Process: Enforcement system is characterized by the probability of detection and the amount of fine to be imposed on the corruptible employees and consumers of electricity. It follows from Equations (3)–(5) that an increase in both these variables can reduce the expected utility of the consumer and resultantly can slash electricity theft down. Economic theory postulates that an individual compares the expected utility of illegal pursuit with that of legal activity. The illegal activities have the risk of associated punishment such that probability of detection and punishment are essential parts of the models (Groenendijk, 1997; Aidt, 2003; Bar-Ilan and Sacerdote, 2004). The number of cases convicted of electricity theft and the charged detection bills are punitive for electricity theft.

The utility employees generally perform functions including the operation and maintenance of electricity distribution system. They are also delegated to monitor electricity meters at the interface of consumers. In addition to this, many utilities have setup separate surveillance department that monitor and detect cases of theft and corruption. These arrangements raise the chances of conviction of corrupt employees and consumers. The collusion and sharing of benefits to utility employees for not detecting theft would become difficult in this overlapping arrangement. As a result, the proportion of theft will decline. Now the level of deterrence and the probability of detection are dependent on the number of monitoring employees and the effort put to monitoring. The matter becomes complex when the monitors become corruptible and utility cannot increase deterrence simply by increasing the number of employees. It can further increase financial losses to the utility.

Punishment and Deterrence: The deterrence hypothesis asserts that people respond to the deterring incentives created by the justice and governance system. On detection of electricity theft, consumers have to pay the penalty. Jain (2001) demonstrates that net utility of corruption depends on a number of factors such as, payoff from corruption, legitimate income, the strength of political institutions, moral and political values of the society and the probability of conviction and penalties. Higher sanctions will help in reducing the crime in case of risk averse and risk neutral individuals. However, sanctions must be devised after deliberations as poorly designed legal penalties can encourage rather than discourage corruption.

Bar-Ilan and Sacerdote (2004) find that higher fines increase deterrence for all groups of individuals and the individuals are responsive to the level of fine. An electricity stealing individual is made to pay a fine with some probability of detection, which is determined by the surveillance expenditures incurred by utility. If it happened to be costless to detect electricity theft, everyone engaged would be caught and fined an amount equal to the harm caused. However, in most of the instances it is difficult and costly to detect electricity theft, especially when the crime is carried out under the patronage of monitors.

Reputation, Morality and fairness Cost of Pilferage: The standard electricity theft model represents theft decision as an expected utility-maximizing problem whereas empirical evidence suggests that some individuals do not pilfer even when they may accept a gamble with purely same expected payoff. Hence, risk-aversion does not fully explain individual behavior and the moral and fairness considerations also affect the individual's utility level. The decision of individual regarding electricity theft seems interdependent between consumers as reflected in the increased likelihood of pilferage when others are believed to be engaged in theft (see, for example, Myles and Naylor, 1996). Even in poorly governed electricity distribution systems, some risk averse consumers may choose to honestly pay for the commodity that can be justified on the basis of moral and fairness arguments. Similarly, the reputational costs of stealing electricity theft are high as the individual belong to a more interactive and vibrant community. The economic concept of utility is taken as an indicator of a person's wellbeing, *i.e.* the word ‘utility’ encompasses everything that raise a person's wellbeing. The sources of this wellbeing are not limited to food, shelter, and all the material and hedonistic pleasures and pains that may affect utility, but so also does the satisfaction, or lack thereof, of a person's aesthetic sensibilities, his sense of what constitutes fair treatment for himself and for others, etc. Thus one can expect that electricity theft decreases with perceived fairness if and only if the consumer's risk aversion is an increasing function of fairness (See, for example, Falkinger, 1995).

Similarly, the reputational considerations may compel the rational utility employee to avoid corruption especially when the hiring and firing is merit-based. Market participants often have the opportunity to trade many times and if the same principal and agent interact or if the previous transactions of the agent with other principals are known to principal, then the agent's past behavior will affect the current contract terms. This essentially will motivate the agent to act honestly, because if he satisfies the principal by performance, his future contract terms would be more attractive (Fehr et al., 2009).

The role of civil society and collective action for improvement of services can be emphasized in the context of reforms of public services as it is learned in some of the countries. Transparency International (2002) in their study of corruption in South Asia recommends enhancing of citizens' participation in governance. For public services, citizen groups may play an important role by putting pressure on culprits of electricity theft if they are convinced that stealing electricity is immoral and a crime that affects them also. The consumers are the primary stakeholders as they are ultimate losers when electricity supply is in disarray due to heavy system losses. The individual consumers, therefore, can be motivated to report electricity theft, since they are to face outages and high tariff rates due to deteriorating financial condition of electric utilities. It is more cost effective to rely on the corruption and theft reporting from consumers by convincing them how theft and corruption impacts are passed on to them in the form of higher tariff rates and outages.

6. Summary and conclusion

Electricity theft and corruption are crimes and combating these crimes is challenging since the enforcers and monitors are frequently themselves engaged in the activity. Electricity theft is a source of substantial losses to the public electric utilities. Various empirical studies examine the issue of electricity theft and offer solution to combating it through technological, institutional, legal and policy measures. This study makes a first step towards better understanding the phenomenon of electricity theft. The study employed the expected utility framework and agency model of corruption to examine the phenomenon of electricity theft and corruption. The criterion is maximizing individual gain along with social welfare that entails to deter the individuals from crimes through law, where external cost of crimes greatly exceeds the individual gains from the crime. It suggests that individual weigh the expected benefits and cost in terms of associated risk of being fined, and steal electricity only if the net expected benefit is positive. Second, we study the agency model of corruption in the context of electric utilities. The corruption spurs the electricity theft by reducing risk of being detected and fined.

This framework enabled us to pinpoint a number of variables that can be operationally measured and used in empirical analysis of electricity theft. Thus, our theoretical models link up theory and empirical modeling. The key policy variables in our analytical framework include electricity tariff rate, wage rate in the electric utility, rate of conviction and being fined and involvement of civil society that may help in reducing electricity theft. These policy variables may affect electricity theft. Fighting corruption and electricity theft entail a commitment from the utility officials and public decision makers, which is inevitable due to overwhelming financial losses and unfavorable conditions for investment in the sector. The issue is generally handled technically through direct, technology intensive and relatively inexpensive measures. Ahmad (2017) offers an overview of technical measures especially smart meters to detect and reduce electricity theft. However, dwindling economic and financial conditions of utilities make it difficult to undertake such investments.

Reliable electricity supply is essential for sustainable economic development. Electricity shortfall due to mismatchment of electricity demand and supply is costly in terms of loss in production and welfare. Shortfall can be avoided either by using pricing policy or through adequate investments in electricity supply infrastructure. The effectiveness of pricing policy to hold back excessive demand in the presence of extensive theft is uncertain. The other option to avoid shortfalls requires investments in capacity additions especially from private sector. If an electricity industry relies on subsidies, investments cannot be attracted from private sector. Electricity theft is a major hurdle in attracting investment in the sector and electricity supply shortage, thus causing long unscheduled outages and making electricity distribution system unsustainable.

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