Research Traffic Congestion in Malta: An Analysis of the Attributes, Attitudes and Solutions

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Abstract: Congestion in Malta is now reaching epidemic levels, driven by the fact that the number of cars being registered on a daily basis has increased significantly, and there is no view that this scenario will attenuate. Due to our limited geographical landmass, and that fact that the population and the ratio of cars per person are both increasing, traffic congestion has become acute. It is therefore important to understand the underlying factors that are creating this phenomenon. Congestion is not a problem that can be attributed to Malta only, as many countries battle this issue on a daily basis. Understanding what causes congestion, what the solutions are, the relationship between said factors and congestion, as well as understanding which solutions could garner public support, are the underlying research aims of this study. The data for this study was gathered through a survey containing Likert scale responses (for both dependent and independent variables) to facilitate its quantitative analysis. In order to satisfy the objectives of this research, the strength or lack of correlation between these variables was tested to ensure that any conclusion derived is sound and statistically proven.

The multivariate analysis comprises a Factor Analysis that identifies 4 key components, followed by a Linear Regression Analysis to test the correlation between these new composite factors and congestion factors. The results show a robust correlation which identifies political responsibility as the main driver of this societal daily wait in traffic until a destination is reached. These findings confirm the present situation Malta finds itself in and, from a solution point of view, there is no doubt that respondents want the government to make bold steps forward. However, due to the lack of support for any fiscal disincentive as a solution, no government has yet taken the leap of faith to promote a real solution beyond widening roads, commissioning surveys and acknowledging that there is a serious problem that requires a long-term solution.

Keywords: Anthropogenic, economic growth, behavioural economics, cars, congestion, government transportation planning, government auto-centric policies, fiscal disincentives, pollution, public transport, traffic.

The Literature Review and Context

The topic of traffic congestion is one that has been, and is still being studied in all emergent and stable economies. A plethora of academic research has been made from various disciplines, from combinatronics (trying to identify and lay down practical algorithmic solutions to tackling the issue through congestion charges or traffic flow modelling), examples of which are Hut (2016) and Shah et altri (2016); from an environmental impact (Imran and Low 2005; Janovic 2016); from a logistics aspect (Hockey et alt. 2017); from a strategic aspect of long term planning (Duarte and Ultramani 2012); from the engineering mechanics of transportation leading to congestion (Alaa et al. 2018); to the sociological and humanistic aspect that effects each one of us (Fenton 2005). What is clear, is that there is no perfect, off-the-shelf solution to traffic congestion, requiring long term strategic, and oftentimes, bold planning initiatives, encompassing different multi-modal solutions adopted for the different scenarios, within the specific countries.

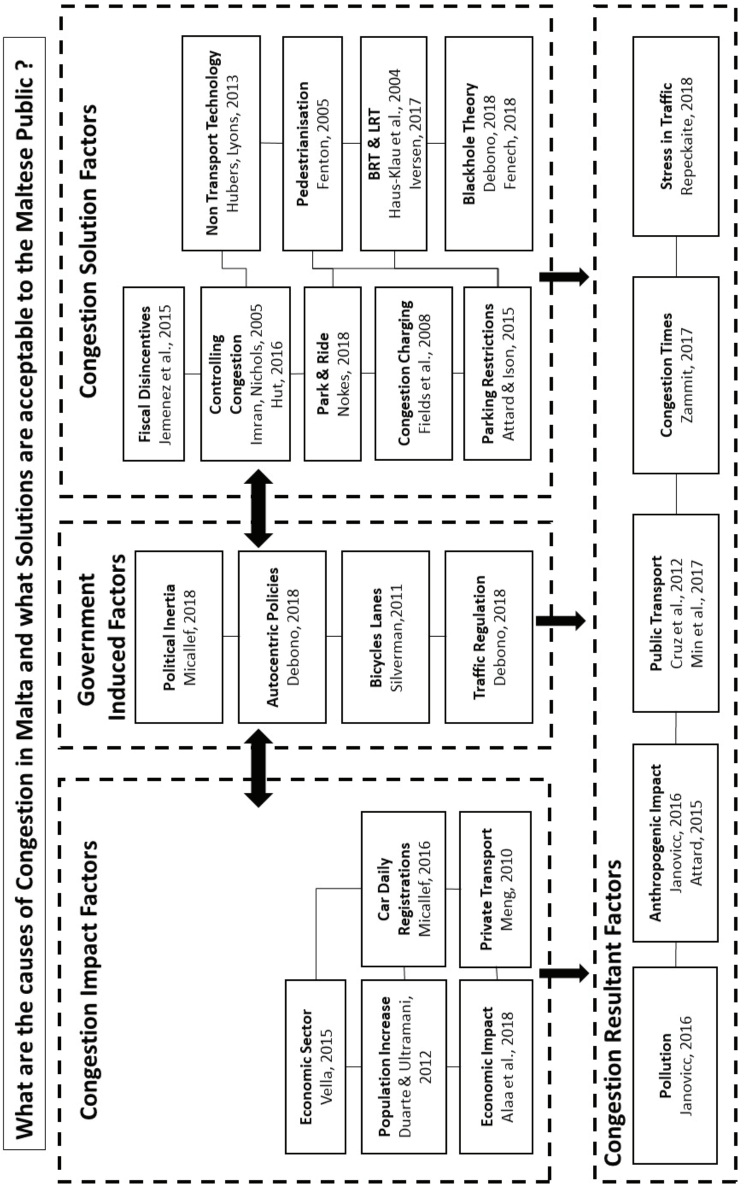


Figure 1: *Literature map from secondary research concerning the factors that affect congestion and solutions proposed worldwide*

Successful implementation of such solutions can be found within the Asian continent (Tart and Ainsley 2001), in the United States (Angel 2004) and in Europe (Hass-Klau, Crampton and Benjari 2004; Olesen 2014). The commonality of all these projects were the resistance to implementation, the funding of such projects (often being of significant infrastructural dimensions), the required maintenance, and the modal shift of transportation that effectively reduced and ultimately eliminates congestion, to an adequate level of service (Fields et al. 2008), to ensure an effective and efficient service to the public by reviewing performance from a Constant Returns to Scale (CRS) or a Varying Returns to Scale (VRS) (Min, Young and Lambert 2017).

As congestion grows various aspects of our society come into play. Whilst air pollution and time delays are the obvious first manifestations of chronic traffic congestion, private motorisation is a personal choice, and allows us to be completely autonomous in our travelling patterns. Owning a car is a symbol of social status, personal freedom and financial affluence. Locally, 20% of households have more than three cars. Malta has one of the highest population densities (road network and population) in the world, and the size of the island is comparable to a medium-sized city. Traffic has been increasing by 2.3% p.a. since 1990 (Department of Transport, Malta). As a result, public transport patronage has decreased drastically over the years. Traffic congestion in Europe is estimated to cost the EU around €80 billion annually, while 50% of all Europeans still commute by car each day. This is the reason why, in recent years, several European countries started analysing various approaches and identifying best practices in urban planning, making drastic choices to tackle traffic congestion, head on (Micallef 2017). Reversing policies that had locked in fuel transportation, means devising transportation policies linked to land use, educational and labour trend policies, that ultimately create non-car choice policies. These policies are not easy to implement, both financially, and due to the social and behavioural change they entail. Such planning would always need to integrate car transportation as part of a multi-nodal travel within our polycentric cities (Hut 2016). With around 1.4 billion cars on the planet, the scenario of having to lock down major cities (as happened in Mumbai and Shangai) due to constant pollution, may become a daily reality (Sohail 2003).

Private businesses and households have to take on the actual costs of congestion. With over 30,000 SMEs (https://www.jc.um.edu.mt), these act as the prime mover of the economy. Locally, with an average salary lower than the EU average, this creates a significant financial burden for many. According to an EU study for 2017, Malta is 16th, with an average salary of €1,021, down from 2014 (€1,094), showing circa 7% decrease in income available. (www.reinisfischer.com, 2017), So, rather than the drivers, who have a choice, the rest of the population have to carry the exogenous and endogenous costs of transportation (Hut 2016). Many would argue, that such choice (using a car) should mean motorists have to bear the true cost of their decision, on the lines of the polluter-pays principle. Some also argue that it is governments who heavily subsidise public transport operators (on average circa 33% in the US to 50% in the EU, Cruz et al. 2012), but it is the public who still pays this through taxes while utilising a non-sustainable form of transport. Adding further charges to motorists is a contentious issue. The perception of many motorists, here in Malta, is that they are already significantly taxed through fuel, licence fees and car maintenance. There is therefore no political appetite to try and force change for the good, as the number of motorists is 375,000 circa within a total population of 450,000 (These figures do not include foreign locals with driving licences. EU law allows them to use their car without registering it in Malta.). It is well demonstrated that infrastructure for public use has the same cost as that of private use for motorised and non-motorised vehicles (Imran and Nicholas 2005). Thus, congestion charges, using a tariff zone integration strategy could balance users' welfare, travel time, quality, and operations costs in the system (Jimenez Serpa et al. 2015). Such a system was successfully implemented in London, Paris and even in Valletta, Malta by the CVA (Controlled Vehicular Access) system which reduced traffic in the capital by 7% between 2007 and 2012 (Attard and Ison 2015). In 2008, the US spent $1.5 trillion on public transportation projects, with 50% earmarked for ongoing maintenance and administration. In other words, what is not spent on motorisation can be spent on public transport, which reducing congestion, environmental impact and allows for the pedestrianisation of city centres (Fields et al. 2008).

One other area that can explain our 'irrational behaviour and attitudes' towards the relentless need to use private transport, is Behavioural economics. The inconsistent nature on preferences, behaviour and experience, affects each individual and his or her subjective well-being (Kahneman and Tversky 2002; Camerer et al. 2003). Behavioural economics supports the development of public policy in this respect (Thaler 1993; Elliott et al. 2010; DellaVigna 2009; Karlan and Appel 2011). This analyses the behaviour of citizens to enable researchers and policy makers to understand recurrent behaviour, and be able to actively manipulate society's behaviour through the introduction of positive policies. Individuals attempt to behave in ways that support the impression of a positive and consistent self-image. So, when things go well, this is attributed to the individual's effort. When it does not, fault is clearly attributed to other individuals or *the situation they have been put in*, also known as the 'fundamental attribution error' (Miller and Ross 1975). It is therefore imperative to understand how a population thinks and behaves, understanding all the factors to be able to forecast the consequences of policy change that create the intended change in transport behaviour (Metcalfe and Dolan 2012).

The NEG (New Economic Geographies) in urban planning taking shape, are influenced not only by population density, but also by transit efficiency. Whilst economic prosperity is not necessarily an indicator of transit efficiency, transit efficiency will affect the local economy (Silverman 2011). Transport is becoming a critical factor for a country's competitiveness providing a favourable business environment, but in Malta very little investment is being made either in transport planning, or in the development of the pre-requisite transport-related skills that any developed country requires (Philips and Burbules 2000; Kahneman, 2002; Attard 2015). What is worse is that any high-rise development will also have a detrimental effect on congestion, but the local Planning Authority, is approving such projects without any full environmental impact assessments (Caruana Dingli 2016). Malta has, on paper, a transportation strategy stretching to 2050, and clear objectives to be reached by 2025, but most of what is accomplished, is being done without any Transport Oriented Development (TOD), and constantly deviating from such plans with the *excuse* of having to be flexible. The reason why traffic congestion will remain a problem in Malta is because, ""*We lead our lives according to the means at our disposal and the norms of human behaviour."*" (Hubers and Lyons 2013), applying no foresight, in creating transportation policies that are economically efficient, environmentally and socially sustainable (Tart and Jolley 2001).

Traffic congestion is one of the top issues today for Maltese citizens (The concern over traffic and roads increased from 9% in 2013 to 26% in the last *MaltaToday* survey of 2018. This matches an increase of almost 47,000 vehicles on Maltese roads between 2012 and 2017.), along with immigration and corruption (Debono 2018). The government, through the *National Transport Strategy 2050* and the *Malta Transport Master Plan 2025*, both issued in 2016, proposes a number of solutions. However, there is a reluctance to implement anything that might change the *status quo* or be seen as too radical, since, "Keeping voters happy in the world of traffic solutions," seems to be the only policy being followed (Caruana Dingli 2016). In the past two legislatures, since 2013, the government laid out plans to tackle traffic congestion, consisting of an information traffic system with 27 cameras spread across Malta's traffic network (Zammit 2017). And since 2017, endeavoured towards a national infrastructure programme widening and improving 51km of road network, using funds from the EU Ten-T network programme (Debono, 2018). For a network of 2,400km of roads, or 762km of roads for every 100km^2, it is one of the densest networks in the world (Attard 2015). Furthermore, according to the Minister of Finance, this may be a temporary solution to ease the traffic. Even Prof. Scicluna – Minister of Finance in 2019 – (The Malta Independent, 03 Aug 2019) concurs that the widening of roads will end up worsening the situation, since there are 36 new cars daily on Malta's roads, rising fromo 2016, and increasing to 42 in 2018-19(see *Figure 2a*). Or as Lewis Mumford (1955) once remarked, "You cannot build your way out of congestion. It is like dealing with obesity by loosening your belt." Congestion effects are anthropogenic, far more wide-ranging within our society and economy, negatively affecting our daily lives in insidious ways. This is because it increases pollution, causing physical and mental health problems and creates an invisible economic cost through the waste of productive time and fuel (Fenech 2013).

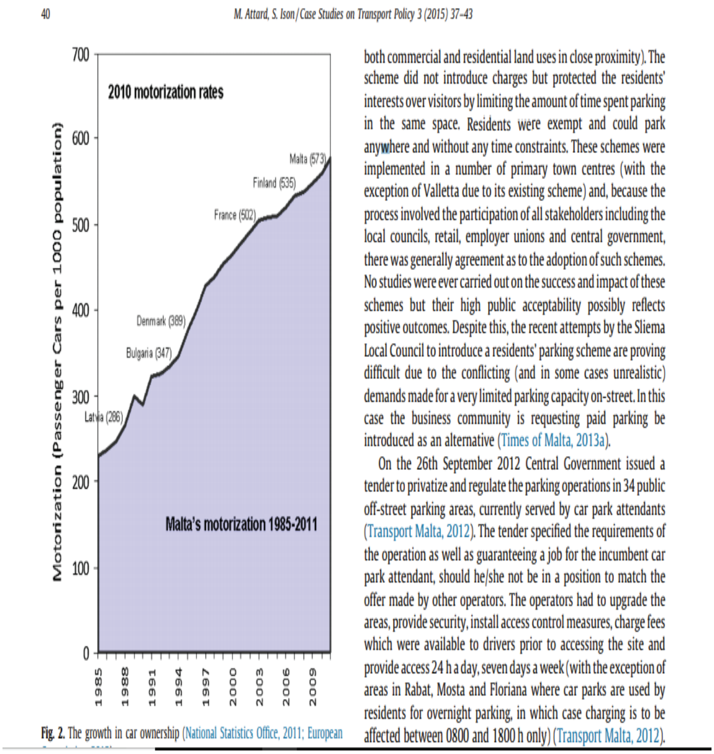


Figure 2a: *A comparison in growth of car ownership across a number of EU countries (National Statistics Office, 2011: European Commission, 2012)*

Traffic congestion has been growing in Malta since the train service was discontinued (1931) in favour of a more flexible bus service. The UK Government started endorsing private transportation policies, shifting the balance from public transport to reduce cost (see *Figure 2b*). Malta as one of its territories followed suit, investing in roads rather than a more coherent public transport. With economic development came a very rapid increase in people's standard of living. Similar to other countries, in a very short period of time, Malta expanded its infrastructure and increased the number of cars on the road (Repeckite 2018). Malta's *Transport Master Plan 2025*, forecasts the adoption of cycling corridors, improved public transit and new pedestrian infrastructure on strategic roads, some by as early as 2021. Regretfully, one can observe that so far, major projects mainly just widen the roads, and take over cycle lanes, calling them 'shared lanes', eg. in Mdina Road, along the Żebbuġ bypass; and uproot centennial trees, eg. the Central Link Project. In other words, there is a historical 'path dependence' onto which transportation can only be seen as private motor transport, and from which, unless there is someone who creates change moving towards a 'critical juncture', the policies of the past decades will continue to dictate the policy of the future ones (Imran and Low 2015). Seemingly, the Maltese population is taking this problem for granted, giving no consideration to the cost and impact of traffic congestion, the magnitude of the problem grows slowly on a daily basis. No one in Malta, seems ready to adopt drastic long-term solutions, as has been done in France, Belgium and Germany (Hass-Klau et al. 2004; Olesen 2014).

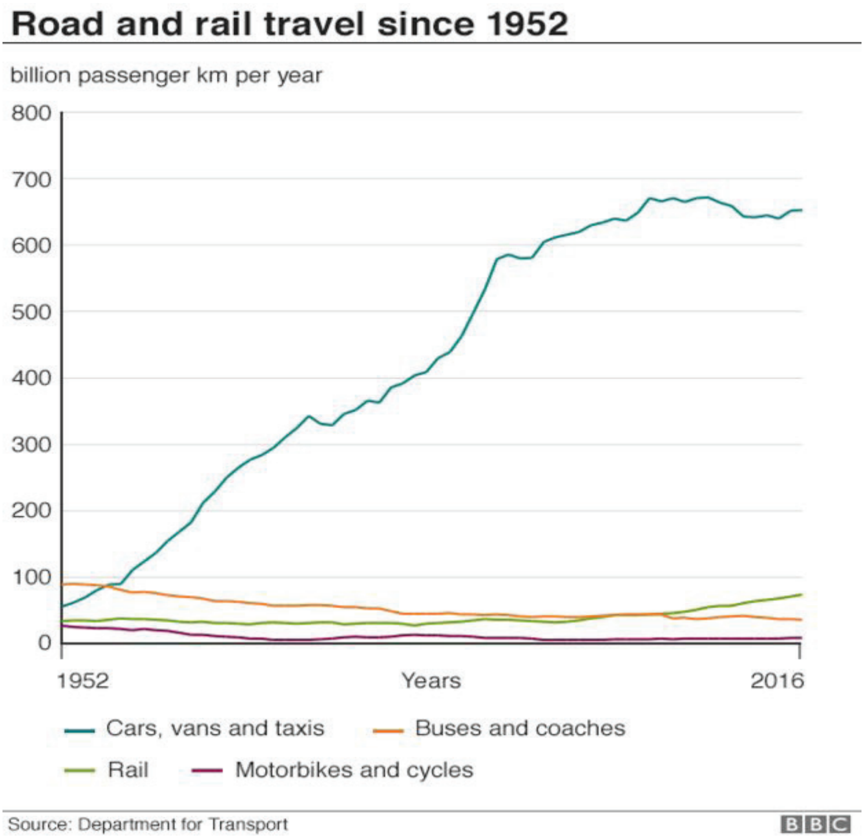


Figure 2b: *Shifting transportation mode in the UK (Source: BBC News)*

Drivers do not take into consideration the environmental effects that traffic and congestion cause nationally or globally, expecting the Government or NGOs to sort things out. Congestion increases carbon footprint significantly on a daily basis (Janovic, 2016). Car usage is the major contributor to our anthropogenic climate change, as it is seemingly cheap to run but extremely polluting (Meng 2010). The emissions are composed of deadly pollutants, namely Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen Oxides (NOx), Sulphuric Oxides (SOx), and Particulate Matter (i.e. dust that is so fine that is only seen by a microscope, namely PM10 and PM2.5), all indicted with causing asthma, respiratory problems and cancer (Gabr et alt. 2018). In Malta, congestion cost the economy €274m in 2012, €155m related to air pollution, accidents, climate change and noise (Attard et al. 2015). The additional costs to our health care system have not been quantified, only estimated, but these are not indifferent both in terms of magnitude and long-term health impacts (Institute of Climate Change and Sustainable Development, UOM 2015). The increasing effort to enlarge our road network will only exasperate the situation because it is simply the same strategy being adopted since 1931.

The data of the impact of congestion on Maltese citizens is staggering and few fathom the extent or levels it has presently reached. A survey commissioned by *The Sunday Times of Malta* revealed that 50% of road users are stuck in traffic for up to 40 minutes a day, while 60% of the population have to plan ahead because of the major impact traffic has on their trips, mainly due to non-recurring delays. The cost of congestion is expected to rise to €317 million by 2020, unless authorities take drastic measures to improve public transport, and reduce private car ownership (Repeckaite 2018). A recent survey by Project Aegle, revealed that 83.2% of journeys were done by car (compared with 74.6 per cent in 2010). In comparison, only 10.8% of trips were made by bus and 1.2% were made by coach or minibus. In almost thirty years, the share of people who walk has decreased by ten times (to 1.2%), and despite the island’s small size, the number of cyclists remains negligible (0.8%). This has been confirmed by a survey conducted by *Illum* between 29 July and 02 August 2019, with 549 participants (Hudson 2019), where it shows that 80.6% prefer to use a car, and only 16.6% use public transport. A mere 1% would rather walk, and only 0.3% would use a bicycle. This survey further confirms that in Malta, the licensed drivers are actually the collective majority, where by the end of 2016, the total number of driving licences amounted to 252,276 or an increase of 1.8 per cent over 2015 (NSO 2017). Translated statistically there are 862 vehicles per 1,000 residents or, 669 passenger cars per 1,000 residents, with 747 driving licence users per 1,000 residents over 18 (NSO 2017). Thus, in Malta, the collective population is simply considered to be those with a driving licence, and locked in this solution, while the commuting needs of rest of the population are simply disregarded (Attard 2019).

The Research Concept and Objectives

This research is a study that identifies and analyses the key aspects and factors that are attributed to congestion, while at the same time, delves into the attitudes of the Maltese public around congestion, discerning which are the acceptable solutions to the same problem. The main variables of this study, both dependent and independent, are all identified from the literature review concerning Traffic Congestion. The overarching topics on congestion delve into a number of other topics, such as, “Demographics, world economies, environment, changing social demands and values, international standards, fossil fuel availability, technology development, power of multinational corporations, and flows of people due to war or disasters” (Tart and Jolley 2001). This is because congestion is a by-product problem and not per se, a self-contained phenomenon. As such, a number of variables (independent and dependent) have been identified to affect traffic congestion (see *Table 1* below for a list of variables).

Variable 1	Stress related to driving in congested traffic
Variable 2	Daily increase in registered cars on the road network
Variable 3	Use of Park and Ride facilities
Variable 4	Use of bicycles and bicycle lanes
Variable 5	Government taking bold decisions for the long term solution on congestion
Variable 6	Tax disincentives to use car and tax incentives for car pooling
Variable 7	Amount of time in congestion during the day
Variable 8	Population increase effects congestion
Variable 9	Use of congestion charging reduces congestion
Variable 10	Certain economic sectors induce increase in congestion
Variable 11	Public transport needs to be adequate and efficient to entice use
Variable 12	Owning and using a car is not a privilege but a necessity these days
Variable 13	Parking restrictions may increase use of public transport
Variable 14	Government auto-dependent policies are not sustainable
Variable 15	Pollution is mainly due to increased traffic and congestion in Malta
Variable 16	Pedestrianisation would reduce congestion by increasing use of public transport
Variable 17	Use of congestion charging and toll fees increases use of public transport
Variable 18	Road widening is a very short-term solution – blackhole theory of transport
Variable 19	Economic growth brings pollution and increased traffic and congestion
Variable 20	Government needs to have and follow a very clear and strict national traffic plan
Variable 21	Use of BRT (Bus Rapid Transport) or LRT (Light Rail Transport) are possible solutions
Variable 22	Use of technology, such as video conference, is a solution to traffic and congestion
Variable 23	Government needs to have a strict enforcement of the law to reduce congestion and traffic

Table 1: *The Independent and Dependent variables in congestion*

Figure 3 shows the Conceptual Framework of the relationship between the 23 variables (both dependent and independent), forming the three emerging themes (Congestion Impact Factors, Government Induced Factors, and Proposed Solution Factors) relevant to the Maltese road network, and the basis of the research questions used during the pilot study.

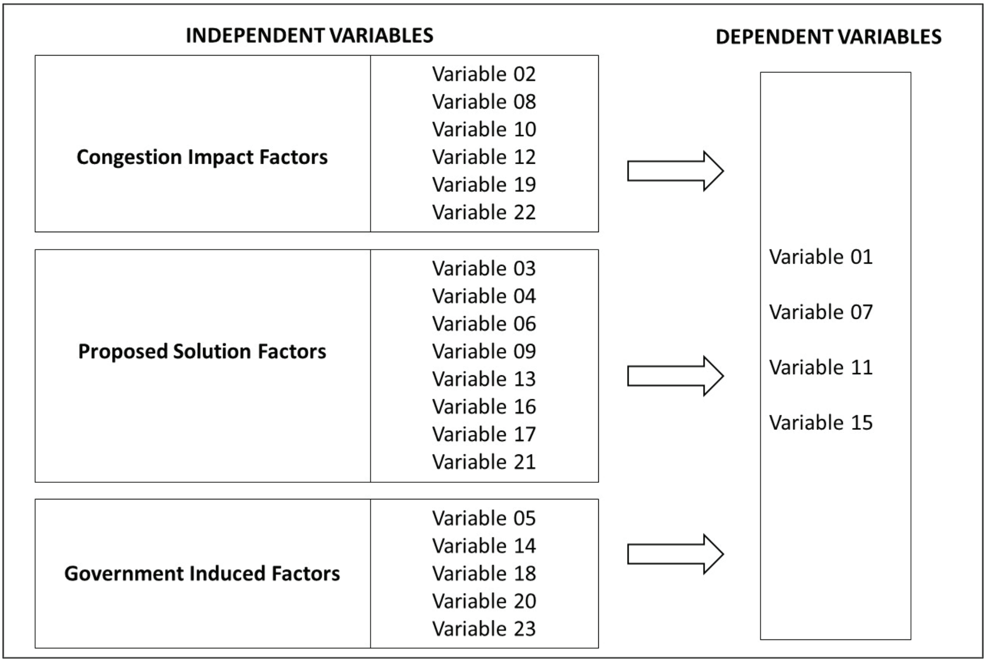


Figure 3: *The Conceptual Framework – the relationship between Independent and Dependent Variables*

This study identifies a correlation between the auto-centric policies and culture in Malta (which can be easily translated to the need and use of cars in Malta), as a set of independent or predictor variables on the dependent (criterion) variables of traffic congestion. The research objectives pursued in this study, are as follows:

- To investigate which congestion-inducing factors are most critical to Maltese drivers
- To investigate the relationship and correlation between the identified independent and dependent traffic congestion variables, and what can be concluded
- To investigate proposed traffic congestion solutions, that the driving population of Malta prefers or supports

Thus, the main research objective is the analysis of the relationship between the auto-centric policies & culture in Malta, and its direct relationship to traffic congestion, taking into consideration the acceptance of various solutions to traffic congestion in Malta.

The Research Methodology

The research methodology in this study is a quantitative analysis, based on a post-positivist approach using a deterministic philosophy, and collecting data through a cross-sectional information instrument (survey/questionnaire), collated from respondents. Close ended questions with a 5 point Likert scale response, are based on the dependent and independent variables in *Figure 3*, identified through a deductive approach on Secondary research, so as to be able to ascertain and then analyse their relationship, in order to answer the questions raised by this study (Philips and Burbules 2000; Creswell and Creswell 2018). This approach uses a worldview whereby a paradigm will be concluded on the basis of the relationship of the different variables. It is extremely difficult to have a fully random approach, so, to allow as many respondents as possible, to complete this questionnaire, the link from *Google forms* was posted on a number of websites where traffic or transportation are the main topics. Although this cannot confirm absolute randomness, the questionnaire was left on these sites for 8 weeks (10th June 2019 to 5th August 2019) thus allowing as many respondents as possible to complete the questionnaire. It is also important to plan and deploy the instrument through such pre-selected channels thusensuring the randomness of the data, and a well-defined stratification in which equal representation, for each social strata is proportionally represented within the entire population of Malta (Creswell and Creswell 2018). To ensure this, all the results were then compared to the latest national statistical data report of 2016 from the National Statics Office (NSO). This questionnaire is designed so as not to allow participants to proceed if a question is not answered, thus avoiding empty responses. Variables were reshuffled before every respondent starts to answer any question, to ensure more randomness, and avoid any structured responses. Additionally, one variable (Variable 17) was used as a validity statement so that any questions that contradicted its complimentary question were discarded. The analysis is a pre-determined interpretation, using SPSS computational software, that allows testing on reliability, collinearity, factor analysis and linear regression. Further analysis is conducted by statements that explore descriptor variables, namely age, sex and locality. This was done so as to perform an initial interpretation of the data as well as to be able to compare it to the statistical data acquired from the NSO.

Any quantitative analysis is bound through a temporal (cross-sectional) order, and thus will be valid within a particular time frame, meaning that the results are geographically valid only for a period of time, depending on the fluidity of the ongoing national politics and cultural norms. Given that circa three out of every four Maltese citizens (NSO news release 11 May 2018, no. 074/2018) have a driving licence, the population sample for this study is of 375,000. The study gathered 114 responses out of which 15 were rejected due to failing the validity test, leaving 99 samples for the study. This improved the outcome of the results by reducing the margin of error, and improving the accuracy of the results attained. The study did not take into consideration foreigners who are presently living in Malta, have a driving licence and drive within the archipelago. Sample size is another important factor to consider when carrying out a quantitative study. To have a confidence level of 95% with a 10% confidence interval, one requires at least 96 respondents, which in this case was achieved. Once the survey was closed, Cronbach's α test is used to ensure that the data is internally consistent and reliable. The α test needs to have results between 0.7 and 1 to ensure that the data being used is reliable and consistent. Ideally such a test is conducted with specific sets of variables to observe their consistency, but at this stage, prior to a Factor Analysis, the test is being done with all the variables to analyse the holistic approach of the study and the variables used. With regards to the ethical aspect of the survey, all participants were informed, through an introduction page, of the key aspects of this study, given absolute anonymity and contact details, if they subsequently, changed their minds on participating.

Comparative Data Analysis and Interpretation

When the collated results were tested for Cronbach's Alpha, (see *Table 2*) of the result was 0.859, which is larger than the 0.7 threshold, thus ensuring the reliability and internal consistency of all the data collected. The data collated also compares well, with the present available national statistical data. Using the NSO 2017 Statistical Transport data, a longitudinal study from 1990 till 2016, the collated data comparison shows that it compares well when checking for age, sex and location. The data from the NSO report, in order to have the same parameters for this study, can be simplified proportionally in percentage basis. The study offered 99 valid responses, allowing a sample size ratio to the overall population of 1:2,581. Table 3 shows that the data is very comparable, if not the same in areas where similar numbers from the proportionate NSO data were obtained by the survey. The most significant similarity is the percentage of male and female respondents.

Reliability Statistics	
Cronbach's Alpha	N of Items
.859	22

Table 2: *Cronbach's a test for the Congestion Data collated*

	Males				Females				
Age	18-24	25-39	40-59	60+	18-24	25-39	40-59	60+	TOTAL
NSO sample	5.1%	17.3%	20.2%	17.1%	4.1%	14.4%	15.5%	6.3%	100%
Congestion Survey sample	16	23	25	6	13	11	17	3	99
	16.1%	23.2%	25.3%	6%	13.1%	11.2%	17.1%	3%	100%

	Males and Females				TOTAL		Males %	Females %
Age	18-24	25-39	40-59	60+				
NSO sample	9.2%	31.7%	35.7%	23.4%	100%		60.2	39.8
Survey sample	29.3%	34.3%	42.4%	9%	100%		61.4	38.6

District	South Harbour	North Harbour	South East	West	North	Gozo & Comino	TOTAL
NSO sample	17.4%	27.7%	15.4%	14.1%	16.2%	9.2%	100%
Survey sample	19.1%	23.2%	24.2%	26.3%	20.2%	2%	100%

Table 3: *Comparison between NSO statistical sample and the conducted Congestion Survey data – highlighted areas show where there is significant similarity.*

Regarding the proposed Congestion solutions, respondents have shown support to some quite radical solutions, but when it came to fiscal incentives to deter the use of private transportation, i.e. using one's own car, preference was less forthcoming. This shows that there is an understanding that a solution is required. In 1972, the Organization for Economic Cooperation and Development (OECD), paved the way for the Guiding Principles concerning International Economic Aspects of Environmental policies where the polluter, in this case the car user, is held responsible for the environmental damage and pollution, However, when it comes to support such solutions by either using the polluter-pays principle, introduced by the OECD, (OECD) or having to drastically change the use of the car, then support or preference within the Maltese population, dwindles significantly (Hudson, 2019). See Variables 6, 12 and 13. The results from the survey are listed below (see *Table 4*) and later recorded as an ordinal set of data on SPSS so as to preserve the data analysis. Additionally, Variable 17 has a high correlation to Variable 9. (Pearson's Correlation of Variable 17 and Variable 09, is 0.765 and Spearman's Rank Correlation is 0.74, p >0.01). That means that only 22 variables are used in the analysis.

Variables	Survey Questions	Will Oppose / Strongly Disagree	Not Acceptable / Disagree	Neutral	Acceptable / Agree	Will Support / Stongly Agree
Variable 1	Stress related to driving in congested traffic	3.51%	3.51%	14.91%	38.60%	39.47%
Variable 2	Daily increase in registered cars on the road network	5.26%	11.40%	5.26%	12.28%	65.79%
Variable 3	Use of Park and Ride facilities	29.82%	33.33%	21.05%	7.89%	7.89%
Variable 4	Use of Bicycles and Bicycle Lanes	4.39%	4.39%	12.28%	12.28%	66.67%
Variable 5	Government taking bold decisions for the long terms solution on congestion	0.88%	0.88%	5.26%	23.68%	69.30%
Variable 6	Tax disincentives to use car and tax incentives for car pooling	10.53%	15.79%	23.68%	24.56%	25.44%
Variable 7	Amount of time in congestion during the day	30.70%	44.74%	7.02%	12.28%	5.26%
Variable 8	Population increase effects congestion	36.84%	34.21%	12.28%	14.04%	2.63%
Variable 9	Use of congestion charging reduces congestion	15.79%	19.30%	16.67%	21.93%	26.32%
Variable 10	Certain economic sectors induce increase in congestion	16.67%	29.82%	31.58%	21.05%	0.88%
Variable 11	Public transport needs to be adequate and efficient to entice use	2.63%	8.77%	5.26%	41.23%	42.11%
Variable 12	Owning and using a car is not a privilege but a necessity these days	17.54%	25.44%	20.18%	18.42%	18.42%
Variable 13	Parking restrictions may increase use of public transport	10.53%	30.70%	15.79%	21.05%	21.93%
Variable 14	Government Auto Dependent policies are not sustainable	34.21%	24.56%	23.68%	13.16%	4.39%
Variable 15	Pollution is mainly due to increase traffic and congestion in Malta	0.88%	0.88%	1.75%	23.68%	72.81%
Variable 16	Pedestrianisation would reduce congestion by increasing use of public transport	2.63%	2.63%	7.02%	36.84%	50.88%
Variable 17	Use of congestion charging and toll fees increases use of public transport	8.77%	13.16%	21.93%	35.96%	20.18%
Variable 18	Road widening is a very short term solution – blackhole theory of transport	28.95%	40.35%	5.26%	19.30%	6.14%
Variable 19	Economic growth bring pollution and increase traffic and congestion	37.72%	37.72%	12.28%	9.65%	2.63%
Variable 20	Government needs to have and follow a very clear and strict national traffic plan	1.75%	2.63%	7.89%	34.21%	53.51%
Variable 21	Use of BRT (Bus Rapid Transport) or LRT (Light Rail Transport) are possible solutions	1.75%	5.26%	6.14%	37.72%	49.12%
Variable 22	Use of technology such as video conference are solutions to traffic and congestion	6.14%	12.28%	7.02%	52.63%	21.93%
Variable 23	Government needs to have a strict implementation of the law to reduce congestion and traffic	28.07%	16.67%	18.42%	18.42%	18.42%

Table 4: *Imputed and ranked (percentage) results from the Congestion Survey*

This bi-polar tendency of the Maltese population of understanding and wanting a solution to key critical national issues, yet sustain an unwillingness to pay or be part of the solution, is more visible in Figure 4. There is strong support for the pedestrianisation of town centres or the introduction of BRT or LRT, as solutions. However, popular opinion among respondents does not support an increase in congestion charging, tax incentives or disincentives to ensure an optimal use of one's own automobile, nor adopting any parking restrictions which would require the use of public transport to reach specific locations. A surprising response is the significant support there is for the use of technology such as WhatsApp, Skype, conference calling or Google Hangouts, as a means to meet face to face, rather than having to physically go to a location for a meeting. The results also show (see Figure 4b) that all respondents have a very clear and uniform view of the negative repercussions congestion is causing. Around 80% of the respondents replied that congestion is causing them significant stress and that it occurs during all times of the day, not just during peak hours (Rush or peak traffic times in Malta are from 7:00am-9:00am and from 5:00pm-6:30pm.). Similarly, they all agree that such traffic congestion is slowing down public transport, which in turn deters potential users and forces more cars onto the roads. More importantly, from an anthropogenic point of view, an overwhelmingly 96.5% of the respondents are acutely aware of the pollution that traffic and congestion cause, and that this will have serious repercussions to their health and that of family members.

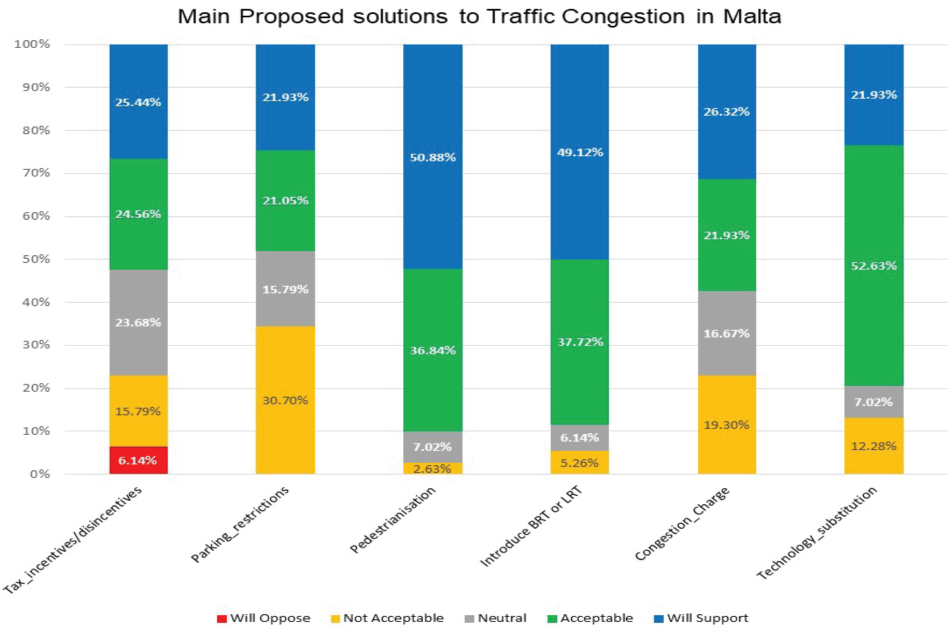


Figure 4a: *Cumulative percentile bar chart for key fiscal solutions to congestion.*

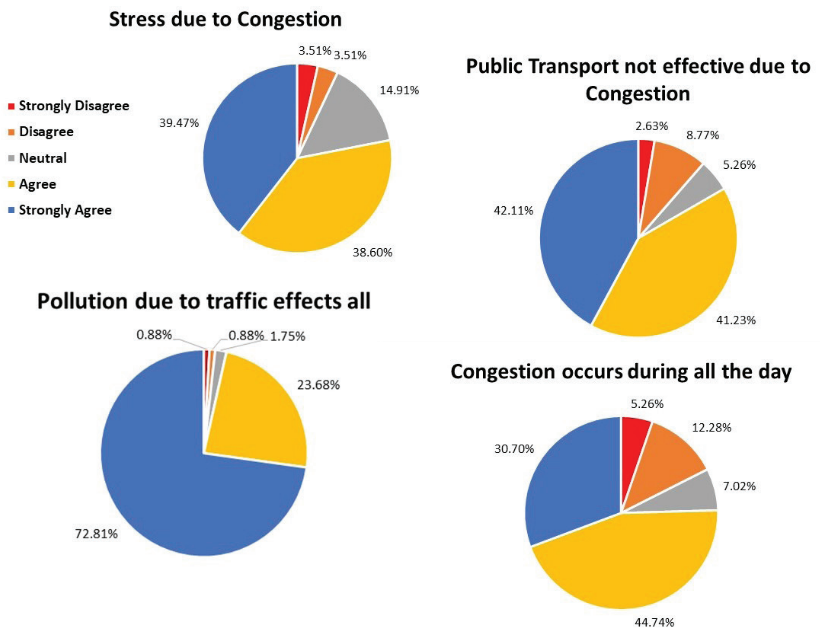


Figure 4b: *Pie Charts displaying Congestion Impacts (Dependent Variables) due to congestion.*

The analysis of the data collected from the Congestion survey, consists of an exploratory approach utilising SPSS. The data is inputted, after which a dimension reduction is applied, using Factor Analysis of the independent variables that maintain coherence to communality. In order to identify the different dimensions and structure of the variables, the use of Varimax rotation allows the dimension reduction to be applied to a few key cumulative constructs (or underlying factors). These are identified using a principal component analysis defining the number of dimension reduction variables that have an Eigenvalue greater than 1. A Scree Plot is used to ensure that the number of factors extracted by the eigenvalue greater than one rule, is sensible. The Varimax Rotation component matrix distinguishes which variables are most dependent on any specific dimensional factor. The final stage of the analysis consists of a linear regression model, to allow each new multi-item scale an interpretation of its estimate change corresponding to the dependent variables (in which case these are also grouped into one component for simplicity's sake), when all the other new independent variables are held constant. This verifies normality, linearity as well as homoscedasticity, and confirms there is no multicollinearity (and thereby related errors of correlation) between the independent variables, although specific tests are later conducted in this paper, to verify each, independently. This process is visually detailed in *Figure 5*.

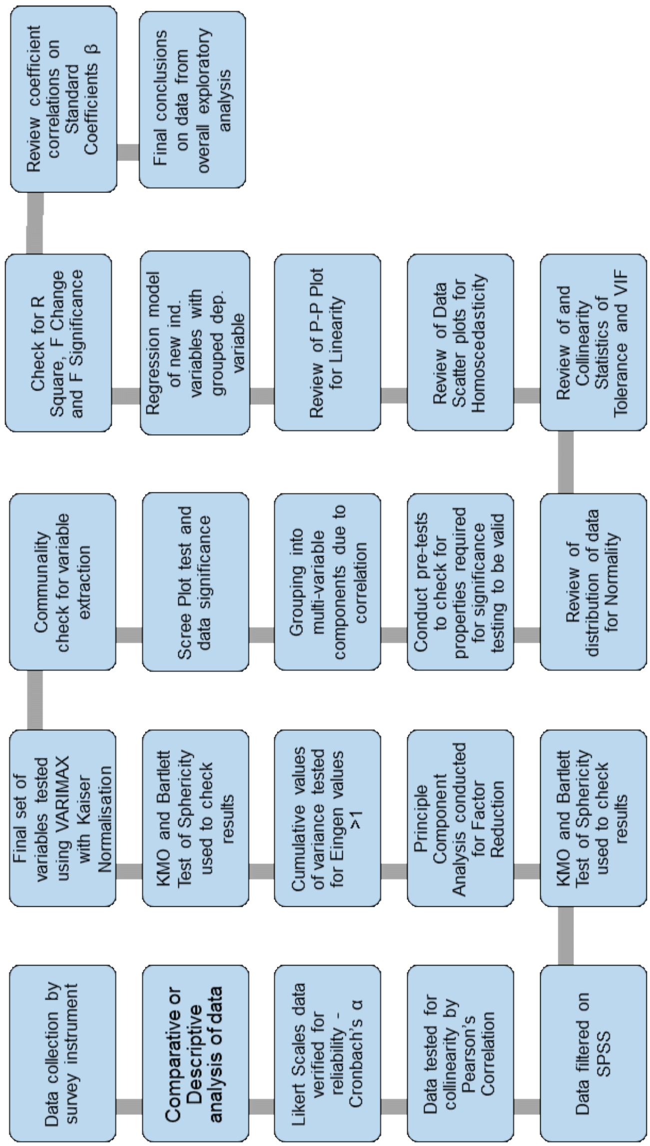


Figure 5: *All the subsequent stages of the quantitative exploratory analysis*

Dimension Reduction: Variable Factor Analysis

The first stage of the exploratory analysis of the data collected from the Congestion survey requires a Principle Component analysis of the independent variables. A Factor analysis is used to test a theoretical model of latent factors causing the observed variables. In executing a Principal Component analysis, the aim is to reduce the correlated observed variables to a smaller set of important independent composite variables. In order to ensure that this model is robust, and that the data has the requisite properties, as well meeting all assumptions required for a Principle Component analysis, the Kaiser-Meyer-Olkin (KMO) Measure of Sample Adequacy, is used to check if such proportion of variance, of the observed variables might be caused by the latent variables, thus reducing the cumulative %. In this case, the value is greater than the usual 0.7 threshold, which shows that the model explains the latent variables. Furthermore, the Bartlett Test of Sphericity has a P Value (significance) of 0.00 thus, confirming that the data chosen is suitable for this Factor analysis (see *Table 7*). The primary check at this stage is the cumulative % variance and the Communalities Tables. The first one will give the % of the extracted components that explain the overall variability in the original independent variables, whilst the second would indicate if the specific variables have a high or low communality (the association between a factor and a variable) with the extracted Factor analysis. The higher the cumulative %, the better, since that means that the component used, explains a large percentage of the variability of the original variables. Any variable that has a communality less than 0.5 should be tested and/or removed as this may have no bearing due to having a low common variance with the variables used. In this case, all variables are tested and after a number of runs, some variables displaying low communality, were discarded. These were Variables 3, 8 and 23. Once a variable is removed other variables may show low communality. By testing the cumulative %, a researcher can decide whether to retain or remove said variables. In this case, it was decided that after removing these three variables, the model was quite stable and all other variables were retained, including Variables 13 and 22, which had exhibited higher communality during previous runs. The method used in this case was Principle Axis Factoring, since maximum likelihood requires continuous data, which is normally distributed.

Communalities		
	Initial	Extraction
Daily_Registrations_IMP	.574	.587
Bold_solutions_IMP	.558	.583
Tax_incentives_IMP	.547	.620
Parking_restrictions_IMP	.476	.496
Pedestrianisation_IMP	.585	.573
Transport_Plan_IMP	.573	.725
BRTorLRT_IMP	.533	.551
Govt_policies_IMP	.672	.769
Economic_growth_IMP	.574	.601
Congestion_Charge_IMP	.536	.620
Economic_sector_IMP	.350	.540
Road_widening_IMP	.608	.647
Bicycle_lanes_IMP	.404	.598
Privelege_or_Need_IMP	.502	.501
Technology_IMP	.222	.107
Extraction Method: Principle Axis Factoring.		

Table 5: *Table of Communalities with the final Independent Variables. Variables 13 and 22 were retained after a number of runs even if exhibiting <0.5 extraction value.*

Table 6 shows the Principle Component analysis where the cumulative % variability is highlighted. In this model the extracted solution explains 68.4% of the variability of all the remaining 15 variables. This is quite a high percentage, and as such shows the reliability and robustness of the model. The model however shows that there is a decrease in the cumulative % from the Initial Eigenvalues to the Extraction of Sum of Squared Loadings to the Rotation of Sums of Squared Loadings. This is reduced in both cases to 57%.

Total Variance Explained									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.389	42.591	42.591	5.983	39.887	39.887	3.356	22.370	22.370
2	1.705	11.365	53.956	1.285	8.567	48.454	2.630	17.532	39.902
3	1.159	7.729	61.685	0.636	4.241	52.694	1.413	9.418	49.321
4	1.009	6.728	68.412	0.616	4.106	56.801	1.122	7.480	56.801
5	0.851	5.671	74.083						
6	0.613	4.086	78.169						
7	0.564	3.761	81.930						
8	0.461	3.076	85.005						
9	0.430	2.863	87.869						
10	0.383	2.554	90.423						
11	0.368	2.455	92.878						
12	0.320	2.130	95.008						
13	0.278	1.854	96.862						
14	0.243	1.619	98.481						
15	0.228	1.519	100.000						

Table 6: *Table of Variance – Principal Component Analysis*

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.882
Bartlett's Test of Sphericity	Approx. Chi-Square	697.811
	df	105
	Sig.	.000

Table 7: *Table showing KMO's (proportion of variance) and Bartlett's test values (data suitability)*

Looking at the eigenvalues of the correlation matrix, it may be deduced that the initial 15 variables are in fact caused by 4 underlying factors. This is because only four eigenvalues are larger than one. This can also be seen by looking at the scree plot where a sharp bend occurs after the fourth factor (see Figure 5). The last factor just squeezes in with a value of 1.009, denoting that this particular factor may have less relevance as a component on the dependent variables. Furthermore, this specific component factor has only 1 variable (Variable 10) to its name, and although retained, the subsequent analysis will further show the lack of variability it has on the overall model. The newly constructed factors may thus be used to explain the effect of the independent variables on the dependent variables of the research.

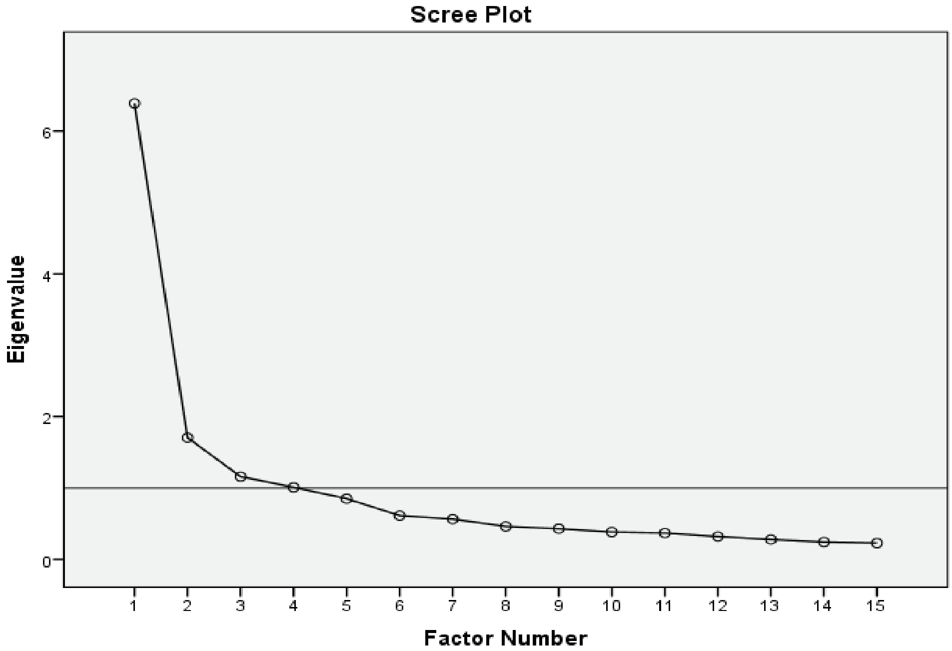


Figure 6: *Scree plot showing clearly the 4 component factors chosen with Eingenvalues ≥ 1.*

When conducting a Principle Component analysis, a specific assumption can be taken in a Dimension Reduction test when doing a rotation of the variables. The assumption is that the data is either Orthogonal (i.e. there is no relationship between the variables) or Oblique (i.e. that there is a relationship between the variables). Whereas the study is based on variables that should have an inter-relationship, the method of rotation of the data chosen is Varimax. In so doing, testing if there is a relationship between the variables, would have been taken for granted in an Oblique rotation. The resultant Varimax Rotation table (see *Table 8*) using Kaiser Normalisation, clearly shows which variables are representing these new combined 4 factors. The method is simple, as the variables exhibiting the largest value (loading) for a specific component is deemed to be part of that factor. It is also relevant to mention that the final result was obtained in only 6 rotations showing that the model is quite coherent and robust. The model is also reliable as the number of factors are quite few, while the first factor is significantly strong with 7 variables. Furthermore, in *Figure 6,* the new Model Framework (albeit still conceptual given that it needs to be verified by a Regression since this is a pre-study) can be drawn using this new variable architecture, with the new component factors renamed. Furthermore, the factors are still exhibiting the same or similar structure to the initial Conceptual Framework (see *Figure 3*), showing that the Secondary research was relevant to the local scenario and the subsequent hypothesis raised. A final test that is used to ensure the consistency of the newly correlated component variables is the Cronbach Alpha test. The results for each composite variable clearly show the consistency and reliability of the factor reduction process (see *Tables 8a*, *8b* and *8c*), further verifying the validity of the overall model.

Rotated Factor Matrix				
	Factor			
	1	2	3	4
National Transport Plan	0.838		0.144	
Road widening programme	0.706	0.349	0.105	0.128
Daily car registrations	0.600	0.255	0.333	0.228
National Economic Growth	0.599	0.169	0.225	0.404
Pedestrianisation of town centres	0.561	0.404	0.307	
IntordThe BRT or LRT in Malta	0.558	0.323	0.363	
Government auto-centric policies	0.548	0.473	0.123	0.480
Congestion Charge	0.198	0.756		
Tax disincentives and incentives		0.720	0.289	-0.106
Parking restrictions imposed	0.262	0.647		
A car is a need to mobility	0.376	0.504	0.119	0.302
Use and encourage Bicycle Lanes		0.272	0.693	0.184
Government needs to embrace bold solutions	0.474	0.236	0.538	0.116
Use of Technology instead of travelling	0.105		0.310	
The boost of a specific Economic sector	0.101	-0.165		0.707
Extraction Method: Maximum Likelihood. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations.				

Table 8: *Rotated Component Matrix with the 4 component factors chosen with Eingenvalues ≥ 1 and grouped with their closely correlated variables.*

Reliability Statistics

Cronbach's Alpha	N of Items
.895	7

Table 8a: *Cronbach a for the first composite variable*

Reliability Statistics

Cronbach's Alpha	N of Items
.795	4

Table 8b: *Cronbach a for the second composite variable*

Reliability Statistics

Cronbach's Alpha	N of Items
.557	3

Table 8c: *Cronbach a for the third composite variable*

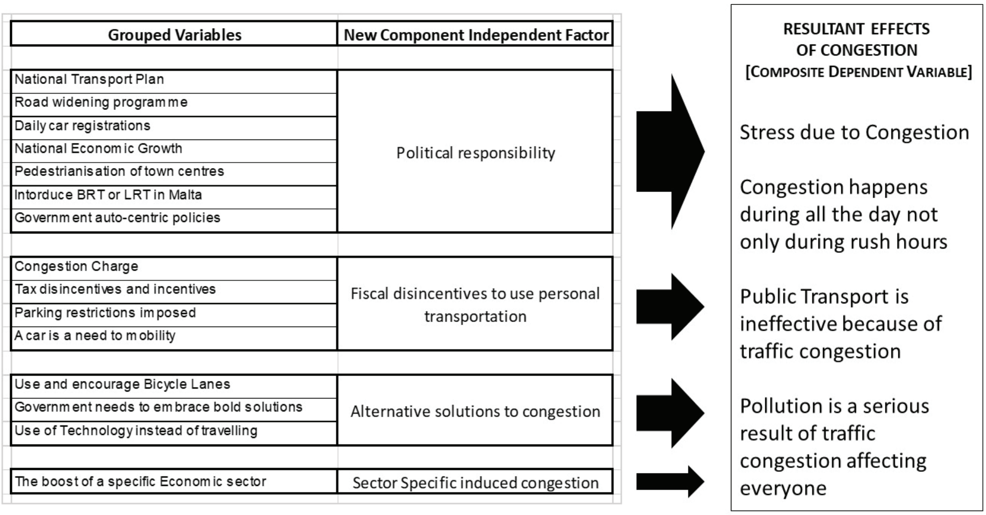


Figure 7: *New proposed Model (Conceptual) Framework where the Independent Variables are grouped into 4 factors directly affecting the 4 remaining Dependent Variables*

Linear Regression Analysis

The Independent Variables grouped into component factors were given different names so as to represent the grouping done from Principle Component analysis. The dependent variables are also grouped into one dimensional dependent variable using their mean values. This composite dependent variable, has been renamed Resultant Effects of Congestion Variable. In order to perform Linear Regression, the data first needs to be tested for Linearity (checking that there is a linear relationship between the independent variables and the dependent variable), Normality (that the residual errors are normally distributed), Homoscedasicity (that the data shows residual errors that are of equal variances and do not deviate too far from the regression line or relationship analysed), and Multicollinearity (that there is no strong correlation relationship between the independent variables that would affect the relationship with the dependent variable). These are the required data characteristics to ensure that inferences made from the data are valid. It is also important to ensure that the model does not have any outliers that can skew the result. In any regression analysis the least number of observations for any independent variable is 20. Hair et al. (2019) state that there should be a minimum of 50 observations per variable, so the 99 observations satisfy this requirement. The Model Summary (see *Table 9*) shows an R square value of 0.486, which means that the independent variables explain 48.6% of the variation in the dependent variable. Furthermore, the Adjusted R Square (which takes into consideration every individual variable) varies very little at 0.464, further adequately defining the model. F Change or F Static, shows the improvement in prediction as a result of fitting the regression model, and it is 22.218 times better than using the mean as a best guess. Or simply stated, it is 22.218 times better if the averages of the independent variables had only been compared to the average of the dependent composite variable. Finally, the Significance is at 0.000, implying that there is zero possibility that such observed relationship worked well, simply by chance.

Model Summary[b]

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.697[a]	.486	.464	.43459	.486	22.218	4	94	.000

a. Predictors: (Constant), Fiscal_Disincentives_COMP, Econ_Sect_COMP, Alternative_Sol_COMP, Political_Resp_COMP

b. Dependent Variable: DependentVar_COMPOSITE

***Table 9:** Linear Regression Model Summary*

The Anova table (see *Table 10*), shows the same F value, and the same Significance value, highlighting a clear and correlated relationship between the independent and dependent variables, as the R Value in Model Summary is 0.697. 'R' is the correlation between the observed values of the dependent variable and the predicted values of the dependent variable (those which are obtained from the model). Such a high value is desirable as it means that the observed dependent variable is highly correlated with the predictions made by the model. In this case, the independent variables contribute or influence the dependent variable by 0.486 or around 50% given by the R^2 (R square) value.

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	16.785	4	4.196	22.218	.000[b]
	Residual	17.754	94	.189		
	Total	34.539	98			

a. Dependent Variable: Dependent Var_COMPOSITE

b. Predictors: (Constant), Fiscal_Disincentives_COMP, Econ_Sect_COMP, Alternative_Sol_COMP, Political_Resp_COMP

***Table 10:** Linear Regression ANOVA*

Table 11 displays the Linear Regression Coefficients table. Each of the independent variables are displayed with their β, Correlation and Collinearity values in comparison to the dependent variable. Of interest are the Standardised Coefficient β that shows how each variable individually influences the dependent variable. The first two factors

(Political Responsibility and Alternative Solutions) are statistically significant ($p<0.01$). The first factor (Political Responsibility) has a 73% influence on the effects of congestion. Not only does it have the strongest influence on the regression, i.e. the strongest direct effect on the Composite Dependent Variable, but it is also composed of the largest number of independent variables. Therefore, Political Responsibility, or in this case lack thereof, or strategies being taken at a governmental level, is what is causing the effects of congestion to be more significant on the overall population. The Significance of the 2nd and 3rd composite independent variables are low, which can mean that the overall equation could possibly do without these variables. However, these have been kept for consistency. Apart from their low values, these two variables are negative, which means they have an inversional proportional effect on the dependent variable. This denotes that the more theseincrease, the effects of congestion reduce. These two variables may need to be further explored to have a clearer understanding of said implications.

Multicollinearity diagnostics is done through the Variance Inflation Factor (VIF), which asses how much the variance of an estimated regression coefficient increases if the predictors are correlated. These are all just above the value of 1, and definitely less than 5. That proves that no factors are alarmingly correlated. Furthermore, Tolerance indicates the percentage value of the variance in any given component that cannot be explained by other predictors, and with values of 71.5% for the 2nd variable and 99% for the 3rd one, further proves that there is an extremely low multicollinearity between the independent variables.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.325	.323		7.192	.000		
	Political_Resp_COMP	.511	.071	.731	7.240	.000	.537	1.864
	Alternative_Sol_COMP	.108	.071	.133	1.522	.131	.715	1.399
	Econ_Sect_COMP	-.070	.044	-.118	-1.588	.116	.991	1.009
	Fiscal_Disincentives_COMP	-.141	.052	-.254	-2.720	.008	.628	1.594

a. Dependent Variable: DependentVar_COMPOSITE

Table 11: *Linear Regression Coefficients*

The Collinearity Diagnostics (see *Table 12*), confirms that there is generally a good spread of values, proving low multicollinearity. Furthermore, the Eigenvalues displayed are all very low, a clear indication that the predictors are not intercorrelated between themselves, whilst the Condition Indexes, are all less than 30 (Hair et al., 2019).

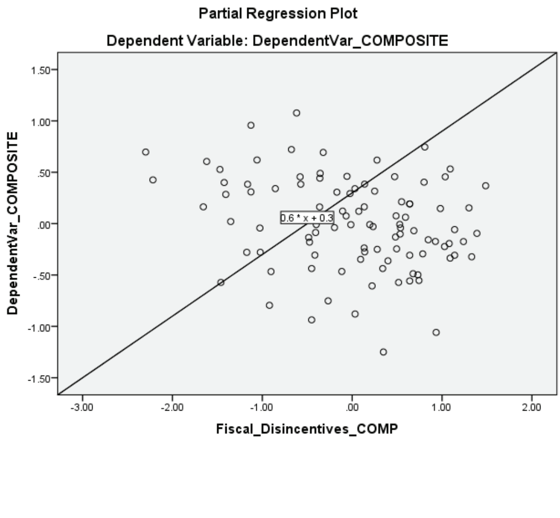
Collinearity Diagnostics[a]

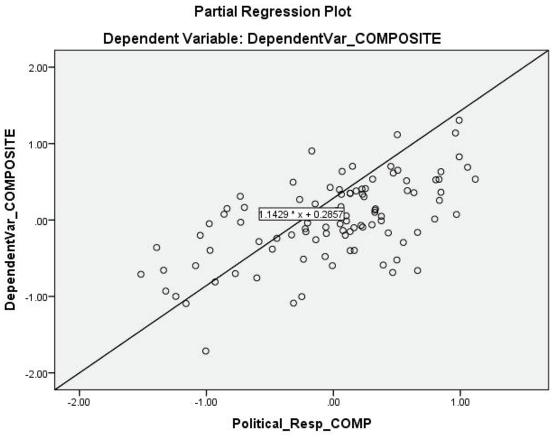
Model	Dimension	Eigenvalue	Condition Index	Variance Proportions: (Constant)	Political_Resp_COMP	Alternative_Sol_COMP	Econ_Sect_COMP	Fiscal_Disincentives_COMP
1	1	4.835	1.000	.00	.00	.00	.00	.00
	2	.093	7.230	.00	.01	.00	.45	.23
	3	.044	10.461	.05	.02	.12	.33	.53
	4	.016	17.315	.13	.96	.15	.03	.23
	5	.012	19.985	.82	.01	.73	.20	.00

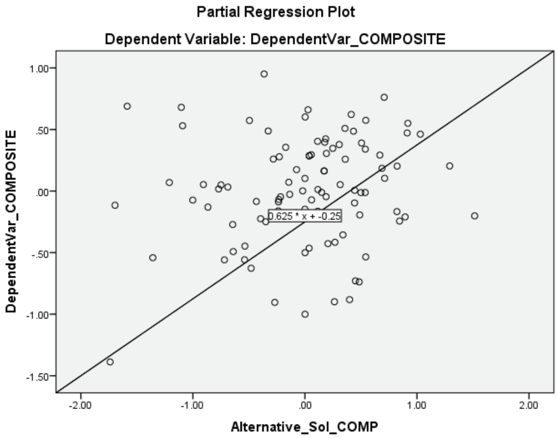
a. Dependent Variable: DependentVar_COMPOSITE

Table 12: *Linear Regression Collinearity Diagnostics*

Homoscedasticity is tested by verifying the Partial Regression Plots. The assumption of equal variances (i.e. assumption of homoscedasticity) assumes that different samples have the same variance, even if they came from different populations. This is an underlying assumption in any linear regression. Unequal variances can have a significant impact on any results and may even invalidate conclusions drawn. The four plots below clearly show that 3 of the Composite independent variables namely, Political Responsibility, Fiscal Disincentives and Alternative Solutions, are homoscedastic. However, the Composite independent variable named Economical Sector is clearly Heteroscedastic, therefore prone to unequal variances from the Linear Regression and will be in any future analysis, discarded. This confirms earlier results from the Linear Regression Coefficients.







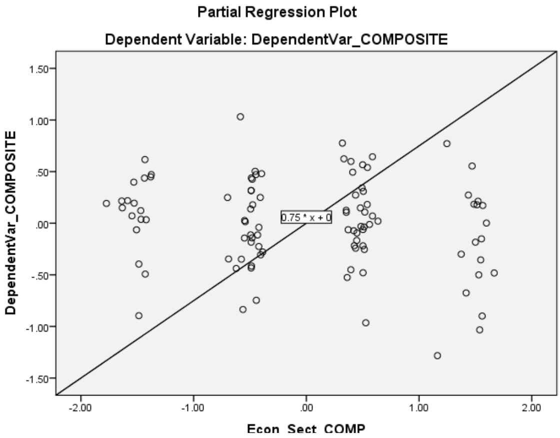


Figure 8: *Linear Regression Partial Regression Plots*

The final check for Linearity and Normality is done using the Normal Probability Plot of Standardized Residuals (Figure 8) and the Histogram Chart (Figure 9). The gradient of the Normal P-P Probability Plot shows that the independent variables are directly proportional to the Cumulative dependent variable, with an R Squared of 49%. The independent variables, thus contribute directly to the Congestion effects that are listed as dependent variables composing the Cumulative dependent variable. This demonstrates the Linear Relationship expected in such an analysis. Furthermore, all values fall along or very near the diagonal with no substantial deviations.

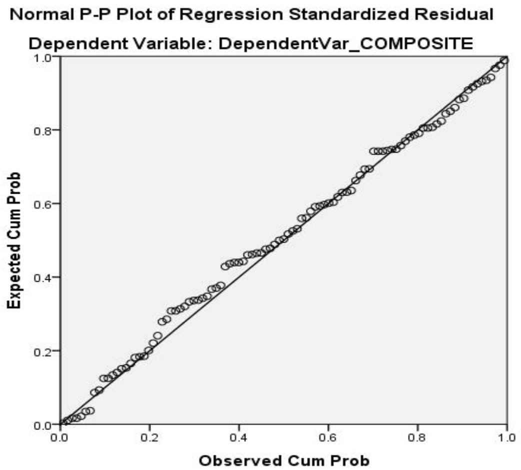


Figure 9: *Linear Regression Normal P-P Plot of Regression Standardized Residuals*

The Histogram, also exhibits a very good distribution with no significant kurtosis or any sign of positive or negative skewness. There are no outliers, and the mean is aligned with the median. It can therefore be concluded that regression meets all the assumptions of Normality, Linearity, Homoscedasticity and Multicollinearity.

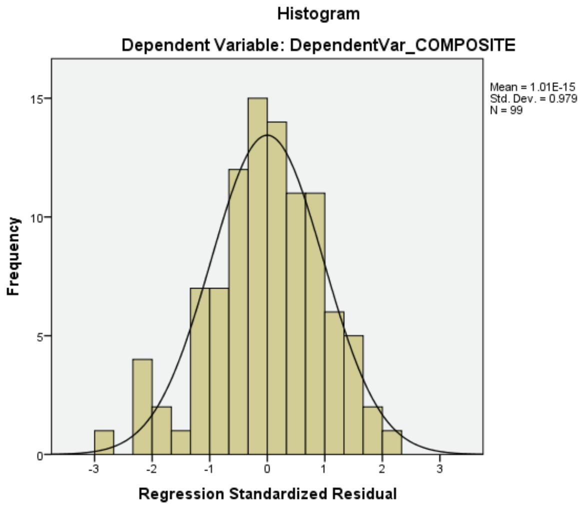


***Figure 10**: Linear Regression Histogram over normal distribution*

Conclusions and Observations

This research has successfully demonstrated which are the most critical Congestion inducing factors according to the Maltese drivers. It has also demonstrated a very strong correlation between these factors and the Congestion repercussions that are daily impacting, not just the drivers, but (due to Pollution, as well as other exogenous and endogenous costs and implications) all the Maltese population. All the Independent and Dependent variables were identified through Secondary research. This study highlights through a Multivariate Analysis, utilising data from a survey instrument that is statistically relevant, which are the main variables that have the most effect on Congestion, utilising a Dimension Reduction analysis, by grouping specific Independent Variables and reducing them to four main components. In order to further prove the model beyond Reliability and Validity, a Linear Regression is utilised to check for Normality, Linearity, Homoscedasticity and Multicollinearity. This ensures that the resultant model is a clear representation of how these components affect, the now agglomerated, Dependent Variable. Any future studies on the topic would need to alleviate the concern of having too much variance loaded onto the first main component (42.5%). This would be done through a redesigned research instrument. The study started with the three main factors causing Congestion. The analysis clearly singles out one specific factor (see *Table 8* and *Table 11*) as the key contributor to the Congestion problem presently in Malta, i.e. Political Responsibility. Respondents indicated the government's responsibility in their responses, highlighting the auto-centric policies that have been pursued since the 1930s in Malta. This conclusion is well supported by *Figure 7*, which shows strong correlation between Political Responsibility and Congestion Effects on society.

This has resulted in the majority of the population being locked both physically and financially, in one mode of transport, while the reform of public transport is losing its impetus. This is mainly due to the congestion in the roads, making it less effective and reliable than it was planned or able to be. All the solutions proposed were supported by the respondents, and thus there is a clear understanding that a drastic solution to the problem is required. Respondents are not amenable to pay or support fiscal disincentives to deter car usage, such as congestion charging, tolls, taxation on single passenger cars (see *Table 4*), as they do not agree that they should also pay for the solution, even though they are the main cause of pollution and key perpetrators of the problem. In the Linear Regression, Fiscal Disincentives also showed an inverse trend (see *Table 11*) to levels of congestion suggesting that such measures would work to reduce Congestion, but would be extremely unpopular. In other words, Maltese drivers want a solution but they do not want to be the ones paying for it, identifying the government as the owner of both the problem and the solution. Thus, the population will not support a polluter pays principle approach. They would rather support a solution that is funded by someone else, even if it is the Maltese government, and indirectly by themselves, that would alleviate congestion, reduce pollution and improve public transport. However, such a solution would require the implementation of a multi-modal national infrastructure implemented over a long-term plan, and enforcing a cultural change. Given any such solutions have significant fiscal, cultural and political implications, no Maltese government seems inclined to opt for a resolution/s, which find significant populous opposition in the short term. And, from a political point of view, such policies are seen as counterproductive, presumably either as a voting deterrent, and definitely not exploitable within a manifesto for any forthcoming general elections due to its long-term deployment.

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