Modeling the Effects of Traffic Congestion on Economic Activities - Accidents, Fatalities and Casualties

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Abstract: Congestion is mainly caused by a desire for people to drive their cars coupled with a failure by constitute authorities to check and balance various indices and factors that contribute to incessant number of vehicles, road maintenance and traffic regulations. If sufficient investment is made to ensure affordable public transport options, implement vehicle regulatory and a better infrastructure the incidence of congestion would decrease in the society. Growing traffic and number of registered vehicles in urban areas are linked with a growing number of accidents and fatalities, especially in the society. Accidents account for a significant share of recurring delays. As traffic increases, people feel less safe to use the roads. It is observed that traffic congestion in the urban centers could be viewed in mandatory daily trips such as workplace, home or voluntary. Mandatory as the name implies is often performed within fixed schedules while voluntary is based on the person's decision to embark on such trip at any given point in time. In many places, persons along for the ride are forced away from public transport by the private companies. Increasing fare prices, especially on the trains, make driving a car with its associated high fuel costs cheaper than public transport. By pushing people back to their cars again they only exasperate the congestion problem. These situations necessitate the need to model the causes and effects of traffic congestions based on the number of vehicle registrations and casualties.

Keywords: Fatalities, Accidents, Casualties, Congestions, Significance, Regression, Correlation, Traffic

1. Introduction

Urban population growth and urbanization are major factors influencing decisions with regards to central business districts development activities worldwide. One of the significance is the traffic congestion issue as a global phenomenon in the management of capital cities, giving the level of population and activity concentration. United Nations first reported the urban population dominance in 2010, revealing that urban areas are home to 3.5 billion (50.5 percent) of world's population and cities population is expected to increase to 5.2 billion in 2050 [1].

Traffics are the vehicles or automobiles that are on a road at a particular time [2]. They are the automobiles that are utilized for the purpose of transportation. The traffic is the major means of terrestrial transportation in urban areas.

Traffic congestion is a condition on any network as vehicle use increases and is characterized by slower speeds, longer trip times, and increased queuing. The most common example is for the physical use of roads by vehicles. When traffic demand is greater enough that the interaction between vehicles slows the speed of traffic stream, congestion is incurred. As demand approaches the capacity of a road, extreme traffic congestion occurs. When vehicles are fully stopped for periods of time, this is colloquially known as traffic jam [3].

The advancement of 21st century's science and technology has a great impact to the world's automobile trends. The growing of urbanization and influence of the western culture has cultivated the diverse and sound updated utilization of the automobiles [4]. The Transport sector contributes about 2.5 percent of the total GDP of a country which is equivalent to Shs1, 428 billion at current prices in 2016/2017 financial

year in Uganda. [5]. The need of time, influence of globalization and steps towards the era of civilization has drastically changed the overall automobile industry supported by wants, needs and desire of people [6]. Owing to the fact, and stipulated intensification towards the public/private ownership of automobiles that are encountered on the roads; the roads in urban cities are about to surrender in front of the crowd. As observed evidenced by the researcher who travels every day for school, it takes about an hour to travel a distance of 10 kilometers in cities with traffic congestions which is a lot of time as compared to traveling in cities where the situation is not observed [7].

The crowded traffic might have various explicit and implicit impacts to human society, civilization and overall beauty of the city [8]. In fact, to diagnose these effects it is enough wiser to go to the root causes of traffic hassles and congestion. The degree and depth of traffic hassles in may mount on various facts and figures but their impact and responsibilities may vary. Here, huge attempt was made to diagnose the open secret facts and the underlying hidden grass-root causes and effects responsible for traffic jam. The main purpose of the study is to diagnose the cause and effects of traffic congestion so that it can be the most powerful benchmark to smoothen the sound traffic that exists in the society. In the cause of this research, efforts were made to ascertain the degree and depth of traffic Jam, the causes of traffic jam and the effects of traffic congestion to the socioeconomic growth and development. Also, this research work examined the relationship between the causes and effects of traffic congestion on the economy. This study was focused on the causes of the heavy traffic congestion around and within the urban cities with its effects on the different socio-economic activities in the capital cities.

This research was basically based on identifying the causes and effects of traffic congestion within on economic growth and development. This study helps to knock out the various problems and their possible alternative solutions. It is a milestone to level the road traffics and consequently smoother the trade, communication and transport. The findings and recommendation of this study will be helpful in planning both in road division and import of vehicles. The depth and the degree of the root cause of traffic jam will help to eradicate the problems on step ahead before worsening the situation. It is also advantageous for the preparedness towards prevention. This study also leads us to focus on the minor factors, which are deviated from the main stream and have acquired poor visibility in the real situation. The main motive was to identify these feasible factors which have strong impact on traffic congestion.

The reason for carrying out this study targets various stakeholders of the society ranging from inquisitive students, teachers, planners, riders, passengers, pedestrians and traffic police. Explicitly or implicitly the audiences of the study are all residents of United States along with visitors who are to be the victim of the traffic congestion.

Historically, the capital city developed as the market square in ancient cities [10]. The market serves as forerunner and point where people, particularly farmers, merchants and consumers gathered on market days to exchange, buy, sell goods, services, ideas and socially interact. The city's centre later grew and developed as fixed capital city location point for retail trading and commerce. This serves as the city's oldest point or core area, which often is the convergence point of major transportation nodes. The 21st century capital cities within metropolitan areas characterized by activities such as residential, retail, commercial, university, entertainment, theatre, shopping malls or complexes, government offices, financial institutions, medical centre, professionals' offices and cultural centre etc.

The capital city is majorly marked by skyscraper structures, high land value, especially at roads intersection. This buttresses the rationale for location of high-rise structures. The existing road networks at the capital cities are usually narrow coupled with inadequate off-street parking facilities that make on-street parking unavoidable. This reduces the road's right of way (row), thus marginalizes its design capacity leading to traffic congestion. Investigation into reasons for the usual traffic congestion in a capital city cited in [11] says "falling real car prices, and improving fuel efficiency, comfort, quality, and reliability of cars have added to usage. Consumers have shown strong preferences for comfort, time saving, convenience, flexibility, reliability, privacy, and refuge from harassment attributes of single-occupant vehicles. So, demand for cars and hence road space has risen with income and value of time". In addition, cars offer substantial time saving advantage over public transport as passengers must get to a bus pick-up point and wait for a bus or train for 15-20 minutes, and then work from the drop-off point to the destinations [12]. All of these discourage the use of public transport by urban residents.

Traffic congestion is a condition on transport networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queuing. The most common example is the physical use of roads by vehicles. When traffic demand is great enough that the interaction between vehicles slows the speed of the traffic stream, it results in congestion. Traffic congestion is a temporal condition on networks that occurs as utility increases, and is characterized by slower speeds, longer trip times, and increased queuing. When volume of traffic is high and so heterogeneous that the interaction between vehicles slows down the speed of traffic, traffic congestion is the result. As demand approaches the capacity of a road or of the intersections along the road, traffic congestion sets in. When vehicles are fully stopped for the period of time, this is colloquially known as a traffic jam [13].

Urban congestion also comes as a result recurrent congestion. The consequence of factors that cause regular demand is on the transportation system, such as commuting, shopping or weekend trips. However, even recurrent congestion can have unforeseen impacts in terms of its duration and severity. Mandatory trips are mainly responsible for the peaks in circulation flows, what this means in essence is that most of the congestion in urban areas are recurring at

specific times of the day and on specific segments of transport system. This is true for most urban centers in United States. In fact some major roads in Ibadan city exhibit these characteristics.

Single centered cities experience traffic Jam in part because of the tendency to concentrate business activities in one area. For example most business activities such as commercial banks, hotels, restaurants and shopping centers are located in the city [14]. Also worthy of mention is the lack of a coordinated approach towards land use and transport planning. With unplanned and scattered densities, it is almost impossible to establish an efficient and congestion free transport system. A large number of people living in urban areas such as use private transport every day to reach their work stations which are located in state capitals. Added to this is the flood of motor vehicles in the cities and its suburbs. Statistics show that 70% of all motor vehicles are registered in urban cities according to [15].

People spend an increasing amount of time commuting between their residence and workplace as a result of congestion. An important factor behind this trend is related to residential affordability as housing located further away from central areas (where most of the employment remains) is more affordable [16]. Pollution, including noise, generated by circulation has become a serious impediment to the quality of life and even the health of urban populations. Most vehicles especially diesel trucks generate a lot of carbon dioxide that is huge enough to impair the vision of the driver of an oncoming vehicle in the opposite direction resulting to accident most times [17].

Alternate routes are also a problem. Cities have limited capacity to expand due to poor funding and planning restrictions preventing building on green belt spaces. Cities are forced to work with the routes they already have. If they can't increase the number of lanes it leads to congestion. Employers can also play a part in dealing with congestion. Congestion almost always happens when people are traveling to and from work. Traffic congestion has eased in recent years as a result of growing unemployment and the introduction of more flexible work hours. By adhering to the traditional routines, there's a greater chance of congestion. Everyone has to travel to and from work at the same time each day. A lack of public transport, or poor public transport options, will also cause problems. If there isn't enough buses, trams, or local trains people are forced to take their cars to work. The ratio of passengers to vehicles decreases, whereas if they were able to take the bus people would feel less of a need to drive their cars.

2. Research Methodology

A combination of both quantitative and qualitative research design was used to obtain detailed information that helped to establish the causes and effects of traffic congestion. Under descriptive we choose cross-sectional study because of the time limitation. Respondents used were selected based on systematic random sampling and purposive

sampling. Systematic random sampling was used when it came to getting samples of riders, passengers and pedestrians so as to reduce the chance of bias. Samples of thirty respondents were chosen. Purposive sampling was used when it came to selecting traffic officer respondents which focused on the right traffic officers found at the busiest streets.

Open and closed questions which required specific answers were adopted. Questions were printed in clear and simple language possible for the respondents to understand. The respondents selected the correct options by ticking the correct answers. Here, questions were determined beforehand while others could arise during the course of the conversation. The interviews were also done on individual-oriented basis to allow expression of personal view points. The use of face to face interviews was employed because of the following reasons; provision of first-hand information, rich data collection, cost effective, speedy and ability to clarify the questions, clear doubts and could add new questions where it was necessary. Hence, adequate scrutiny was espoused to get information and record relevant information for the research so as to minimize predisposition.

Considering the case study and its relevant as the center of research in contemporary findings, the data published in statista.com was used for most of the quantitative analysis of the situation [18]. First, examination of the relationships that existed between the data was carried out to establish the dependent and dependent variables. Hence, the situation was modeled in a simple linear regression format. The model was done on the casualties as dependent variable and the number of registered vehicles as the independent variable. After that, both casualties and registered vehicles were modeled with respect to time to predict future values Analysis and interpretation of the findings resulting were carried out on the data collected. The unit of analysis is the causes and effects of traffic congestion. The issues from the results used for analysis include the prevention or curbing traffic congestion. It owes to the research objectives and research questions that need to be answered.

3. Result and Discussion

There were more than two million, three hundred thousand traffic-related injuries recorded in 2013 in the United States [20]. Furthermore, there was an incessant record of the number of traffic-related fatalities in the United States from 2010 to 2016 as a result of the increase in the number of registered vehicles. When the two indices were analyzed using SPSS, there exists strong positive correlation which is an indication the more vehicles registered in the state, results to the greater amount of fatalities. In 2016, the number of traffic-related fatalities and the number of registered vehicles in the United States amounted to around 37,400 and 268,800 respectively. Though there was a strong positive correlation between the number of injuries recorded and the number of registered vehicles in the state, correlation is significant at 0.01 levels which is an indication that the increase or decrease in the number of registered vehicles affects the

number of injuries. All thing being equal, increase in the number of registered vehicles results to increase in congestion thereby causing injuries and fatalities if adequate control measures are not taken.

Again, the number of killed persons in motor vehicle crashes in the United States by person type from 1990 to 2016 was analyzed. The sum of 1064826 persons was killed within the periods. In 2016 alone, 7,079 non-occupants of vehicles were killed in U.S. motor vehicle crashes while the average of persons killed within the stipulated years was 39438. According to [21], the number of passenger cars involved in fatal crashes in the United States from 1995 through 2016 was about 524,000. In 2016, there were almost 20,800 passenger cars crashes in the United States. While the number of registered passenger cars in the United States

increased to a figure of about 6 million units between 2011 and 2015, the number of passenger cars involved in fatal crashes concurrently increased by approximately 2,000 cars [22]. During the research study, huge attempt was made to extend the studies to relationship between the number of fatal light truck crashes and the number of registered vehicles in the United States from 1995 to 2016. The Pearson correlation was -0.076 which is an indication of a very weak negative correlation. In fact, correlation was not significant which indicates that the distribution of this vehicle type was normally in line with the road facilities which made its contribution to traffic congestion no significant. The average number of fatal light truck crashes in the United States from 1991 through 2016 was 18755 [23]. The number as at 2016 was about 1400 higher than the 2015 figure.

Table 1. *Correlation Coefficient.*

	Injuries	Fatalities	Killed persons	Fatal Crash
Pearson Correlation (Reg. Vehicle)	-0.890	0.838	-0.571	-0.541
Significant	0.01	0.05	0.01	0.01

However, the reverse was the case in the data of the number of fatal large truck crashes in the United States from 2001 to 2016. There was a significant correlation of 0.99 at 0.05 levels. There were a total of about 6300 within the years. In 2016, 4,213 fatal crashes of large trucks occurred in the United States, which is significantly lower than the

20,069 light truck crashes that same year. It was discovered from all indications that a total of about 6286848710 numbers of motor vehicles was registered in the United States from 1990 to 2016 in 1,000s which gives a mean of about 225 per second [24].

Table 2. *Summary of Vehicle situations in the United States from 1990 to 2016.*

Years	Reg Vehicles	Injuries	Fatalities	Killed Persons	Killed Occupants	Killed Nonoccupants	Killed Motorcyclists	Fatal Passengers Crash	Fatal Light Truck crash	Fatal Large Truck crash
Min.: 1990	Min.: 192314	Min.: 2217000	Min.: 32479	Min.: 32479	Min.: 22307	Min.: 4888	Min.: 2116	Min.:17508	Min.: 16806	Min.: 3211
1st Qu.: 1996	1st Qu.: 211011	1st Qu.: 2331750	2nd Qu.: 32819	1st Qu.: 36454	1st Qu.: 24811	1st Qu.: 5578	1st Qu.: 2466	1st Qu.: 18693	1st Qu.: 18030	1st Qu.: 3787
Median: 2003	Median: 236760	Median: 2467000	Median: 32999	Median: 41501	Median: 31998	Median: 5842	Median: 3714	Median: 24715	Median: 19271	Median: 4089
Mean: 2003	Mean: 232846	Mean: 2566562	Mean: 33978	Mean: 39438	Mean: 29761	Mean: 5985	Mean: 3693	Mean: 23854	Mean: 19608	Mean: 4224
3rd Qu.: 2010	3rd Qu.: 253926	3rd Qu.: 2813250	4th Qu.: 34634	3rd Qu.: 42130	3rd Qu.: 33334	3rd Qu.: 6384	3rd Qu.: 4661	3rd Qu.: 27748	3rd Qu.: 21459	3rd Qu.: 4744
Max.: 2016	Max.: 268799	Max.: 3189000	Max.: 37461	Max.:4 4599	Max.: 34105	Max.: 7465	Max.: 5312	Max.: 30940	Max.: 22964	Max.: 4951
NA's:1	NA's:1	NA's:12	NA's:21	NA's:1	NA's:1	NA's:1	NA's:1	NA's:6	NA's:6	NA's:13

Figure 1. shows the number of vehicles, accidents and fatalities in the U.S. from 1990 through 2017. In 2016 alone, about 268799 thousands were registered. The figures include passenger cars, motorcycles, trucks, buses, and other vehicles. Also, the number of fatalities, accidents and number of persons killed in various cases were plotted. The number of cars sold in the U.S. per year stood at 6.3 million in 2016. According to [25], second only to China, the United States is one of the world's largest automobile markets based on the number of new light vehicle registrations, with around 17.55

million new light vehicle registrations in 2016. However, of the 68.6 million passenger cars produced worldwide in 2016, less than four million automobiles were produced in the U.S. Just like many other countries, the United States imports a significant amount of vehicles from various countries such as Japan, Mexico and Canada which amounted to huge increase in the number of vehicles used in the country. Also, passenger cars assembled within the country increased from about 2 million, 200 thousand produced in 2009 to about 4 million units in 2016 [26].
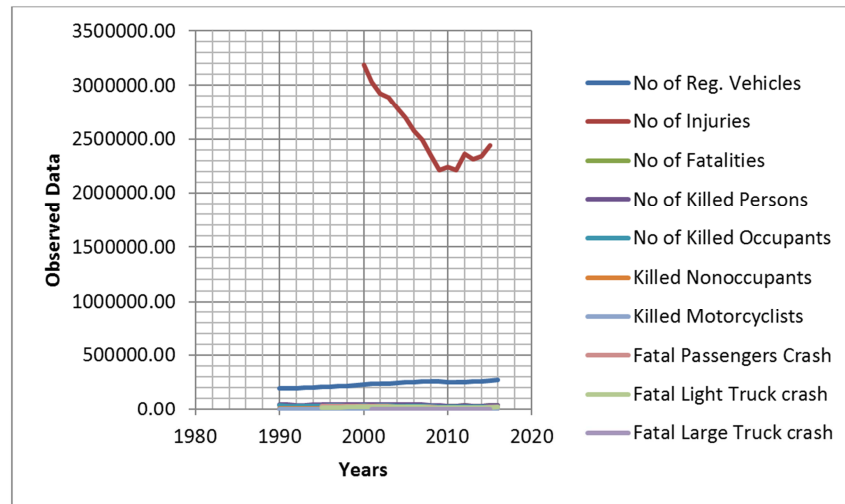
***Figure 1.** Number of vehicles, Accidents and Fatalities in the U.S. from 1990 through 2016.*

In the cause of this research, efforts were made to model the numbers of injuries, fatalities, persons killed and fatal crashes as dependent variables with respect to the number of registered vehicles. Since there is the correlation analysis showed evidence that there existed either a decrease or increase in the relationship between each of these selected indices as with the number of registered vehicles, it therefore, implies that they respectively depends on the number of registered vehicle [27]. The models were presented below $Y = 9200000 - 26.7X_1$, $Y = -26046.589 + 0.233X_2$, $Y = 60719.04 - 0.091X_3$, and $Y = 86367.249 - 0.166X_4$, for the number of injuries, fatalities, persons killed and fatal crash respectively. When the number of registered

vehicles in US for the period was analyzed, correlation was significant at the 0.01 level. The correlation coefficient is 0.617. In other words, the number of registered vehicles increases simultaneously with the number of casualties in the state. The regression model estimated the parameters of the number casualties and registered vehicles as dependent and independent variables respectively. The estimated parameters are shown in the model $R = -6057000 + 32.505C_4$ where R and C represent the number of registered vehicles and the number of casualties respectively.

Furthermore, efforts were made to examine the causes and effects of congestion over the period of time, from 1990 to 2016.

***Table 3.** Number of Registered Vehicles and Casualties in United States.*

years	No of Registered Vehicles (1000)	No. of Casualties	years	No of Registered Vehicles	No. of Casualties
Observed			**Predicted**		
1990	193057.38	44599	2018	278495.88	3182369
1991	192313.83	41508	2019	281530.32	3285531.7
1992	194427.35	39250	2020	284564.76	3388694.4
1993	198041.34	40150	2021	287599.2	3491857.1
1994	201801.92	40716	2022	290633.64	3595019.8
1995	205427.21	91344	2023	293668.07	3698182.6
1996	210441.25	91036	2024	296702.51	3801345.3
1997	211580.03	90700	2025	299736.95	3904508
1998	215496	89904	2026	302771.39	4007670.7
1999	220461.06	89703	2027	305805.83	4110833.4
2000	225821.24	3279245	2028	308840.26	4213996.2
2001	235331.38	3128436	2029	311874.7	4317158.9
2002	234624.14	3022634	2030	314909.14	4420321.6
2003	236760.03	2985466	2031	317943.58	4523484.3
2004	243010.55	2883906	2032	320978.02	4626647
2005	247421.12	2795594	2033	324012.45	4729809.8
2006	250844.64	2669145	2034	327046.89	4832972.5
2007	254403.08	2581558	2035	330081.33	4936135.2
2008	255917.66	2427165	2036	333115.77	5039297.9
2009	254212.61	2290465	2037	336150.21	5142460.6
2010	250070.05	2343787	2038	339184.64	5245623.4
2011	253108.39	2319905	2039	342219.08	5348786.1
2012	253639.39	2469008	2040	345253.52	5451948.8
2013	255876.82	2417593	2045	360425.71	5967762.4
2014	260350.94	2442292	2050	375597.9	6483576
2015	263610.22	2556229	2055	390770.09	6999389.6
2016	268799.08	115830	2100	527319.8	11641712

The number of registered vehicles and casualties recorded from 1990 to 2017 was presented in Figure 2. In that case, casualties were accounted as the sum of the number of injuries, fatalities, killed persons and fatal crashes.
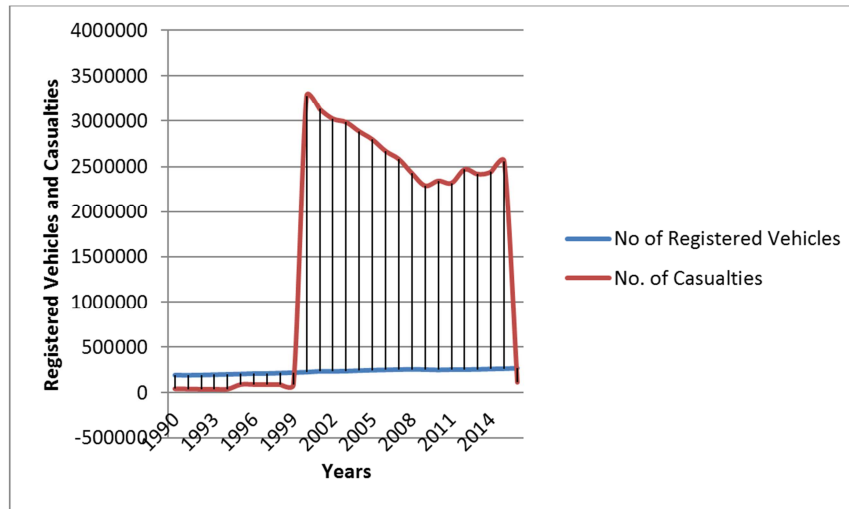

Figure 2. *Number of Registered Vehicles and Casualties in the U.S. from 1990 to 2016.*

The model of the number of registered vehicles were across the years and the number of casualties are $R = 3034.438t − 5845000$ and $C = 103162.72t − 205000000$ respectively. Correlation is significant at 0.01 level with positive coefficient of 0.976 and 0.514 for registered vehicles and casualties with respect to time measured in years.

Table 4. *Analysis of Variance of R and C models with Respect to Time.*

Model		Sum of Squares	df	Mean Square	F	Sig.
	Registered Vehicles					
1	Regression	1.508E10	1	1.508E10	478.534	.000ᵃ
	Residual	7.879E8	25	3.152E7		
	Total	1.587E10	26			
	Number of Casualties					
1	Regression	1.743E13	1	1.743E13	15.635	.000ᵃ
	Residual	2.787E13	25	1.115E12		
	Total	4.531E13	26			

Critically looking at both models from the analysis of variance table, both models were significance. Non-significant model parameter is not ideal as it denotes lack of fit of the model [28]. In other words, adopting linear regression model for the data is adequate for prediction and further decision making. Hence the model was used to predict the future number of casualties and registered vehicles in United States. Figure 3 was used to show the predicted future values of the country's data on the number of casualties and registered vehicles. The linear for both models were super-imposed on the predicted model. That is to say that there is no variation between the predicted and the actual model. The model was adequate and a true representation of observed data.

It was observed from the analysis and the trend of the regression model that the number of registered vehicle increases across the years. The analysis of the observed data indicated that the number of registered vehicles will increase to 284564760, 375597900 and 527319800 in the years 2020, 2050 and 2100 respectively.
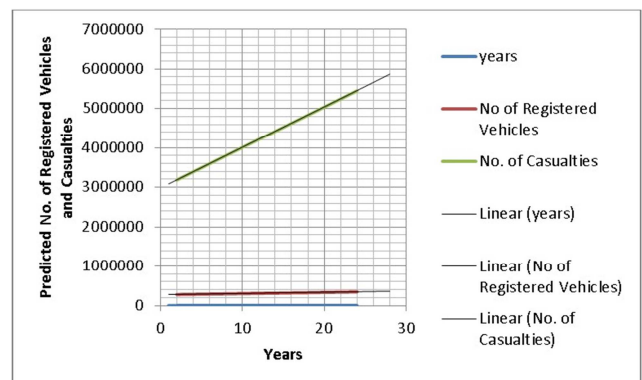

Figure 3. *Predicted Number of Registered Vehicles and Casualties in the U.S.*

4. Conclusion

The evidence gathered from the analysis of the data shows that the government should not overlook the rate by which vehicles are manufacture, imported and used in the country. This is due to the high level of positive

relationship that exist between the number of vehicles used in a country and the level of casualties recorded. The two indices increase simultaneously. In that vein, adequate measures should be taken to moderate and control the number of injuries, fatalities, death and automobile crash by check and balance of the rate by which vehicles are registered in the country. This research work examined the independent effects of either manufacturing or importing vehicles in United States. Though automobile crashes, the number of persons killed and the level of injuries sustained as a result of uncontrolled acquisition of vehicles were negatively related, it was observed that fatalities were of paramount increase with the number of registered vehicles.

The research accounted for the mean, quartiles and median of registered vehicles, number of injuries, fatalities, persons killed, motorcyclist killed, fatal passengers crash, fatal light truck crash, fatal large truck crash, occupants and non-occupants of the vehicles killed in the United States from the period 1990 through 2017. The maximum number recorded per indication for the duration was also calculated. Hence, the situation was represented in a plot to enable actual visualization of the causes and effects of traffic congestions, uncontrolled number of vehicle registration and the casualties caused in the country. When the variables were modeled, it was observed that there is a rapid increase of the number of registered vehicles and the casualties caused. After fitting the linear regression model of the number of registered vehicles and the casualties with respect to the years, efforts were made to predict the future scenario. It was observed that in 2020, 2030, 2040, 2050 and 2100, the estimated number of casualties is likely going to be 3388694, 4420322, 5451949, 6483576 and 11641712 respectively. It is expected that adequate measure such as control purchase of vehicles, adequate check and balance of the number of automobile production, effective control of excess automobile importation, provision of good roads and road facilities, proper training, mobilization and orientation of the masses on the causes and effects of traffic congestions should be taken to curb future casualties in the country and other countries that is undergoing same situation.

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