Impacts of Fuel Tax on the Reduction of Emissions from Road Transport Sector in Bangladesh

KAMRUZZAMAN MOHAMMAD HAIDER[1*],
MIZUNOYA TAKESHI[2],
YABAR HELMUT[3]
[1] Master's Student, University of Tsukuba. Email: s201726058@s.tsukuba.ac.jp
[2] Associate Professor, University of Tsukuba, Email: mizunoya.takeshi.ff@u.tsukuba.ac.jp
[3] Associate Professor, University of Tsukuba, Email: yabar.mostacero.h.ke@u.tsukuba.ac.jp

Abstract

Transport sector consumes 47% of petroleum products in Bangladesh in 2015. At present, Bangladesh emits 82.77 mill tons of CO2 in 2017. Though it is not a big amount compared to the developed countries, but the emission is growing at 10% per annum. Recent statistics from Bangladesh Road Transport Authority shows vehicle growth rate is almost 10%. Bangladesh's Intended Nationally Determined Contributions sets 5% and 15% as unconditional and conditional reduction in greenhouse gas emission (GHG) by 2030. Many countries apply fuel tax to curb GHG emissions. So, this study applies the basic log-log regression model to calculate the price elasticity of demand for vehicles miles travelled. Then, COPERT software uses to find road emissions for both businesses as usual and different fuel tax scenarios. Reduction in GHG emissions by 5% and 15% by 2030 uses to find a range of fuel tax. Finally, a benefit-cost analysis applies to compare social benefits of emission reduction over road users' cost to find a range of good fuel tax. This study hopes to find a range of fuel tax which not only reduces road transport emissions but also helps to achieve the emission reduction targets from road transport sector.

Keywords: Fuel Tax, COPERT, GHG emissions

1. Introduction

Bangladesh is experiencing rapid economic growth recently. Its per capita real GDP has increased at 5.39% per annum over the last 10 years. Agriculture, industry and service sector are three broad sectors of the GDP. Among them, service sector contributes 56.28% of total GDP. At present, contribution of transport sector in service sector is increasing at a faster rate (8.6% per annum) than GDP. Transport sector consumes 47% of petroleum products consumed in Bangladesh which is mostly imported (Energy Scenario Bangladesh, 2016). Petroleum and oil import constitute 11% of the total imports (https://tradingeconomics.com/bangladesh/imports). Bangladesh emits 82.77M mt carbon di oxide in 2017(https://ycharts.com, LA August 21, 2018). Though it is not a big amount compared to the developed countries, but the emission is increasing at 7.3% per annum which is also faster than GDP growth rate. According to UN, population in Bangladesh may rise to 265.43 million by 2050. Thus, given this growth in transport sector and the population, it is essential to address CO_2 emission in Bangladesh.

At present, Bangladesh spends 90% of its budgetary allocation of transport sector in road sector. This stimulates vehicle growth in land transport. Recent statistics from Bangladesh Road Transport Authority shows vehicle growth rate is almost 10%. This rapid growth of vehicle population demands more investment in road sector. But the government allocation is less than the required fund for sustainable growth. So, the government established road fund for the development of this sector. Currently, fuel tax has been recommended for potential revenue sources of the Road Fund (Strategic Transport Plan for Dhaka, 2015).

Road transport is a significant source of CO2, NOx, CO and NMVOCs, however it is also a small source of N2O, CH4 and NH3. Bangladesh sets Intended Nationally Determined Contributions in greenhouse gas reduction by 5% and 15% as unconditional and conditional reduction by 2030. Fuel tax can be a good instrument to achieve the target. But, historically, climate externalities have played a small role (if any) in motivating fuel taxes. There might be debate whether fuel tax is powerful enough or not. But the experience of fuel taxes in Europe, Japan and a few other countries is in fact a full-scale demonstration of how powerful economic instruments can be (Sterner, 2007)!

2. Literature review

A sound understanding of transport elasticities is crucial in making transport policy decisions. Such knowledge can inform attempts to achieve emissions reductions and help show how traffic levels might be manipulated by making some change to the cost of driving (Graham and Glaister, 2004). Numerous studies have been conducted so far to explain how road transport gasoline demand elasticity is related to income, price, and other variables, such as vehicle stock and vehicle characteristics. These studies differ depending on the types of data, time stratification of the data (monthly, quarterly, annually), model structure (static or dynamic), demand specification (functional form and variables included), and econometric approach. Static models usually give coefficients that fall between the short and long run estimates of dynamic models that capture the fact that adaptation takes time, due to costs of adjustment and imperfect information (Crottea, Noland and Graham, 2010).

An underlying assumption used in policy analysis on the effectiveness of higher gasoline taxes and the optimal gasoline tax is that consumers react to gasoline tax changes the same as to gasoline price changes. Li, Linn and Muehlegger (2012) shows that the gasoline tax has a stronger effect for VMT than the tax-exclusive price.

Most studies of motor gasoline demand focus on the industrialized countries (McRae, 1994). However, few studies concentrate on developing countries. McRae (1994) uses econometric model to find elasticities for eleven developing countries including Bangladesh. He found short run price elasticity -0.35, income elasticity 0.016 for Bangladesh using dataset from 1973 to 1987. Lin and Zeng (2013) used Eq. (1) to estimate intermediate run VMT elasticity for China. Their model was static. Bangladesh is experiencing rapid growth in per capita GDP and per capita energy consumption which China experienced earlier. So, double log model can give a good prediction of intermediate run VKT elasticity for Bangladesh.

Price elasticity of VKT

$$\log VKT = \beta_0 + \beta_p \cdot log\, P + \beta_I \cdot log\, I + \in \quad \dots\dots\dots\dots\dots\dots\dots\dots(1)$$

Here, VKT= Vehicle Kilometers Travel by a vehicle class
P= Real Price of Fuel
I= Real Disposable Income
βp=Price Elasticity of Fuel Demand
βI=Income Elasticity of Fuel Demand
∈= error

We can estimate hypothetical vehicle kilometer travel using elasticities due to fuel tax increase by the following equation.

$$VKT_{Hd} = VKT_d \times \left(\frac{\rho}{P}\right)^{\beta p} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

Here, F_{Hd}= Hypothetical Vehicle Km travel
ρ= Fuel Price with Tax
P=Fuel Price

The IPCC has prepared a guideline for calculation of road transport emission. But IPCC Guidelines present two sets of emission factors based on the vehicle fleets in USA and Europe. The emission models are also based on the statistical data available. Thus, the vehicle types used, and the available statistics are related to the legislation (e.g. vehicle licensing) in those countries (Eggleston and Walsh, 2001). A review of vehicular emission standards for Bangladesh (2012) shows that Bangladesh follows European emission model COPERT.

European emission model COPERT is used to estimate emission inventory in some countries like Spain, Italy and Mexico. For example, Buro´n et al. (2003, 2005) uses COPERT III to estimate vehicular emission inventories in Spain from 1988 to 2010. In China, Cai and Xie (2007) use COPERT III model to establish vehicle emission inventory from 1980 to 2005. Literature shows there are some pollution studies in Bangladesh. Begum, Hopke and Markwitz (2013) studied fine particulate matter in air at Dhaka. Iqbal, Allan and Zito (2016) studied vehicle emission at some major roads in Dhaka city. Ahmed, Fujiwara, & Zhang (2010) suggests modal shift, fuel switching, energy efficiency and technical improvement in transport mode can reduce 39% GHG by 2025 compared to 2007. However, no studies have been found on vehicle emission inventory and fuel tax in Bangladesh so far.

3. Methodology

We shall use secondary data published by government agencies, international organizations and journals. First, calculate price elasticity of fuel demand using equation (1). Then, we shall review existing and future vehicle technology to match vehicle class with COPERT model. We shall rearrange vehicle population data according to the COPERT vehicle class. Then we input fuel specification, meteorological data, activity data, driving condition and other variables in COPERT IV. We calculate road transport emission for base case using those variables. We, then, calculate hypothetical VMT for different fuel tax rate using equation (2). At this stage, we assume that impose of new fuel tax has the same impact as the rise in fuel tax. We calculate road transport emission for different fuel tax rate. By comparing both scenarios, we get emission reduction due to fuel tax. We calculate social benefits by multiplying emission reduction with social costs of emission.

$$\text{Social Benefit} = \sum (\text{Emission reduced X Social Cost}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Then, we review road user cost to get total road user cost due to fuel tax. We calculate benefits over costs ratio.

3.1. Calculation of emissions

The emission of each particular pollutant is calculated by COPERT IV based on the emission factor of each particular vehicle category and the corresponding mileage traveled, using Eq. (4).

$$Q_m = \sum\left(V_i \times M_{i,j} \times EF_{i,j}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where Q_m represents the emission (tons) of pollutant m; V_i is the population of vehicles in category i; $M_{i,j}$ is the annual mileage (km) for vehicles in category i under driving condition j; and $EF_{i,j}$ is the emission factor (g/km) of vehicles in category i under driving condition j. $EF_{i,j}$ for each vehicle category were calculated by COPERT IV, while V_i and $M_{i,j}$ will be collected from secondary sources.

3.2. Identification of parameters for COPERT IV

The calculation of emission factors by COPERT IV program requires the compilation of reliable data for the following specific parameters:
(a) fuel-related data like the sulfur contents in gasoline or diesel;
(b) meteorological data like the ambient temperature and the Reid vapor pressure (RVP);
(c) driving condition data like average speeds, driving share in urban, rural and highway setting, cold start time;
(d) mileage of vehicle class.

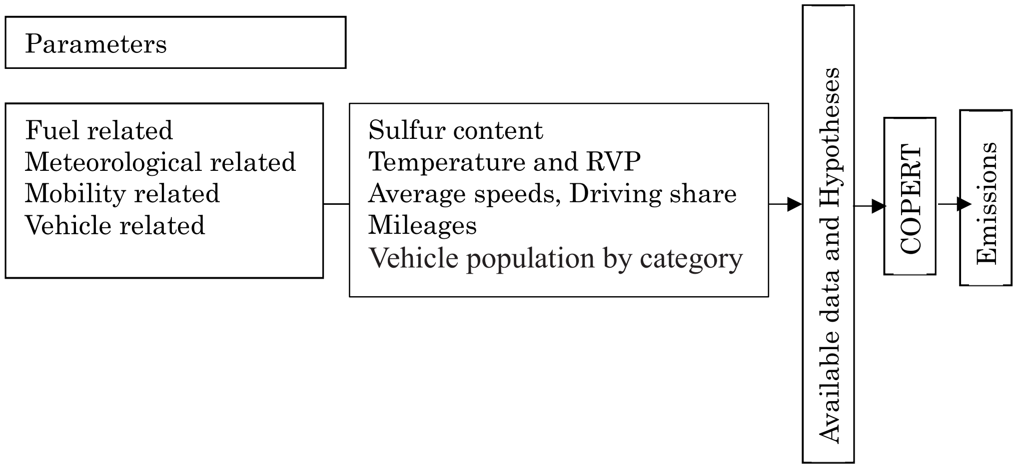

Fig 1: Summarization of detailed procedures for estimation of emissions

4. Expected outcome and discussion
   The expected result will be an inventory of road transport emission at national level. We shall get percentage of each pollutant according to vehicle class. This will help us to understand which vehicle class is responsible for a pollutant. We shall also get the pollutant amount according to the driving share in urban, rural and highway settings. This will help us to understand future pollution control scenario. We shall find a range of fuel tax which reduces road emissions. We shall also get social benefits of each fuel tax scenario. Our B/C ratio > 1 means social benefits exceeds individual cost of fuel tax. By considering B/C ratio and emission reduction targets, we shall get a good fuel tax range.

5. Conclusion

Finally, many developed countries have implemented fuel tax. There is no single rule for determining optimal fuel tax. Though fuel tax rates differ from country to country, their function converge to curb the transport emissions. These emissions are responsible for health impact and global warming. Bangladesh as a developing country should seriously consider this option. Because, it is the most vulnerable country to the climate change impacts. But the tax should not be a burden on the people. It should be high enough to cover the social costs of emission. Hence our study can add good contribution to this purpose.

References

1. Ahmed, A., Fujiwara, A., & Zhang, J. (2010). Land Transport Sector in Bangladesh: An Analysis Towards Motivating GHG Emission Reduction Strategies. *Journal of International Development and Cooperation, 16*(2), 55-68
2. Begum, B. A., Hopke, P. K., & Markwitz, A. (2013). Air pollution by fine particulate matter in Bangladesh. *Atmospheric Pollution Research, 4*(1), 75-86. doi:10.5094/apr.2013.008
3. Burón, J. M., Aparicio, F., Izquierdo, Ó, Gómez, Á, & López, I. (2005). Estimation of the input data for the prediction of road transportation emissions in Spain from 2000 to 2010 considering several scenarios. *Atmospheric Environment, 39*(30), 5585-5596. doi:10.1016/j.atmosenv.2005.06.013
4. Cai, H., & Xie, S. (2007). Estimation of vehicular emission inventories in China from 1980 to 2005. *Atmospheric Environment, 41*(39), 8963-8979. doi:10.1016/j.atmosenv.2007.08.019
5. Crôtte, A., Noland, R. B., & Graham, D. J. (2010). An analysis of gasoline demand elasticities at the national and local levels in Mexico. *Energy Policy, 38*(8), 4445-4456. doi:10.1016/j.enpol.2010.03.076
6. Department of Environment, (2012). REVISIONS OF VEHICULAR EMISSION STANDARDS FOR BANGLADESH
7. Eggleston, S., & Walsh, M. (2001). EMISSIONS: ENERGY, ROAD TRANSPORT. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories,* 55-70. Retrieved from https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_3_Road_Transport.pdf.
8. Energy Scenario Bangladesh (2016). Ministry of Power, Energy and Mineral Resources Last accessed on August 21, 2018) http://hcu.portal.gov.bd/sites/default/files/files/hcu.portal.gov.bd/publications/0e59b1e1_cbfd_426c_9d8c_7acdabde37cb/171012%20Energy%20Scenario%20_Bangladesh%202015%20-16.pdf
9. Goodwin, P., Dargay, J., & Hanly, M. (2004). Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Review. *Transport Reviews, 24*(3), 275-292. doi:10.1080/0144164042000181725
10. Graham, D. J., & Glaister, S. (2004). Road Traffic Demand Elasticity Estimates: A Review. *Transport Reviews, 24*(3), 261-274. doi:10.1080/0144164032000101193
11. Iqbal, A., Allan, A., & Zito, R. (2016). Meso-scale on-road vehicle emission inventory approach: A study on Dhaka City of Bangladesh supporting the 'cause-effect' analysis of the transport system. *Environmental Monitoring and Assessment, 188*(3). doi:10.1007/s10661-016-5151-4
12. Li, S., Linn, J. and Muehlegger, E. (2012). Gasoline Taxes and Consumer Behavior. *SSRN Electronic Journal*.
13. Lin, C. C., & Zeng, J. (2013). The elasticity of demand for gasoline in China. *Energy Policy, 59*, 189-197. doi:10.1016/j.enpol.2013.03.020
14. Mcrae, R. (1994). Gasoline Demand in Developing Asian Countries. *The Energy Journal, 15*(1). doi:10.5547/issn0195-6574-ej-vol15-no1-9
15. Ntziachristos, L., Gkatzoflias, D., Kouridis, C., & Samaras, Z. (2009). COPERT: A European Road Transport Emission Inventory Model. *Information Technologies in Environmental Engineering Environmental Science and Engineering,*491-504. doi:10.1007/978-3-540-88351-7_37
16. Sterner, T. (2007). Fuel taxes: An important instrument for climate policy. *Energy Policy, 35*(6), 3194-3202. doi:10.1016/j.enpol.2006.10.025