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Efficiency Comparison of Bus Operators in Delhi

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Abstract

There is an apparent inefficiency in the workings of the primary bus operators in New Delhi. The paper focuses on labor inefficiency and compares the compensation schemes offered to the conductors of the two major bus operators in Delhi- Delhi Transport Corporation (DTC) and Delhi Integrated Multi-Modal Transit System (DIMTS). Such a study which compares the labour efficiency, and incentive schemes offered by these two primary bus services has not been done before. The results from the interview of bus conductors of DTC and DIMTS are used to establish the presence of moral hazard. The wide literature on the principal-agent problem is then examined, to find a wage scheme for DTC employees, which provides adequate incentives to them to perform efficiently. Hart and Holmstrom's (1987) non-linear wage model is suggested in this case study to eliminate the problem of moral hazard. It is also found that the wage scheme offered by DIMTS is more efficient than that of DTC.

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Introduction

Inefficiency in public sector enterprises has been a relevant study topic and is well documented. One such study done on the Indian industries, Mookherjee (1997), reviewed industrial policy and selected aspects of performance of Indian Industry between 1950 and 1990. It concluded that the burden on the exchequer increased when there were other social objectives to fulfill. In case of the primary bus operator Delhi Transport Corporation (DTC), which is a public enterprise, data suggests something similar. The burden on the exchequer has been constantly increasing due to the losses that the bus service has been incurring from 2003-04 to 2009-10. The decomposition and analysis of data points towards inefficiency amongst its employees and lack of adequate incentives to work productively. In order to solve this problem, an optimal wage scheme is suggested for DTC employees and its comparison is also made with the one offered by its competitor Delhi Integrated Multi-Modal Transit System (DIMTS). There has so far been no such comparisons made between the workings of DTC and DIMTS, particularly one that focuses on labour efficiency, wage and incentive schemes offered by the two bus services. Theoretical literature on principal-agent problems is rich and this literature is explored with reference to this case study to find the optimal wage scheme for DTC bus employees. Hart and Holmstrom's (1987) non-linear wage model is suggested in this case of imperfect information and unobservable effort to incentivize the bus operators in a way that encourages them to perform efficiently.

The average population in the six metro cities of India has multiplied by 1.8 times between 1981 and 2001, but the number of vehicles has shockingly increased over six times over the same period. According to "Mobility Crisis – Agenda for Action 2010,"a publication of Centre for Science and Environment (CSE), cars in Delhi use about three fourth of the road space and meet only a fifth of the city's commuting demand. Estimates show total CO_2emissions load from vehicles is increasing in Delhi. Cars and two-wheelers contribute maximum to the total CO_2 emission load from vehicles in Delhi (around 60 per cent). It is also important to note that buses carry several times more people and consume significantly less fuel per passenger. There is an obvious need to strengthen the public transport system in the city as private vehicles cause congestion on the roads and emit more fuel per passenger per kilometer in comparison to public modes of transport like buses. For the same cause, Delhi government introduced around 6000 low floor DTC green buses in 2009 and in 2011 Delhi Integrated Multimodal Transport System (DIMTS) introduced private buses to meet the increasing commuting demands after the complete withdrawal of blue line buses from Delhi.

A brief description of the DTC's earnings and expenditure is provided in the first section. The second section summarizes the theoretical background on moral hazard. It is important to mention that the present paper has no contribution in this context. Section three describes the data collected by means of interview, after which the economic model is introduced and then in the last section, application of the economic model to the existing problem is discussed.

1. Revenue and Expenditure of Delhi Transport Corporation

The losses of Delhi Transport Corporation (DTC) were expected to reduce in the last three years with the complete removal of Blue line buses from the roads in 2009 but Operational statistics of DTC show otherwise. There has been a uniform increase in the losses suffered by the corporation since 2003-04 (See Figure 1) with a loss of about Rs. 97 per kilometer 2009-10.

To increase public transport commuters in the city, the Govt. of National Capital Territory of Delhi's (GNCTD) introduced the private busses (orange colored buses) run by Delhi Integrated Multimodal Transport System (DIMTS) in May, 2011. With around 220 buses, DIMTS is currently breaking even despite having the same fare rates as DTC. It therefore becomes pertinent to compare the workings of the two bus operations and to investigate the inefficiency in the public sector enterprise with respect to individual inefficiency. The following plots the net profits and the increasing working expenditure of DTC in the last decade.

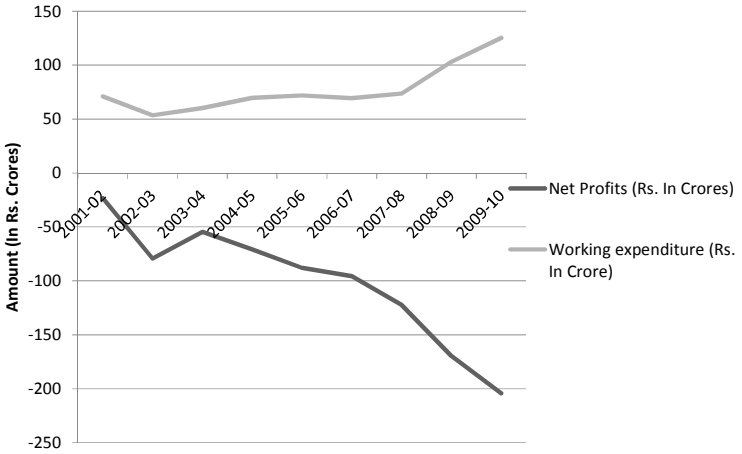

Figure 1 - Net losses and Working Expenditure of DTC buses.
Source: DTC Operational Statistics, April, 2011

Cost analysis indicates that labor costs have been increasing continuously over the last five years. Also, the average number of buses on roads has increased but fleet utilization has actually declined from 90.51% in 2005-06 to 75.03% in 2010-11. There is an apparent inefficiency in terms of administration and cost management in DTC. As a large part of the variable cost/working expenditure suffered by DTC is due to the rising labor cost, the main objective of this study is to identify factors that led to a better performance of DIMTS buses taking the performance of the conductors as a source of comparison. We take into account that inefficiency in DTC is primarily due to two factors- a higher staff to bus ratio and inadequate incentive design leading to lower performance of the employees. While the first factor is determined among other things by the socio-political influences in PSUs, the second factor may be caused by social motivation to insure employees against fluctuations in demand. The latter often results in what is usually described in economics as "moral hazard"- the tendency of workers to under-work even in favorable circumstances. The theoretically optimal wage scheme in the presence of unobservable effort is discussed and is compared with the wage scheme offered by the two enterprises.

2. Theoretical Background

"In the University of Oxford, the greater part of the public professors have for the many years, given up altogether even the pretense of teaching" [Adam Smith, Wealth of Nations, p. 718]

It is commonly alleged that inefficiency is a primary characteristic of a public enterprise, mainly due to the absence of a profit motive or any direct financial incentive in a government enterprise stimulates indolence in workers leading to inefficiency. Arrow (1963, 1970) formally demarcated the analysis of asymmetric information in to two categories: unobservable action which is also called moral hazard problem; and hidden information also called adverse selection. He said that the general idea while forming a contract between two asymmetrically informed parties is to ensure that the cost of concealment is made high for the informed party.

A possible solution of the problem of asymmetry of information arising due to unobservability of individual actions is to invest resources into monitoring of actions. Complete monitoring leads to a first-best solution. However, full observation may not be possible or may be prohibitively costly. In such cases, imperfect estimates of actions are available which then can be used to alleviate moral hazard problem. In case of imperfect information, the question arises as to how to improve a contract initially solely based on payoffs. One such method is illustrated by Harris and Raviv (1976) who address these questions in the context of employer-employee relationship in which the employee provides a productive input (e.g., effort) that cannot be observed by the employer directly. They study monitoring which provides information that is independent of the state of nature and allows the principal to detect any shirking by the agent with a positive probability. It turns out that the information is necessarily useful and allows a first best solution. Otherwise, they make the fee depend only on the outcome and set it such that risk is appropriately shared.

Holmstrom (1979) took the analysis further by showing that any additional information about the employee's action, (or state of the world) however imperfect, can be used to improve the welfare of both the employer and the employee and also improve the contract. When the marginal return from effort is positive to the agent, then the agent should be provided with incentives for the increased effort i.e., share of outcome to the agent in second best solution should be greater than the share of outcome to the agent in case of first best solution of perfect information . A penalty should be imposed on the agent in the opposite scenario. The benefit-cost ratio of deviating from the optimal risk sharing outcome is estimated and deviations are made proportional to this ratio with individual risk aversion taken into account. The penalties or bonuses should be paid in

proportion to this measure. Therefore, in problems of moral hazard and adverse selection, proper incentives should be provided so that the contract enforced achieves efficient outcomes in an incentive compatible manner. Hart and Holmstrom (1987) discussed the optimal non-linear wage scheme when performance measures are described by the agent's effort and some random variable representing the state of nature. In their model, the agent is punished for outcomes that revise the beliefs about high effort in the downward direction and rewarded for outcomes that revise beliefs up. The paper uses the model explained by Hart and Holmstrom (1987) to compare the contracts offered by DTC and DIMTS. The problem of moral hazard has been established by way of survey findings (in the subsequent section).

3. Database

The goal of the paper is to find a way to reduce the inefficiency in the government run DTC, and the focus is only on individual inefficiency. The paper tries to probe into the workings of DTC and compare it with its competitor DIMTS. In order to do this, senior officials of both the companies were interviewed and bus conductors were surveyed. One of the major differences in the operations of DTC and DIMTS buses is their varying remuneration methods. According to my interview with a Senior DIMTS official, while creating the wage scheme, they lay emphasis on timely performance of their workers based on number of trips made (if there were any missing trips) and whether the bus reaches the stop on time and waits for the allotted time at every stop. It is observed that DIMTS buses pay their drivers and conductors on a fixed basis up to a point and then on a variable basis on the basis of productivity and behavior in public space. (Refer to Table 1)

Table 1 - Compensation Schemes

Compensation scheme offered by DTC
• Incentive based on physical attendance.
• For presence on 12 days in a month- Rs.100 over the fixed salary of Rs.301 per day.
• Rs.100 in addition per day for presence on more than 11 days. Rs.1500 over the salary for presence on all 26 days.
• They also get Rs.10 per day worked in a year as *Diwali* Bonus (festival bonus).
Compensation scheme offered by DIMTS
• Incentive based on physical attendance and ticketed earning.
• Rs. 248 per day plus 1% of the ticketed earnings if worked for more than 11 days out of 15 days.

3.1 Survey Results

There are around 15,000 DTC conductors and 800 DIMTS conductors in all. The sample interviewed consisted of 50 DTC conductors and 20 DIMTS conductors. DTC conductors from three different depots were interviewed and for DIMTS their only depot in Delhi was considered. The primary variables of interest for analyzing the efficiency of operations of the two firms are ticketed earnings, under/over staffing and the opportunity cost of working in a government/ semi- government firm. For the number of passengers carried by the different buses in a shift of eight hours, for DTC conductors, the lowest was 250 and the highest was 1200. For DIMTS, the lowest was 350 and the highest was 1500. This could be because the DIMTS have been given the most profitable routes while DTC is operating on all routes. Another reason for high footfalls could be that DIMTS buses wait at every stop for the optimal time and the difference between the arrival times of two DIMTS buses at bus stops is also optimal. When asked if the number of passengers carried had reduced with the introduction of DIMTS buses, the DTC employees in charge of the new buses said that the number of passengers had reduced by about 50% for old buses (as expected) but had reduced considerably (by about 30% per cent) for the new low floor DTC buses as well. This clearly indicates that the number of passengers carried by the two almost identical buses run by two different companies results in one performing better than the other.

3.2 Summary Statistics

The table below presents the summary statistics of the variables. Firstly, the mean of average ticketed earnings in a shift of 8 hours is found to be much higher for DIMTS than for DTC conductors. The standard deviation for the average ticketed earning from its mean value is much higher for DTC than DIMTS. This could be due to the poor performance of DTC employees or the fact that DIMTS have been given the most profitable routes. Secondly, the mean average monthly salary earned in the previous job as recalled by the contractual employees in DTC was higher than that for DIMTS employees with the latter showing more deviation. A plausible reason for sacrificing a high salaried private job for the government job can be the high regard that a government job has in the society or the lure of a job in which there is less monitoring and smoothened income stream over the course of time.

Table 2 - Summary Statistics (Source: Author's own calculations based on the survey data).

	Mean	**Standard Deviation**
Average Ticketed Earning (In Rs.) in one shift (8 hours) – DTC	3317.308	902.8779
Average Ticketed Earning (In Rs.) in one shift (8 hours) - DIMTS	4455	457.3171
Average monthly earning(In Rs.) in the previous job (DTC)	10388.89	2665.441
Average monthly earning (In Rs.) in the previous job (DIMTS)	9857.143	4007.434

The low number of passengers carried by the DTC conductors and the low ticketed earning earned by them along with their reluctance to leave their job to work in DIMTS clearly indicates the presence of "moral hazard" among the employees.

4. Model Development

The principal is risk neutral and the agent or the worker is assumed to be risk averse. The output is affected by the actions/performance of the worker. The actions of the worker are not observable (hidden action). We assume that the worker has two possible effort levels - high and low represented by $e_h$and e_l respectively. $e_h$is the high effort choice that leads to a higher profit for the principal than $e_l$but it entails greater difficulty/disutility for the worker. This results in a conflict of the interest between the principal and the agent. Π denotes the observable profit which can take values from [0, ∞] if the firm is a profit maximizing firm. Profits are a function of effort and some random variable θ representing state of nature, π(θ, e).The distribution of profits depends on the level of effort but is not fully determined by it. 'π' is stochastically related to 'e' in a manner described by the conditional density function f(π /e), with f(π /e) > 0 for all e and π.

The distribution of π conditional on e_h first-order stochastically dominates the distribution conditional on e_l i.e., $F(\pi/e_h) \leq F(\pi/e_l)$at all profit levels. We assume the conditional density f(π/e)to be exponentially distributed:

$$f(\pi/e) = \frac{1}{e} exp\left(-\frac{\pi}{e}\right) \text{for} \pi = \{-\infty, \infty\} \quad (1)$$

The exponential function is used as the distribution is a family of continuous probability distributions and it supports [-∞, ∞] thereby ruling out negative quantities. The worker is risk averse and is an expected utility maximizer with the utility function assumed to be constant relative risk averse (CRRA) utility function. We take the utility form to be logarithmic so that $U(w, e) = \log w - \log e$. The function is concave with $u'(.) > 0$ and $u''(.) \leq 0$. The principal is risk neutral and therefore has the objective to maximize its expected returns or minimize the expected value of owner's compensation costs. Therefore, the optimal incentive scheme in case of unobservable effort (Hart and Holmstrom (1987)), offered by the principal for implementing a high effort level minimizes the principal's expected wage payment subject to two constraints.

$$\max_{w(\pi)} \int_{-\infty}^{\infty} -w(\pi) \frac{1}{(e_h)} . \; exp\left(-\frac{\pi}{e_h}\right) d\pi \quad (2)$$

$$\text{s.t.} \int_{-\infty}^{\infty} \log w . \; \frac{1}{e_h} . \exp\left(-\frac{\pi}{e_h}\right) . d\pi - \log(e_h) \geq 0 \quad (3)$$

$$\int_{-\infty}^{\infty} \log w . \frac{1}{(e_h)} . \exp(-\frac{\pi}{(e_h)}) d\pi - \log(e_h) \geq \int_{-\infty}^{\infty} \log w . \frac{1}{(e_l)} . \exp(-\frac{\pi}{(e_l)}) d\pi - \log(e_l) \quad (4)$$

The first constraint is that the principal must provide the agent with an expected utility level of atleast their reservation utility. We have neutralized this reservation utility to zero. This constraint always binds at a solution to this problem. If the constraint did not bind then the principal could keep lowering the agent's wages while still getting him to accept the contract. The second constraint is the incentive compatibility constraint. The utility attained by the worker when he puts in high effort should exceed the utility he derives from putting low effort so that the he chooses a high level of effort. After setting up the Lagrangian and letting $\mu_1 \geq 0$ and$\mu_2 \geq 0$ denote the multiplier on constraints (i) and (ii) respectively, w (π) must satisfy the Kuhn Tucker conditions. The optimal wage (w*) derived is:

$$w * = \mu_1 + \mu_2 [1 - \frac{e_h}{e_l} . \frac{\exp\left(-\frac{\pi}{e_l}\right)}{\exp\left(-\frac{\pi}{e_h}\right)}] \quad (5)$$

The constraints 3 and 4 bind when e =e_h.

$\mu_1$is the fixed part of the salary and $\mu_2$the variable part of the salary. The conditions below can be used to obtain the shape of the optimal compensation scheme:

$$A) \; w(\pi) = \mu_1 \text{ if } \mu_2 = 0$$

$$B) \; w(\pi) < \mu_1 \text{if} \quad \frac{e(h)}{e(l)} . \frac{\exp\left(\frac{\pi}{e(h)}\right)}{\exp\left(\frac{\pi}{e(l)}\right)} > 1$$

$$C) \; w(\pi) > \mu_1 \text{ if} \quad \frac{e(h)}{e(l)} . \frac{\exp\left(\frac{\pi}{e(h)}\right)}{\exp\left(\frac{\pi}{e(l)}\right)} < 1$$

The application of the above model to the comparative study of efficiency in DTC and DIMTS is done next.

5. Application of the Model

There are two main bus operators in Delhi - one fully run and managed by the government and the other run by private owners but managed by the semi-government DIMTS. Government owned DTC, has outsourced a part of their operations to the private sector which is managed by DIMTS; a Joint Venture of a public and private sector enterprise. The two bus companies sell identical goods and compete with each other for market share i.e., number of passengers and not on prices. The prices of tickets are not market determined and are fixed by the government to ensure the affordability of bus commuting.

In such a scenario there are two ways in which the profits of a company can be increased- by reducing the costs or by increasing the output. As labor costs are fixed according to the minimum wage specified, they cannot be reduced. Therefore, only the number of passengers can be increased to increase profits. Along the same route, the number of passengers of one company can be increased if the bus conductors and drivers put in high efforts. Both the operators face identical demand patterns, hence their relative performance varies with differences in their internal organization. The optimal wage should therefore be such that it gives the conductor the incentive to put in high effort and penalizes him for any dysfunctional behavior. The problem is that perfect monitoring of actions of the conductors is not possible. The relationship between the output and effort cannot be established accurately. The output is reflected by the ticketed earnings. This output is affected by the actions/performance of the worker (bus conductor). The actions of the worker are not observable (hidden action) and the bus company will have to design the compensation scheme so as to indirectly give the worker an incentive to take correct action. π denotes the observable profit which can take values from [-∞,∞]. Since DTC is a public enterprise it will operate even if its profits are negative. So, the company can be in losses or achieve infinite profits. The optimal compensation scheme in case of unobservable effort should be to pay more than the fixed payment μ_1 for outcomes that are statistically relatively more likely to occur under $e_h$than under e_l. This occurs when the likelihood ratio is less than one. This

provides the conductors an incentive to choose high effort level. The DIMTS wage scheme as discussed in section 3 is a non-linear one.

It is not that the salary offered by DIMTS is theoretically appropriate. The ticketed earning on which the compensation is based may not solely depend on the level of effort of the workers. The ticketed earning could vary with the demand along the route, traffic congestion, weather conditions etc. The conductor should not be punished for such unforeseen problems. As the compensation scheme gives some but not all weightage on the ticketed earning, it can perhaps be said to be optimal in extracting high effort from the conductors without sharing the entire burden of risk with them. If a major part of the salary is linked to the ticketed earnings then all the conductors would want to stop for a substantially longer time at the profitable bus stops. The buses in such a scenario would be fighting for road space and passengers. They would also want to make as many trips as possible which would result in rash driving and chaos on the road.

Conclusion

The main objective of the paper is to suggest a way to reduce the inefficiency of the bus operators in Delhi. Comparisons were made on the basis of the compensation schemes offered to the bus conductors of its competitor DIMTS. Such a study which compares the labour efficiency; wage and incentive schemes offered by these two primary bus services has not been done before. The results from the interview of bus conductors of DTC and DIMTS point towards the presence of moral hazard. Hart and Holmstrom's (1987) non-linear wage model is suggested in this case study to eliminate the problem of moral hazard. We find that the compensation offered by them is not in accordance to the desired wage scheme. However, the DIMTS seems to have a two-part wage scheme which works in its favor as reflected in the high ticketed earnings earned by its employees. The DIMTS's non-linear wage scheme shares the risks with the employees thereby making greater profits than DTC. The DTC on the contrary allows no such risk-sharing. The summary result is that the DTC wage structure does not take into account moral hazard, but rather provides full/close to full insurance to its employees. But this does not make DIMTS a model to be emulated. There were problems found in the workings of DIMTS while interviewing its employees. They pointed out that their working condition is not very conducible. They are hired through an employment agency and are working without signing any formal contract with DIMTS. The presence of an official employment contract is the foundation of contract theory and in its absence, the employer can make its staff over-work or lay them off without any notice.

The field data suggests that as the ticketed earnings are dependent not only on the effort level put in by the employee but also on a host of other factors. The incentive given to the employees should not be based completely on the ticketed earnings. The optimal wage should be such that it rewards for outcomes or profit levels which are statistically more likely to occur with high level of effort. Even if the employers want to share the risk of the uncertainty of profits with their workers, they should link the ticketed earnings to the wages only at the margins. This would provide the conductors with an incentive to work efficiently, at the same time not burdening them with the losses associated with unforeseen risks.

As almost all the empirical studies conducted in this field have used panel data, the lack of the same for DTC and DIMTS bus conductors casts doubts on the application of such a wage scheme. Application of the suggested non-linear wage scheme would require an extensive study to establish the relation between ticketed earnings/ profit levels with level of effort which was outside the scope of this paper.

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