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Improving Urban Air Quality In India: Lessons from the Kolkata Clean Air Regulations of 2009

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Parikshit Ghosh and Rohini Somanathan†

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Abstract

A concern with the health effects of air pollution in India has led to court-mandated clean air plans in many Indian cities. The resulting transitions to clean fuels and new vehicles have been smooth and speedy in some cases and violent and protracted in others. One reason for these varied experiences may be differences in the costs and benefits of the new technology to those most affected by it. Based on a survey of 100 auto rickshaw drivers in Kolkata in the summer of 2010, we find that operating profits declined for many auto-drivers when they were forced to switch to autos fuelled by LPG. The largest increases in costs were faced by drivers who rented (rather than owned) their autos. Rents doubled after the change and there were no substantial fuel savings for many of these drivers because they relied on cheap adulterated fuel, rather than petrol, prior to the switch-over. These distributional effects may be important for understanding both the political resistance to clean air policies and their welfare implications.

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1 Introduction

Indian cities are highly polluted spaces. Although claims about anthropogenic effects on global climate change are still fiercely contested, local environmental effects of urbanization and modernization are firmly established by data. Measures of air quality in Indian cities show dangerously high levels of pollutants and chemicals present in the air we breathe. Concentrations of particulate matter are 5 times the levels in U.S. cities (Greenstone and Hanna 2011) and carbon monoxide, nitrogen oxides and benzene often far exceed the safety limits recommended by the World Health Organization. While there are several sources of this pollution, including urban industry, household fuel choices and the indiscriminate burning of leaves and other waste by municipal workers, vehicular pollution has come to be recognized as a leading contributor (Ghose, R. Paul and S.K. Banerjee 2004).

There are two major sources of vehicular pollution: First, the economic boom combined with an inadequacy of public transport has led to rapid growth in the sales of motorized vehicles. Second, most Indian cities are serviced by an ageing fleet of public and commercial vehicles, whose poor emissions characteristics are compounded by use of low grade or adulterated fuel. In 2001, there were almost 55 million vehicles on Indian roads and over 90% of these were privately owned. This reflected a 10-fold increase over the number in 1981. There are virtually no buses designed for urban conditions. State transport authorities are cash-strapped because of political demands to keep fares down and this has limited investment in the modernization of their fleet and encouraged them to allow private bus and auto-rickshaw operators to serve unmet public transport needs. Given the enormous gap between the demand and supply for public transport, private operators have managed to stay in business without investing in new vehicles (Singh 2005). A recent report by the Central Pollution Control Board in India states that 60% of vehicular pollution is attributable to vehicles that are over 10 years old and these form less than 30% of the total population of motor vehicles.[1]

Several initiatives to control air pollution have been introduced by the Ministry of Environment and Forests. The Central Pollution Control Board (CPCB) was set up in 1974 to monitor air and water pollution and began systematically monitoring air quality in Indian cities in 1984.[2] Not surprisingly, regulating pollution through changing emission norms for new vehicles has been much easier than bringing about changes in existing fleets. Starting in the late 1990s the Supreme Court of India has been active in enforcing the transition of public transport

[1] Central Pollution Control Board (2010) (CPCB) p.18.
[2] Central Pollution Control Board (2006), p.1.

towards cleaner fuels in India's most polluted cities based on a citizen's right to clean air. These transitions have not been easy. Judicial activism and public interest litigation by environmental pressure groups have taken the lead and legislative and administrative branches of the state have grudgingly complied. Regulators have faced stiff resistance from affected segments of the transport industry vehicle owners, operators and unions who have adopted tactics ranging from street protests and strikes to legal action. This resistance gets broken down eventually and some reform package is implemented, but only after long delays and years of legal and political quagmire.

There are now a number of studies of the effects of clean air legislation on air quality in India's metropolitan cities. Most of these focus on the transition to Compressed Natural Gas (CNG) in public transport vehicles in Delhi and evaluate the ability of these policies to solve problems of urban air quality (Kumar and Foster 2007; Kumari, Attri and Gurjar 2011; Singh, Ranu and Mandal 2011). In contrast, we know almost nothing about the distributional effects of city action plans for clean air on those most affected by them. These distributional changes are likely to be critical in understanding both the political resistance to clean air policies and their welfare implications.

The costs and benefits of clean air policies are sensitive to the urban environments in which they are implemented for both technological and institutional reasons. Slower traffic, due the narrow roads, for example, leads to greater health hazards from a given fleet. The paved road space in Kolkata, for example, is only 6% of total space while in Delhi it is 20%.[3] Patterns of ownership of public transport vehicles and the fixing of user charges by city transport authorities also vary considerably across cities.

In this paper we set ourselves the relatively modest objective of documenting changes in the economic returns of auto-rickshaw drivers in Kolkata, roughly one year after they were required to shift to liquified petroleum gas (LPG) in July 2009. Rather than suggesting general lessons that can be drawn from this exercise, we would like to emphasize the need for a series of similar case-studies which, taken together, can provide us with some insight on the impact of these regulations on those within the public transport sector.

[3]Ghose et al. (2004), p. 350

2 Clean air legislation and litigation

Norms for vehicular pollution were first established in India in 1990 and incorporated into the Environmental Protection Act, 1986. Following this, a number of committees were created to suggest strategies to control air pollution. Most of these regulated new vehicles and expanded the availability of better quality petrol and diesel. In 1998, the Supreme Court of India ordered all public transport vehicles in Delhi to run on Compressed Natural Gas (CNG) by April, 2001. After several strikes and clashes between the government, transport operators and the court, compliance was achieved by December 2002 (Kathuria 2004).

Meanwhile, the Supreme Court continued to push other cities in the same direction as seen in the following order issued to the central government in May 2002:[4]

> [The] Union of India will give a scheme with regard to compulsory switchover of all the two-wheelers, three-wheelers and motor vehicles to LPG/CNG in cities other than Delhi which are equally or more polluted.

In August 2003, based on CPCB data, the Court noted that the "Respirable Particulate Matter (RSPM) levels in Ahmedabad, Kanpur, Sholapur, Lucknow, Bangalore, Chennai, Hyderabad, Mumbai and Kolkata are alarming"and directed the CPCB to work with local regulatory bodies to develop action plans to improve air quality. Between 2004 and 2009 many of these cities, and others, initiated the transition to liquefied petroleum gas (LPG) or CNG, depending on which of these could be realistically supplied.[5]

In Kolkata, after years of legal and political gridlock, the Calcutta High Court passed a judgment on July 18, 2008, ushering in a new regulatory regime for the city's transport system. All vehicles 15 years or older were banned from the streets and all auto-rickshaws were required to have 4-stroke engines that run only on LPG.[6] In the case of the three-wheelers, these regulations

[4]Excerpts from court directives and the account of regulatory changes in this section is based on Central Pollution Control Board (2006).

[5]Details of action plans and the dates of the transition can be found in Central Pollution Control Board (2006).

[6]According to a fact sheet put together by Priyanka Chandola for the Centre for Science and Environment, Delhi:

> A division bench of the Calcutta High Court headed by Chief Justice S. S. Nijjar on July 18, 2008 converted an environment department's notification into a judicial directive and directed the state government to phase out all two-stroke three-wheelers plying in the city by December 31, 2008 and

effectively required replacement of the entire fleet of around 40,000 vehicles running in the Kolkata Metropolitan area. At that time, levels of suspended particulate matter in the winter months were twice the permissible levels and benzyne levels were over 35 micrograms per cubic meter, while WHO norms were between 5 and 16 micrograms.[7] High benzyne emissions were believed to result from the widespread use of adulterated fuel *katatel* by 2-stroke auto-rickshaws.

Following wide-spread violence on the streets of Kolkata in January 2009 and pleas from the state government, the court gave a six-month extension until July 1, 2009. The string of appeals and disagreements on the road to implementation meant that the transition, when it did occur, was hurried rather than planned. The city moved to LPG rather than compressed natural gas (CNG) which was known to have superior combustion properties and inflict less damage to motor engines. Oil companies that already supplied domestic LPG were tapped for the additional supplies and existing fuel stations were fitted with the necessary equipment. CNG would have required the laying of special pipelines which was infeasible in the time available.[8] Even LPG continued to be in scarce for many months. Supply shortages were common in most cities transitioning to cleaner fuels, including Delhi. The Kolkata transition was however especially difficult because auto-rickshaws in the city were required to operate on particular routes specified in their permits at fairly low, fixed fares. This meant that the burden of supply bottlenecks fell dis-proportionately on those drivers for whom re-fueling stations were far from their permitted route.[9]

In June 2010, close to a year after the official start of the switch over to LPG, we designed a survey that was administered to 100 auto drivers. The extent of the conflict over the move to LPG was a matter of some puzzlement to many outsiders at the time because LPG was significantly cheaper than petrol and one might have thought that lower operating costs would offset some of the capital costs, especially if purchases of new autos were subsidized by the state. Our objective was to obtain an account of costs and revenues before and after the transition

> to ensure that only four-stroke three-wheelers on clean fuel operate. All four-stroke threewheelers plying within the Kolkata Municipal Corporation area have to convert to liquefied petroleum gas (LPG) by March 31, 2009 and those plying within the Kolkata Metropolitan Area by December 31, 2009.

[7]These figures have been taken from a presentation by Sunita Narain and Anumita Roychowdhury of the Centre for Science and Environment in February, 2009.

[8]Based on an interview with a transport department official in January 2009.

[9]Express India (Jan 3, 2009) reports:

> Mahbub Alam, whose auto plys on the Kadapara-Mechua route, has to take a detour to Manicktala - an extra five kilometers - every time he wants to refuel his vehicle.

to LPG in order to ascertain whether the protests were a result of temporary frictions that were politicized in the unionized environment of Kolkata or rather that the private economic benefits from the transition to transport operators were minimal. Contrary to our expectations, we found that even operating costs increased for most auto-drivers. For those who owned their autos, increased maintenance costs were not offset by cheaper fuel. For those who rented, rents doubled after the change and fuel costs rose as they replaced cheap adulterated fuel with LPG. These distributional effects may be important for understanding both the political resistance to clean air policies and their welfare implications. To be successful, policies aimed at clean air in Indian cities clearly need to pay more attention to their potential impact on the earnings of transport operators.

3 The Auto-Rickshaw Survey

Our Sample

We surveyed a total of 100 auto-rickshaw drivers at 12 gas filling stations across Kolkata in June 2010. These are regular petrol pumps in which the equipment necessary to fill LPG has been installed in one section. There are now a total of 24 filing stations in Kolkata, there are likely to have been fewer then, so our sample was drawn from a large fraction of all filling stations at the time[10]. Figure 1 shows a map of the city in which we have marked the stations at which our survey was conducted and some of the routes licensed to autos in the survey. While we made no attempt to arrive at a sample that was representative in terms of either the city's geography or population, we were able to get autos from 54 distinct routes.[11] These routes and their lengths are shown in Table 9 in the Appendix, along with the questionnaire used.

The survey was conducted while autos waited in line for refueling. The average length of the refueling line was 29 autos and the average time taken to refuel was close to two hours, so the drivers were quite willing to answer our questions while they waited. Overall, about one-third of the auto drivers surveyed owned the auto they were driving. While our sample is admittedly small, it appears from Table 9 that ownership patterns differ across routes. Two of the four autos

[10]This number is from the website of the Indian Auto LPG Coalition (http://www.iac.org.in)

[11]We requested the transport department for a list of all routes in the city and were provided with 126. It is likely that a lot of routes are not registered and do not therefore have official permits. Banerjee, Sengupta and Bandyopadhayay (2012) report 203 official routes and roughly 500 in total. It may be that the smaller number of registered autos given to us by the transport department refers to only part of the metropolitan area.

on the Tollygunge-Garia route were owned, while all of the 7 autos on the Phoolbagan-Ganesh Talkies route were rented. A cursory glance at the map in Figure 1 suggests that a higher fraction of autos in the northern part of the city were rented. If there are indeed geographical patterns in auto-ownership, vintage and fuel used, then the benefits from the transition are also likely to vary across regions in the city.

Our overall impression from the survey was that the transition had been difficult and most auto drivers were unhappy with the move in spite of acknowledging benefits in terms of cleaner air. Table 1 reports what they considered to be their biggest problems during the transition. Each respondent was allowed to list multiple difficulties and there were a total of 154 problems listed. Refueling related problems were the most commonly cited, followed by economic hardship. Some of these problems such as the temporary unemployment that resulted from lags in the processing of loans for new autos and the acute shortage of refueling stations were transitional. Others, such as the higher maintenance costs with LPG are likely to be more permanent and may be accentuated by the sharp rise in fuel prices since the legislation came into place. In the following sections we explore these changes in some detail.

TABLE 1: Problems in LPG Transition

Item	Number	Per cent
Refueling (Time/Distance/Ava.)	49	32
Financial Difficulties	43	28
Harassment by Officials	16	10
Temporarily Unemployed	15	10
Higher Maintenance Costs	13	8
Longer Work Hours	8	5
Increase in Auto Rents	6	4
Lower Performance of LPG Auto	4	3
Total	154	100

Source: Auto Survey, 2010.

Auto Vintages

All those surveyed reported driving a 4-stroke LPG auto at the time of the survey and a 2-stroke petrol auto before the transition. Details on vintages for current and previously driven autos are in Table 2. Not surprisingly, most autos sampled were less than a year old. We also found 45% to be less than six months old. The police started seizing illegal petrol-fueled autos starting Jan

FIGURE 1: Auto Routes and LPG Filling Stations in the Auto-Survey, June 2010

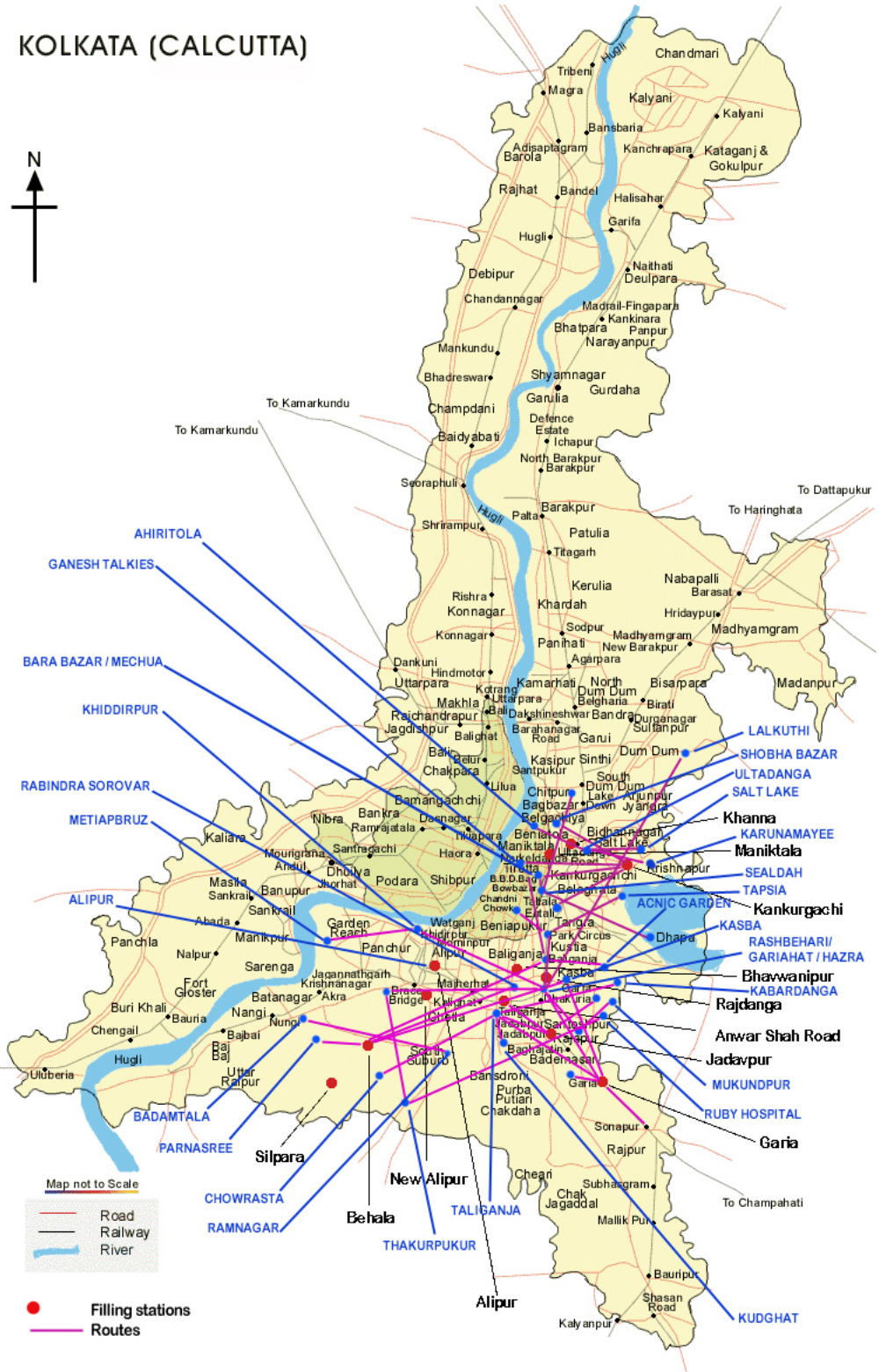

TABLE 2: Auto Vintages and Ownership Before and After the LPG Transition.

	Previous Auto	Current Auto	Total
Auto Vintage			
upto 6 months	0.0	45.0	23.2
6 months-1 year	1.1	41.0	21.6
1-5 years	24.5	13.0	18.6
5-10 years	43.6	1.0	21.6
10-15 years	21.3	0.0	10.3
over 15 years	9.6	0.0	4.6
Total	100.0	100.0	100.0
Auto Ownership			
rented	71.0	68.0	69.5
owned	29.0	32.0	30.5
Total	100.0	100.0	100.0
N	100	100	200

Source: Auto Survey, 2010.
Note: Each vintage category includes the upper end point of the respective interval.

1, 2010 and this may have hastened the transition after that date. Some of the older LPG autos may be those that were retro-fitted to LPG. It appears that the new autos replaced fairly old 2-stroke autos. Of the 94 drivers that provided us information about autos that they previously drove, we find that a quarter were less than 5 years old, the median age was 8 years, 25% were over 12 years and about 10% were over 15 years old.

Driver Characteristics

Table 3 shows selected characteristics of drivers by their ownership status. The two groups look fairly similar with differences mainly visible in the tails of the distribution of each characteristic. Renters are less educated and are younger. Owners are concentrated in the 30-40 year age range and more of them have passed the two major school-leaving exams that take place at the end of the tenth and twelfth year at school. More than half of all owners have been driving autos for between 6 and 10 years. Renters, in contrast, are in the tails of this experience distribution. Almost all respondents report auto-driving as their only occupation.

The most striking difference between the two groups in Table 3 is the fraction that report health benefits from the transition to LPG. Among renters, 60% report such benefits while

TABLE 3: Driver Characteristics, by Ownership.

	Rented	Owned	Total
Age group			
20-30 yrs	55.9	43.8	52.0
31-40 yrs	32.4	46.9	37.0
41-50 yrs	11.8	9.4	11.0
Total	100.0	100.0	100.0
Education level			
Below primary	19.1	12.5	17.0
Primary	22.1	15.6	20.0
Middle	27.9	31.2	29.0
Class 10	25.0	28.1	26.0
Class 12	5.9	12.5	8.0
Total	100.0	100.0	100.0
Experience driving autos			
0-5 yrs	20.6	13.3	18.4
6-10 yrs	36.8	53.3	41.8
11-15 yrs	26.5	23.3	25.5
More than 15 yrs	16.2	10.0	14.3
Total	100.0	100.0	100.0
Health Benefits from LPG			
No	38.2	59.4	45.0
Yes	61.8	40.6	55.0
Total	100.0	100.0	100.0
N	68	32	100

Source: Auto Survey, 2010

the corresponding fraction among owners is 40%. We believe this is because renters relied on adulterated fuels with poorer combustion properties. If in addition, if renters are concentrated in certain parts of the city, as suggested by Figure 1 and Table 9, the spillover effects from switching from two-stroke autos run on *katatel* to the new LPG autos may have been large.

Costs and Revenues

On the costs side, the drivers were asked about both fuel and maintenance costs. Table 4 reports the median value of some important cost categories that were reported. Our most surprising finding relates to daily fuel costs. While drivers who owned their autos reported a decline in these costs, those who were renting did not. Cheaper fuel is commonly believed to be the major

TABLE 4: Median Costs for Selected Cost Categories (Indian Rupees)

Cost Category	Rented	Owned	Total	N
Previous Period				
Reported fuel cost (daily)	200	240	200	100
Maintenance costs (monthly)	225	200	212	90
Union dues (monthly)	105	120	120	77
Fines and bribes	400	300	400	43
Oil and filter change (last incurred)	150	150	150	39
Tax and insurance (annual)	2,225	2,200	2,200	45
Current Period				
Reported fuel cost (daily)	200	200	200	100
Maintenance costs (monthly)	600	550	600	97
Union dues (monthly)	120	120	120	78
Fines and bribes	450	300	425	60
Oil and filter change (last incurred)	600	500	600	40
Tax and insurance (annual)	3,725	4,000	3,750	45

Source: Auto Survey, 2010

advantage for transport operators in moving from petrol to gas and if these savings were absent or minimal, it is not surprising that the transition was politically difficult and opposed by most drivers.

We asked drivers about 3 broad cost categories of non-fuel costs (i) maintenance costs that they had incurred over the past month before the survey (ii) other recurring costs over the past year (iii) other costs, including taxes, insurance, union dues, fines and bribes. We also asked what these costs had been in the corresponding time period before the transition. We use responses only in the first and third of these categories because most LPG autos were not old enough for drivers to have a good estimate of annual maintenance costs. Furthermore, we separately tabulate the most frequent of these recurring costs, the oil and filter change, since its specificity makes a comparison across the two periods easier.

Most of these costs seem to have gone up. Annual tax and insurance costs nearly doubled and oil and filter changes (the main recurring cost reported) went up by a factor of four. There are 10 drivers who separately reported taxes and insurance. From this it seems that taxes stayed roughly the same (median values for the two periods are 700 and 720) but insurance rates doubled. This is not surprising; LPG autos were mostly new and insurance rates depend on the value of the vehicle. We were told that maintenance charges are much higher now because

oil changes are required more frequently and auto parts are not only more expensive, but they come bundled together.

We are concerned about measurement error in these cost estimates. Drivers were clearly unhappy about the higher maintenance costs and may have exaggerated or anticipated costs that they did not actually incur. We do not have a systematic or fine break-up of maintenance costs and found our analysis limited in this respect. We have therefore reported medians and do not report any tests of statistical significance as we do for revenues and other working conditions below.

Fines, bribes and union dues went up marginally for renters but not for owners. We do not have any information that allows us to explore the reasons for the changes in fines. It may be that more of the rented autos are retro-fitted because it was owners and not renters who were provided loans. It is also possible that renters switched later because the owners of their autos were not directly facing the regulatory authorities. It is also possible that owners are better connected with police authorities. At this point, this is only speculation. Unions dues were typically 3 rupees per day both before and after the transition. There are some differences in union membership across the two groups and a few drivers switched unions- this may account for differences we observe across the two periods. We discuss union membership and its influence in greater detail below.

On the revenue side, we asked drivers about their total revenue from a full day's work as well as their monthly take-home income. Mean figures by ownership and time period are shown in Table 5. Mean revenues are higher for renters before the transition while there is no statistical difference in revenues for the renters and owners after the transition. When we look across time periods, the differences in incomes and revenues for owners are not statistically significant, whereas the decline in both revenues and incomes for renters is significant at the 10% level.

Table 6 shows mean values of hours worked per day, days worked per week and kilometers travelled per day. We find that daily hours worked and the length of the working week is longer for rented autos after the transition but not for owners. Mean hours worked by renters go up from 10.4 to 11 hours per day while the increase for owners is much smaller (11.3 to 11.5). The total daily distance travelled is also slightly higher for renters. Most of these differences are small and not statistically significant. The big change is working conditions in the increase in time taken for refueling. The mean waiting time went from 5 minutes before the LPG transition to nearly two hours after it. Based on these numbers, it is understandable that refueling related problems ranked first in Table **??**. This may also explain why revenues have fallen for rented

TABLE 5: Monthly Income and Daily Revenue (Means in Indian Rupees).

Time Period	Rented	Owned	Total	N
Monthly Income				
Previous Period	6,149	11,707	7,793	98
Current Period	5,431	11,078	7,256	99
Total	5,795	11,377	7,523	200
Daily Revenue				
Previous Period	751	647	720	98
Current Period	698	699	698	98
Total	725	674	709	200

Source: Auto Survey, 2010

autos in spite of an increase in the working day and in the length of the work week.

Capital costs and loans

All of the 32 owner-drivers financed the purchase of their new auto with a loan. Of these, 25 were financed through bank loans. The price of a new LPG auto at the time was 1,26,000 rupees. The financing of new autos was managed through an agreement between auto manufactures, state-owned banks and the West Bengal Government. These loan contracts were commonly discussed in the press at the time. The auto manufacturer Bajaj Autos, was offering a rebate of 5,000 plus a buy-in price for the old auto of Rs. 6,000. The state offered a subsidy of 10,000 and nationalized banks provided 60-month loans of Rs. 95,000 at 12.25% per annum, with a 3 month moratorium on interest payments.[12] The owner had to put as a down payment the remaining amount of 10,000 rupees.

Our survey responses match many of these figures. Most loans in our data were for 5 years (88%) and the median monthly installment was Rs. 2200 per month. Five of the twenty-five drivers claiming to have taken a bank loan reported paying a bribe during the loan process. The average time taken between surrendering the old auto and getting the new one was 2.25 months and 80% of all drivers had received their new autos within three months. This may

[12]These numbers are taken from an article in the Business Standard on Feb. 26, 2009 (http://www.business-standard.com/india/news/banks-steploans-to-autorickshaw-owners-for-cng-conversion/350026/)

TABLE 6: Working Conditions (Means)

Time Period	Rented	Owned	Total	N
Hours per day				
Previous Period	10.4	11.3	10.7	100
Current Period	11.0	11.5	11.2	100
Days per week				
Previous Period	6.4	6.3	6.4	100
Current Period	6.4	6.3	6.4	100
Refueling times (minutes)				
Previous Period	4.9	5.0	5.0	47
Current Period	114.4	116.2	115.0	99
Distance travelled (km/day)				
Previous Period	119.7	108.8	116.7	98
Current Period	122.0	107.5	117.5	98

Source: Auto Survey, 2010

explain the temporary unemployment reported by drivers as one of the major problems during the transition. On sale proceeds, we find that one third reported receiving 6,000 rupees which was the trade in offer by the auto manufacturer but about half sold their autos for 12,000 rupees and 2 reported receiving 20,000. Surprisingly, the relationship between the age of the previous auto and the sale proceeds from it is quite weak. For example, a total of 8 owners report getting Rs. 6,000. Of these 3 had autos less than 5 years old, 3 were above 10 years old and 2 were between these two vintages. Similarly, of the 12 owners who reported receiving Rs. 16,000, one third had autos less than 5 years old, one-third were above 10 years and the rest were in-between.

Political support and resistance

We asked each auto driver whether he favors the move to LPG and what his position on LPG was in July, 2009 when the legislation was first enforced. We also asked which auto union he was a member of, if any. Less than one-third of all drivers supported the move. Table 7 shows patterns of support for the LPG law by union membership and ownership of autos. Two-thirds of our respondents were members of the Centre of Indian Trade Unions (CITU) which is backed

TABLE 7: Support for the LPG Transition by Union Membership.

	None	CITU	Trinamool	Congress	Total
Support LPG, June, 2010					
Oppose	63.6	40.6	83.3	66.7	52.1
Support	27.3	39.1	11.1	33.3	32.3
Neutral	9.1	20.3	5.6	0.0	15.6
Total	100.0	100.0	100.0	100.0	100.0
Support LPG, July, 2009					
Oppose	63.6	43.8	94.4	100.0	57.3
Support	27.3	42.2	5.6	0.0	32.3
Neutral	9.1	14.1	0.0	0.0	10.4
Total	100.0	100.0	100.0	100.0	100.0
Involved in LPG protests					
No	54.5	85.9	16.7	100.0	69.8
Yes	45.5	14.1	83.3	0.0	30.2
Total	100.0	100.0	100.0	100.0	100.0
Auto Ownership					
Rented	81.8	67.2	61.1	66.7	67.7
Owned	18.2	32.8	38.9	33.3	32.3
Total	100.0	100.0	100.0	100.0	100.0
N	11	64	18	3	96

Source: Auto Survey, 2010

by the Communist Party of India (Marxist). This was the party in power at the time of both the legislation and the survey. The second largest group (19% of our 96 respondents) was affiliated to the Trinamool party which came to power in the state elections of 2011. Not surprisingly, those affiliated to the incumbent party were far less vocal in their opposition to the legislation than those affiliated to the challenger. Among our respondents, 29 drivers reported that they had been involved in a protest against the LPG law. These protestors were very unevenly distributed across the trade unions. While over four-fifths of drivers affiliated to the Trinamool party participated in a protest against the move to LPG, a roughly equivalent fraction of CITU drivers abstained from doing so. We also found that owners were disproportionately unionized.

4 Fuel adulteration and fuel cost savings

Kolkata-based newspapers have often carried reports on the prevalence of adulterated fuel before the transition to gas. It was claimed that *katatel*, a mixture of kerosene, petrol and naphtha, was sold by private operators who were supplied with petrol stolen from tankers. It was used by Kolkata autos because it was significantly cheaper than petrol and easily available.[13] There were also some claims that it allowed autos to carry more passengers than LPG.[14]

Since the use of *katatel* was illegal, it has always been difficult to estimate its prevalence. One nice aspect of our data is that it allows us to do this indirectly through reported values of fuel costs, distance and mileage.

Total fuel costs are equal to the unit price of fuel times the quantity bought per day. This quantity is the distance travelled divided by the mileage. We therefore have the following identity:

$$\frac{\text{fuel cost}}{\text{distance/mileage}} = \text{unit fuel price} \tag{1}$$

Under the LPG regime, the unit fuel price is known and homogeneous across all autos. We begin by computing the empirically observed counterpart of left hand side of (1) using our survey data. We then scale the mean in order to get the correct LPG price of Rs. 32.89 at the time of the survey in 2010. The idea behind the scaling factor is to correct for reporting biases in these estimates. Daily fuel costs are particularly subject to rounding error. We then apply the same scaling factor to reported fuel costs in the previous period to get at an imputed price for that period. If this price is close to the price of petrol at the time of the transition, we infer that the auto used petrol. Katatel being illegal, does not have an official price but investigative reports by journalists cite prices between Rs 30 and Rs. 40. If our imputed price is in this range, we infer that the auto was using *katatel*.

[13] The Telegraph, 7 Jan 2009 reports:

> Katatel is easily available from 250-plus centres across the city; there are only 12 LPG stations.

[14] Telegraph, 7 Jan 2009:

> A four-stroke auto running on LPG can only take three passengers because of the load factor. The stronger katatel kick-start allows autos to pack in more passengers. This can almost double the auto's earnings on any given trip (five, instead of three passengers

The steps in this computation are outlined below:

1. Start with the two-way length reported for each route. In some cases there is variation in responses for drivers on the same route. For these cases we use the median length.

2. Multiply route length by the average number of trips for each driver per day. This gives us the distance travelled by the auto on a typical work day.

3. Divide the distance by the mileage reported by each driver. This gives us the fuel demand for each driver.

4. Divide the reported daily fuel cost by fuel demand to get our first estimate of an imputed price. This is driver-specific.

5. Compute the mean imputed price based on these estimates and scale it to arrive at a mean price of 32.89 rupees per litre, which was the actual price of LPG at the time of the survey.

6. Multiply the value of the LHS variable in (1), computed separately for the current period and the previous period, by the scaling factor just derived, to arrive at imputed fuel prices in the two periods.

The results of this exercise are shown in Table 8. The price of petrol in Kolkata in January 2009 was Rs. 44.05 per litre and in July 2009, it was 48.25. Given that drivers switched to LPG at difference stages, the mean imputed fuel price of Rs. 46.1 that we get for owners in the pre-transition phase seems to match market prices of petrol remarkably closely. On the other hand the mean imputed price of fuel for renters was only Rs. 37.1 and suggests that a large fraction of drivers were buying fuel at well below the price of petrol. This supports the hypothesis that owners used petrol and renters relied primarily on *katatel*. After the transition, we find mean imputed fuel prices for owners and renters to be very similar as we would expect if both groups were using LPG. A test for differences in the means of imputed prices for the two groups rejects the null of equal means at the 1% level of significance for the pre-transition phase, and cannot reject equality at conventional levels for the LPG phase.[15]

[15]There were claims that some LPG autos were retro-fitted to be able to continue using *katatel*. Our survey data does not allow us to explore this in any detail. The auto manufacturers claimed that autos would not last long if used on katatel and it is therefore likely that the renters would be more likely to do this than owners since they would care less about the decline in the market value of their auto. The lower imputed prices for renters under the LPG regime are consistent with this pattern, but given our sample size and the resulting standard errors, we think it is more likely that these differences are simply due to sampling error.

TABLE 8: Mean Imputed Fuel Prices by Time Period and Ownership

Time Period	**Rented**	**Owned**	**P-value** $H_0 : p_R < p_0$	**N**
Previous Period	37.1	46.1	.007	97
Current Period	32.0	34.9	.14	97

Source: Auto Survey, 2010

These different patterns of fuel consumption in the pre-transition phase implied that the per kilometer fuel cost to owners before the transition was much higher than for renters and correspondingly, the potential for LPG to affect fuel savings was also larger. The median reported mileage with their old autos was 21 kilometers per liter for owners and 22.75 for renters. In July, 2009 the market price of petrol in Kolkata was Rs. 48.25. For owners using only petrol, the fuel cost per kilometer with these figures was Rs. 2.29 per kilometer. If we assume a *katatel* price of Rs. 35, and the median reported mileage for renters, we get a per km. cost of Rs. 1.54. If instead, we use the imputed fuel prices in Table 8, we get Rs. 2.2 per km. and Rs. 1.63 per km. for owners and renters respectively. At the time of the survey in June 2010, both owners and renters reported the same median mileage of 18 kilometers per kg. of LPG. The market price of LPG at the time was Rs. 32.89 resulting in a per km. cost of Rs. 1.83. This means that even if we ignore all other financial and opportunity costs associated with the transition, renters were worse off.

To calculate changes in daily fuel costs resulting from LPG, we use the mean distance travelled per day from Table 6. This is 121 km. for renters and 108 km. for owners. Using the market price for petrol for owners and Rs. 35 for renters, we get a fuel cost saving of Rs. 50 per day for owners and a loss of Rs. 35 for renters. Using imputed fuel prices would result in slightly lower gains and losses. Our calculations so far assume that autos carried equal numbers of passengers in both regimes. We often heard (and newspaper reports also claimed) that LPG autos are able to carry fewer passengers. This would only lower the cost savings by owners and further heighten the disadvantage of renters.

5 Lessons for Policy

We see the main contribution of our study as documenting the effects of clean air legislation on those most immediately affected by it. Those renting autos found their rents double and there were no compensating benefits in terms of cheaper fuel because this group of drivers appears to have relied not on petrol, but on cheaper adulterated fuel that cost less per kilometer than LPG. For owners, fuel costs went down by about 25%, but these declines were smaller than the monthly installments they needed to service the loans taken for the new autos. In addition, maintenance costs went up considerably.

It seems that unions did take divergent positions on the legislation and so the decision of auto-drivers to formally support or oppose the legislation was influenced by the union they belonged to. It is not however the case that the unions politicized what could otherwise have been a smooth transition. Moreover, the difficulties of the transition were not transitory. While their suffering was made worse by fuel shortages, long lines and temporary unemployment, the change would have been unattractive even in a frictionless economy because it raised capital and operating costs without influencing revenues. A majority of surveyed drivers perceived health benefits from cleaner air. Yet, they could not look upon the legislation favorably because if its negative economic impact on their lives.

The first lesson for policy makers would be to preserve the welfare of relatively marginalized groups of transport operators most affected by new regulations. In the case of Kolkata, it does not seem that this would have been difficult because the total number of autos were small relative to other vehicles, as seen in Figure 2. In 2008, at the time of the LPG court order, there were a total of 18,512 registered auto-rickshaws and probably an equal number of unregistered ones. This was less than 5% of the total number of registered cars and jeeps and less than 2% of the total number of registered vehicles. A policy which imposed a relatively modest registration tax on other vehicles and transferred this to the auto-rickshaw drivers could have completely changed the net benefits of the transition for the latter group.

Figure 3 shows the trend in fuel prices in Kolkata between 2008 and 2012. The relative advantage of those using diesel relative to those using either petrol or LPG is striking as is the steep recent rise in the price of LPG. Diesel is established to be a greater air pollutant than either petrol or CNG and the fuel tax regime followed during this period certainly does not seem to have been Pigovian.

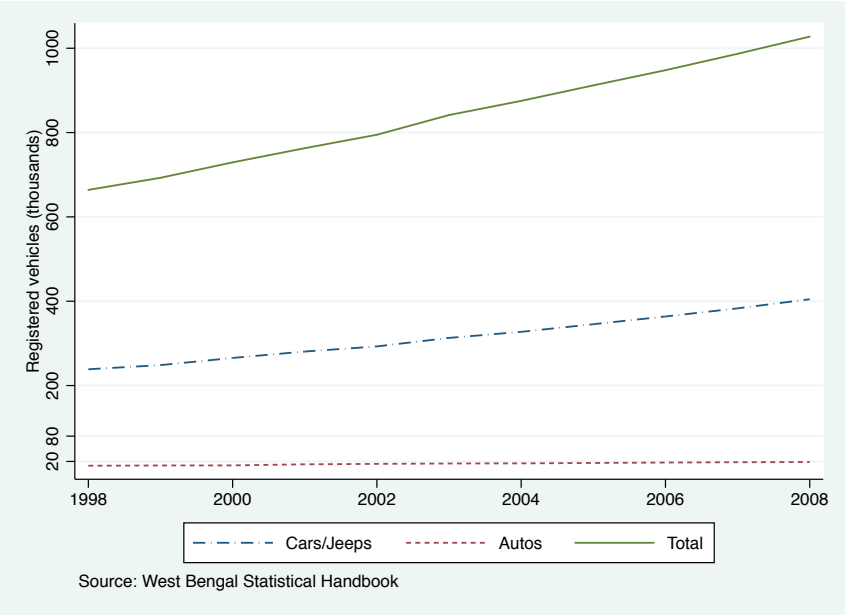

FIGURE 2: Total Number of Registered Vehicles by Type, 1998-2008.

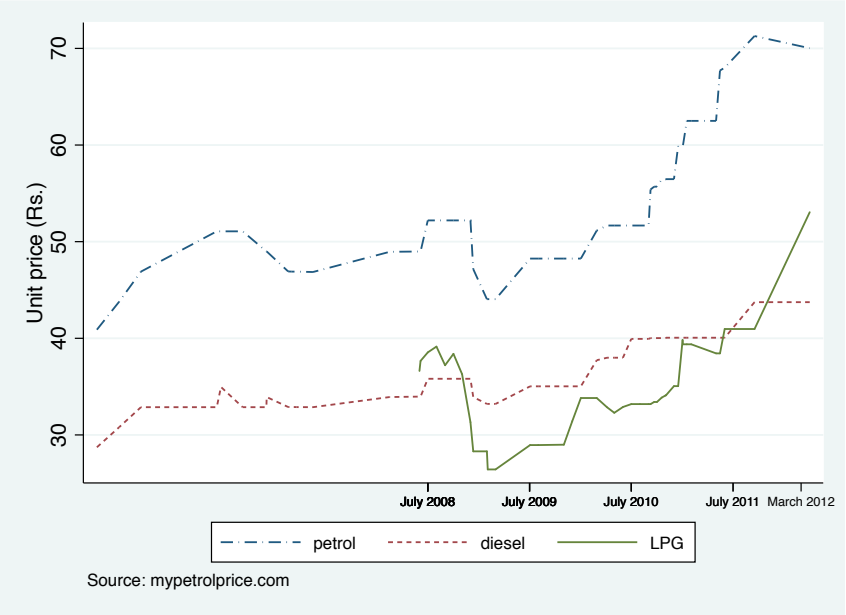

FIGURE 3: Petrol, Diesel and LPG Prices in Kolkata, 2008-2012.

While the cleaner air of Kolkata and othe Indian cities has been welcomed by many, the process through which it has been achieved could have been both faster and fairer if the LPG transition was planned as one part of an integrated transport policy rather than a late reaction to judicial activism.

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6 Appendix

Table 9: Routes and Numbers of Surveyed Autos

Route	Route Name	# surveyed	Fraction Owned
2	Ahiritola–Ultadanga	3	0
65	Ballygunge–Behala	1	0
68	Ballygunge–Chetla	2	.5
98	Behala–Hazra	1	1
1	Behala–Parnasree	3	.67
17	Bengal Chemical–Sealdah	1	1
157	Boral–Garia	2	0
159	Chandni–Park Circus	1	0
11	Dhapa–Sealdah	1	0
150	Garia–Ganga Joar	2	.5
5	Garia–Golpark	5	.2
6	Garia–Hazra	1	1
34	Hazra–Bondel Gate	2	1
37	Hazra–Chittaranjan Avenue	2	0
35	Hazra–Khidderpore	2	1
151	Jadavpur–Anwar Shah Road	1	1
152	Jadavpur–Asutosh Colony	1	1
38	Jadavpur–Taratala	1	1
153	Jadavpur–Tollygunge	1	0
44	Kadapara–Mechua	3	.33
30	Kali Bazaar–Garia	1	1
41	Kasba–Behala	1	0
394	Kudghat–Anandapally	2	0
40	Lalkuthi–Gariahat	1	0
47	Loharpul–Dharamtala	2	0
52	Metiabruz–Khidderpore	1	0
160	Orient Row–Dharamtala	1	0
54	Park Circus–Dharamtala	1	0
56	Park Circus–Gariahat	1	1
45	Park Circus–Tapsia	1	0
59	Phoolbagan–Ganesh Talkies	7	0

Continued on next page

Table 9 – continued from previous page

Route	Route Name	# surveyed	Fraction Owned
8	Picnic Garden–Ballygunge Phari	1	1
158	Picnic Garden–Gariahat	1	0
394	Purba Anandapalli–Kudghat	2	0
119	Rabindra Sarovar–Behala	1	1
26	Ramlal Bazar–Gariahat	3	.33
60	Ramnagar–Badamtala	1	0
107	Rashbehari–Behala	3	0
65A	Rashbehari–Garia	1	0
27	Ruby Hospital–Gariahat	2	0
108	Ruby Hospital–Thakurpur	1	0
155	Santoshpur–Mukandpur	1	0
74	Sealdah–Burra Bazar	1	0
154	Sonarpur–Garia	1	0
29	Taratala–Gariahat	1	1
15	Taratala–Thakurpukur	5	.4
156	Thakurpukur–Kabardanga	1	1
75	Tollygunge Phari–Behala	1	0
12A	Tollygunge–Chowrasta	3	.67
89	Tollygunge–Garia	4	.5
12	Tollygunge–Kabardanga	2	.5
57	Ultadanga–Karunamayee	1	1
83	Ultadanga–Saltlake	6	.17
81	Ultadanga–Shobhabazar	2	0

AUTO DRIVER QUESTIONNAIRE (INDIVIDUAL) : JUNE 2010

Instructions: *These questions are to be asked of drivers while they wait at one of the 13 gas filling stations.*

Interviewer_____ Date:__ __/__ __/__ __ Time__ __:__ __ Filling Station_____ #Autos in line _____

Route Name_____ Route #_____ Length_____(km)

SECTION 1: VEHICLE CHARACTERISTICS AND COSTS

		Current Auto	Previous Auto
1	What type of vehicle is this? (*4-stroke LPG…..L4, 2-stroke LPG…L2, 2-stroke petrol….P2, 4-stroke petrol…..P4*)		
2	How old is the auto?		
3	Is this auto owned or rented? (*Owned…..O Rented……R*)		
4	If rented, what is the rent per day?	Rs.	Rs.
5	How many drivers share this auto?		
6	Does this vehicle have a route permit?		
7	How much do you pay for fuel (per litre/kg)?		
8	How much mileage do you get (kms per litre/kg)?		
9	How many times a week do you buy fuel? (*daily…1, every 2 days…2, etc.*)		

10	How much fuel do you buy on average each time? (kg/litre/Rs)		
11	What is your daily fuel cost?		
12	What distance do you travel to get to the filling station?		
13	What is the average waiting time at the filling station?		
14	What were the recurring maintenance costs over the past month? Specify item and cost.		
	(a)		
	(b)		
15	Have you incurred any other maintenance costs over the past year for the new auto and over the last year that your old auto was in use? Specify item and cost.		
	(a)		
	(b)		
16	Other Costs: (a) tax and insurance (yearly)		
	(b) union dues (monthly)		
	(b) fines or other payments to the police (monthly)		

SECTION 2: REVENUE AND INCOME

		Current Auto	Previous Auto
1	How many trips on average do/did you make per day (Mon-Fri; 1-way trips)?		
2	How many trips on average do/did you make on Saturdays?		
3	How many trips on average do/did you make on Sundays?		
4	How many hours do you work per day?		
5	How many days do you work per week?		
6	If you work less than 7 days, which days are off *?(Monday…1…….Sunday….7, No fixed day..8)*		
7	What is the fare, per passenger, per trip, for this route?		
8	What is the total revenue earned (fares from passengers) from a full day's work?		
9	What is your monthly take-home income (before deducting loan payments and taxes)?		
10	Do you have any other job? Please specify.		
11	If yes, what is the monthly income from this job?		
12	How many members are there in your household?		
13	What is the total household income per month?		

SECTION 3: LOANS AND RE-SALE VALUES (for owners)

		Current Auto	Previous Auto
1	Did you finance the purchase of the auto with a loan? *Yes….Y No….N*		
2	From whom was the loan taken? *Bank….B Private Financier….F Other…. (specify)*		
3	What is the duration of the loan (in years)		
4	What is the monthly installment (EMI)?	Rs.	Rs.
5	How long did it take to obtain the loan?		
6	What was the time interval between surrendering your previous auto and getting delivery of the new one?		
7	Did you pay any bribes while getting the new auto/loan? How much?		
8	What was the outstanding amount on your previous loan at the time of conversion?		
9	What is the monthly amount you are still paying on your previous loan?		
10	How long (months) will you need to make payments on your previous loan?		
11	If you sold an auto to buy this, what did you obtain in sale proceeds?		

SECTION 4: PERSONAL CHARACTERISITCS AND OPINIONS

1. How old are you? _____
2. What is your education level? _____
3. How long have you been driving autos? _____
4. How long have you owned an auto? _____
5. Which union are you affiliated with? *CITU……..C Trinamool……T Other……* _____
6. Have you switched unions over the last 2 years? *Yes….Y No…..N* _____
7. If yes, which union were you previously associated with? *CITU….C Trinamool……T Other……* _____
8. Do you support or oppose the change to LPG? *Oppose…O Neutral…..N Favour…..F* _____
9. Did you support or oppose the change to LPG in March 2009? *Oppose…O Neutral…..N Favour…F* _____
10. Were you involved in protests against the LPG law? *Yes….Y No….N* _____
11. Have you felt any environmental and health benefits after the change to LPG? *Yes….Y No….N* _____
12. What are the biggest problems faced by auto owners/drivers during the LPG conversion? _____