The Impact of The Unified Vehicular Volume Reduction Program in Reducing Air Pollution

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ABSTRACT

Air pollution has been one of the main problems in Metro Manila. A large percentage amounting to this pollution arises from mobile sources or vehicle congestion. In addition to this, a significant drop in the price of fuel resulted to an increase in congestion. This paper analyses if UVVRP plays a major role in reducing air pollution. However, results using TSLS have shown that congestion does not contribute to the same amount of pollution as it did before due to advancement in technology

Keywords: UVVRP, Fuel Price, Congestion, Air pollution

1. INTRODUCTION

Pollution has brought numerous problems to society especially in urban areas. One of the major factors contributing to the air pollution is from vehicle emission. Vehicles are one of the major point sources of pollution that emits various particulates that, at some degree, cost the society loss in valuable resources. The air quality of urban areas is slowly deteriorating especially for the case of Metro Manila. With the lack of needed resources, increase of air pollution is inevitable especially for the case of developing countries like the Philippines. Despite this, there is an existing provision of a law that pursue balancing economic development and environmental protection. In the section 3c of the Republic Act 8749 or the Clean Air Act of 1999 (An *Act providing for a comprehensive air pollution control policy and for other purposes)* mentioned that "Focus primarily on pollution prevention rather than on control and provide for a comprehensive management program for air pollution". One example of preventing air pollution is to locate the sources of which and determine the means of reaching of a significant drop in the drop of Air Pollution, especially for the case of Metro Manila. Vehicle emission is defined as "Mobile source" by RA 8749.

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The Metro Manila Development Authority (MMDA) implemented Modified Unified Vehicle Reduction Program (UVVRP), commonly known as “Color Coding Scheme”, a type of Traffic Demand Management that addresses the issue of the traffic congestion through the use of driving restrictions. In June 1996, the Coding scheme was only imposed for the purpose of reducing the number of vehicle traversing Metro Manila road during the period of road construction on going in the metro using the odd-even scheme. Eventually, the temporary program turned into a long-term program that has been the basis of permanent policy of the government in addressing the traffic situation. The program has evolved into numerous modification until it reach the current scheme, where the number of vehicles are assumed to be equally distributed into ten digits (ending license plate number from 0 to 9) and two numbers are allocated on each weekday (Monday to Friday, restrictions are lifted on weekends and holidays), ideally, this reckons a 20 % decrease in number of vehicle traversing Metro Manila road. Some cities in the metro implement the 7:00 am to 7:00 pm car restriction, some have window hours starting from 10:00 am to 3:00 pm and others do not promulgate it at all(due to the fact that vehicles only goes to the places where the Central Business Districts are located). The latest modification of UVVRP was made on 2010 whereas the vehicle restriction includes public transportation vehicle.

However, there was a 1999 study by the MMDA that it does not give significant reduction of vehicles on the road. In fact, from the ideal 20% reduction, it was only 4.3 % reduction in the number of vehicles traversing during the coding scheme hour. The impact of UVVRP affects the vehicle owners and has responded variedly in order for them to adjust in the restriction of UVVRP. A person, who belongs to the upper class, tends to buy a new car, while the middle class tend to buy a 2nd hand car. Owners also drive the vehicle before and after the restriction hour (but these adjustments results into a longer time of rush hour) or shift into using the public transportation. This adjustment differs greatly affects the changes in the amount of pollution in the metro. We want to know the impact of UVVRP or the coding scheme in the traffic congestion and further, the Air Quality situation of Metro Manila whether is an alteration in the amount of travel demand. We assumed that there is a short term effect and the long term effect of the coding scheme since the policy was originally designed for short-run travel demand management in response to temporal effects of road construction in Metro Manila. This paper only aims to study the part of air pollution where it is emitted by the Mobile source since it is the major emitter of air pollution.

This policy is very important for the case of Metro Manila since the traffic conveys significant economic losses of an amount of 6 billion peso from 2.4 billion pesos if there is no government initiative that will address this problem according to a Japan International Cooperation Agency (JICA) study. There is already a question regarding the effectiveness of the Unified Vehicular Volume Reduction Program since it is only designed for short-run travel demand management. The outdated program is also expected to address more traffic problems as the government starts numerous road constructions happening in the Metro Manila Road. The first implementation of UVVRP coincides with heavy road construction at that time. The efficient volume reduction of vehicle crossing the metro will most likely reduce “mobile sources”. These mobile sources are also considered harmful to well-being of the people. According to

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Environmental Management Board of the Department of Environment and National Resources (EMB-DENR) and the World Health Organization (WHO), there is a significant improvement of the air quality of 130ug/Ncu.m in Manila but still not that good because the air quality standard set by the WHO is below 90 ug/Ncu.m.

Prominent policy that can be in par with UVVRP is the Hoy-no-Circula (HNC) policy of Mexico City in Mexico given the same economic conditions and scenarios of addressing the congestion problems of both countries. The difference between HNC and UVVRP is that HNC incorporates a policy tackling the air quality of the metro which the later does not mention any environmental provisions. There are also other policy of driving restriction that uses the same types of scheme that researcher has looked into: Rodizio or Rotation in Sao Paulo in Brazil, and a temporary road rationing-turned into permanent policy in Beijing that started during the 2008 Summer Olympics.

The researchers wanted to know the impact of the Unified Vehicle Volume Reduction Program on air pollution. The study will determine the effectiveness of the UVVRP not only includes the reduction of the traffic congestion in Metro Manila but also the conciliation of the air quality of the atmosphere in Metro Manila.

2. LITERATURE REVIEW

2.1 AIR POLLUTION

Studies have shown that air pollutants in the urban transport sector have caused many health and environmental problems Proost and Dender (2001). Most of these pollutants come from greenhouse gas emissions and particulates. The results in this study have shown that transport policies and air pollution regulation would have a very significant impact on the urban transport inefficiencies like congestion. The Republic Act 8749 or the “Philippine Clean Air Act of 1999” is a law that was implemented to lessen the air pollution and improve the air quality by requiring private and public vehicles to undergo emissions tests and be inspected. But for some instances, this edict cannot be felt across Metro Manila. Records show that 70% - 80% of the air pollution in Metro Manila came from mobile sources and 20% - 30 % comes only from industrial factories (DOST, 2014).

The increasing number of air pollution is inevitable in emerging economies especially for the case of Metro Manila since it is the center of economic growth for the country. If negligence persist from the agencies concerning air pollution, emissions from motor vehicles could lead in to the deterioration of air quality and consequently, affecting health of the citizens. Areas with concentrated air pollution increase the risk of premature mortality by 26% Quah and Boom (2003). It was also suggested the use of cleaner fuels to avoid emission of harmful pollutants in the air and to remove old vehicles in the road which are the main contributors of air pollution (DENR, 2014). In the U.S., the implementation of their version of Clean Air Act made their gasoline prices go up because cleaner fuels was used to reduce their air pollution Chakravorty, Nauges, Thomas (2009). Heterogeneity in the fuel price following the Clean Air Act caused the fuel price to change.

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Quah and Boon (2012) showed the economic lost (US$362 damages on health) brought by the total particulate air pollution in Singapore. Different policies and regulations also have something to do with air quality. Chen, Huang et al. (2009) analyzed the three policies: Carbon tax, renewable energy standard and low fuel standard and its effect on greenhouse emissions. By utilizing a numerical simulation model they showed that the carbon tax policy has an unclear impact on biofuel consumption but reduces greenhouse gas emissions. Renewable energy standard causes a large reduction in the U.S. gasoline consumption. However, the other two polices have a larger reduction in greenhouse emissions.

For Tanaka (2015) he viewed the relationship of the environmental regulation and infant mortality in China. Using the difference in differences approach results show that when TCZ policy was assigned to a city infant mortality decreased by 20%.Tanaka also said that those children who have low maternal education tend to be particularly susceptible to fluctuations in air quality. Proost and Dender (2001) compared the effectiveness of alternative fuel efficiency, environmental and transport policies in a specific urban area. Utilizing a TRENEN-URBAN model, results show that transport policies causes a large shift in modal and time distribution in traffic. Lastly, policies about emission on fuel efficiency only cause small shifts in total travel of private vehicles.

Lastly, there are few information publicized with respect to the cost of air pollution in the Philippines. Ambrey, Flemming and Chung-Chan (2012) used the Indirect Utility Function to measure the cost of air pollution in Australia. In this way, we may be able to determine the actual impact of Air Pollution in Metro Manila. The marginal external cost of air pollution was mainly derived from the damages caused by air pollution to health and environment (Proost and Dender, 2001). An increase in the number of air pollution appears to correspond on a drop in the life satisfaction (MacKerron and Mourato, 2008). PM_{10} was used as the measurement of air pollution.

2.2 UNIFIED VEHICULAR VOLUME REDUCTION PROGRAM

Traffic management needs a rigorous work to study with. Dealing with the leading problem, construction of additional roads, includes increasing degree of congestion. As mentioned above, congestion can lead into a drastic rise in air pollution as slower vehicle amassed in a particular area, thus exponentially increasing the degree of air pollution. It is obvious to say that in order to reduce congestion is to build new roads for the vehicles to traverse with. But this can lead to induced demand or an increase in demand when there a lot of supply available. The other way to have a congestion mitigation is to altering one side of the problem, or both: the traffic demand or the supply of transportation service (Kurzhansky and Varaiya ,2015). A much cheaper and faster way to address the problem is to modify the demand side. Congestion pricing is one good example of which. Lindsey (2012) discuss the three dimensions that road pricing serves three functions: controls the usage of roads, generates revenue and warrants more investment for roads. However this scheme is hard to be implemented for developing countries, how much more for the case of the Philippines. So far there are toll gates in the Philippines only for the purpose of recuperating the investments made by the government or the private partners that invested in the highways that have tolls.

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Gallego, Montero and Salas (2013) analyzed a travel demand management policy called “Hoy-No-Circula” by the Mexican Government that was implemented on Mexico City. It is a road rationing and driving restriction scheme. This policy banned private vehicles from driving one weekday per week to lower the air pollution and congestion in the city. They used the plotted average daily concentration levels for peak hour. They said that the switch of mode of transportation, which is from private vehicle to public transportation, increases the demand for public utility vehicle thus decreasing the number of traversing vehicles. While on the other part of switch of transportation, households opted to buy cheaper vehicles but less efficient vehicles. All in all there is a temporary decrease in the number of vehicles traversing the metro. It is a short-run policy that effectively addresses the reduction of number of air pollution through the decreasing congestion. As the time goes, there will be adjustment on the daily routine of the vehicle owners, and this adjustment can worsen the air pollution situation (Davis, 2008).

Contrary to HNC, the Chinese counterpart of this driving restriction disagrees to the argument of Gallego et.al and Davis. According to Sun, Zheng and Wang (2014) a more stringent implementation of driving restriction can alleviate traffic congestion in the city. They argued that methodological case used by the former can change the tide of having a conclusion. The HNC includes other time-varying variables. Beijing is a solid proof of this scheme. High compliance of the driving restriction can reduce congestion up to the extent of reducing air pollution (Viard and Fu, 2015). However, China is changing in terms of economic prosperity and cannot be treated as how Sun et.al and Viard and Fu.

H1: An increase in the UVVRP violators, leads to a decrease in congestion

2.3 FUEL PRICE

It was studied that an increase in fuel price can reduce congestion and air pollution. According to Bento, Hughe and Kaffiene (2013) an increase in fuel price will reduce the amount of vehicles in the road because drivers response to this by carpooling or the sharing of one car by many people. When this happens, cars on the road will reduce thus resulting to a reduction of car emissions. Congressional Budget Office (2008) stated that when there is an increase in fuel price consumers will shift from road to rail transport, will be encouraged to car pool, or change their workplace in order to reduce the distance that they will be traveling. Brand (2009) also stated that when fuel price are high the following things will happen: more use of public transportation, more fuel efficient cars would be preferred, shorter highway traffics, and lastly more opportunities for ridesharing matches.

Delasaut (2013) studied the change in travel behaviour when there is an increase in fuel price for France. Using OLS method on the four models, it was shown that in the short term and long term when an increase in fuel price happens, there would be a reduction in road traffic. However for Goodwin, Dargay and Hanly (2004) it was said that fuel price has a low impact on traffic because of the increase in wage along with the increase in price of the fuel. Barnett and Knibbs (2014) examined the effects of a higher

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fuel price in Brisbane and concluded that there is a decrease in traffic emissions when the price of fuel increased. And by raising the cost of using vehicles there will be a reduction in air pollution.

The usage of cleaner fuels has also help reduce air pollution. Chakravorty, Nauges and Thomas (2008) examined the effects of the U.S. Clean Air Act to gasoline prices. There are different standards to this regulation examples are the Reformulated Gasoline Program and the Oxygenated Gasoline program. By using OLS techniques it was found that this boutique fuels can cause the gasoline prices to increase. This was done by increasing the cost of refining and segmenting the markets. With this, an improvement of air quality and reduction from car emissions will most likely happen. According to Hughes (2011) biofuels such as ethanol when blended with gasoline can reduce air pollution and greenhouse gas emissions.

Drivers in the U.S. also tend to drive slower when there is an increase in the price of fuel. According to Wolf (2014) a reduction of 0.27 mph happens when there is a dollar increase of the price of gasoline per gallon. Lin and Prince (2011) showed how the fuel price volatility can impact the consumer's price elasticity demand for gasoline. Results showed that when the volatility of fuel price increases the demand for gasoline decreases in the medium run. Also, consumers tend to be less responsive to the change of fuel price this means that the volatility of the gasoline price has an effect to the consumer's elasticity demand for gasoline. For Burke and Nishitateno (2013), they studied the impact of gasoline pump prices on road sector gasoline demand and the fuel economy of many countries. It was stated that pump prices could affect the vehicle choices of the consumer and a country that has a 10% higher gasoline price than the other similar country would have a 2% increase in their fuel economy.

Another possible way to reduce air pollution is setting policies on the price of the fuel. According to Young, Hyun and Moon (2011) by estimating the gasoline price elasticity and using a partial equilibrium model it was shown that when there is a rise in gasoline tax a fall on greenhouse emissions would follow. It was also proven that carbon tax policy is one of the effective ways to reduce emissions. Li, Linn and Muehlegger (2011) also stated that taxing gasoline can decrease its consumption and help the consumers to choose more fuel efficient vehicles that are more cleaner and not that harmful to the environment. Klier and Linn (2013) compared the United States and Europe's new fuel economy and how fuel prices can impact their economies. It was suggested that raising fuel taxes would raise the fuel economy and reduce CO2 emission rates in Europe rather than the U.S. which fuel taxes are much lower. It was shown that fuel prices have a smaller impact on Europe's C02 emission rates because most people living there drive less and prefer to take public transportation. Cozad and Lariviere (2012) used an event study to measure a sudden increase in fuel price leads to a simultaneous substitution on the extensive and intensive margin. By using the oil price increase of 1979 as the event, it was shown that there was a large fall on CO2 emissions from passenger vehicles and the driving behaviour of people tend to change frequently.

H2: An increase in fuel price, leads to a decrease in congestion

2.4 CONGESTION

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Congestion has been a major variable when it comes to air pollution. Countries across the world have done their part in trying to reduce congestion to better their environment and the health of its people. According to Armah et.al. (2010), government policies which include investing more on public transportation, Traffic Demand Management (TDM), and supply management, were some of the proposals provided to solve congestion. Other authors including, Boquet (2013), Fabian and Gota (2009), and Issa (2014) have also included in their the study the use of TDM. Traffic Demand Management is the improvement of overall activity and mobility in the present traffic system Issa (2014). This is to provide multiple transportation management strategies that would reduce congestion in the area which in turn would reduce air pollution. One of these is the HOV lanes provided by the author Issa, 2014. HOV or High occupancy vehicles would have lanes available to them only, for example bus lanes. In addition to the TDM, transit improvements are also an option to reduce private vehicle use.

According to Boquet (2013), the rail transit in metro manila is very insufficient compared to other countries. We had a population of around 12 million people in 2013 for metro manila alone and it cannot be expected to be handled only by these 3 operating railways. According to Boquet (2013), metro manila has the lowest length in kilometers of railways, compared to other Asian megacities. CO2 emissions from the transport sector in the Philippines have accounted for 38% of the total from fuel combustion alone and private vehicles have become the focus of this country's investment rather than alternative transportations (Fabian, 2009). According to Fabian (2009), results have shown that TDM and Motor Vehicle Inspection System (MVIS) have had the largest effect on reducing air pollution in the Philippines.

Fuel taxes which led to fuel conservation resulted to better urban infrastructures and reduction of congestion due to the rise of fuel prices Fabian (2009). Fuel prices have also been a means to reduce congestion according to Delsalle (2002), the increase in fuel prices created a negative impact on travel demand, fuel consumption, and emissions. The study presented a model called TREMOVE which was used to simulate the effects of various types of policy measures on the key factors driving transport emissions. According to authors Gorham (2002) and Kazimi and Small (2000), congestion is positively related to air pollution where the degree of pollutants depends on the area where in this case metropolitan areas or cities where large amounts of congestion are found. Rivasplata, 2012 concluded congestion being positively related to air pollution as well and supports the claim on TDM and investing on public transportation would improve on reducing congestion and increasing environmental status.

A study has given a fundamental law on highway or traffic congestion which talks about how opening more roads to avoid congestion, would eventually lead again to congestion. (Hsu and Zhang, 2014) This study shows that congestion can only be avoided if we find the equilibrium road elasticity of traffic. This means if the elasticity is less than 1, more transport infrastructures may be built in order to accommodate the congestion. According to a study done by Viard and Fu (2015) driving restrictions have both a negative and a positive result; Positive because if implemented, these restrictions may help reduce air pollution and vehicle congestion and negative because this would

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lower economic activity and increase commute costs. (Su, 2011) Due to urbanization, this input of more households in the area will result to higher congestion and an increase in fuel consumption. Not to mention the amount greenhouse gas emissions this would emit and contribute to global warning.

According to a different study, long-run growth is attainable through investing more in transport infrastructures and private mobility systems because this would satisfy household demand for transportation and increase supply for labor (Bonatti and Campiglio, 2012). Gasoline taxes and public transportation have helped alleviate a number of problems concerning the environment and congestion (An and Zhang, 2011). Policies given by Santos (2010) namely, “command and control” and “incentives based”, would also help with the different types of externalities revolving around road transport. Command and Control policies are regulated by the government to encourage consumers and producers to alter their behaviour in a way that reduce vehicle emissions and fuel standards. Parry (2002) discovered that congestion taxes help achieve efficiency during freeway congestion. Congestion taxes are fees imposed on road users during peak hours. This would help reduce or efficiently reduce traffic.

H3: An increase in congestion leads to an increase in air pollution

3. SYNTHESIS

Established on the discussion of the variables above, Unified Vehicular Volume Reduction Program, Fuel Price affects Congestion. The UVVRP Policy aimed to decrease the number of vehicles traversing in Metro Manila. Higher Fuel Prices caused the private vehicle user to car pool, to take public transportation and to take shorter travel distance, meaning, and lesser congestion. As congestion increase, air pollution through increases drastically due to the traffic buildup in the road. The number of vehicles emits particulates that can contribute to air pollution.

4. CONCEPTUAL FRAMEWORK

For our simulacrum, on the part of the stage, Congestion represents the instrumental variable while UVVRP and Fuel Price represent our independent variables. On the second stage part, Air Pollution is the dependent variable while congestion is the independent variable. We are trying to research if these independent variables would have an effect on air pollution whether it may be positively or negatively. This simply shows the relationship of our independent variables with the dependent variable.

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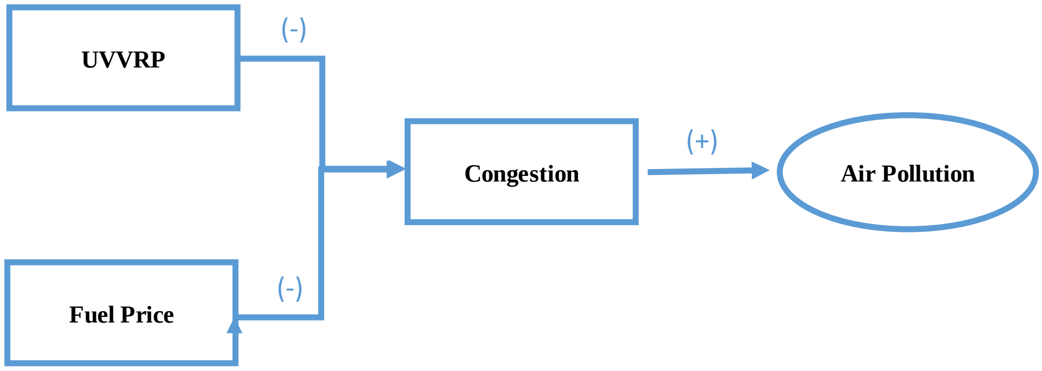

Figure 1.1: Simulacrum

5. HYPOTHESIS

H1: An increase in the UVVRP violators, leads to a decrease in congestion
H2: An increase in fuel price, leads to a decrease in congestion
H3: An increase in congestion leads to an increase in air pollution

6. METHODOLOGY

This thesis (The Impact of Unified Vehicular Volume Reduction Program in Air Quality) seeks to identify the impact of the travel demand management scheme on reducing the air pollution in Metro Manila.

The researchers gathered their quantitative data from local government and international institutions. For the UVVRP, they used the number of violators for the Unified Vehicular Volume Reduction Program in Metro Manila. The Metro Manila Development Authority (MMDA) only publishes the number of violators on a monthly basis due to the length of the processing of applications of drivers' licenses for the violators, which usually takes a month; starting from the day of confiscation to the day of repossession of the driver's license. The fuel price data, collected from the Organization of Petroleum Exporting Countries (OPEC), is called as OPEC Basket Price (OBP) since the Philippines we import their our petroleum products from countries such as Saudi Arabia and United Arab Emirates. OBP is the weighted average oil prices measured in dollars per barrel for oil producing countries who are members of OPEC. For the congestion variable, we used the Traffic Advisory announcement of MMDA as an auxiliary for congestion which consists of There are five degrees of traffic conditions namely: light traffic, light to moderate traffic, moderate traffic, moderate to heavy traffic and heavy traffic. The researchers assumed that this can be treated as a categorical variable and assigned increasing numerical values as the degree of traffic increases. Data for air pollution was obtained from the Air Quality Management Section of the Environmental Management Bureau (EMB-AQMS). The EMB-AQMS recently shifted from Total Suspended Particulate (TSP) to Particulate Matter-with an aerodynamic diameter of less than or equal to 10 (ug/Ncu.m) (PM-10) (Environmental

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Protection Agency). Although EMB-AQMS released a daily monitoring status of Air pollution around Metro Manila, these datum are subject to National Ambient Air Quality Guidelines Quality Assurance and Quality Control (QA/QC), which only publishes Monthly Average Continuous Ambient Air Quality.

The researchers need to estimate the unknown parameters; however, a regression must avoid the risk of autocorrelation of errors between explanatory variables. In order to avoid this, they used the Two Stage Least Square (TSLS) method to identify the impact of UVVRP on air pollution based on time-series data at the metro-wide level. A simultaneity problem also exists. The econometric specification estimated the instrumental variable which is only correlated to the explanatory variable. This was patterned after the model used by Souche (2010).

The first stage regression is a multiple regression of UVVRP with fuel price as the independent variable while congestion as the dependent variable. For the second stage, congestion was used as an independent variable while air pollution as the dependent variable. These are the regression equations:

$$\theta = \beta_0 + \beta_1 UVVRP - \chi_1 FP + \ni \quad (1)$$

Function (1) describes the effect of UVVRP and fuel price to congestion.

$$\gamma = \lambda_0 + \lambda_1 Cong + \ni \quad (2)$$

Function (2) describes the effect of congestion to the air pollution in Metro Manila.

7. RESULTS AND DISCUSSION

The Unified Vehicular Volume Reduction Program was implemented by Metro Manila Development – Traffic Discipline Office through the Traffic Ticket Management Division. The division was in charge of compilation of the Apprehension Report of Violation code 176 or the violators of UVVRP. The number of violators peaked at around 1,700 and down at 900 violators of UVVRP. The figure 4.1 shows the line plots of the monthly number of apprehensions starting from January 2012 until December 2014.

The Organization of Petroleum Exporting Countries (OPEC) Basket Price covers the oil prices of its member states. OPEC control almost 40% percent of oil world market. The Philippines is highly oil dependent and imported its oil from these member-countries. The drop in oil price was mainly due to the drop in demand on oil. Figure 4.2 shows the line plots of the monthly average of crude oil prices starting from January 2012 until December 2014.

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The traffic advisories were broadcasted by MMDA – Traffic Control Center through their monitoring arm "MetroBase". The advisories were divided into five categories. The researchers assigned values on each type of advisory based on the traffic intensity it represents. They obtained the data on the official twitter account of MMDA (as suggested by an MMDA staff when they procured the UVVRP data from the main office.) Figure 4.3 shows the line plots of the aggregated monthly intensity of traffic in Metro Manila starting from January 2012 until December 2014.

The air quality of Metro Manila was recorded by the Environment Management Bureau – Air Quality Management Section of the Department of Science and Technology. The data was measured through Particulate Matter-with an aerodynamic diameter of less than or equal to 10 (ug/Ncu.m) (PM.10). Figure 4.4 shows the line plots of monthly treated quality assurance/quality control of air pollution (PM.10) in Metro Manila starting from January 2012 until December 2014.

In finding the impact of UVVRP on air pollution, the researchers need to have a method that addresses simultaneous scenario. The researchers came up with TSLS as the method for the model. The model was divided into two parts and runs the regression: the first part and the second part ordinary least squares.

Table 4.1 shows that the initial result showed a low R-squared, making it unreliable as the desired model. The Durbin-Watson is 0.57 which is not within the critical value. The critical values for 36 observation with 3 variables is 1.35 to 1.59 which shows that the d-value is way below the critical value, resulting to a strong evidence of positive autocorrelation. The autocorrelation can also be affirmed by the Breusch-Pagan Test for Heteroscedasticity on Table 4.2. It resulted into a 0.05 p-value for the probability Chi-Square which rejects the null hypothesis of homoscedasticity.

In order to solve the problem of autocorrelation (and heteroscedasticity), the researchers added a variable that can explain the current and lagged value of error terms. This can be possible with the Box-Jenkins (BJ) methodology using the moving average (MA) model. The MA model was determined by the use of correlogram. There are significant spikes through the lags in the Autocorrelation function pattern which indicates a MA as the type of model to be used. The results in table 4.3 shows favorable results in comparison with the former.

Table 4.4 and table 4.5 verifies the methodology that the researchers underwent through the use of BG LM Test and BPG Heteroscedasticity test.
The null hypothesis of no serial correlation is accepted since the probability Chi-Square of 0.06 is more than 0.05. Also, the null hypothesis of homoscedasticity is accepted since the probability Chi-Square of 0.11 is more than 0.05. By comparing the adjusted R-square (since they are dealing with multiple regression models), the result improved from 25% to 56% which means that 56% variation of traffic in Metro Manila can be explain by UVVRP violators and oil prices. The p-value of oil prices which is 0.009 is less than 0.05 therefore the impact of Oil price to traffic is significant. However the p-value of UVVRP which is 0.9868 is more than 0.05 therefore the impact of UVVRP on air pollution is insignificant.

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The second part of the TSLS model also uses OLS with BJ methodology using the moving average (MA) model. The MA model was determined by the use of correlogram. There are significant spikes through the lags in the autocorrelation function pattern which indicates that MA should be the type of model used. The durbin-watson of the second stage, which is 1.5, satisfied the condition of critical values for 36 observation with 3 variables (1.35 to 1.59). The adjusted R-square can explain 46% of variation of air pollution. There is an inverse relation between congestion and air pollution however, this is insignificant because the p value is more than 0.05. The researchers also ran the method using TSLS directly which can support the first method of running two ols.

8. CONCLUSION

The researchers aimed to analyze the impact of the UVVRP on reducing air pollution in Metro Manila (EDSA in particular). The effects of each variable were parallel to what the researchers have hypothesized. In other words, oil price has an inverse relation with congestion while UVVRP violators was also have an inverse relation with congestion but it is insignificant. This might be because the drivers now realizing that there is a way to bypass the Unified Vehicular Volume Reduction Program. At the same time, congestion does not have a strong impact on air pollution which may be due to factors such as firmer policies that address air pollution.

9. POLICY IMPLICATION

Based from the research, since congestion has insignificant to no impact on air pollution and the current specification of UVVRP does not greatly impact the congestion, UVVRP policy does not impact the air pollution. This is opposed to the version of UVVRP in other countries that is also aimed at reducing air pollution. The researchers suggest modifying the coding scheme from that of reducing the vehicle usage for only once a week to an odd-even scheme. This may be drastic but it certainly calls for the situation given that there are a lot of constructions of infrastructures happening. Besides, UVVRP again, is a short-term solution to addressing traffic congestion brought by the lack of a long-term solution to the increasing traffic demand. The researchers also recognize other factors that might affect air pollution (to be tackled in another research) which are already taking place such as The Clean Air Act. The smoke belcher can be charged against the said law. Another means of reducing congestion is through heavy improvement of public transportation. With this improvement, the people may now opt to choose to ride public transportation over their cars. Increasing toll fees, limiting road construction, prohibiting parking on some roads and implementing a no-parking-space-no-car policy are some alternatives that may help reduce congestion.

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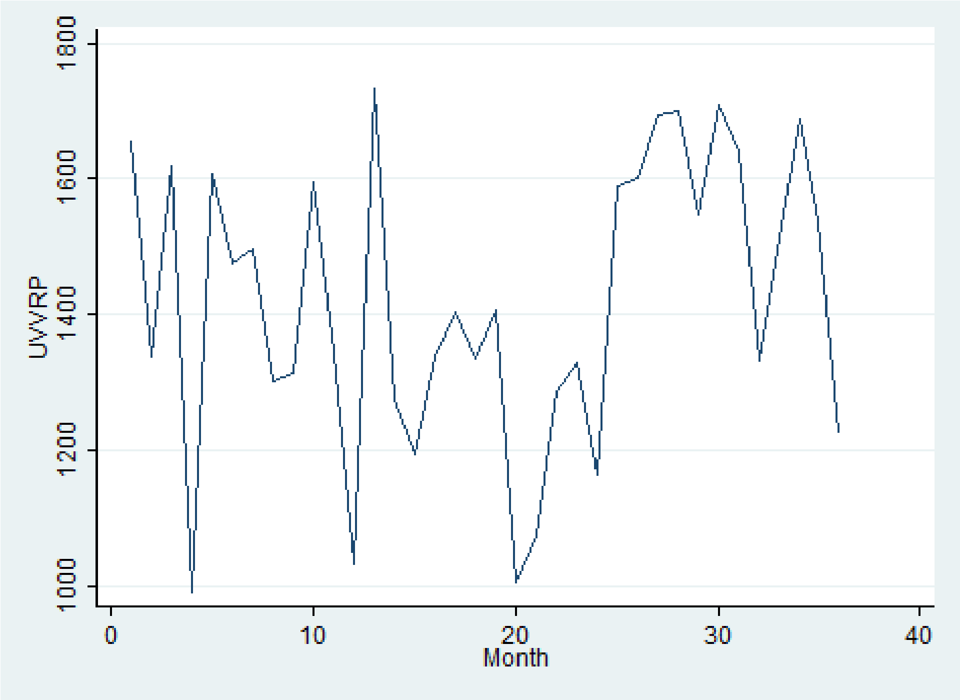
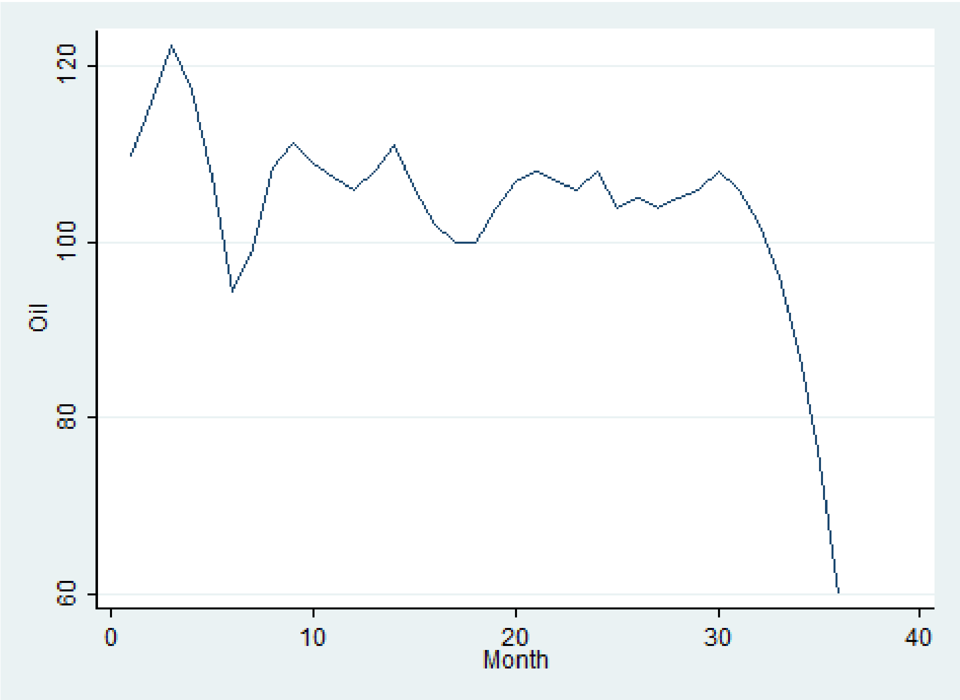
10. APPENDIX

Figure 1. Number of UVVRP Violator



Source: MMDA

Figure 2. Historical prices of crude oil per barrel in dollars



Source: OPEC

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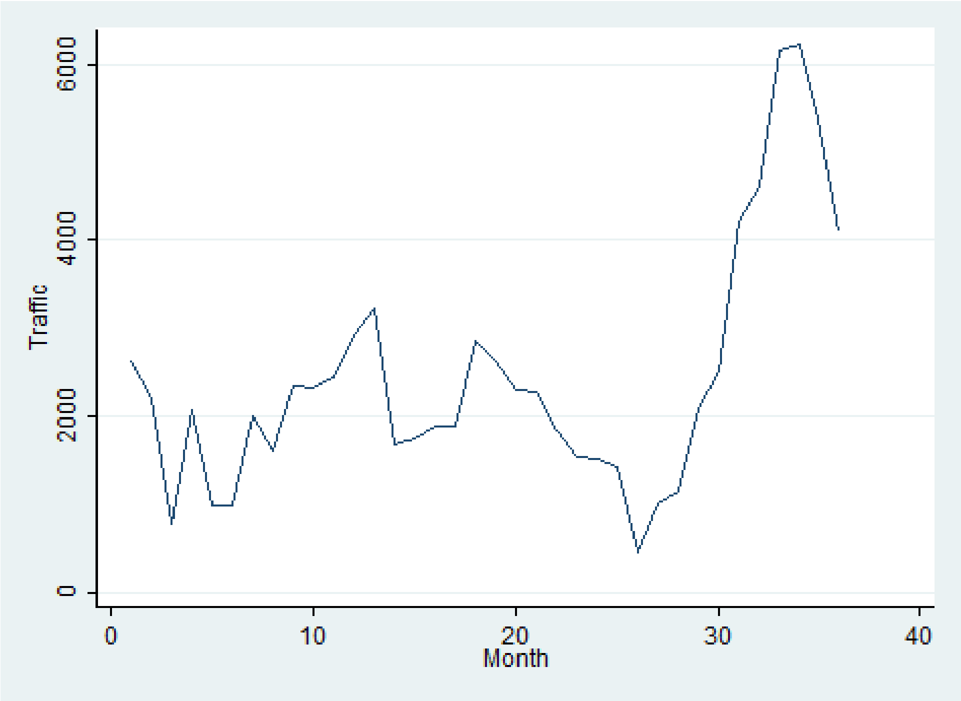
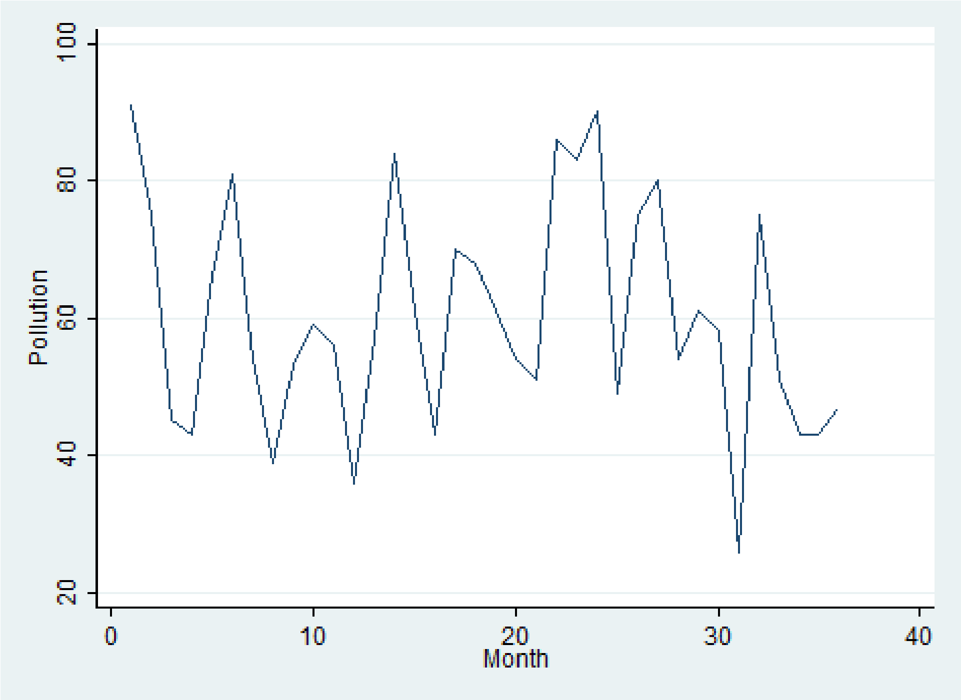
Figure 3. Number of mentions of Traffic Advisory in Metro Manila



Source: MMDA

Figure 4. Particulate Matter diameter 10 in Metro Manila



Source: DENR-EMB

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Dependent Variable: TRAFFIC
Method: Least Squares
Date: 10/19/15 Time: 22:44
Sample: 1 36
Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	26918.28	7110.350	3.785789	0.0006
UWRP	0.722547	2.779566	0.259950	0.7965
OIL	-199.6927	54.60575	-3.656991	0.0009

R-squared	0.291752	Mean dependent var	7225.278
Adjusted R-squared	0.248828	S.D. dependent var	4065.615
S.E. of regression	3523.677	Akaike info criterion	19.25205
Sum squared resid	4.10E+08	Schwarz criterion	19.38401
Log likelihood	-343.5369	Hannan-Quinn criter.	19.29811
F-statistic	6.796920	Durbin-Watson stat	0.573564
Prob(F-statistic)	0.003373		

Table 4.1: First Stage OLS

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	4.571897	Prob. F(2,33)	0.0177
Obs*R-squared	7.810797	Prob. Chi-Square(2)	0.0201
Scaled explained SS	7.907605	Prob. Chi-Square(2)	0.0192

Table 4.2: Heteroscedasticity Test: BGP

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Dependent Variable: TRAFFIC
Method: Least Squares
Date: 10/20/15 Time: 01:39
Sample: 1 36
Included observations: 36
Convergence achieved after 34 iterations
MA Backcast: 0

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	24391.37	6600.482	3.695392	0.0008
UVVRP	-0.029190	1.753941	-0.016643	0.9868
OIL	-165.7206	59.88715	-2.767216	0.0093
MA(1)	0.659177	0.146375	4.503356	0.0001

R-squared	0.593922	Mean dependent var	7225.278
Adjusted R-squared	0.555852	S.D. dependent var	4065.615
S.E. of regression	2709.506	Akaike info criterion	18.75136
Sum squared resid	2.35E+08	Schwarz criterion	18.92731
Log likelihood	-333.5245	Hannan-Quinn criter.	18.81277
F-statistic	15.60085	Durbin-Watson stat	1.365836
Prob(F-statistic)	0.000002		

Table 4.3: OLS (MA) Model

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.165129	Prob. F(2,30)	0.0118
Obs*R-squared	9.221080	Prob. Chi-Square(2)	0.0599

Table 4.4: BG LM Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.734999	Prob. F(2,33)	0.1921
Obs*R-squared	3.425279	Prob. Chi-Square(2)	0.1804
Scaled explained SS	4.430066	Prob. Chi-Square(2)	0.1091

Table 4.5: Heteroscedasticity Test: BPG

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Dependent Variable: AIR_POLLUTION
Method: Least Squares
Date: 10/20/15 Time: 10:37
Sample: 1 36
Included observations: 36
Convergence achieved after 11 iterations
MA Backcast: 0

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	72.23393	3.228497	22.37386	0.0000
FITTED	-0.000840	0.000458	-1.833907	0.0757
MA(1)	0.788193	0.118537	6.649356	0.0000
R-squared	0.467156	Mean dependent var	72.87454	
Adjusted R-squared	0.434862	S.D. dependent var	14.44735	
S.E. of regression	10.86089	Akaike info criterion	7.687869	
Sum squared resid	3892.645	Schwarz criterion	7.819829	
Log likelihood	-135.3816	Hannan-Quinn criter.	7.733927	
F-statistic	14.46591	Durbin-Watson stat	1.508248	
Prob(F-statistic)	0.000031			

Table 4.6: OLS (MA) Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	84.95505	7.543562	11.26193	0.0000
TRAFFIC	-0.001811	0.000953	-1.900780	0.0667
MA(1)	0.740475	0.295887	2.502560	0.0178
R-squared	0.552775	Mean dependent var	72.04951	
Adjusted R-squared	0.523921	S.D. dependent var	14.29594	
S.E. of regression	9.863979	Sum squared resid	3016.241	
Durbin-Watson stat	2.116063	J-statistic	1.282564	
Instrument rank	7	Prob(J-statistic)	0.864327	

Table 4.7: TSLS (MA) Model

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Oil	UVVRP	Traffic	Air Pollution
110	1655	8033	95
116	1339	7056	78
122	1619	2430	69
117	991	6093	64
107	1607	3165	79
94	1474	3019	84
99	1497	6315	67
109	1303	5036	55
111	1315	6975	58
109	1594	6867	79
107	1343	7378	81
106	1033	8693	81
108	1734	9371	72
111	1276	4969	93
106	1194	5121	86
102	1338	5504	73
100	1403	5572	80
100	1335	8478	68
104	1406	7626	54
107	1006	6735	51
108	1075	6667	57
107	1287	5418	81
106	1330	4498	83
108	1163	4412	86
104	1590	4125	102
105	1601	1315	90
104	1695	2952	98
105	1701	3328	81
106	1547	6137	67
108	1710	7464	76
106	1641	12310	54
102	1331	13306	53
96	1514	18020	53
87	1687	18126	56
76	1538	15650	65
60	1225	11946	54

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