Petrol & L.P.G. Pricing: price discrimination & incentive schemes to reduce subsidy burden

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CERTIFICATE

This is to certify that the dissertation entitled **"Petrol & L.P.G. Pricing: price discrimination and incentive schemes to reduce subsidy burden"** submitted by **Mr. ABHINAV PRAKASH** in partial fulfillment of the requirement for the award of the degree of **MASTER OF PHILOSOPHY** (M. Phil.) of this university, has not been submitted, in part or full, for any other degree of this or any other university.

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DEDICATED TO MY MOTHER LATE SMT. KISHORI MISHRA

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Chapter 1: Introduction

In the present world energy security is crucial for the developmental needs of the economy. Petroleum constitutes an important component of energy security in Indian perspective. Any fluctuation in either its price or quantity has a widespread ramification across all sectors of the economy. The non–renewable nature and limited availability of petroleum products calls for developing an efficient price mechanism reflecting its scarcity value. Import dependence, international situations, price variability etc are the different basis for the adoption of different price mechanism in petroleum sector in India

In the past, the first major policy shift in pricing of petroleum products occurred in 1976, when the Government replaced Import parity pricing(henceforth IPP) of the 1960s by cost-plus pricing. This came to be known as Administered Pricing Mechanism (henceforth APM). The first oil shock in 1973-74 and the commencement of production from Bombay–high were the main cause of this policy shift However later in April 2002 this policy was dismantled.

During April 2002 to January 2004 oil companies changed the domestic consumer prices of petrol and diesel and domestic LPG based on market factors. However, kerosene price was not changed. As oil prices started moving upward in 2004, the question of smoothing the volatility in international prices assumed importance.

The period from 2004 to 2008 witnessed different policy phases to address oil price volatility, like as price band mechanism or formula of trade parity pricing (TPP).

Reasons for the failure of different policies:

Price volatility and overtime increase in petroleum prices in global market are a reality rather than an exception. Due to large import dependence (more than 80% in case of India), domestic prices must be reflective of the global prices which is not clearly visible under the present scenario where political consideration generally dominates. At the same time there exists a large group of domestic consumers whose per capita demand and level of income are relatively low consequently they are vulnerable to these high prices. There is a dilemma in petroleum market which is created by international price compulsion and social reality.

In terms of price stability APM was quite successful on social factor but due to absence of full pass through which as the basic feature of self balancing nature of the oil pool mechanism, there was a huge oil pool deficit ,which weakened the financial position of government and public sector oil companies. Other weakness of APM was that it did not induce competition in the marketplace and seems to have failed in fulfilling the consumer's desire for better products and services emerging from greater competition. Nor did it enable domestic oil companies to generate adequate financial resources for project development and capacity addition in this within the sector. The price band mechanism adopted in July 2004 was also not very effective. Government gave limited freedom to oil marketing companies to revise retail prices within a band of +/-10% of the mean of rolling average of last 12 months and last 3 months of international C&F prices. As oil prices rose sharply and there was uncertainty in international oil markets, the price band mechanism was abandoned.

In October 2005, the Government constituted Committee under C. Rangarajan to examine the pricing and taxation of petroleum products with a view to stabilizing their prices and establishing transparent mechanism for autonomous adjustment of prices by the oil companies. The Committee recommended a formula of trade parity pricing (henceforth TPP) for petrol and diesel at refinery level as well as at retail level. The formula was a weighted average of import parity and export parity prices, in which the percentage share of import/export of these products provided the weights. The Committee suggested that these TPP prices should serve as indicative ceilings within which the marketing companies would have flexibility to fix the actual retail prices of petrol and diesel. As regards subsidies, the Committee recommended elimination of subsidy on LPG and its restriction of kerosene subsidy to BPL families. The Government implemented switching over to TPP and rationalized taxes on crude oil, petrol and diesel, but could not implement rationalization of subsidies and other changes recommended by the Committee. Even TPP was confined to the refinery level and the retail prices of petrol, diesel, domestic LPG and PDS Kerosene fixed by the Government remained below their TPP levels. These internal conflict leads to this policy to failure.

The essence of the suggestions of different committees on petroleum sector was very similar.They are as follows (a) zero subsidies on petrol and diesel. (b) in case of domestic LPG and PDS kerosene subsidies should be given to BPL family only. Such subsidies should be disbursed through Smart Cards or cash transfers and not through supply of products much below their market prices.

Recent price hike in 2007-2008:

The unprecedented spike in oil prices and general worsening of economies in 2007-08 led to government interventions in oil price setting in many developing countries. Such interventions took many forms, such as price control, reduction in taxes, increase in fuel subsidies, operation of Price Stabilization Fund, fuel procurement by the government, enforcement of law to lower prices by companies etc. The broad forms of such measures are given below:

1) **Formula based pricing** .These take two forms

a) Import parity /export parity pricing.
b) Price ceilings.

2) **Price smoothing option**

a) Generally, price revisions are made on monthly/ fortnightly basis
b) Adjustments in domestic prices are called for when the price movement based on the formula exceeds a certain per cent .
c) A moving average of international prices with or without bands has been applied

3) **Price bands**

a) Max-Min rules: These rules specify a band around a central price. If the retail price(computed with a cost-plus formula) is above the band's ceiling, the government absorbs the difference between the two prices by paying out a subsidy and setting the retail price at the upper level of the band. If the retail price computed as indicated before is below the minimum price set by the band, the government taxes away the difference and sets retail prices at the minimum level.

b) Trigger rules: Retail prices are adjusted whenever the current formula price change exceeds a certain trigger band (e.g., plus or minus 10 percent around the current price). Whenever, the retail prices are adjusted, the price band shifts up or down depending on the adjustment.

4) **Price stabilization fund—**

Price Stabilization Fund is based on the notion that smoothing of consumer prices can be made by the Fund which is self-balancing between periods of low prices vis-à-vis high prices. When international prices are low, the domestic prices are not lowered, which provides inflows to the Fund. Conversely, when international prices rise, the domestic prices are not raised and companies are compensated from the Fund. Ideally, the fund can be self-balancing if, for example, the oil prices were mean-reverting

5) Price subsidies:

To reduce the impact of high oil prices, governments applied subsidies which are applied to all customers as also those which are targeted to specific class of customers. Agriculture, public and goods transport, and fisheries are some important sectors which received fuel subsidy.

6) Rationing:

Limiting availability of subsidized fuels has been adopted by countries to reduce the financial burden. Iran was a prime example of rationing petrol in June 2007. There were different monthly quotas for different class of vehicles. The government set up a smart card system to monitor fuel consumption by different class of vehicles. Malaysia has been operating a Smart Card system for fishing vessels and transport operators who can by discounted fuels under quota system.

Consequences of price control:

As per the Kirit Parikh report government control of petroleum product prices can have several adverse consequences including the following:

a) Artificially low prices can widen long term supply-demand imbalances by discouraging refiners and marketers to expand capacity and, on the other hand, encouraging demand growth.

b) Fuel shortages are nearly universal when prices are kept low.

c) Market malpractices like hoarding, black marketing, and adulteration thrive when prices are controlled arbitrarily.

d) Major oil exporters that subsidize petroleum product prices can actually become product Importers for lack of investment in the downstream sector. Iran, Iraq, Nigeria and Mexico are prime examples.

e)Cross-border price difference trend to widen when prices are kept low; it encourages "Fuel tourism".

Research Question addressed in the dissertation:

In this thesis we try to develop two alternative frameworks. First framework deals with the possibility of price discrimination in petrol and the second one deal with the gas stealing problem in case of domestic LPG.

Framework: 1

This framework deals with revenue neutral price discrimination in petrol on efficiency basis. In our country consumers (petrol consumers) are treated homogeneously, in terms of price being paid per unit of petrol irrespective of the quantity purchased. Such an approach seems to be problematic on account of widespread heterogeneity amongst its users. For instance, some of them (bikes) are demanding less unit of petrol and using it with greater efficiency while others (heavy vehicle user) are demanding it in larger quantity and less efficiently (in terms of mileage). By and large we can summaries the whole story within three points (in case of petrol).

(a) Some people are efficient users with lower demand and lower purchasing power.
(b) Some people having higher income level are demanding larger quantity and using it with lower efficiency.
(c) As the demand increased overtime, to decrease subsidy burden prices became more and more market determined.

So in other words efficient consumers share the burden of inefficient consumers.

In this frame work I am trying to develop a price discrimination model in case of petroleum such that some initial amount of fuel (q) will be provided at lower rate to all those persons who satisfy some conditions (in the framework I have used two such conditions) like as having vehicle and driving license (DL). The initial q is that quantity which is required to travel one month by using efficient means. The person who needs larger amount has to pay higher price.

How it is differs:

Firstly up to now we use price discrimination in terms of quality (high octane numbers) but still we treat consumers as a homogenous unit. Now in this case we can differentiate them in terms of efficiency in use. The social factor of dilemma that works in the situation of homogenous treatment will be less strong in second case and it will be easy to tackle international factor of dilemma with greater ease.

Secondly, as after certain quantity consumers have to pay more price so it will decrease demand, increase efficiency that leads to decrease in the imbalance of supply and demand. It will be revenue neutral so there will be no adverse impact on government and companies. There will be no fuel shortage. Since smart card (with DL) will be used in distribution with proper checking there will be no" fuel tourism".

In this framework there is a possibility of black marketing which will be from consumer side and in small quantity. This problem will be discussed in second chapter.

Framework 2

This framework will focus on an incentive mechanism which can stop gas stealing not only in single stage transaction but also in long run. It is true that there is a huge subsidy on domestic LPG. To reduce this subsidy burden by and large all committees advised similarly like as to reduce per unit subsidy i.e. increase per unit price; provide subsidy only BPL families, rationing etc. But there is a huge gas stealing of domestic gas and domestic gas is used for commercial purpose. If we can stop gas stealing, subsidy burden will automatically decrease without any price increase or rationing.

Gas stealing is only possible when vendor, a person who is responsible to LPG supply has strictly positive net expected gain in gas stealing. If commercial consumer has net gain after paying bribe or fine using domestic LPG for commercial purpose, he will always try to do so for an officer, who is responsible for checking, if there is more gain in accepting bribe then as a rational person he will try to do so.

We try to create an incentive mechanism such that vendor's net expected gain is negative in case of gas stealing, net expected gain for commercial consumer is negative when he uses domestic gas for commercial purpose and an officer has more gain in imposing fine rather than getting bribed.

In the second framework in chapter 3 we will try to evaluate whether such a framework can stop gas stealing in case of single transaction as well as in long run.

Chapter -2: Framework: 1

This chapter deals with possibilities or revenue neutral price discrimination in case of petrol.

In terms of efficiency petrol consumers are basically heterogeneous in nature. In the society petrol consumers may be divided in two categories, one group which uses bike has lower demand and greater efficiency in comparison to second group who posses car .Although both these groups are different even in terms of purchasing power but government treat them similarly in terms of petrol pricing.

Methodology:

In this price discrimination model there are some simple assumptions, average distance travelled by a man and absolute and relative efficiency of vehicles are some of them. Under these assumptions total petrol required by both type of vehicles per month can be calculated. With total number of person who needs petrol and average consumption per vehicle, total quantity of fuel demanded and amount of revenue can be calculated.

To provide average amount of fuel that is needed by a bike to travel one month at a particular rate which is lower than normal price and any person (mostly by car owners) who needs larger amount has to pay higher price is the basic idea of this proposed model .Amount of total revenue can be calculated in this case also. By equating both revenues we may create a revenue neutral price discrimination mechanism. That is, we envisage

Total revenue in general case =Total revenue in proposed framework

This chapter will be divided in to five parts:

Part 1 deals with assumptions of this framework and illustrations of assumptions.

Part 2 is all about of the working of my framework in case of general demand function.

Part 3 deals about the working of my framework in case of inelastic demand (a special but more general case).

Part 4 deals with properties of solution, its merit and application problem.

Part 5 deals with some shortcomings of framework and their expiations.

<u>Part 1:</u>

ASSUMPTIONS: this frame work depends on some simple assumptions.

Firstly only bikes and cars use petrol.

No of people who have bike = B

No of people who have bike and driving license both = B_L

$$B \geq B_L$$

No of people who have car =C

No of people who have car and driving license both = C_L

$$C \geq C_L$$

B≤No of bikes (one person may have more than one bike)

C≤ No of cars (one person may have more than one car)

B and C are mutually exclusive. Petrol is largely an item of final consumption. Only two wheelers (bikes, bike is used for all type of 2 wheelers that needs petrol), three wheelers (auto), and four wheelers (cars) use it. Three wheelers and some fraction of four wheelers (taxi) are mainly commercial vehicles where rate or tariff is proportional to price of fuel. My framework is all about own use and for house hold. So we can divide all petrol using vehicles in two groups, bike and car. It may be possible that one person may have more than one vehicle so to travel a certain distance in one month using efficient means , the required units of petrol at lower rate must be provided an person basis, otherwise a person who has more vehicle will get larger amount of petrol although he has to travel same distance.

A group of people who may have bikes as well as cars. Inclusion of these people will be extension of the model and it will only complicate the solution. As these people may get initial q units at lower rate (depends on availability of driving license) and they are free to use it either way so inclusion of this group will not mitigate the basic idea of price discrimination.

Secondly, average efficiency (km/l) of a bike = e_B

Average efficiency (km/l) of a car = e_c

Relative efficiency = $e_B / \ e_c \ = \ E$

It means to travel same distance car needs E times more fuel than a bike.

Following the Kirit Parikh report, the average annual use of petrol per vehicle is given in table 1

Type of vehicle	Average distance travelled annually	Fuel efficiency (km/liter)	Liters/vehicle/year
Bike(petrol)	6300	73.0	86
Car(petrol)	8000	13.5	593

Source: 'Residential and Transport Energy use in India: Past Trend and Future Outlook' by Ernest Orlando Lawrence Berkeley National Laboratory, USA, January 2009.

The above table shows that e_B, e_c, E can be measured. It is used to compare them on efficiency basis.

Thirdly, average distance travelled by a man = x km/day

Using bike a person needs q unit of petrol per month.

Where

$$q = \frac{30x}{e_B}$$

Similarly car needs Eq amount of petrol.

Only that person will get cheap petrol who has vehicle and driving license .so only B_L and$C_L$will get first q unit at cheap rate which is required to travel x distance through efficient means to get cheap petrol there are two conditions having driving license (DL) and having vehicle. To find out q, average distance travelled by a person (who has a vehicle) is required, so it is assumed x in the framework. Following the table 1 it can be measured .Although it is different for bike and car but different distance travelled is an extension of model.

Fourthly, pricing of petrol ----

We have three types of prices, P_1,P_2, P_3, Where P_1 denotes for general price of petrol and P_2 P_3 denotes for the proposed price of petrol.

P_1 = General Price that prevail in market

P_1 = Base price (B) + Fixed component (f) + Tax(T)

Base price depend on international price level. It may be calculated on import parity price (IPP) or trade parity price (IPP) or at any other mechanism that will be decided by government. At any time it is fixed in nature and it is out of the control of government.

Fixed component includes some fixed components like transportation cost firm's margin, pumps margin etc. all above are almost fixed in nature at a time.

T= Tax component, decided by government only.

T- is revenue part of government.

$$P_1 = B + f + T \qquad \text{--}(1)$$

$B + f = F$ (Fixed component, say)

$$P_1 = F + T$$

Where , P_1=price of petrol

F= fixed component

T= tax component decided by government. Here all government bodies that can impose tax are treated as government.

Proposed price structure where $Q_i$is demand for petrol by individual ' i'

If $Q_i \leq q$ then $P_1 = P_2$

$$\text{Where} P_2 = F + \delta T \qquad 0 < \delta \leq 1$$

$Q_i > q$ then, $P_1 = P_3$

$$\text{Where } P_3 = F + T + Z \qquad Z \geq 0$$

Z , δ are positive constant.

Fifthly q is fixed for a month and any $q - Q_i > 0$ will not be added to next month's q. q is that amount of petrol which is needed by an efficient user to travel one month. Providing q at different rate is a reward to the efficient user and this quantity separates two different types of consumers who have different reaction on any price hike. This separation will provide greater ease to the government in case of price change and as far as revenue is concerned.

Sixthly, the demand function of an individual is $Q(P)$and it is a constant elasticity demand function

$Q(P) = AP^{-\alpha}$

For bike it is $Q(P)$ and for car it will be $EQ(P)$.Demand function in such a form is often taken. Where, P is the price of petrol.

Part –2 case of general demand:

In general case that prevails in market.

Price of petrol $=P_1$

Demand for petrol from an individual having bike at price P_1 $= Q(P_1)$

Number of individuals having bike=B

Revenue from one unit of petrol= T

Revenue from bikes = $B \times T \times Q(P1)$

Demand for petrol from an individual having car at price $P_1 = EQ(P_1)$

Number of individuals having car=C

Revenue from one unit of petrol= T

Revenue from cars =C$\times$ $T \times EQ(P_1)$

Where,

B=no of persons who have bike

C=no of persons who have ca

T =tax per unit petrol

E=relative efficiency

$Q(P)$=general demand function for a Person having bike

$EQ(P)$=general demand function for a person having car

Total revenue = Revenue from bikes + Revenue from cars

$$=TQ(P_1)(EC + B) \qquad \text{------------} \qquad \text{eq(1)}$$

With proposed price discrimination----

Up to q amount C_L and B_L get cheap petrol at priceP_2 , otherwise they have to pay P_3

Demand for petrol from a person having bike at price $P_2 = Q(P_2)$.

Since$Q(P_2) \lesseqgtr q$ so there will be two cases

Case (a) when $Q(P_2) \leq q$

Case (b) when $Q(P_2\ ) > q$

Case (a) $Q(P_2\ ) \leq q$

For B_L demand per individual at price $P_2 = Q(P_2\ )$.

Revenue per unit of petrol $=\delta T$

Total revenue from$B_L = B_L Q(P_2)\delta T$

For $B - B_L$, $B - B_L$ has to purchase all quantity at price P_3 this group hasn't access to cheap petrol.

For $B - B_L$demand per individual at price P_3= $Q(P_3)$.

Revenue per unit of petrol $=T + Z$

Revenue from $B - B_L$=$(B - B_L)Q(P_3)(T + Z)$

Where,

B_L = No of people who have bike and driving license both

C_L=No of people who have car and driving license both

Z , δ are positive constant.

Total revenue from bikes in case (a) = $B_L Q P_2\ \ \delta T + (B - B_L)Q(P_3)(T + Z$ -------eq (2)

Case (b) since $Q(P_2 > q$ but B_L will get only q amount at the cheap rate after that he has to pay P_3 per unit for each extra unit. Q_i (Q_i is demand for petrol by individual i) where $i \in B_L$

$Q_i = \tilde{Q}(P_3) + q$

$\tilde{Q}$=extra amount purchased by i over q unit.

let $\exists\ \bar{A}$, $\bar{A}$ is that part of A which is used purchasing of q

s.t. $Q(P_2\ ) = \bar{A}\ \ P_2{}^{-\alpha}$

$. Q(P_2) = q$

$\bar{A} < A$

$\Rightarrow \quad q = \bar{A} P_2^{-\alpha}$

$\bar{A} = qP_2^{\alpha}$

$\tilde{Q}(P_3) = (A - \bar{A}) P_3^{-\alpha}$

$$Q_i = \tilde{Q}(P_3) + q$$

$$Q_i = (A - \bar{A}) P_3^{-\alpha} + q$$

$$Q_i = (A - qP_2^{\alpha}) P_3^{-\alpha} + q$$

For BL ,demand of an individual = $Q_i = (A - qP_2^{\alpha}) P_3^{-\alpha} + q$

Revenue per unit of petrol =δT,for initial q unit + $(T + Z)(A - qP_2^{\alpha}) P_3^{-\alpha}$ on each extra unit

Revenue from B_L =$BLq\delta T + B_L(T + Z)(A - qP_2^{\alpha})P_3^{-\alpha}$

For $B - B_L$, they have to purchase all quantity at price P_3 this group hasn't access to cheap petrol.

For $B - B_L$ demand per individual at price P_3= $Q(P_3)$.

Revenue per unit of petrol =$T + Z$

Revenue from $B - B_L$ =$(B - B_L)Q(P_3)(T + Z)$

Total revenue from bikes=

$$B_L q\delta T + B_L(T + Z)(A - qP_2^{\alpha})P_3^{-\alpha} + (B - B_L)(T + Z)Q(P_3)$$

$$= B_L q\delta T + B_L(T + Z)Q(P_3) - B_L(T + Z)q\left(\frac{P_2}{P_3}\right)^{\alpha} + (B - B_L)(T + Z)Q(P_3)$$

$$= B_L q\delta T + B(T+Z)Q(P_3) - B_L(T+Z)q\left(\frac{P_2}{P_3}\right)^{\alpha} \qquad \text{--------eq(3)}$$

Revenue from cars

For $C - C_L$, $C - C_L$ has to purchase all quantity at price P_3 this group hasn't access to cheap petrol.

For $C - C_L$ demand per individual at price $P_3 = EQ(P_3)$.

Revenue per unit of petrol $= T + Z$

Revenue from $C - C_L = (C - C_L)EQ(P_3)(T + Z)$

Revenue From C_L , C_L will get only q amount at the cheap rate after that he has to pay P_3 per unit for each extra unit Q_i (Q_i is demand for petrol by individual i) where $i \in C_L$

Q_i=initial q at price P_2 after that rest amount is purchased at P_3

By similar process as we adopt in case for B_L

$Q_i = q + (EA - qP_2{}^{\alpha})P_3{}^{-\alpha}$

Revenue per unit of petrol $=\delta T$, for initial q unit + $(T + Z)(A - qP_2{}^{\alpha})P_3{}^{-\alpha}$ on each extra unit

Revenue for $C_L = C_L\delta Tq + C_L(T + Z)(EA - qP_2{}^{\alpha})P_3{}^{-\alpha}$

Total revenue from cars = Revenue from $C - C_L$ + Revenue from C_L

$$=(C - C_L)(T + Z)E\,Q(P_3) + C_L\delta Tq + C_L(T + Z)(EA - qP_2{}^{\alpha})P_3{}^{-\alpha}$$

$$=(C - C_L)(T + Z)E\,Q(P_3) + C_L\delta Tq + C_L(T + Z)\,E\,Q(P_3) - C_L(T + Z)\,q\left(\frac{P_2}{P_3}\right)^{\alpha}$$

$$=C(T + Z)E\,Q(P_3) + C_L\delta Tq - C_L(T + Z)\,q\left(\frac{P_2}{P_3}\right)^{\alpha} \qquad \text{---eq(4)}$$

For revenue neutral price discrimination

Revenue without price discrimination (normal case) = revenue in case of price discrimination (proposed).

Case (1) when $Q(P_2) \leq q$

eq(1)= eq(2)+eq(4)

Case (2) when $Q(P_2) > q$

eq(1)= eq(3)+eq(4)

Case(1)

$$TQ(P_1)(EC + B) = B_L Q(P_2)\delta T + (B - B_L)Q(P_3)(T + Z)$$

$$+C(T + Z)E\,Q(P_3) + C_L\delta Tq - C_L(T + Z)\,q\left(\frac{P_2}{P_3}\right)^{\propto}$$

$$TQ(P_1)(EC + B) = \delta T\{B_L Q(P_2) + C_L q\} + (T + Z)\left\{Q(P_3)(B - B_L + EC) - C_L q\left(\frac{P_2}{P_3}\right)^{\propto}\right\}$$

$$T + Z = \frac{TQ(P_1)(EC+B) - \delta T\{B_L L Q(P_2) + C_L q\}}{Q(P_3)(B - B_L + EC) - C_L q\left(\frac{P_2}{P_3}\right)^{\propto}}$$

$$\boldsymbol{Z = T\left[\frac{Q(P_1)(EC+B) - \delta\{B_L Q(P_2) + C_L q\}}{Q(P_3)(B - B_L + EC) - C_L q\left(\frac{P_2}{P_3}\right)^{\propto}} - 1\right]}$$ --------------------eq(5)

$$\boldsymbol{\delta = \frac{Q(P_1)(EC+B) - \left(\frac{Z}{T}+1\right)\left\{Q(P_3)(B - B_L + EC) - C_L q\left(\frac{P_2}{P_3}\right)^{\propto}\right\}}{B_L Q(P_2) + C_L q}}$$ ------eq(6)

Since Z and δ are dependent variables, above condition shows the situation when price P_1even P_2 are so high that a bike owner (efficient user) can't afford the required amount q to travel a month.

Case (2) eq(1)= eq(3)+eq(4)

$$TQ(P_1)(EC+B) = B_L q\delta T + B(T+Z)Q(P_3) - B_L(T+Z)q\left(\frac{P_2}{P_3}\right)^{\propto}$$

$$+C(T+Z)E\,Q(P_3) + C_L\delta Tq - C_L(T+Z)\,q\left(\frac{P_2}{P_3}\right)^{\propto}$$

$$TQ(P_1)(EC+B) = \delta Tq(B_L+C_L) + (T+Z)\left\{ECQ(P_3) + BQ(P_3) - \left(\frac{P_2}{P_3}\right)^{\propto}(B_L+C_L)\right\}$$

$$T+Z = \frac{TQ(P_1)(EC+B) - \delta Tq(B_L+C_L)}{ECQ(P_3)+BQ(P_3) - q\left(\frac{P_2}{P_3}\right)^{\propto}(B_L+C_L)}$$

$$\boldsymbol{Z = T\left[\frac{Q(P_1)(EC+B) - \delta q(B_L+C_L)}{ECQ(P_3)+BQ(P_3) - q\left(\frac{P_2}{P_3}\right)^{\propto}(B_L+C_L)} - 1\right]} \text{ ---------------------eq(7)}$$

$$\boldsymbol{\delta = \frac{Q(P_1)(EC+B) - \left(\frac{Z}{T}+1\right)\left\{ECQ(P_3)+BQ(P_3) - q\left(\frac{P_2}{P_3}\right)^{\propto}(B_L+C_L)\right\}}{q(B_L+C_L)}} \text{ ----eq(8)}$$

Above conditions show the situation when price P_1 or P_2 are so low that a bike owner (efficient user) may purchase the amount greater than requirement.

In the above equations we have two sets of Z and δ, depending on the situation that at price P_2 how much a bike owner demands. Since $P_2 = F + \delta T$,by manipulating $\delta$and Tgovernment may affect consumption of petrol and revenue. Instead of eq(1)= eq(2)+eq(4)or eq(1)= eq(3)+eq(4) if we put L.H.S.<R.H.S then it leads to revenue increasing price discrimination.

Policy implication-

By using $\delta$and T we can change higher price$P_1$to lower price P_2 and vice-versa.With varying F (fixed cost) government has to change T (tax),but in proposed price structure we have to only change a fraction Z that will leads to revenue neutral situation. Whatever be the international conditions we get revenue neutral price discrimination in which a group which has lower purchasing power has to pay less.

Part 3 –special case with inelastic demand for petrol

Initially without price discrimination to move x distance bikes and cars need q and Eq unit per month respectively.

Revenue from an unit of petrol= T

Total revenue from bikes= qBT

Total revenue from cars= $EqCT$

Total revenue =$qT(B + EC)$ -------------------------eq(1)

In proposed situation

Revenue from bikes

Demand of petrol from an individual that belongs to B $= q$

ForB_L, revenue from an unit of petrol=δT

No of people who have bike and driving license both =B_L

Revenue from B_L=$B_L q\delta T$

For $B - B_L$, $B - B_L$ has to purchase all quantity at price P_3 this group hasn't access to cheap petrol

People with bike and without driving license=$B - B_L$

for $B - B_L$, revenue from an unit of petrol=$T + Z$

Revenue from $B - B_L$=$(B - B_L)q(T + Z)$

Total revenue from bikes= Revenue from B_L + Revenue from $B - B_L$

Total revenue from bikes= $B_L q\delta T + (B - B_L)q(T + Z)$ ---------eq(2)

Revenue from cars

No of people who have car and driving license both=C_L

People with car and without driving license $C - C_L$

Revenue from C_L,C_L will purchase initial q unit at cheap price P_2 and rest $Eq - q$ amount will be purchased at P_3.Rate of revenue on q is δT and on $Eq - q\ it$ will be $(T + Z)$

Revenue from C_L =$C_L q\delta T + C_L(E - 1)q(T + Z)$

Revenue from$C - C_L, C - C_L$ has to purchase all quantity at price P_3 this group hasn't access to cheap petro

Revenue from$C - C_L$ =$(C - C_L)Eq(T + Z)$

Total revenue from cars = $C_L q\delta T + C_L(E - 1)q(T + Z) + (C - C_L)Eq(T + Z)$ ---eq(3)

Total revenue from petrol = Total revenue from bikes+ Total revenue from cars

$$= B_L q\delta T + (B - B_L)q(T + Z) + C_L q\delta T + qC_L(E - 1)(T + Z) + Eq(C - C_L)(T + Z)$$

-------eq(4)

Comparing eq(1) and eq(4) we get revenue neutral Z and δ.

$$qT(B + EC) = B_L q\delta T + (B - B_L)q(T + Z) + C_L q\delta T + qC_L(E - 1)(T + Z) + Eq(C - C_L)(T + Z)$$

$$qT(B + EC) = B_L q\delta T + qBT + qBZ - qB_L(T + Z) + q\delta T C_L + qEC_L(T + Z) - qC_L(T + Z) + EqCT + EqCZ - EqC_L(T + Z)$$

$$Z(qB_L + qC_L + EqC_L - qB - qEC_L - EqC) = qB_L\delta T + q\delta T C_L + qEC_L T - qB_L T - qC_L T - EqC_L T$$

$$Z = \frac{T(\delta B_L + \delta C_L - B_L - C_L)}{B_L - B + C_L - EC}$$

$$\boldsymbol{Z = \frac{T(B_L + C_L)(\delta - 1)}{(B_L - B) + (C_L - EC)}}$$ --------------------------eq(5)

In eq (5) $Z \geq 0 \rightarrow (\delta - 1) \leq 0$

It shows that our $Z$and δ are consistent with our assumptions .So such price discrimination is at least theoretically possible. When $B_L = 0 = C_L$ then Z will be minimum at 0.when $B_L = B$ and $C_L = C$ then Z will be maximum.

Part 4 Properties

The solution of part 3 (in case of inelastic demand function) has various properties.

Firstly $\frac{dz}{d\delta} < 0$, for lower δ higher Z will be required.

Secondly Z Does not depends on 'q'

Thirdly let efficient consumers (bikers) will now pay τ rs/unit less than earlier for initial q unit of petrol. $\tau = T - \delta T \quad T(1-\delta)$

$$\tau = T(1-\delta) > 0$$

$$1 > \delta > 0$$

From eq(5) we get value of δ

$$\delta = Z\frac{\{(C_L - EC) + (B_L - B)\}}{T(B_L + C_L)} + 1 \qquad ----eq(6)$$

$$\tau = T(1-\delta)$$

$$\tau = \frac{-Z\{(C_L - EC) + (B_L - B)\}}{B_L + C_L}$$

$$\tau = \frac{Z\{(EC - C_L) + (B - B_L)\}}{B_L + C_L}$$

τ is independent of T. .

For $Qi > q$ consumers has to pay $(\tau + Z)$ more.

Fourthly Let θ =oil consumed by car riders s.t. the benefit he gets in first q liters will be neutralized by further consumption.

$$\theta T = q \times \delta T + (\theta - q)(T + Z)$$

$$\theta T - \theta T - \theta Z = q\delta T - q(T + Z)$$

$$\theta = \frac{q(T+Z-qT)}{Z} = q + \frac{qT}{Z}(1 - \delta)$$

The further consumption of $\frac{qT}{Z}(1 - \delta)$ will neutralize the gain on first q unit. Car owners have to pay $(Eq - \theta) \times Z$ amount of money more in this framework with respect to initial condition.On initial q unit car owners will save τ per unit, up to θunits their net saving will be zero they have to pay Z amount per unit more. and on the last $(Eq - \theta)$ unit theyhave to pay Z amount per unit more so they will pay $(Eq - \theta) \times Z$amount more than initial condition, where as bike owners has to pay δTamount less than for q units.

MERIT OF THE FRAMEWORK:

1) It discriminates in terms of efficiency. It separates efficient users with inefficient users. Up to now government has a political and social binding in terms of raising petrol prices. Now government has more liberty to increase price as both groups are by and large separated.
2) It is revenue neutral discrimination, in which inefficient have to pay more since they consume more so they must pay for their inefficiency in terms of high prices.
3) It promotes fuel efficiency.
4) It promotes road safety.
5) It may decrease pollution and demand of petroleum.
6) It shows that theoretically such price discrimination is possible.

Application problem

Smart card attached with driving license can be a good way. Smart card includes ownership information also may be calculated with some simple renovation at petrol pumps.

For simplicity q may be delivered in 3 or 4 steps.

If $q = I + f \quad \rightarrow \quad \exists a, b \in [0,1,2,---]$

Such that. for n steps $\frac{q-(a+f)}{n-1} = b$

In first step a+f unit will be delivered, after that b unit and so on.

Suppose q=7.5 then for 4 steps a=1.5 and b=2.

Part 5: Shortcomings

Since $T + Z - \delta T > 0$ so there exist a price difference and it may provide an incentive for black marketing. Since consumption of cheap petrol is connected through smart card so this black marketing will be from consumer's side and it will be small in nature. Suppose there is an individual (i) whose demand Q_i Is less than q.He has access of $(q - Q_i)$unit of petrol at priceP_2 and he can sell it at any price ρ, where $\rho \in [F + \delta T, F + T + Z]$ and depends on i's bargaining capacity.Since $(q - Q_i)$will be lower quantity, reselling is possible only from consumer's side and possibility of price hike in the near future, all these factors may discourage the incentive of reselling. Since this reselling is very difficult to invigilate and imposition of the fine may not be decrease the incentive of black marketing, government may try an incentive mechanism which is given below,

Since q is an average quantity so if there exists individual (i) whose demand Q_j is less than q then at the same time there will be an individual (j) whose demand Q_j is greater than q and

$$q - Q_i = Qj - q$$

There will be two situations possible

(a) When individual (i) will resale$(q - Qi)$.
(b) When individual (i) won't purchase$(q - Qi)$.

In case of resale –

Quantity not used by (i)= $(q - Q_i)$.

Revenue of the unused part to the government = $(q - Q_i)\delta T$.

If (j) purchase this $(q - Q_i)$from government then revenue of the government due to this purchase=$(q - Q_i)(T + Z)$

If (j) does not purchase this $(q - Q_i)$from government then revenue to the government due to this purchase=0

So in the case of resale loss to the government=$(q - Q_i)(T + Z - \delta T)$.

So the best situation for the government, not only in terms of revenue but also in administrative point of view will be the situation when there is no reselling. This problem is very similar to

$$\varphi_i + \varphi_j + \varphi_g = (q - Q_i)(T + Z - \delta T).$$

Where,

φ_i=share of individual (i) in extra revenue $(q - Q_i)(T + Z - \delta T)$.depends on resale and bargaining power of individual (i)

φ_j = share of individual (j) in extra revenue$(q - Q_i)(T + Z - \delta T)$. Depends on resale and bargaining power of individual (j)

φ_g= share of government in extra revenue$(q - Q_i)(T + Z - \delta T)$. Depends on resale

$\varphi_i, \varphi_j, \varphi_g \geq 0$

Since$(q - Q_i) \times (T + Z - \delta T)$will be very smallit is per individual per month. This black marketing can be possible only by final consumers and it is very difficult to catch. So even with φ_g =0,government does not loose any big quantitybut to maintain administratively better situation government can prevent it by providing some incentive to consumer (i) and that incentive must be equal to $(q - Q_i) \times (T + Z - \delta T)$, the maximum gain that will be possible in black-marketing. Government may provide it in terms of road tax concession or any other way.

Chapter 3: Framework-2

In India there is a subsidy on domestic L.P.G. and the subsidy burden is increasing over time. To decrease this burden different committees have recommended either fixing the gas quota or increasing the price (i.e. decrease subsidy). According to Kirit Parikh committee report (2010) quota will not be a feasible option it needs proper checking and for distribution purpose it needs smart card. In spite of all above there is always a possibility of more connection by one family .Since domestic needs are fixes and it is almost constant (According to Kirit Parikh committee report it is 10.2 unit for high income group).so fixing a quota below 10 units will compel consumers to purchase additional unit at higher price.

In India there is a big diversion of domestic L.P.G. for commercial use .If we can stop this (diversion) then without increasing gas price we may decrease subsidy burden. To stop this gas stealing apart from traditional administrative measures some innovative technical ways are also prescribed, for example fixing a microchip in each cylinder so that we can easily locate it, or create such type of nasal which can be used only for domestic purpose.

In this whole exercise I want to check the possibility of fine imposition such that on demand side there will be no incentive to use domestic cylinder for commercial use and for supply side there will be no supply of domestic gas for commercial use.

Methodology:

If we can create a situation in which the net expected profit for vendor who is responsible for L.P.G. delivery in case of gas stealing is negative, for officer who is responsible to stop gas stealing and gas diversion, there is more incentive to impose fine rather than be bribed and net expected benefit for commercial users who use his domestic gas for commercial use is negative.

Research question:

This framework also tries to find out that what should be the fine and will it works in single as well as long term transactions.

ASSUMPTIONS:

1) There are two types of consumers.

D = Domestic consumers and their demand is (d)

D_c = Commercial consumers and their demand is (d_c)

D are general type of consumers they need L.P.G. for domestic use.

D_c are commercial consumers like hotels, tea stalls etc

2) There is a vendor (V) who is responsible for L.P.G. delivery

3) There is an officer (O) who is responsible to stop any gas stealing.

4) There are four types of prices in the L.P.G. market

P=price of domestic L.P.G. (decided by government)

$\hat{P}$ = general price of L.P.G., without subsidy depends on international market

αP = price of commercial gas decided by government

P_1 = price of stolen gas

$\alpha P > \hat{P} > P$

$\hat{P} = P + S$

Where S =subsidy per unit of cylinder

Since , $\alpha P - P > 0$,it provides an incentive for gas stealing.

General price level that prevail in markets

$\alpha P \geq P_1 > \hat{P} > P$

αP will be the maximum price for stolen gas .

5) There is a fine (F/cylinder) which is fixed in nature

F_V will be imposed on V (in case when he caught).

F_C will be imposed on D_c (when domestic gas is used for commercial purpose by commercial consumer)

6) For V

$Þ_S$= probability of gas stealing by V

For O

$Þ_C$ = probability of checking of V

$Þ_b$= probability of getting caught (of V)

$Þ_S$,$Þ_C$ and $Þ_b$ all are independent.

For commercial consumer D_c

$\widehat{Þ}_S$ = probability of gas diversion by domestic consumer for commercial purpose.

$\widehat{Þ}_C$= probability of checking (of D_c)

$\widehat{Þ}_b$= probability of getting caught (of D_c)

$\widehat{Þ}_S$, $\widehat{Þ}_C$ and $\widehat{Þ}_b$ all are independent.

7) V and O both are rational person. They take decision on economic basis

V will steal gas iff expected gain ≥ 0

V will pay fine or give bribe up to that limit when his expected gain ≥ 0

On each caught an officer can impose fine or gets bribe X/unit .If he imposes fine he gets nothing so he will acts as a rational person and he will take bribe.

Bribe from vendor $=X$

Bribe from commercial user $D_c=\hat{X}$

8) No supply constraint.

In an ideal world when there is no gas stealing

Subsidy on domestic users = $d\ S$

Subsidy on commercial users $= dc\ (\hat{P} - \alpha P)$

Total subsidy$= d$ X $S + \ dc\ (\hat{P} - \alpha P)$ -----------------------------------(i)

Where d =demand of domestic L.P.G.

S =subsidy per unit on domestic L.P.G.

dc = demand of commercial L.P.G

$\hat{P}$=zero subsidy price

αP=price of commercial gas.

dS is positive whereas $\hat{P} - \alpha P$ <0 so government will actually earn from commercial users.

In actual situation (when gas stealing happens)

By stealing gas expected per unit gain of vendor (V) = $\text{Þ}_S\ (P_1 - P) + (1 - \text{Þ}_S)(p - p)$

$= \text{Þ}_S\ (P_1 - P)$

Where,

Þ_S = probability of gas stealing by V

P_1=price of stolen gas

P=price of domestic gas

For officer O probability of getting caught will be…

$$\text{Þ}_S \times \text{Þ}_C \times \text{Þ}_b = \text{Þ}^* \qquad \text{(let)}$$

Þ*= probability of getting bribe or imposing fine by an officer. When he caught the vendor with stolen gas during checking. Now he can either impose fine or may take bribe.

$Þ_S$= probability of gas stealing by V

$Þ_C$= probability of checking

$Þ_b$= probability of getting caught (of V)

$Þ_S$, $Þ_C$and $Þ_b$ all are independent.

$Þ^* F_V$ = expected fine per unit in case when V will be caught

$Þ^*X$ = expected bribe per unit in case when O get bribe

$Þ^*X \leq Þ^* F_V$ --eq(ii)

Maximum expected bribe per unit can't be more than expected fine per unit.

There are three possibilities

(a) Expected gain per unit of vendor > expected fine per unit imposed on vendor ≥ expected bribe per unit

$$Þ_S (P_1 - P) > Þ^* F_V \geq Þ^*X$$

(b) Expected fine per unit imposed on vendor >expected gain per unit of vendor ≥ expected bribe per unit

$$Þ^* F_V > Þ_S (P_1 - P) \geq Þ^*X$$

(c)) expected fine per unit imposed on vendor > expected bribe per unit >expected gain per unit of vendor

$$Þ^* F_V > Þ^*X > Þ_S (P_1 - P)$$

In case (a) when $Þ_S (P_1 - P) > Þ^* F_V \geq Þ^* X$

Nash equilibrium in case (a)

Players = {officer(O),vendor(V)}

Strategies of O ,

c =co operate with V (ready to take bribe)

nc = no co-operate with V (impose fine)

Strategies of V

s = Stealing gas

ns=not stealing gas

Payoff matrix (where payoffs are expected gain per unit of gas)

		V: s	V: ns
O	c	$Þ^* X$, $Þ_S (P_1 - P) - Þ^* X$	0,0
	nc	0, $-Þ^* F_V$	0,0

$$Þ_S (P_1 - P) - Þ^* X \geq 0 > -Þ^* F_V$$

(c,s) is dominant strategy Nash equilibrium. .There will be no mixed strategy. Here both players will cooperate. There will be always gas stealing.

To stop gas stealing Fv should be

$$Þ^{*} F_V \quad > Þ_S (P_1 - P) \quad \text{--eq (iii)}$$

Nash equilibrium in case (b) when expected fine per unit imposed on vendor >expected gain per unit of vendor $\geq$ expected bribe per unit .

$$Þ^{*} F_V \quad > Þ_S (P_1 - P) \geq Þ^{*}X$$

Players = {officer (O), vendor (V)}

Strategies of O ,

c =co operate with V (ready to take bribe)

nc = no co-operate with V (impose fine)

Strategies of V

s = Stealing gas

ns=not stealing gas

Payoff matrix (where payoffs are expected gain per unit of gas)

		V: s	V: ns
	c	$Þ^{*}X$, $Þ_S (P_1 - P) - Þ^{*}X$	0,0
O	nc	0, $- Þ^{*} F_V$	0,0

$$Þ_S (P_1 - P) - Þ^{*}X > 0$$

$$-Þ^{*} F_V < 0$$

(c,s) is dominant strategy Nash equilibrium. .There will be no mixed strategy. Here both players will cooperates. There will be always gas stealing. In this situation although paying a fine will be not beneficial for V but he will still stealing gas and paying bribe to O.

Nash equilibrium in case (c) expected fine per unit imposed on vendor > expected bribe per unit >expected gain per unit of vendor

$$Þ^* F_V > Þ^* X > Þ_S (P_1 - P)$$

Players = {officer(O),vendor(V)}

Strategies of O ,

c =co operate with V (ready to take bribe)

nc = no co-operate with V (impose fine)

Strategies of V

s= Stealing gas

ns=not stealing gas

Payoff matrix (where payoffs are expected gain per unit of gas) .

		V: s	V: ns
O	c	$Þ^* X$, $Þ_S (P_1 - P) - Þ^* X$	0,0
	nc	0,-$Þ^* F_V$	0,0

$$Þ_S\ (P_1 - P) - Þ^* X < 0$$

$$-Þ^*\ F_V\ < 0$$

Here all things are same as like case (b) except,

$$Þ_S\ (P_1 - P) - Þ^* X\ < 0$$

(c,ns) is weakly dominant strategy Nash equilibrium. .There will be no mixed strategy. In this case there will be no gas stealing. Expected bribe is so much that gas stealing is not profitable for V

Here although O opts strategy c but his demand for bribe is so high that (c,ns)is Nash equilibrium.

Comparing the outcomes of both cases (b) and (c) a rational officer will opt case (b) and (c,s) will prevail in market as a dominant strategy. So in the one stage game (c,s) is Nash equilibrium.

Nash equilibrium in case of finitely repeated game

As one stage has unique Nash equilibrium (c,s),so (c,s) will be solution at each stage.

Nash equilibrium for infinitely repeated game…

With co-operation O gets $Þ^* X$ each time

Total value= $Þ^* X$ /1-δ

Where

δ = discount factor

With deviation O gets 0 each time

$$Þ^* X\ /1-\delta > 0$$

So stage game Nash equilibrium will always exist.

To stop this gas stealing if government opts

- increase Fv
- increase salaries of O,V
- increase strict checking

All these will not change the eq .(c,s) will prevail as Nash equilibrium

Subsidy burden in this case..

As fraction of Dc use domestic L.P.G..,let this fraction be γ

Total subsidy = $(d + \gamma\, dc)\ S + (1-\gamma)\, dc\ (\hat{P} - \alpha P)$ ....(iv)

R.H.S. of eq(i) is less than R.H.S. of eq (iv).

$$d \times S + \ dc\ (\hat{P} - \alpha P) < \ (d + \gamma\, dc)\ S + (1-\gamma)\, dc\ (\hat{P} - \alpha P)$$

So subsidy burden is increased and it will always greater than (i) unless gas stealing will stop.

Proposed structure.....

(i) F_V should be s.t.

$$Þ^*\ F_V > \quad Þ_S\ (P_1 - P)$$

(ii) A fraction β of this F_V must be given to O as an incentive. This β will be s.t.

$$\beta\ Þ^*\ F_V > Þ^* X \quad \text{...............(v)}$$

Maximum bribe will be

$$Þ^* X \ \leq Þ_S\ (P_1 - P) \quad \text{.......(vi)}$$

One stage Nash equilibrium in this situation

Players = {officer(O),vendor(V)}

Strategies of O ,

c =co operate with V (ready to take bribe)

nc = no co-operate with V (impose fine)

Strategies of V

s= Stealing gas

ns=not stealing gas

Payoff matrix (where pay offs are expected gain per unit of gas).

O	V	s	ns
	c	$Þ^*X$, $Þ_S (P_1 - P) - Þ^*X$	0,0
	nc	$\beta Þ^*F_V, - Þ^*F_V$	0,0

$Þ_S (P_1 - P) - Þ^*X > 0$

$- Þ^*F_V < 0$

$\beta Þ^*F_V > Þ^*X$

(nc,ns) is weakly dominated pure strategy Nash equilibrium . There will be no mixed strategy. In this case there will be no gas stealing. Expected bribe is less than the incentive provided by government on each caught.

Nash equilibrium in case of finitely repeated game

As one stage has unique Nash equilibrium (nc,ns),so (nc,ns) will be solution at each stage.

Nash equilibrium for infinitely repeated game…

With co-operation O gets $Þ^{*}X$ each time

Total value= $Þ^{*}X$ /1-δ

where

δ = discount factor

With deviation O gets $\beta Þ^{*}F_V$ first time (by imposing fine) and then 0 each time

$$\beta Þ^{*}F_V + 0 + 0 + \cdots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \infty$$

$$= \beta Þ^{*}F_V$$

If $\beta Þ^{*}F_V >$ $Þ^{*}X$ /1-δ → (nc,ns) will be N.eq in infinite game .

$\beta Þ^{*}F_V >$ $Þ^{*}X$ /1-δ

→ $\beta\ F_V >$ X /1-δ …………………………………….(vii)

L .H.S.= incentive to O (decided by government)

R.H.S. depends on X (bribe per unit, $X \leq (P_1 - P) \leq (\alpha P - P)$) and δ (patient of an officer)

Following eq (vii) we can formulate a fine structure in which there will be no gas stealing in any case.

By period limitation for a person to be an officer (O) we can make an infinite game to finite game and by this way we can decrease value of δ .

Subsidy burden in this case…

γ = fraction of commercial users (Dc) use domestic L.P.G

As there is no gas stealing γ =0

Total subsidy

$$= \quad d\ S + dc\,(\hat{P} - \alpha P) \qquad \text{.................(viii)}$$

Subsidy burden in proposed situation (eq (viii))is equal to ideal case (i) and less than actual case when gas stealing exists.

So without increasing price government can decrease her subsidy burden. It is very interesting that in proposed case government has nothing to pay as an incentive.

In case of gas stealing since (c,s)is N.eq so total fine collected= 0

In case of incentive as (nc,ns) is N.eq . Here total fine collected= 0

Total incentive paid=0

So only by one mere proposal government can decrease his subsidy burden, stop gas stealing without paying anything. All this is possible at least theoretically.

Magnitude of F_V

Will be the solution of several inequalities

For F_V we have several inequalities

$$X < \beta F_V < F_V$$

$$Þ^{*}X \leq Þ_S\,(\alpha P\text{-}P) \quad < \quad \beta Þ^{*} F_V$$

$$0 \leq Þ^{*} \leq 1$$

Solution…

$$Þ_S\,(\alpha P - P) \quad < \quad \beta Þ^{*} F_V$$

$$\frac{Þ_S\,(\alpha P - P)}{\beta Þ^{*}} < F_V$$

Where..

β=fraction of Fv as an incentive to officer

P=price of domestic L.P.G. (decided by government)

αP=price of commercial gas decided by government

F_V= will be imposed on V(in case when he caught).

$Þ_S$ = probability of gas stealing by V

$Þ_C$ = probability of checking

$Þ_b$ = probabilityof getting caught (of V)

$$Þ_S \times Þ_C \times Þ_b = Þ^{*}$$

Here $F_V, \alpha P, P, \beta$ are decided by government. By βF_V we can increase value of $Þ_b$.As $Þ_b$increases over time and (nc,ns) is Nash equilibrium ,over time

$$Þ_S \rightarrow 0$$

What government has to do is to announce a good sum as βF_V ,by the way which you don't need to pay.

All the above exercise is to stop supply of stolen gas. But D_c can use their own domestic gas for commercial use. Since both types of L.P.G.units are not homogenous so they can be caught by inspection.

For commercial consumer D_c

By stealing gas expected per unit gain of commercial consumerD_c

$$= \widehat{\mathrm{P}}_S \ (\alpha P - P) + \ (1- \widehat{\mathrm{P}}_S \ ) \ (\alpha P - \alpha P)$$

$$= \widehat{\mathrm{P}}_S \ (\alpha P - P)$$

Where,

$\widehat{\mathrm{P}}_S$ = probability of domestic gas diversion by commercial consumer for commercial purpose

. αP = price of commercial gas(decided by government)

P=price of domestic L.P.G. (decided by government)

For officer O probability of getting caught will be

$$\widehat{\mathrm{P}}_S \quad \widehat{\mathrm{P}}_C \quad \widehat{\mathrm{P}}_b = \widehat{\mathrm{P}}^* \text{ (let)}$$

$\widehat{\mathrm{P}}_S$ = probability of domestic gas diversion by commercial consumer for commercial purpose

$\widehat{\mathrm{P}}_C$ = probability of checking of D_c

$\widehat{\mathrm{P}}_b$ = probability of getting caught(of D_c

$\widehat{\mathrm{P}}_S$, $\widehat{\mathrm{P}}_C$ and $\widehat{\mathrm{P}}_b$ all are independent.

$\widehat{\mathrm{P}}^*$ = probability of getting bribe or imposing fine by an officer. When he caught the commercial user using his domestic gas for commercial purpose during checking. So now he can either impose fine or may take bribe.

$\widehat{\mathrm{P}}^* \ F_C$ = expected fine per unit in case when commercial consumer D_c will be caught

$\widehat{\mathrm{P}}^* \ \hat{X}$= expected bribe per unit in case when O get bribe

$\widehat{\mathrm{P}}^* \hat{X} \leq \ \widehat{\mathrm{P}}^* \ F_C$ --------------------------eq(ix)

Maximum expected bribe per unit can't be more than expected fine per unit.

There are three possibilities

(a) Expected gain per unit of commercial consumer D_c > expected fine per unit imposed on commercial consumer D_c ≥ expected bribe per unit

$$\hat{P}_S \; (\alpha P - P) \; > \hat{P}^{*}F_C \geq \hat{P}^{*}\hat{X}$$

(b) Expected fine per unit imposed on commercial consumer D_c >expected gain per unit of commercial consumer D_c > expected bribe per unit

$$\hat{P}^{*}F_C > \; \hat{P}_S \; (\alpha P - P) \; > \hat{P}^{*}\hat{X}$$

(c)) expected fine per unit imposed on commercial consumer D_c > expected bribe per unit >expected gain per unit of commercial consumer D_c

$$\hat{P}^{*}F_C > \; \hat{P}^{*}\hat{X} > \; \hat{P}_S \; (\alpha P - P)$$

In case (a) $\hat{P}_S \; (\alpha P - P) > \hat{P}^{*}F_C \geq \hat{P}^{*}\hat{X}$

Nash equilibrium in case (a)

Players = {officer (O), commercial consumer Dc }

Strategies of O ,

c =co operate with D_c (ready to take bribe)

nc = no co-operate with D_c (impose fine)

Strategies of commercial consumer D_c

d = diverting of gas for commercial use

n d = not diverting of gas for commercial use

Payoff matrix (where payoffs are expected gain per unit of gas)

D_c

		d	nd
O	c	$\hat{\text{P}}^*\hat{X}$, $\hat{\text{P}}_S$ $(\alpha P - P) - \hat{\text{P}}^*\hat{X}$	0,0
	nc	0, $-\hat{\text{P}}^* F_C$	0,0

$$\hat{\text{P}}_S\ (\alpha P - P) - \hat{\text{P}}^*\hat{X} \geq 0 > -\hat{\text{P}}^* F_C$$

(c,d) is dominant strategy Nash equilibrium. .There will be no mixed strategy. Here both players will cooperates. There will be always gas diversion .

To stop gas stealing $F_C$should be

$$\hat{\text{P}}^* F_C > \hat{\text{P}}_S\ (\alpha P - P) \text{---eq (x)}$$

Nash equilibrium in case (b) when expected fine per unit imposed on commercial consumer D_c >expected gain per unit of commercial consumer D_c $\geq$ expected bribe per unit

$$\hat{\text{P}}^* F_C > \hat{\text{P}}_S\ (\alpha P - P) > \hat{\text{P}}^*\hat{X}$$

Players ={officer(O), commercial consumer (Dc) }

Strategies of O ,

c =co operate with D_c (ready to take bribe)

nc = no co-operate with D_c (impose fine)

Strategies of commercial consumer D_c

d = diverting of gas for commercial use

n d = not diverting of gas for commercial use

Payoff matrix (where payoffs are expected gain per unit of gas)

D_c

O		d	nd
	c	$\hat{\text{Þ}}^*\hat{X}, \hat{\text{Þ}}_S(\alpha P - P) - \hat{\text{Þ}}^*\hat{X}$	0,0
	nc	$0, -\hat{\text{Þ}}^*F_C$	0,0

$$\hat{\text{Þ}}_S\ (\alpha P - P) - \hat{\text{Þ}}^*\hat{X} > 0$$

$$-\hat{\text{Þ}}^*F_C < 0$$

(c,d) is dominant strategy Nash equilibrium. .There will be no mixed strategy. Here both players will cooperates. There will be always gas diversion. In this situation although paying a fine will be not beneficial for $D_c$but he will still diverting gas by paying bribe to O.

Nash equilibrium in case (c) expected fine per unit imposed on commercial consumer D_c > expected bribe per unit >expected gain per unit of commercial consumer D_cDc

$$\hat{\text{Þ}}^*F_C > \hat{\text{Þ}}^*\hat{X} > \hat{\text{Þ}}_S\ (\alpha P - P)$$

Players ={officer(O), commercial consumer Dc }

Strategies of O ,

c =co operate withD_c (ready to take bribe)

nc = no co-operate with D_c (impose fine)

Strategies of commercial consumer D_c

d = diverting of gas for commercial use

n d = not diverting of gas for commercial use

Payoff matrix (where payoffs are expected gain per unit of gas) .

O	D_c: d	nd
c	$\hat{Þ}^*\hat{X}, \hat{Þ}_S(\alpha P - P) - \hat{Þ}^*\hat{X}$	0,0
nc	$0 \; -\hat{Þ}^* F_C$	0,0

$$\hat{Þ}_S \; (\alpha P - P) - \hat{Þ}^*\hat{X} < 0$$

$$-\hat{Þ}^* F_C < 0$$

Here all things are same as like case (b) except,

$$\hat{Þ}_S \; (\alpha P - P) - \hat{Þ}^*\hat{X} < 0$$

(c,nd) is weakly dominant strategy Nash equilibrium. .There will be no mixed strategy. In this case there will be no gas stealing. expected bribe is so much that gas stealing is not profitable for D_c.

Here although O opts strategy c but his demand is so high that (c,nd) is Nash equilibrium. Comparing the outcomes of both cases(b) and (c) a rational officer will opt case (b) and (c,d) will prevail in market as a dominant strategy. So in the one stage game (c,d) is Nash equilibrium.

Nash equilibrium in case of finitely repeated game

As one stage has unique Nash equilibrium (c,d),so (c,d) will be solution at each stage.

Nash equilibrium for infinitely repeated game…

With co-operation O gets$\hat{P}^*\hat{X}$ each time

Total value= $\hat{P}^*\hat{X}/1\text{-}\delta$

Where

δ = discount factor

With deviation O gets 0 each time

$$\hat{P}^*\hat{X}/1\text{-}\delta>0$$

So stage game Nash equilibrium will always exist.

To stop this gas stealing if government tries to increase F_C or strict checking all these will not change the equilibrium and (c,d) will prevail as Nash equilibrium

Proposed structure…..

(i)Fc should be s.t.

$$\hat{P}^* F_C > \hat{P}_S\ (\alpha P - P)$$

Expected per unit fine on D_c > Expected per unit gain ofD_c

(ii) A fraction $\hat{\beta}$ of this F_C must be given to O as an incentive. This $\hat{\beta}$ will be s.t.

$$\hat{\beta}\ \widehat{\text{P}}^{*}F_C > \widehat{\text{P}}^{*}\hat{X} \quad \text{.......................................(xi)}$$

incentive to officer on each caught > Maximum expected bribe that can be offered by D_c on each unit

Maximum bribe will be

$$\widehat{\text{P}}^{*}\hat{X} \leq \widehat{\text{P}}_S\ (\alpha P - P) \text{...(xii)}$$

One stage Nash equilibrium in this situation

Players ={officer(O), commercial consumer D_c }

Strategies of O ,

c =co operate with D_c (ready to take bribe)

nc = no co-operate with D_c (impose fine)

Strategies of commercial consumer D_c

d = diverting of gas for commercial use

n d = not diverting of gas for commercial use

Payoff matrix (where payoffs are expected gain per unit of gas)

O		D_c: d	D_c: nd
	c	$\hat{Þ}^*\hat{X}$, $\hat{Þ}_S(\alpha P - P) - \hat{Þ}^*\hat{X}$	0,0
	nc	$\hat{\beta}\ \hat{Þ}^* F_C, -\hat{Þ}^* F_C$	0,0

$\hat{Þ}_S\ (\alpha P - P) - \hat{Þ}^*\hat{X} > 0$

$-\hat{Þ}^* F_C < 0$

$\hat{\beta}\ \hat{Þ}^* F_C > \hat{Þ}^*\hat{X}$

(nc,nd) is weakly dominated pure strategy Nash equilibrium . There will be no mixed strategy. In this case there will be no gas diversion. Expected bribe is less than the incentive provided by government on each caught.

Nash equilibrium in case of finitely repeated game

As one stage has unique Nash equilibrium (nc,nd),so (nc,nd) will be solution at each stage.

Nash equilibrium for infinitely repeated game…

With co-operation O gets $\hat{Þ}^*\hat{X}$ each time

Total value= $\hat{Þ}^*\hat{X}/1\text{-}\delta$

where

δ = discount factor

Magnitude of F_C

Will be the solution of several inequalities

For Fc we have several inequalities

$$\widehat{X} < \hat{\beta}\, F_C < F_C$$

$$\widehat{Þ}^{*}\widehat{X} \leq \widehat{Þ}_S\ (\alpha P - P) < \hat{\beta}\ \widehat{Þ}^{*}F_C$$

$$0 \leq \widehat{Þ}^{*} \leq 1$$

Solution...

$$\widehat{Þ}_S\ (\alpha P - P) < \hat{\beta}\ \widehat{Þ}^{*}F_C$$

$$\boldsymbol{F_C} > \frac{\widehat{Þ}_S\ (\alpha P - P)}{\beta\ \widehat{Þ}^{*}}$$

Where..

P=price of domestic L.P.G. (decided by government)

$\widehat{\beta}$=fraction of Fc as an incentive to officer

αP=price of commercial gas decided by government

F_C = will be imposed on Dc(in case when he caught).

$\widehat{Þ}_S$ = probability of gas stealing byDc

$\widehat{Þ}_C$ = probability of checking

$\widehat{Þ}_b$= probabilityof getting caught (ofDc)

$$\widehat{Þ}^{*} = \widehat{Þ}_S\ \mathrm{X}\ \widehat{Þ}_C\ \mathrm{X}\ \widehat{Þ}_b$$

Here $F_C, \alpha P, P, \widehat{\beta}$ are decided by government. By $\widehat{\beta}\ F_C$ we can increase value of $\widehat{Þ}_b$.As $\widehat{Þ}_b$increases over time and (nc,ns) is Nash equilibrium ,over time

$$\widehat{Þ}_S \rightarrow 0$$

What government has to do is to announce a good sum as $\widehat{\beta}\, F_C$,by the way which you don't need to pay.

Comparison with other proposals

There are several proposals in India to decrease subsidy burden and to stop gas stealing like as providing L.P.G. through gas pipe line, providing subsidy on gas only to BPL families and selling it at market price for all consumers, rationing of the subsidized cylinders etc.

Using of gas pipe line for distribution could be one of the best situations although it needs some early investment in the form of equipments and pipe settings but in long term it will be very effective and subsidy burden may be equal to the ideal case subsidy burden. In spite of its effectiveness, there are some difficulties with it. It may be effective and popular in big cities but it is very difficult to set up in the unplanned area and in the slums. a In India where there are more than six lakhs villages it is very difficult to supply gas to all places through pipes. Even in supply of gas through pipe there is always some possibilities of gas stealing by gas meter tampering (Gas meter is a device that measure total gas consumed) and to stop this there will be need of proper checking of meters and staffs who will be responsible for gas meters tampering.

At first sight providing subsidy only to BPL families seems very attractive but this proposal has many loopholes particularly in India where measurement of poverty is still one of the biggest debates. There is no consensus on the exact number of the poor families. Following Arjun Sen Gupta committee report on informal sector, almost 77 percent of the population has less than 20 rupees per day income whereas according to Suresh Tendulkar committee report on poverty in India rural poverty is 41.8 percent, urban poverty is 25.7percent and overall poverty is 37.2 percent.

According to Kirit Parikh report rural households use from 5.17 to 7.91 cylinders per year. The LPG-using rural households belonging to the four poorest deciles use less than 6 cylinders per year and the richer households use more than 6 cylinders. Rural households use fewer cylinders than urban households as the former have access to alternate fuels such as fuel wood etc. The households belonging to the poorest deciles of urban consumers use 8 cylinders whereas the top 5 deciles use 10 cylinders.

With the recent price hike in July 2011 price of domestic L.P.G. cylinder in Delhi is 395.35 rupees whereas loss of marketing company on each domestic L.P.G. cylinder is 381.14 rupees so at the market price cost per cylinder will be 776.49 rupees. As we have seen above 77 percent of the population have income below 600 rupees per month (Arjun Sen Gupta Report). Given the demand of domestic gas, gas price without subsidy and low income level (following Arjun Sen Gupta report) success of above discussed policy is very doubtful. Even though we provide domestic gas at market price but as far as commercial gas is concerned, either government set price of commercial gas cylinder higher than market price or government has to treat domestic and commercial consumers at par and charge same price from both.

If the price of the commercial gas is higher than the market price then in this case as there exists a price differentiation between both types of gas use (domestic and commercial) so as far as gas stealing is concern it may continue. Only the expected gain per cylinder and expected bribe per cylinder will decrease.

In case of rationing in which government will provide some units (in recent proposal it is 4 units) at subsidized rate and rest units at market price then even in this case there are number of people as described above can't afford gas and this policy will also be highly affected by gas stealing. All types of proposals discussed above are not paying much attention on the problem of gas stealing which is one of the biggest problems in L.P.G. sector. Issues like gas connection are also ignored. One person may have more than one gas connection or many members of same family could gas connections.

Apart from all above mechanism increase in price is also a way to decrease subsidy burden and it is most used and a reliable way of government but it also puts pressure on consumers and environment. The proposed model here would without increasing price may decrease subsidy burden by stopping gas stealing and for this it also does not needs any bulk investment. It is based on human nature. The government has to only form a law and without any extra spending gas stealing could be stopped.

Chapter 4

Conclusion

With the increasing demand of petroleum products this (petroleum) sector needs a pricing policy which is of long term perspective. Our dependence on these products has been increased not only for fuel for vehicles but also for cooking. With increasing disparity between Indian and Bharat, it is necessary that politics should revise. According to Prof. C.P Chandershekhar there are five alternatives available to government and these alternatives are:

Raising retail prices

Reducing customs and excise duties even with exchanged retail prices so as to transfer the benefits of the duty reduction to the oil marketing companies

Generating revenues by taxing super profits of oil companies that are involved in production and export of crude at the current high price, so as to compensate marketing companies

Generating resources through additional taxes on or lower tax concession for India's super-rich individuals and the corporate sector, so as to pay, for subsidy that protect ordinary consumer against the effects of global oil price shock;

Borrowing money by issuing oil bonds to compensate oil marketing companies for their losses.

The second framework of the chapter two provides one of the possible way to do so since the framework is based on average and relative efficiency of vehicles so it not only discriminate between bike and cars but within same group keep discriminate between higher and lower efficiency. Following Kirit Parikh the average mileage of petrol cars in India is 13.5 km/liter. But there are some cars like Tata Indica or Maruti Alto whose mileage are greater than average mileage and at the same time there are some cars whose mileages is below 10 km/litre or even below 5 km/L (like BMW).

The benefit of such discrimination is that an individual has to pay more and more for his luxury and extravagance. The value of relative efficiency E as described in earlier chapters is higher for low efficiency car and relatively lower for high efficiency cars.

For example,

Relative efficiency E,when average mileage of bike is 73.0 km/liter and average mileage of car is 13.5 km/liter = $\frac{73.0}{13.5} \approx 5.4$

Requirement of petrol =5.4 times of q

Relative efficiency E,when average mileage of bike is 73.0 km/liter and average mileage of car is 20 km/liter = $\frac{73.0}{20} \approx 3.65$

Requirement of petrol = 3.65 times of q

Relative efficiency E,when average mileage of bike is 73.0 km/liter and average mileage of car is 5 km/liter = $\frac{73.0}{5} \approx 14.6$

Requirement of petrol = 14.6 times of q

The same condition is for bike. Less efficient bike has to purchase petrol at higher price P_3 same as like as cars. Since expensive bike has lower mileage so even bike owners has to pay for their luxury.

This type of framework will promote the fuel efficient vehicles and government will provide required fuel for your need not for your greed. If a person has choice for any luxury vehicle whose efficiency is lower than average then it means it is his preference and he is ready to purchase petrol at higher price, for any purchase more than q. Increasing prices of petrol may promote public transport and it will also reduce environment pollution.

As far as LPG subsidy burden is concerned we have to focus on the real problem which gas stealing. Since policies are made for human being and it is conducted by human being, so for policy success it is very important that we treat human as a rational being who may take decisions on economic basis rather than as an ideal person who takes decision on the basis of ideal values.

Economic survey 2010-11 also indicates about this fact. We may increase prices or use rationing to decrease subsidy burden but there is serious doubt about the success of this method and this phenomena has serious implication on environment also, as discussed in chapter 3.

Since gas subsidy is one of the biggest contributor in total for subsidy burden and policy failure so it will be better that we focus on this real problem rather than increasing gas price.

As the third chapter shows we may create a situation in which by using rational behavior of human being there will be no gas stealing at least theoretically. Since real world is different and more complex than theory, it may be possible that gas stealing will be existed even after the adoption of the framework but there is large possibility that its volume will decrease and for this government won't have to pay anything extra. The government has just to frame a law.

It may be possible that both the framework is not appropriate enough and they are more theoretical rather than practical .But the main motive of this exercise is to exercise focus on these points. Frameworks are just one of the way there may be better forms, but for that we have to think in this direction also.

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