4D'S OF TAXI FARES: A BEHAVIOURAL MODEL FOR THE ICT AGE

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ABSTRACT:

Price influences the behaviour of people. It follows that the quality of a taxi service and the behaviour of the driver depends on the fare structure. This paper finds that the contribution approach to pricing as opposed to the cost plus pricing used universally can provide the 'motivation handles' to influence the behaviour of drivers, passengers and all stake holders. A real life example from Chennai, India is used to demonstrate a scientific fare structure. It is based on the four Ds of a fare mix: Distance, Duration, Drop and Discern. Such pricing granularity can be implemented with the advances in information and communication technology (ICT) of today. The transparency of the structure can balance the needs and costs of all the stake holders—passengers, drivers, other road users, owners, capital and society.

BIOGRAPHY OF THE AUTHORS

P Mahalingam is Coordinator of The Public Administration Help Tank (PAHT), a not-for-profit organisation. The Government of Tamil Nadu, India declared to have based the recent fare revisions on this work. Professionally, Mr Mahalingam is Chairman of Door Sabha Nigam Limited (DSNL) and Telekonnectors Limited. This paper is based on his doctoral dissertation at Anna University, Chennai, India.

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INTRODUCTION

Time's (1985) humorous article on taxis around the world is a must read for those associated with taxis or For Hire Vehicles (FHV). FHV's across the world are mostly regulated for one or more factors (Beesley and Glaister, 1983), ie fare, capacity, quality of vehicles, driver, and traffic practice. Still, in many cities taxis are known to refuse rides, demand higher fares, take circuitous routes, and be rude to passengers.

From Doolittle (1915) through Turvey (1961) to Beesley (1973, 1979, 1983) taxis have attracted attention in one way. Orr (1969) mentions Freidman's (1962) seventeen problems and how the taxicab is probably the most discussed. Even in other areas, researchers have generally emphasized financial and cost analyses to reach pricing decisions (Rao, 1984) or in case of taxis how regulation can improve service.

Modern marketers seem to be able to price successfully to influence the behaviour of all the parties in their chain. Two easy examples are the airline industry (it is easy to believe that no two passengers in a flight have paid the same amount) and a department store where a 'sale' galvanises customers, the channel, manufacturers and fellow merchants into a happy all pervading feeling of win-win. The biggest price manipulators are governments nudging public behaviour with facilities, tariffs, subsidies and fines.

According to Bandura (1974), people change their behavior rapidly if told directly which behaviors will be rewarded and which will be punished, than if left to discover it for themselves. They adapt their behavior based on the reward systems if followed by training.

The fare is the common factor for the many stake holders of the FHV service: To a driver the fare is income. To the passenger fare is cost. For owners and capital, the fare determines return on investment. Road users will be affected by the fare as driver income will influence who becomes a driver. Fares influence demand for FHVs, maintenance and upkeep for the industry. For society, this fare determines how precious road resources will be used.

FHV fares around the world do not disclose any behavioural basis or how the final figures were arrived at. The structures and granularity have been limited by the legacy of the mechanical taximeter.

A fare structure can be resolved into Four D's: Distance, Duration, Drops and Discern. An experience with FHV fares in Chennai is used to demonstrate the linkages between the factors transparently for all round benefit of the stake holders: drivers, passengers, owners, road users, capital, regulators and society.

FHV FARES TODAY

FHV systems vary round the world: Usually a taximeter charges by distance. When the vehicle is stationary as when held up in traffic or a signal the meter changes to charging by time. A fixed amount is usually added when the meter is "engaged" at the beginning. Smaller towns have a "fixed fare to anywhere" method. Washington, DC in the USA has a fare based on zones. In Chennai (formerly Madras), India, the meter is an adornment and drivers will negotiate the fare

The cost of taxi service around the world is as wide as their reputations. London and Tokyo are usually mentioned as the best. A comparison of the cost of a 5Km trip may explain some of the reputations (Table 1).

Table 1: Fare for 5Km/30 min trip (USD, May, 2006, nearest 0.05)

		LON	TYO	NYC	PAR	SIN	HKG	MAA
1	Rate / Km	3.25	2.40	2.00	0.85	0.30	0.90	0.08
2	Rate / min	0.55	1.00	0.20	0.50	0.15	0.20	Nil
3	**5Km/30 min**	**18-21**	**15-18**	**12–15**	**7 – 10**	**3 – 5**	**5 – 7**	**0.40***

* Drivers negotiate to $1.00+ depending on time and traffic.

Some cities increase the charge above certain distance or duration, probably to force the trips closer to the heuristic or to compensate for opportunity loss to the operator. There are the novel surcharges in some cities as “pet surcharge” and ‘soiling charge’. Some charge for a third or fourth passenger.

THE FARE DETERMINATION PROCESS

Gluck et al (1980) have developed a taxonomy of the various stages of a planning process. We see the fare setting process to be of three distinct stages: A legacy stage, an analytical stage, and a strategic stage. These three can be considered as three distinct stages of development in the fare regulation process. The “Legacy” stage is what most regulators have started with. The “Analytical” stage is when costs are used to determine the fare structure. The final sophistication is what can be called a “Strategic Stage” when a quality of service (QoS) is used as the objective to create a service to meet the expectations of the society.

Legacy Stage

This is the current stage in many cities. There is an existing fare basis. This has been handed down to the present regulator. The fares are usually based on negotiations with the operators and based on some rudimentary factors of costs.

Revision time in this stage is marked qualitative arguments: Fuel has gone up, cost of living has gone up, and hence fares have to be increased. The relationship between these costs and the increase demanded is sketchy, and so are statistics on utilisation or service levels. Rates are compared with other cities without realizing the influence of size of the city, traffic, demand or supply.

Analytical Stage:

This is the next stage and the first step to a scientific fare basis. In this stage there is an attempt to quantify cost. This stage also uses utilization statistics. If statistics are not available, then assumptions are made. This is an essential step as it introduces the stake holders to the future. Every body wants “good quality” but defining quality is under evolution. Quality of Service remains in qualitative statements or on individual complaints or perceptions on how long it takes to get a FHV. There may not be a method to integrate formal analysis of waiting time into the fare structure. Likewise demand may not be translated into number of permits or for optimizing capital and labour.

Strategic Stage

In this model the expectations of the service is defined as Quality of Service (QoS). Factors are built into the analysis to reach this expectation. The attitude is 'strategic' or creating the future. The analysis is thus integrative.

The QoS factors have a direct impact on cost of the service. The London Cab is an example of expensive special taxicabs (Turvey, 1961). Excess capacity leads to better quality of service (De Vany, 1975). For example, waiting time is indirectly proportional to the number of FHVs. To be able to get a taxi anywhere, taxis have to be cruising around empty. The transit authority or government can facilitate the service such as a special lane or a fiscal benefit for vehicles. Table 2 presents a comparison of the stages.

Table:2: Comparison of The Stages of Planning

	Legacy stage	*Analytic stage*	*Strategic stage*
Provocation	Need	Stability	Sophistication
Process	Intuitive	Projective	Integrative
Basis	Viability	Cost	**Contribution?**
Fare Revision	Incremental	Zero based	Service based
Efficacy	Low	Medium	High

If each factor can bring in an identified contribution to the driver he will adapt his behaviour to maximize income. If the fare has a number of variations for different services, a passenger will modify his behaviour to minimize expense or maximize comfort. So a fare structure must be granular enough with a number of inputs or “handles” to be able to evoke a wide variety of behavioural outputs.

THE FARE MIX AND THE 4 DS

A revenue model of an enterprise is the plan of revenues, expenses and money flows. A fare mix is the combination of the streams that produce the revenue. For the FHV business, two factors in the stream correspond to the cost factors in any enterprise: the output process or product and the duration of providing the output. The other two factors are derived from these primary factors and are the behaviour modifiers.

Distance

A FHV is meant to give distance utility. When the FHV provides this utility it incurs a direct cost of fuel. Hence distance is one chargeable factor.

Duration

Inherent to a live service is the time it takes to provide the service. Fixed cost is amortised over the time.

Drop

This is a derived factor. The Drop is made up of three factors which may be called the “Three Minor Ds”:

Flag Drop

This is usually the minimum fare when the FHV is hired. The term is the drop or turning of the “flag” or dickory. It usually includes some travel.

Meter Drop

This is the least count of the meter. A high meter drop will negatively influence the perception of the passenger. For example, if the drop is $1, then the passenger may display a “meter anxiety” as he nears the destination. His response may be to beat the meter by getting off before the next drop. On the other side a small drop like 10 cents will make the meter rotate faster and give a feeling of the meter running “faster than the cab”—For some it may induce meter anxiety throughout the trip!

Inclusion Drop

This is the travel that is included in the minimum fare or Flag Down charge. A large inclusion makes short trips expensive to the passenger and more remunerative to the driver. It thus contributes significantly to driver and passenger behaviour.

Discern

If fares influence behaviour, then surcharges and discounts are the sweeteners to nudge behaviour to expected fronts for immediate and direct effect. There are many models developed from the Pigouvian principle on price and cost of time to a user. The application of these theories with buyer and seller behaviour is the same: There is a price at which people will advance or postpone a purchase to a favourable time. This can be a surcharge on a standard rate or a discount from a higher rate. A surcharge gives a feeling of penalizing undesired behaviour while a discount gives a feeling of rewarding desired behaviour.

Thus the entire fare basis may be converted to a choice of surcharges or discounts – a bus stop charge can be a bus stop discount from minimum fare, A cleaning surcharge can be a clean cab discount, a peak time surcharge can be an off peak discount and so on.

Generally the immediate effect of surcharges is positive on the drivers and negative on passengers. The converse happens with discounts. Both shift traffic or compensate the inconvenience to other stake holders.

Discerns also help remove hidden subsidies between kinds of trips and make the actual users pay. Without an airport surcharge, the one way dead return cost from an airport will be loaded on the other trips. A well calculated surcharge loads costs equitably.

Surcharges can be fixed or usage sensitive. A simple across the board tweaking can compensate the driver for any situation. For example instead of Rs x per km, x + Δx can increase total revenue over the day to cover the loss from a dead return. This is in effect a proportional Discern. Table 3 lists the types and examples of Discern.

Table 3: Discerns and Classification

Discerns to Even Traffic	
1	Peak Hour Surcharge/ Discount:
2	Inner City Surcharge/ Discount:
3	Long Trip Surcharge/ Discount:
Discerns of Convenience	
1	Reservation charge/ Discount
2	Negotiated Trip Charge/ Discount
3	Shared Service Surcharge/ Discount
4	Shed Run Surcharge/ Discount
5	Bus Stop Charge/ Discount
Discerns of Marginal Income	
1	Additional Passenger charge
2	Luggage Surcharge
3	Pet Surcharge
Discerns of Compensation	
1	Airport Surcharge
2	Theater Surcharge
3	Out of City Charge
4	Holiday charge
5	Night Fare or Surcharge
6	Soiling charge
7	Special Surcharge/ Discount
8	Fuel price adjustment

THE REVENUE MODEL

The Revenue Model of a FHV is decided by the heuristic of the traffic in the location. The traffic is of the locality is first analysed from historical data. The trips are analysed by the primary factors trip distance and trip duration (Fig 1).

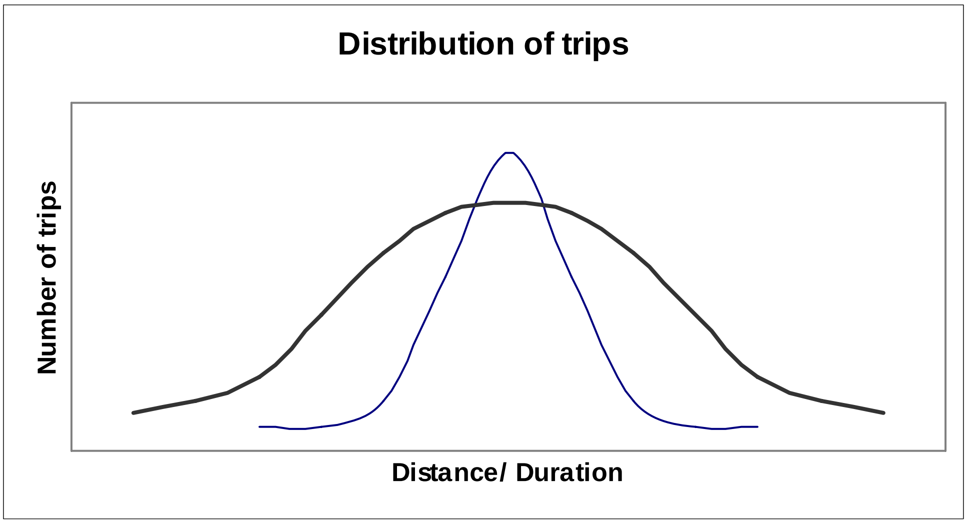

Figure 1: Distribution of trips: One wide and one narrow

A large dispersion shows that the factor lends to greater discrimination. In a charging situation the first requirement is equity. So users must be charged proportional to their usage. The behaviour of passengers will respond to the increased granularity in the charging as contribution will be in sync with the usage.

Four combinations are possible with the two factors on the two axes. They are characteristics of four situations and corresponding fare basis (Fig 2):

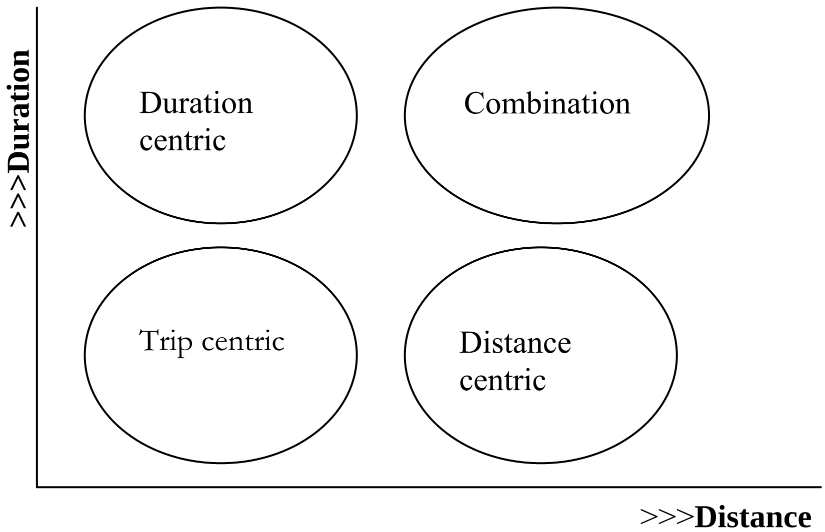

Figure 2: Selection of Revenue Model

Trips in small towns are short in distance and duration. So the charge is by trip.

Medium sized cities have dense traffic. So the trips are long durations but short distances. Hence a duration based charge is appropriate.

Trips in large cities are long in distances and durations. Hence a combination of distance and duration is used.

The fourth is the typical intercity traffic. The trips are long distances. Duration cannot be differentiated. So the fare is by distance alone. This principle can be applied even to situations in cities where the population is in clusters: The run between the clusters can be by surcharge while the travel within the cluster can be by another model.

CONTRIBUTION METHOD TO INFLUENCE BEHAVIOUR

While Rao (1984) remarked at the modest research in pricing, American newspapers were huge bundles with flyers of Sales'. The Blue Light Sale at Kmart was very revealing: When the blue light was switched on, did it switch off shoppers brains? Recently Hosken and Reiffen (2004) have noticed the gap in sale behaviour and the theoretical models.

A restaurateur buys water. It is a cost to him. But water is served free to the customers. So the price for the water is zero. The restaurateur can of course charge for the water and serve the food free. Cost is what a seller incurs to make a product or to provide the service. Price is what a buyer pays the seller to buy that product or service. Cost is a fact while price is a policy: Thus price can be lower than cost. In a going concern, the study of cost is required only to ensure that revenue covers cost. Skinner (1970) remarks that firms using cost plus pricing could well end up with no sales or no profit at all.

A commonly mentioned relationship in pricing is:

Price = Fixed cost + Variable Cost + Profit

When there are ten products in a company, the fixed costs have to be met from the many products. This same equation becomes:

Revenue = Fixed Cost + ∑Variable Cost + ∑Profit

This means that revenue (not price) must cover fixed costs and variable costs and give a profit. Price depends on fixed costs and the quantity sold will depend on price. So it becomes a vicious cycle. It becomes even more vicious if we imagine price being varied by discounts and coupons and promotions.

So the equation can be repackaged as:

Price = Direct Cost + Contribution

Revenue = ∑(Direct Cost + Contribution)

In a situation where there are many products under one fixed cost, marketers use "contribution" as a decision tool. The fixed cost is a pool of costs. The revenue first meets the direct cost. Any excess of revenue after meeting direct cost goes towards meeting the fixed cost. Any surplus after meeting fixed cost is counted a profit.

Profit = ∑Contribution – Fixed cost

When a person buys many items, the equation becomes

Total Price = ∑ (Direct cost + Contribution) 1 – n

where n is the number of items.

Contribution is a perspective from the market side of revenue. Price may even be negative as when running a promotion. Absorption costing is more useful in investment decisions.

In case of the FHV the equation can be made as:

Total fare = ∑ (Direct cost + Contribution) 1 – n

This means that if a number of services are offered by a FHV, each service can be analysed individually for the direct cost and a total contribution can be reckoned for the service. For short time frames of consideration, this contribution approach offers more 'motivation handles' than absorption costing. Cost is fixed but contribution can be varied and with it behaviour. The contribution approach is able to delineate variable and fixed costs. Each factor can be made a handle for different expectations for different stake holders. Table 4 reviews Table 1 with the contribution.

Table 4: FHV Fares and Contribution

		LON	**TYO**	**NYC**	**PAR**	**SIN**	**HKG**	**MAA***
1	Rate / Km	3.25	2.40	2.00	0.85	0.30	0.90	0.08
2	Rate / min	0.55	1.00	0.20	0.50	0.15	0.20	None
3	5 Km/ 30 min	18 - 21	15 - 18	12 – 15	7 – 10	3 – 5	5 – 7	1.00
4	**Contribution per trip**	**2.40**	**5.00**	**2.50**	**8.00**	**2.00**	**1.60**	**0.20**
5	**Contribution per Km**	**2.90**	**2.15**	**1.10**	**0.65**	**0.30**	**0.70**	**0.05**
6	**Contribution per 5 min**	**2.75**	**5.00**	**1.00**	**2.50**	**0.75**	**1.00**	**0.05**

* Estimated. Chennai does not have time fare.

THE CHENNAI EXPERIENCE

Chennai is a major metropolis in the South India. It is spread over 175 sq Km with a population of 6 million. The public have few alternatives for to-door transit: Auto rickshaws or "autos" in Chennai are three wheelers used as "For Hire Vehicles" (FHV). Some forty six thousand autos provide the to-door service and are a critical link in the transit transportation of Chennai estimated move 1.5 million people. There are some one thousand “taxis” but they cannot fill in the transit requirement of the city.

The following working was used as a basis by the Government of Tamil Nadu to get a first agreement between the stakeholders. More than thirty groups from driver unions, meter mechanics, passengers, consumer forums, regulators and public agreed on the figures. The first test was met.

The process starts with an articulation of policy on transit and the role of FHVs in the transit map. The next step is defining some parameters for quality of service. The third step is a heuristic of the FHV traffic. This will give the starting point for the fixed and variable costs. The heuristic helps determine the relative importance of the 4 D’s. Also, the fare had to be implemented in mechanical meters.

Table 5: Traffic Heuristic For fare Basis

	Item	*Unit*	*Value*
1	Live distance	Km	100
2	Dead distance	Km	50
3	Live duration	hrs	7
4	Shift duration	hrs	11
5	Trips per day	Nr	20

Table 6: Costs of Service

	Item	*Unit*	*Value*
6	FHV Costs	Rs/ shift	65
7	Driver remuneration	Rs/ shift	370
8	Fuel Cost of dead travel	Rs /day	100
9	Total fixed cost	Rs/ shift	535
10	Running cost	Rs / Km	2.00
11	Revenue required per	Rs / shift	735
12	Contribution required	Rs /shift	535

In the Chennai scene the first requirement was that drivers must be agnostic to long trips, short trips and trips through traffic. Such a condition is possible if the drivers earn the same amount under these traffic conditions. Table 7 shows that the contribution from the three factors Distance, Duration, and Drops was made equal. (It is worth noting that Chennai does not have a distance fare. Hence drivers negotiate all trips.) For the first iteration, the contribution from Discern was kept minimal with just three factors. The estimate from Discerns was pegged at Rs 40 per shift. Discerns for night service or special long distance trips such as to the airport are not demonstrated here.

Table 7: Contribution Iteration

	Item	*Initial value*	*1st iteration*	*2nd iteration*
13	**Total Contribution required / day**	**535**	**535**	**535**
14	Contribution from distance	165	125	200
15	Contribution from duration	165	210	125
16	Contribution from drops	165	160	140
17	Contribution from discern	40	40	35

Table 8: Fare Mix for Contribution

	Item	*Unit*	*Initial value*	*Alt 1*	*Alt 2*
18	**Minimum fare**	**Trip**	**10.00**	**10.00**	**10.00**
19	Flag drop	Trip	10.00	10.00	10.00
20	Inclusion drop	Trip	2.25	2.00	3.00
21	Meter drop	Trip	1.00	1.00	1.00
22	**Distance fare**	**Km**	**3.65**	**3.25**	**5.00**
23	**Duration fare**	**min**	**0.40**	**0.50**	**0.30**
24	**Drop**	**Trip**	**8.25**	**8.50**	**7.50**
25	**Discern**	**Shift**	**40.00**	**40.00**	**30.00**

The sum of the contributions from the 4Ds is equal to the contribution required for the day. The initial value allots Rs 165 for Distance, Duration and Drops. A sum of Rs 40 is allotted for Discerns as the concept is being introduced now.

Line Numbers refer to Table 5 to Table 9

Line 22: If the contribution from 100 live Km is Rs 165, the contribution from each Km must be Rs 1.65. With a direct cost of Rs 2 per Km, the distance fare should be Rs 3.65.

Distance fare = Rs 3.65 per Km

Line 23: For the Chennai auto, duration does not have any direct cost. In case where there is a direct cost such as a parking fee that is paid in bulk, then the direct cost will be used.

The contribution is Rs 165 for 7 live hours, or 420 live minutes.

Duration fare: = Rs 165/ 420 min = 0.40 per min

Line 24: The contribution from Drops is Rs 165. The heuristic is 20 trips a day.

Contribution per trip = Rs 165/ 20 = Rs 8.25.

Line 21: Every trip includes a meter drop. Meter drop is by convenient tender. An elaborate probabilistic calculation can be done to see how much the driver will earn. In a KISS approach (Keep It Simple, Stupid) it can be assumed that half the trips may be to the passenger's advantage.

Balance contribution required/ trip = Rs 8.25 - 0.50 = Rs 7.75.

Line 19: The Flag Drop was again taken as Rs 10. This figure was expected to be acceptable to the passenger groups. Smaller Flag Drop tempts passengers to short trips.

Inclusion Drop for the first iteration = Rs 10 – 7.75 = Rs 2.25

The inclusion in the flag drop can be in duration or distance. This is based on the duration and distance fare calculated earlier.

Inclusion drop duration = Rs 2.25 / .40 = 5.5 minutes

Inclusion drop distance = Rs 2.25 / 3.65 = 0.6 Km

The inclusion is by distance or duration, one at a time. So whether the auto is running or stopped at a traffic light, the driver earns the amount. It will appear that there is a double contribution included in the inclusion drop. It is not as the contribution from the drop is already accounted for.

For a meter drop of Rs 1, the travel will be as below:

At Rs 3.65 per Km = Rs 1/ 3.65 = 0.273 Km
At Rs 0.40 per minute = Rs 1/ .40 = 2.5 minutes

Again, the distance and duration are independent here as the meters are mechanical. For the drop of Re 1, the passenger gets 2.5 minutes or 273 meters or combination. The process is repeated to get more options for consideration by the stake holders or for convenience.

The Discerns were kept to a minimum and to what have been in vogue. It was to be limited to three: A peak hour surcharge of Rs 5, a luggage surcharge of Rs 5, and a third person surcharge of Rs 5.

Line 13: The work sheet shows that the earnings of the driver are constant but the fare structure can be varied infinitely. It is evident that for each combination the behaviour of the driver will vary, and so will the behaviour of the passenger. Together the variations provide a number of factors to influence behaviour of the stake holders.

The Public Administration Help Tank (PAHT), a not-for-profit organisation is working on creating an experimental auto service in Chennai aided by the findings of this dissertation. The objective is to provide an affiliation umbrella for the drivers, a standardised service to the public, and a statistics data base of the service for the regulators (Mahalingam and Supriya, 2002).

THE METER

Modern electronic meters can combine programmed logic, global positioning, real time communication, and any other sensing to give an integrated fare (A mechanical meter can handle limited inputs, like the cash register of yester years.)

The meter can work with a base system as in radio paging and auction. Meters with GPS can sense special road pricing without sensors on the road. They can incorporate tolls and taxes into the fare. The present complex pricing of the retail and airline industry examples is made possible only by technology. Thus an advanced behaviour modifying fare basis is also possible with the current technology.

RESEARCH METHOD

In Chennai trip logs are no longer maintained by FHVs. So there are no statistics on the traffic or demand. As there is no documented study on the auto rickshaws in Chennai or in India, a survey of 260 drivers was done. A multi stage sampling protocol was adopted with the stratification followed by a second stage systematic selection. Three prominent destinations were selected: The railway station, bus terminus, and the leading shopping centre. This ensured that the destinations were well known, the routes were fairly straight forward, and the familiarity would keep the fare and distance to norms. The survey took the fare demanded, the estimated distance and the actual distance for each was documented. Capacity to estimate distance and if charging is related to the estimated distance.

The fares quoted by the drivers were subjected to a regression analysis on the predictor variables. Eight important variables from the survey were tested for fit: day of travel, time of travel, distance, duration, age of driver, education, ownership of auto, and originating place.
The maximum variation accounted for was 75.79%, 57.43% and 69.9% respectively of the three groups of samples. Only two variables, distance and duration were significant with the intercept and the figure rose slightly to 75.92%, 57.67% and 68.77% of the variations respectively. The models appear to be a good fit with over 99% significance.

The regression analysis shows that intuitively the fares fall into a pattern of three factors: a charge proportional to the distance travelled-- a charge proportional to the duration of the trip and a fixed amount (constant).

The model to the railway station was (8.139 + 2.906 distance + 0.7 duration). It is significant at 99% explaining 75.92% of the variability. The model to the bus terminus was (11.859 + 3.755 distance + 0.444 duration). It is significant at 99% explaining 57.67% of the variation. The model to the shopping centre was (7.864 + 1.285 distance + 1.085 duration). It is significant at 99% explaining 68.77% of the variability.

The constant is higher in the trip to the bus head that is out of town. This suggests a fourth factor which is the 'Discern' of the driver-- like a surcharge. This is also reinforced by the lower variation compared to the other fares. The loading on distance fare is also highest suggesting that the driver expects to return empty for a longer distance. The duration fare loading is smaller (.444) showing that the trip is through an area where traffic is faster.

The duration and distance are fairly equal in the trip to the shopping centre in town. This suggests that the driver expects the traffic to be slower and hence a higher charge for time.

The regression analysis demonstrates the existence of the following factors that make up a fare: duration, distance and a trip constant, the drop. The fourth factor of discern is reflected in the difference in the constants.

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