Pertanika J. Soc. Sci. & Hum. 23 (S): 33 – 48 (2015)

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Fuel Prices and Road Transportation Fares in Ghana

Andoh, C[1]* and Quaye, D[2]

[1]*Department of Finance, University of Ghana Business School, Legon, Accra, Ghana*
[2]*Department of Marketing and Customer Management, University of Ghana Business School, Legon, Accra, Ghana*

ABSTRACT

We develop a mathematical model for automatic adjustment of new transportation fares in terms of old transportation fares, the number of litres of petrol/diesel a vehicle requires, the quantum of adjustment, the number of trips a vehicle makes on a specified route and the number of passengers a vehicle carries. We recommend that any adjustment to existing fares should be exactly the loading and that any additional amount to the existing fares differing from the loading leads to either overcharging or undercharging of passengers. We also show that any negotiation about the quantum of adjustment to existing fares reduces to the proper assignment of the number of trips a vehicle plies on a specified route. We tested our models on privately operated commercial vehicles using data from major lorry stations in Accra, the National Petroleum Authority and Drivers and Vehicular License Authority in Ghana. The results indicated that passengers are undercharged on some routes whereas they are overcharged on others. The model should be useful to transportation planners, coordinators and administrators in setting and adjusting road transportation fares. It should assist in settling disputes about new transportation fares between passengers and drivers that arise when there is adjustment in fuel prices.

Keywords: Asset replacement cost, destination distance, expected charge, loading, viability condition, stability model

ARTICLE INFO

Article history:
Received: 30 March 2015
Accepted: 30 June 2015

E-mail addresses:
chandoh@ug.edu.gh (Andoh, C),
danquaye@ug.edu.gh (Quaye, D)
* Corresponding author

INTRODUCTION

Increases in transportation fares are frequent in the Ghanaian transportation sector and other developing countries of the world especially in the non-oil producing countries. Whenever there is an increase or decrease of oil prices at

ISSN: 0128-7702

the global level, countries tend to adjust prices to reflect the prevailing prices of the world market. Historically, fuel costs have been subsidised in Ghana; however, with successive governments unable to shoulder the increasing cost of the subsidy, removal of subsidies has become the adopted approach. Hence, in 2005, by an act of Parliament (Act 691), the National Petroleum Authority (NPA) was mandated to regulate the downstream sector of the petroleum industry. As a result, the NPA adjusts prices of petroleum products every two weeks to reflect recurrent global market costs of the commodity. Minimal increases in global oil price account for the Ghanaian fuel price increases. Largely, the increases are triggered by the depreciation of the local currency, the Ghana Cedi (GHS), to the United States Dollar (USD), the currency Ghana uses for its oil payments. Thus on July 14, 2014, transportation fares went up by 15%. This increment was the sixth for the year 2014, and cumulatively accounted for a 40% increment since the beginning of 2014. This led to a sharp increase in fuel prices. The regular increase in fuel prices imposed a corresponding pattern of increase in transportation fares that did not seem commensurate with the fuel price adjustments. As most goods and services are transported by road in Ghana, an increase in fuel prices automatically leads to increases in prices of other goods and services. In addition, whenever there is an adjustment of fuel prices as is currently the case, there are disputes between drivers and possibly their assistants (fare collectors) on one hand and passengers on the other as to the amount that has to be added or subtracted from the existing fares. Thus, Ghanaian passengers feel they are paying unrealistic transportation fares and, therefore, feel cheated.

In Ghana transportation fares are largely determined by the Ghana Road Transport Coordinating Council (GRTCC), which is an umbrella institution for transportation associations throughout Ghana. To ensure economic viability of their operations, the GRTCC usually maximises revenue by adjusting fares upwards, in a manner which does not seem commensurate with fuel price increase. If Ghanaian commuters are ever to pay realistic transportation prices for each increase in fuel price then it is essential that a framework is put in place that determines what constitutes a fair price for commuters based on each increase.

There are several important questions to which passengers, vehicle operators, GRTCC and the Ministry of Transport are awaiting answers. What is the fair price that passengers have to pay when there is an adjustment in fuel price? Is there a model that can be employed by GRTCC that can minimise the frequency of adjustments in transportation fares? What is the minimum number of trips that vehicle operators have to make on a specified route so that their operations are profitable? Thus, there is the need to have a model that transportation planners, coordinators and administrators can employ to automatically adjust transportation fares. In addition, there is the need to have a model that can be employed to minimise the frequency of adjustment in fuel prices.

In this study, we developed a model for lorry fare adjustment to verify whether the lorry fare adjustments in 2014 were reasonable for some major routes. In addition, we proposed a model that would assist in minimising the frequency of adjustments not only for transportation operators but other businesses that are likely to be affected by fuel price increases to enable all involved to properly plan their budgets.

Very little has been written in this area. In fact, hardly any study exists within the Ghanaian context that this study could draw from. Arndt *et al.* (2008) studied fuel price increases in Africa. However, they linked fuel price increases to food prices in Mozambique, concluding that increase in fuel prices led to higher food prices in Mozambique. In Europe, Delsalle (2002) conducted a study on fuel price changes in the transportation sector and concluded that increase in fuel prices led to higher transportation costs. Furthermore, Ortuna-Padilla and Fernandez-Aracil (2013) analysed the impact of the variation in the price of fossil fuels on the development of the urban sprawl in Spain. Their study combined the principles of the natural evolution theory with the price of fuels and two types of family house. The analysis was empirical and was based on a panel data collected in the provinces of Alicante, Almeria, Balearic Islands, Barcelona, Cadiz, Castellon, Cordova, Girona, Granada, Huelva, Jaen, Lleida, Madrid, Malaga, Murcia, Seville, Tarragona and Valencia from 2000 to 2010. The main finding drawn from the econometric analysis was that an increase in the price of fuel led to a decrease in the construction rate of single-family houses. In Australia, Jago and Sipe (2007) assessed the socio-economic risks from higher urban fuel prices, and found that there was wide spatial variability in the vulnerability of Australia's urban populations to rising fuel costs, which might compound existing socio-spatial divisions. However, a study conducted by Setwayan (2014) in Indonesia found that increasing fuel prices had a devastating impact on the transportation sector of the economy. Pizer (2006) on his part, researching fuel economy in the United States, concluded that improvements can be cost-effective; that is, gasoline savings can pay for the cost of fuel-saving technologies.

Shang and Guo (2005) established a trip cost model for a bus rapid transit (BRT) system in the Taipei metropolitan area (the main metropolitan area in Taiwan). The main purpose of the BRT system was to provide high-efficiency low pollution and lower construct costs in order to lower the misuse of social resources and to reduce social costs (Shang & Guo, 2005). This was accomplished through the combination of the advantages of rail service quality and bus operation flexibility. The main finding of the study was that the total cost of private transportation was much higher than public transit.

Notwithstanding the effort of the preceding studies to highlight the effects of fuel price increases, there was a point of departure from this study in that this study went further to develop a framework that ensured transportation fare increases arising from increase in fuel prices were based on fair adjustment.

The rest of the study is organised as follows: in Section 2 we develop the mathematical models for managing the pricing of road transportation. Here, we develop the pricing model for fuel price adjustments and give conditions under which the operations of vehicle operators will be viable. In addition, we provide the expected charge for any specified destination and propose a model that can be employed to minimise the frequency of fuel price adjustments. The empirical results are contained in Section 3 while the discussion of the results is given in Section 4. Section 5 concludes the study.

MODEL DEVELOPMENT

In this section, we develop mathematical models for setting and adjusting fuel prices. We also develop conditions under which the transportation business will be viable for transportation operators. A model for minimising the frequency of fuel price adjustments is provided and the expected charge for any destination of the vehicle is also given.

Vehicles that Ply Specified Destinations

We denoted the profit function of vehicular class operations by

$$p_f = N_t(n_p s_p d) - [t_f + V_c + \\ + w_i AR_c(1+r)^i], i = 1,\ldots,n$$

N_t is the number of trips a vehicle makes in a week to a specified destination. n_p is the permissible number of passengers a vehicle may carry; s_p is the price per kilometre travelled by a passenger and d, the destination of a passenger, which we called the destination distance. Thus $s_p d$ is the amount a passenger pays for getting to her destination. t_f is the fixed cost of operations within a week. These fixed costs are the amount paid for the annual insurance, parking tickets, assembly permits, vehicle income tax and roadworthy certificate, which has to be renewed semi-annually from the Drivers and Vehicular License Authority (DVLA). We split the variable cost, V_c, into two parts: one part triggered by fluctuation in the fuel price, v_c, and the other part, $\tilde{v}_c$, that changes only when there is an upward review of fuel prices, a characteristic peculiar to the Ghanaian economy (compare with Andoh *et al.* (2012), p. 65). The part of the variable cost, v_c, triggered by fluctuation in fuel prices is defined by:

$$v_c = n_l p_l$$

where n_l is the number of litres of petrol or diesel that a vehicle requires in a week and p_l is the price per litre. Other expenses such as vehicle lubricant engine oil, spare parts, washing or cleaning cost, cost of settling passengers' lost items, servicing of the vehicle, driver and possibly, driver's assistant fees, booking fees and vehicle income tax have been merged $\tilde{v}_c$.

Here, AR_c, has to be interpreted as the purchase price of the vehicle and the cost of vehicle tyres, which has to replaced semi-annually. We assumed that AR_c was paid over *n* weeks. w_i ($0 < w_i \le 1$) is the fractional part of AR_c that has to be paid in a week and satisfies:

$$\sum_{i=1}^{n} w_i = 1$$

For viability of transportation business operations, the transportation fare per kilometre travelled, s_p, must be such that:

$$s_p \ge \frac{t_f + n_l p_l + \widetilde{v}_c + w_i AR_c (1+r)^i}{N_t (n_p d)} \quad [1]$$

It can be seen from [1] that vehicle operators can charge less for increasing number of trips and yet obtain some profit. On the other hand if s_p is fixed, then, for transportation business operations to be viable:

$$N_t \ge \frac{t_f + n_l p_l + \widetilde{v}_c + w_i AR_c (1+r)^i}{d s_p n_p}$$

In a typical transportation business, v_c is the only item in the above inequality that typically triggers a change in $\widetilde{v}_c$ within a short period of time. Note also that greater distance triggers greater increases in v_c. For example, more fuel has to be purchased for increasing d. Thus v_c varies directly as the destination distance d. Hence, we may write:

$$v_c = kd$$

for the constant, k. Consequently, the constant may be determined by:

$$k = \frac{n_l p_l}{d}$$

We denote the profit from old fares of vehicular class operations by p_{f^o} and the profit from new fares of vehicular operations by p_{f^n}. Then we may write:

$$p_{f^o} = N_t (n_p s_{p^o} d) - [t_f + n_l p_{l^o} + \widetilde{v}_{c^o} + w_i AR_c (1+r)^i] \quad [2]$$

where s_{p^o} is the old fare per kilometre travelled by a passenger, p_{l^o} is the old price per litre of petrol or diesel and $\widetilde{v}_{c^o}$ is the old variable cost.

In similar fashion we may write:

$$p_{f^n} = N_t (n_p s_{p^n} d) - [t_f + n_l p_{l^n} + \widetilde{v}_{c^n} + w_i AR_c (1+r)^i] \quad [3]$$

where s_{p^n} is the new fare per kilometre travelled by a passenger, p_{l^n} is the old price per litre of petrol or diesel and $\widetilde{v}_{c^n}$ is the new variable cost.

Assuming the number of trips a vehicle operator makes on a specified distance does not alter when there is adjustment in fuel prices, subtracting [2] from [3], we get:

$$p_{f^n} - p_{f^o} = N_t n_p (s_{p^n} - s_{p^o}) d +$$

$$p_{f^n} - p_{f^o} = N_t n_p (s_{p^n} - s_{p^o}) d +$$

The viability condition implies that the new price per kilometre s_{p^n} must be such that:

$$s_{p^n} \ge s_{p^o} + \frac{n_l (p_{l^n} - p_{l^o}) + (\widetilde{v}_{c^n} - \widetilde{v}_{c^o})}{N_t n_p d}$$

Obtaining an estimate of $(\widetilde{v}_{c^n} - \widetilde{v}_{c^o})$ in practice can be tedious and so we obtained an estimate via the following observation peculiar to Ghana. A decline in fuel prices does not cause a reduction in the prices of goods and services. Consequently, we may write:

$$(\tilde{v}_{c^n} - \tilde{v}_{c^o}) \propto \left| p_{l^n} - p_{l^o} \right|$$

Thus,

$$(\tilde{v}_{c^n} - \tilde{v}_{c^o}) = k\left| p_{l^n} - p_{l^o} \right| = \frac{n_l p_{l_A}}{d} \left| p_{l^n} - p_{l^o} \right|, \; p_{l_A} = \frac{p_{l^n} + p_{l^o}}{2}.$$

Therefore,

$$s_{p^n} \geq s_{p^o} + \frac{n_l (p_{l^n} - p_{l^o})d + n_l p_{l_A} \left| p_{l^n} - p_{l^o} \right|}{N_t n_p d^2}$$

$$ds_{p^n} \geq ds_{p^o} + \frac{n_l (p_{l^n} - p_{l^o})}{N_t n_p} + \frac{n_l p_{l_A} \left| p_{l^n} - p_{l^o} \right|}{N_t n_p d}$$

with equality if $p_{l^n} = p_{l^o}$. A reduction or increase in fares is completely determined by the difference in the price $p_{l^n} - p_{l^o}$, p_{l_A} and the total distance $N_t d$ as s_{p^o}, n_l and n_p remain the same for every kilometre travelled. Thus, the appropriate new fare for any destination is ds_{p^n}. The expression:

$$\frac{n_l (p_{l^n} - p_{l^o})d + n_l p_{l_A} \left| p_{l^n} - p_{l^o} \right|}{N_t n_p d^2}$$

is the price each passenger pays per kilometre for adjustment in fuel prices, called the loading. A large value of N_t means a smaller addition to existing fares. As vehicle operators are generally interested in increasing their profit, they would prefer N_t to be as small as possible. Nonetheless, any addition to any destination should lie in:

$$\left(0, \frac{n_l (p_{l^n} - p_{l^o})d + n_l p_{l_A} \left| p_{l^n} - p_{l^o} \right|}{n_p d^2} \right]$$

It should be noted that negotiations with vehicle operators about the quantum of adjustment to existing fares reduces to the proper assignment of N_t.

Expected Charge

We could not completely rely on the word of vehicle operators to determine N_t as these operators tend to be interested in maximising their profit. Consequently, we obtained a just price for any destination, called the expected charge, via the following technique.

Observe from [1] that the amount each passenger pays for her destination, ds_p, must be such that:

$$ds_p > \frac{t_f + n_l p_l + \tilde{v}_c + w_i AR_c (1+r)^i}{N_t n_p}, i = 1, \ldots, n$$

Keeping all other inputs on the RHS constant, the amount each passenger pays hinges on the number of trips a vehicle operator makes on a specified route. Consequently, for all reasonable values of $N_t = 1, 2, \ldots, M \in \mathbb{N}$, generate the paths $C_1, C_2, \ldots, C_M$ and select the median $\tilde{C}_j, j = 1, 2, \ldots, M$ for each path. Then, the expected charge, EC, can be approximated by:

$$\frac{1}{M} \sum_{j=1}^{M} \tilde{C}_j \approx EC$$

EC is the amount each passenger pays for every destination.

We may also compute:

$$\hat{S}_c = \sqrt{\frac{1}{M-1} \sum_{j=1}^{M} \left(\tilde{C}_J - \hat{\mu}_c \right)^2}, \hat{\mu}_c = E\hat{C}$$

Then an $\alpha\%$ confidence interval for the expected charge, $E\hat{C}$, is given by:

$$\left[\hat{\mu}_c - \frac{c\hat{S}_c}{\sqrt{M}}, \hat{\mu}_c + \frac{c\hat{S}_c}{\sqrt{M}}\right]$$

where c is a number that satisfies $P(-c \le T \le c) = \frac{\alpha}{100}$ and T obeys the t-distribution with $k = M - 1$ degrees of freedom (see Berstimas & Freund, 2004, p. 167).

Avoiding Rampant Changes in Transportation Fares

Individuals, businesses and organisations are typically worried about the uncertainty associated with prices of petroleum products. They want stable prices so that they can properly plan their activities. To avoid rampant change in transportation fares, we proposed the following strategy. Set:

$$p_l^c = p_{l^n} - p_{l^o}$$

as the difference in price between the old and the new per litre. Then, for reasonable past data

$p_{l_1}^c, p_{l_2}^c, \ldots, p_{l_T}^c$, up to a period T, compute $\overline{P}_l = \frac{1}{T}\sum_{t=1}^{T} p_{l_t}^c$ and set:

$$s_{p^n}^* = s_{p^o} + \frac{n_l \overline{P}_l d + n_l p_{l_A} \left|\overline{P}_l\right|}{N_t n_p d^2} \qquad [4]$$

We called [4] the stability model. Thus $| s_{p^n} - s_{p^n}^* |$ will be the gain or loss per kilometre to the vehicle operator when there is adjustment in petroleum prices. This works well in regions where the prices of petroleum products are relatively stable. The analysis can be done in a stable currency and converted to the unstable currency in regions where prices are volatile.

EMPIRICAL RESULTS

We tested our models on privately operated long distance commercial vehicles commonly used by vehicle operators on the Ghanaian road transportation sector.

Assumptions and Data Analysis

Historical prices of premium gasoline and gas oil for our analysis were obtained from the website of the National Petroleum Authority, the sole agency responsible for setting the prices of petroleum products in Ghana (http://npa.gov.gh/npa_new/index.php). Primary data of vehicular operational costs were also obtained from randomly selected vehicle operators in Ghana at major lorry stations in the capital city, Accra.

To get a sense of their operating expenses such as maintenance cost, salary etc. per week we asked respondents questions pertaining to the amount they spent weekly maintaining their vehicles, the amount they received as salary, the amount they paid their assistants daily and other expenses they incurred in a week. To reduce the impact of extreme values in the data we used 5% trimmed mean of data collected for our analysis.

Data on the amount vehicles paid for renewal of roadworthy certificates were also obtained from DVLA, the sole agency in Ghana responsible for the issuance of certificates to vehicles that ply Ghanaian roads. The amount the transportation operators' typically paid for insurance cover was obtained from the largest insurance company in Ghana, the State Insurance Company Limited. All these information are summarised in Table 1 for the various vehicle seating capacities.

TABLE 1
Operational Costs (in GHS) for Commonly Operated Private Vehicles

Costs	Private vehicle operators				
		5-seater	6-13 seater	14-19 seater	20- 33 seater
Fixed cost	Components	Amount in (GHS)	Amount in (GHS)	Amount in (GHS)	Amount in (GHS)
	Yearly insurance	83.95	93.02	96.27	135.47
	Semi-annual Roadworthy cost	37.22	40.66	60.02	60.02
	Quarterly vehicle Income tax	12	12	15	35
	Yearly assembly permits for vehicle	7	15	15	15
	Yearly assembly permits for driver	10	12	12	12
Yearly total fixed cost		223.39	249.39	375.81	422.51
Weekly total fixed cost		5.20	5.80	8.74	9.83
Variable costs ($\tilde{v}_c$)	Weekly wage of driver	50	62.5	75	87.5
	Weekly assistance wage	-	120	120	150
	Weekly booking fees	3.5	77	77	105
	Weekly parking tickets	3.5	28	28	28
	Other weekly Expenses	54	62.29	72.74	75.72
Weekly total variable costs ($\tilde{v}_c$)		111	349.79	372.74	456.22
	Vehicle cost	16500	16500	30000	40000
AR_c	Tyre cost (Long distance)	450 × 76	450 × 76	450 × 76	450 × 76

A difference in quality of vehicle of a particular type used for the transportation sector does not generally cause a difference in the transportation charges. Consequently, we assumed that all vehicles used for the transportation business were not new vehicles, and their corresponding costs in Ghana cedis are indicated in Table 1. In addition, we assumed the lifespan of all vehicles used for the operations was 10 years. This information was obtained from vehicle operators at major lorry stations in Accra. The rate of interest employed for the analysis was 31%, the current rate banks charge on loans.

We assumed drivers worked 43 weeks in a year (all Sundays and public holidays in Ghana excluded). AR_c as indicated in Table 1 is in two parts: the cost of the vehicle and the cost of tyres for the entire life of the vehicle. We also assumed that vehicle operators would replace their tyres semi-annually. For long distance vehicles 76 tyres would be required for the entire lifespan of the vehicle. Observe that the first set of tyre replacements is at the end the first sixth month of vehicle operation and, therefore, 76 tyres would be required for long-distance operations.

Column one of Table 2 shows the names of some of the common vehicles operated privately by vehicle owners. The seating capacities including for the driver are shown in column 2 and the type of fuel used by the vehicle is indicated in the last column of the table. Columns 3 and 5 are respectively the destination from Accra and the number of litres of fuel required for a full tank. Column 4 is the average number of trips vehicle operators make in a week for the various destinations. This information was obtained from questionnaires designed for the operators.

TABLE 2
Most Common Private Operator Vehicles that Ply Ghanaian Roads

Vehicle type	Seating capacity	Destination from Accra (in km)	Average number of trips in a week	Number of litres for full tank	Fuel type
609 Benz bus	33	Accra-Oda (125 km)	7	74	Diesel
Sprinter bus	27	Accra-Oda (125 km)	10.5	90	Diesel
Sprinter bus	23	Accra-Cape Coast (144km)	2.5	75	Diesel
207 bus	23	Accra-Breman Asikuma (123km)	2.5	75	Diesel
Sprinter bus	23	Accra- Bogoso (295km)	2.5	75	Diesel
Erton bus	20	Accra-Takoradi (221km)	4	88	Diesel
Urvan	15	Accra-Kpandu (203km)	8	64	Diesel
Toyata Hiace bus	15	Accra-Hohoe (224 km)	3	67	Diesel
Ford	14	Accra-Cape Coast (144km)	12	66	Petrol
Hondai Asterisks	12	Accra-Aflao (33km)	4.5	63	Diesel
Urvan	15	Accra-Ho (158km)	3	64	Diesel
Ford	14	Accra-Kumasi (258km)	3	66	Petrol
Urvan	15	Accra –Koforidua (82km)	6	64	Diesel

Data Analysis

Fig.1 shows a plot of petroleum prices from January 2007 to mid-July 2014 as posted by the National Petroleum Authority in US dollars and in Ghana cedis. It can be seen from the figure that the first 17 months from 2007 till somewhere mid-2008, the Ghanaian cedi was stronger than the US dollar. As can be seen from the prices of the petroleum products for the two currencies, the gap between the two currencies began to widen until the mid-July 2014. Thus, while petroleum products in US dollars remained relatively stable, the same quantity of products kept rising in Ghana cedis.

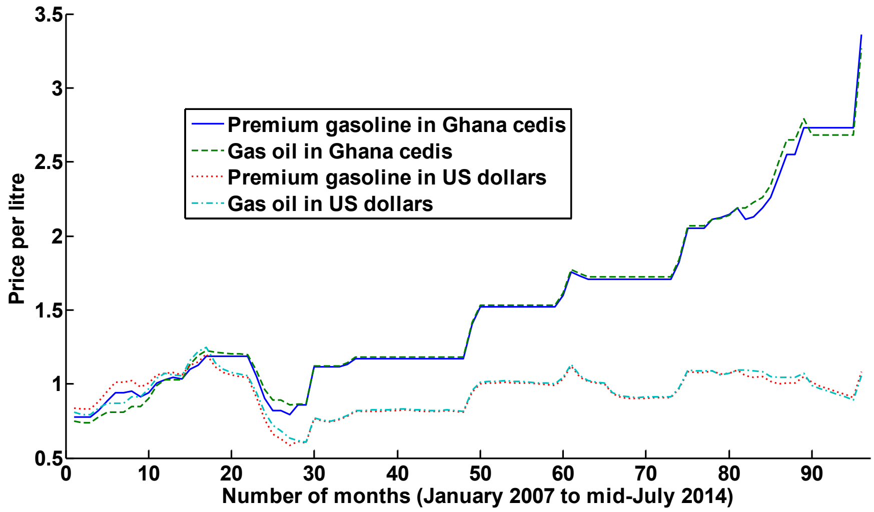

Fig.1: Comparison of petroleum prices in Ghana cedis and US dollars.

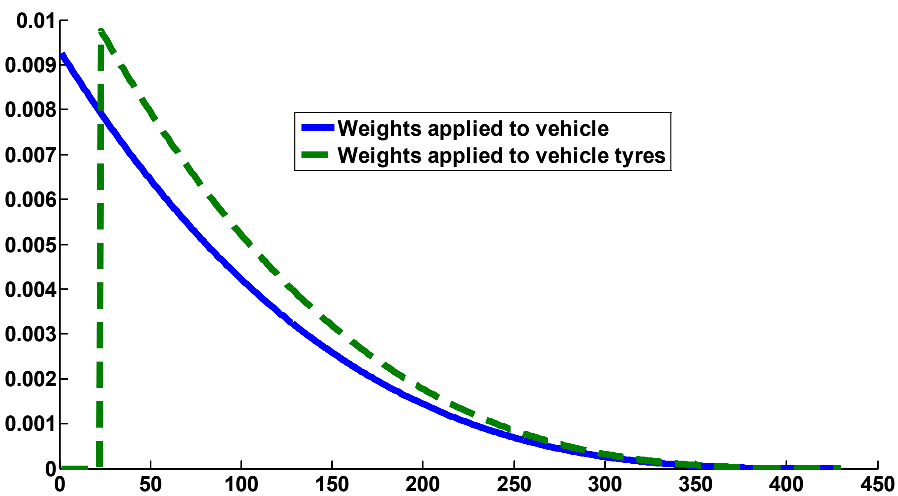

Fig.2: Weights applied to vehicle and vehicle tyres.

A number of things can be deduced from Fig.1. In the first place, it is clear that Ghana has not been able to manage her currency well against the US dollar. This has accounted for the continual devaluation of the Ghanaian cedi against the dollar. It can also be seen from Figure 1 that the prices of premium gasoline and gas oil were relatively stable in US dollars whereas they kept rising in Ghana cedis.

Fig.2 shows the weights applied to the cost of the vehicle and the cost of tyres for vehicle that had to be replaced semi-annually. Observe from the figure that in the first six months no tyre is needed to be replaced and so no weights were assigned for that period. This accounts for the initial zero weights seen in Fig.2. We also paid a greater part of the cost of vehicle and tyres in earlier years than in later years as the vehicle and the tyres were more useful in the earlier years. The weighting style was good for commuters as they would otherwise have to be paying higher transportation fares in later years. Thus, the chosen weighting style is good for both commuters and vehicle operators.

We demonstrated our analysis pictorially for a bus (Ford) that runs from Accra to Kumasi. The results for some selected destinations can found in Table 3.

TABLE 3
Expected Charge for Selected Destination from Accra, the Current Transport Fare, the Number of Trips per Week to Break Even and a 95% Confidence Interval for the Expected Charge

Destination from Accra and vehicle type	Expected charge (in GHS)	Current charge (in GHS)	Number of trips per week to break even	95% Confidence interval for the expected charge
Cape Coast (Sprinter bus)	13.37	11	4	[6.63 20.12]
Bogoso (Sprinter bus)	22.66	23	2.5	[11.30, 34.01]
Kumasi (Ford)	31.25	30	2.5	[20.28, 42.22]
Koforidua (Urvan)	13.40	10	5	[6.78, 20.02]
Akim-Oda (609 Benz bus)	16.10	12	4	[6.81, 25.24]
Ho (Urvan)	17.19	16	4	[7.97, 26.40]
Hohoe (Toyota Hiace)	32.36	20	2.5	[16.84, 47.87]
Aflao Hundai (Asterisks)	9.95	18	7	[4.76,15.14]

Kumasi: Ford (14-seater)

From [1], the lorry fare to Kumasi, over the life of the vehicle should be such that:

$$ds_p \geq \frac{381.48 + 3.36n_l + w_i AR_c (1+r)^i}{13N_t}, i, \ldots, 430$$

Substituting appropriate values for a 14-seater vehicle from Tables 1 and 2 we get:

$$ds_p \geq \frac{29.3446 + 0.2585n_l + \tilde{w}_i 2630.8(1.0072)^i + w_i 2307.7(1.0072)^i}{N_t}, i = 1, \ldots, 430$$

Typically, N_t is not known in advance but it is reasonable to expect (considering the competition from other vehicle operators) a driver to make a trip daily to Kumasi from Accra each day for six days.

Thus for $N_t = 1,2,\ldots,6$ we generate the paths $C_1, C_2, \ldots, C_6$ depicted in Fig.3. It can be seen from the figure that as the number of trips an operator makes in a week increases, the amount the commuter pays reduces. Observe from Fig.3 that profit increases at a decreasing rate as N_t increases. Thus, vehicles operators should not strive to increase the number of trips per week beyond a reasonable number as this does not lead to much profit.

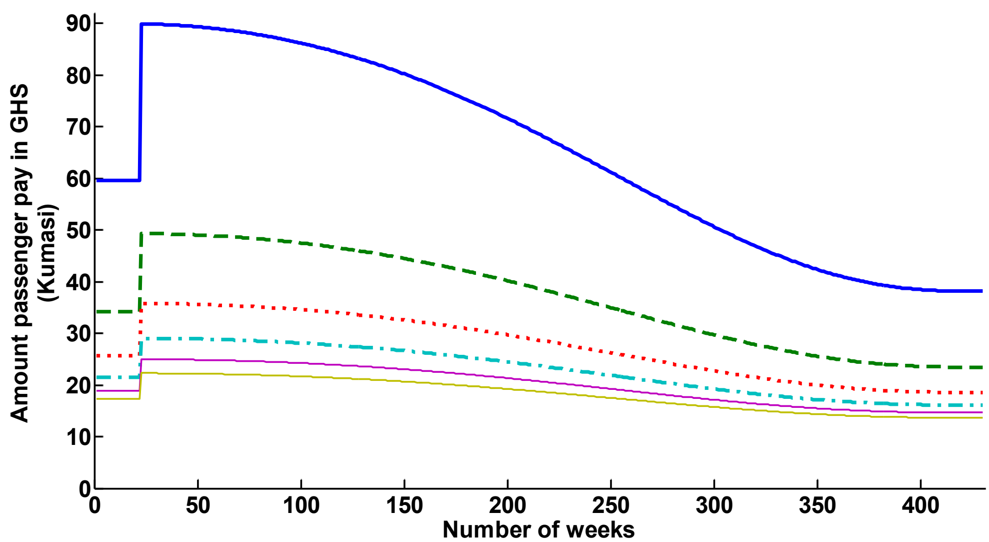

Fig.3: Possible cost for a trip from Accra to Kumasi over 430 weeks.
$N_t = 1$ (thick line), $N_t = 2$ (broken line), $N_t = 3$ (dotted line), $N_t = 4$ (broken-dotted line)

The expected charge, EC, is given by:

$$\frac{1}{6}\sum_{i=1}^{6}\tilde{C}_i \approx E\hat{C} = 31.25$$

The path of the median charge against number of trips in a week is depicted in Fig.4. The minimal number of trips that break even for the vehicle operator on this route is 2.5 trips per week (i.e. the vehicle operator has to do two trips in a week and also load passengers' half-way through a town between the two cities to break even). Note that as operators cannot increase transportation fares arbitrary to make up for a fewer number of trips in a week, the profitability region is smaller than the shaded region in Fig.4. Consequently, if the lorry fare setting is not set right, there is the tendency for operators to over-speed on the road to stay in business but this comes along with causing potential accidents.

It can be seen from Fig.4 that for the operator to make a profit for the expected charge GHS31.25, the number of trips to make a week has to be greater than 2.5. The vehicle operator breaks even if 2.5 trips is made in any particular week. Table 3 shows similar results for expected charge and the corresponding 95% confidence interval for some selected destinations. We have included the current fares and the number of trips a vehicle operator must make to break even.

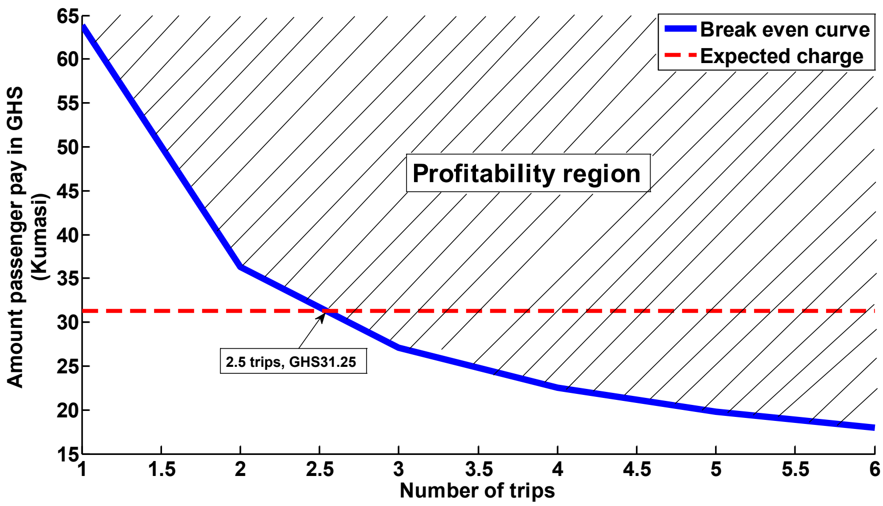

Fig.4: Median charge (solid line) for 6 paths and the expected charge (broken line).

DISCUSSION

A number of things can be done to stabilise the Ghanaian cedi. There is the need to minimise the importation of vehicles and other transportation devices such as motorbikes and bicycles and for Ghana to manufacture her own transportation. After all, Ghana was manufacturing its own vehicle, called "Boafo", in the early 1980s. That technology and effort should be revamped. The cost of tyres form a substantial operating cost of vehicles in the Ghanaian transportation sector. Consequently, we call on the government to revive the Bonsu tyre factory as this would halt the importation of used tyres imported into the country. Also, Tema Oil refinery has to be rehabilitated to allow for the refining of locally produced crude oil (Ghana currently produces crude oil in commercial quantities). Thus, there will be no need to export locally produced crude and import the same crude in US dollars. In addition, the government can create buffer stocks of oil for future use. This would ensure that there would be enough oil for continuous use so that even when world market prices go up, the country would have existing oil stocks to rely on. The public transportation system should be made comfortable (it is largely overcrowded, causing passengers to endure the journey in heat and discomfort) and reliable (it is largely not time bound) for people to patronise. Other means of transportation such as cycling to work and short distances should be encouraged. This would mean making provision for cyclists in the construction of roads in Ghana. Hedging the price of oil over a period of time (perhaps semi-annually) is another strategy that can be employed. This strategy would minimise the frequency of fuel price adjustments.

In recent times, a number of microfinance institutions have offered loans to drivers to utilise for purchasing vehicles at the interest rate of over 50% per annum, a much higher rate of interest than the 31% employed in this study. As vehicle operators cannot arbitrarily increase their fares, they have to increase the frequency of trips per week to increase their profits in order to stay in business. The division of the Bank of Ghana responsible for the supervision of microfinance institutions should place a cap on the maximum rate of interest these institutions can charge on loans offered to vehicle operators, thereby minimising the interest rate, and as a result, lowering the number of trips per week as well as the number of accidents on Ghanaian roads.

CONCLUSION

The model we have developed is a very useful tool for setting the road transportation fares. It allows transportation planners, coordinators, administrators and vehicle operators to determine every point in time of the vehicle's lifespan whether their operations are profitable. Some passengers are undercharged while others are overcharged on some routes and so there is the need for adjustment of the fare to reflect the true cost of operation. Prudent financial management is especially necessary in the early years of operations by vehicle operators. Significantly, the stabilisation of the transportation fare must be preceded by the stabilisation of the Ghana cedi.

REFERENCES

Andoh, C., Mills E. A., & Quaye, D. (2012). Public private partnership as an alternative source of financing highways in Ghana. *Annals of Management Science, 1*(1), 61-82.

Arndt, C., Benfica R., Maximiano, N., Nucifora, A., & Thurlow, J. T. (2008). Higher fuel and food prices: Impacts and responses for Mozambique. *Agricultural Economics, 39*(s1), 497-511.

Bertsimas D., & Freund, R. M. (2004). Data, models, and decisions: The fundamentals of management science. *Dynamic Ideas*, *167*.

Delsalle, J. (2002). *The effects of fuel price changes on the transport sector and its emissions simulations with TREMOVE* (No. 172). Directorate General Economic and Monetary Affairs (DG ECFIN), European Commission.

Jago, D., & Sipe, N. (2007). Oil vulnerability in the Australian city: Assessing socioeconomic risks from higher urban fuel prices. *Urban Studies*, *44*(1), 37-62.

Ortuno-Padilla A., & Fernandez-Aracil, P. (2013). Impact of fuel on the development of the urban sprawl in Spain. *Journal of Transport Geography*, *33*, 180-187.

Pizer, W. A. (2006). The economics of improving fuel economy. *RESOURCES-WASHINGTON DC-*, *163,* 21-25.

Setwayan, D. (2014). The impacts of the domestic fuel increase on prices of the Indonesian economic sectors. *Energy Procedia, 47,* 47-55.

Shang, G., & Guo Y-J. (2005). Trip cost analysis of bus transit rapid transit. In *Proceedings of the Eastern Asia Society for Transportation Studies*, Vol. 5, 2195-2210.