ON THE CORRELATION FACTOR BETWEEN KEY CHARACTERISTICS OF EFFICIENT DRIVING AND SAFE DRIVING

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Abstrak

Dalam kajian ini, beberapa pendekatan telah dilakukan atas faktor korelasi antara ciri-ciri utama cekap memandu dan pemanduan yang selamat. Kaedah mendekati adalah kaedah penyelidikan kualitatif yang pada dasarnya dan kaedah kajian kuantitatif. Kajian ini terutamanya adalah untuk menunjukkan hubungan antara penggunaan yang lebih selamat dan cekap memandu. Ia cuba untuk memberikan motivasi betul selamat memandu ke arah cekap memandu, kerana sebahagian daripada memandu cekap keadaan yang mungkin tidak selamat, dan kadang-kadang cekap memandu boleh membawa kepada keselamatan.

Semasa perkembangan penyelidikan, ciri-ciri utama memandu telah disenaraikan dan dianalisa tentang hubungan dengan keselamatan dan kecekapan. Walau bagaimanapun, tahap kecekapan dan tahap keselamatan pada salah satu daripada ciri-ciri setiap memandu tidak mempunyai cara yang standard untuk mengukur seperti ketinggian dan berat badan dikira centimetre dan kilogram. Untuk meletakkan penggunaan yang lebih selamat dan cekap memandu di dengan pengiraan, setiap satu daripada ciri-ciri setiap memandu telah disenaraikan dari yang paling selamat untuk paling berbahaya dan yang paling berkesan kepada yang paling dalam-cekap. Kedudukan setiap setiap ciri-ciri Keselamatan didasarkan pada peluang membawa ciri-ciri yang memandu kepada kemalangan dan keseriusan kemalangan jika kemalangan itu berlaku disebabkan oleh amalan ciri-ciri memandu. Ranking bagi setiap ciri-ciri setiap memandu pemanduan cekap diukur oleh faktor tahap melahu, pecutan, brek dan kelajuan. Skala wajaran yang diberi kepada kedudukan Peti Deposit Keselamatan.

Kajian ini telah membuat beberapa pendekatan untuk mendapatkan nilai-nilai berangka daripada faktor korelasi antara ciri-ciri utama cekap memandu dan selamat memandu yang pada mulanya kedua-dua tahap keselamatan dan tahap kecekapan memandu ciri-ciri yang telah boleh diukur. Faktor korelasi antara ciri-ciri utama cekap memandu dan pemanduan yang selamat adalah secara keseluruhannya positif dan signifikan.

Abstract

In this research, a few approaches were done on the correlation factor between key characteristics of efficient driving and safe driving. The approaching method was basically qualitative research method and quantitative research method. This research mainly was to indicate the relationship between safe driving and efficient driving. It attempts to give correct motivation on safe driving towards efficient driving, because some of the circumstances efficient driving may not be safe, and sometimes efficient driving can lead to safety.

During the progress of the research, the main driving characteristics were listed and analysed on the relationship with safety and efficiency. However, the level of efficiency and level of safety on each of every driving characteristics does not have a standard way to measure like height and weight is measured in centimetre and kilogram. In order to put safe driving and efficient driving in to calculation, each of every driving characteristics were ranked from the safest to most dangerous and the most efficient to the most inefficient. The ranking of each of every characteristics on safety were based on the chance of the driving characteristics leads to accident and the seriousness of the accident if the accident happened due to the practice of the driving characteristics. The ranking for each of every driving characteristics on efficient driving were measured by the factor of the level of idling, acceleration, braking and speed. Weightage scales were given to the ranking of safe driving and efficient driving where the magnitude of the safety or efficiency was represented by the numerical values of the weightage. Thus, calculation on the correlation factor could be conducted by the mathematical formula.

This research had made several approaches to obtain a numerical values of correlation factor between key characteristics of efficient driving and safe driving which initially both of the safety level and efficiency level on the driving characteristics were non-measurable. The correlation factor between key characteristics of efficient driving and safe driving was overall positive and significant.

Chapter 1: Introduction

1.1 Overview

It is still unclear on the correlation factor between the key characteristics of safe driving and efficient driving. In this project, the relation between efficient driving and safe driving will be investigated. The key characteristics common to both driving pattern will be studied using quantitative and qualitative research method. Analysis of data will involve statistics that should yield an algorithm to be used for simulations.

In qualitative research method, the study on the current definition available about what define correlation, safe driving and efficient driving and also categorise the key characteristic on safe driving and also the key characteristic on efficient driving. In quantitative research method, survey and statistical study was carry out to determine the correlation factor between key characteristics of efficient driving and safe driving.

1.2 Problem Statement

Most of the people think that safe driving is positive correlation with efficient driving, which the safer of the driving, the more efficient the driving is (Bob Belanger, 2017). However, some of the circumstances efficient driving is not relevant with safe driving or sometimes efficient driving may not be safe. For example, slow driving in highway may not be a safe driving as most of the vehicle are driving fast on the highway, however drive faster would not be driving efficiently base on fuel efficiency. Also, if one who are coasting across red traffic light is dangerous, however it is very efficient to skip the drive cycle of brake deceleration, pick up acceleration and idling.

Thus the study on the actual correlation factor between key characteristics of efficient driving and safe driving is interesting to know and justify.

1.3 Scope of the project

1) Study on the key characteristic of safe driving and the key characteristic of efficient driving.
2) Study on the meaning of correlation factor.
3) Make a hypothesis on the correlation factor between key characteristics of efficient driving and safe driving
4) Study the relationship between each of every key characteristic of efficient driving and safe driving using quantitative and qualitative research method.
5) Make a conclusion on the correlation factor between key characteristics of efficient driving and safe driving.

1.4 Objective

1) To find the correlation factor between key characteristics of efficient driving and safe driving.
2) Give correct motivation on safe driving towards efficient driving.

Chapter 2: Literature Review

2.1 Safety and Fuel Economy Regulation

The importance of automobile safety is evident simply from the scale of injuries and fatalities each year. In 2008 there were 37,261 fatalities in car accidents on U.S. roads and more than 2.3 million people injured.14 The National Highway Traffic Safety Administration (NHTSA) is tasked with monitoring and mitigating these risks and oversees numerous federal regulations that include both automobiles and the design of roads and signals.

To motivate the concern about fuel economy standards with respect to safety consider the very rough estimate provided in NRC (2002): approximately 2,000 of the traffic fatalities each year are attributed to changes in the composition of the vehicle fleet due to the CAFE standards. If we further assume that the standards are binding by about 2 miles per gallon, this translates to a savings of 7.5 billion gallons of gasoline per year. When valuing the accident risks according to the Department of Transportation's methodology this implies a cost of $1.55 per gallon saved through increased fatalities alone. This does not consider injuries, or any of the other distortions associated with fuel economy rules, yet by itself exceeds many estimates of the externalities arising from the consumption of gasoline.

Conversely, a finding that accident risks improve with stricter fuel economy regulation would present an equally strong argument in favor of more stringent rules. The magnitude of the implicit costs involved in vehicle safety motivate the importance of a careful economic analysis, and mean that even small changes in the anticipated number of fatalities will carry great weight in determining the optimal level of policy. (Mark R. Jacobsen, 2012)

2.2 Driving in urban vs highways

Driving environments is the factor that dictate the way of driving. While driving in urban, regularly the driver have to stop at traffic lights, stop and give-way signs, pedestrian crossings, the school, shops, for incidents on the road, and traffic jams. Even when moving, drivers almost always driving in a transient mode, such as accelerating, decelerating and braking. Which acceleration, braking and idling is maximised. Driving in highways usually more fuel efficient compare to urban as it is always getting going at a more stable speed, seldom brakes and the practice of force and un-force idling are not practical. Which so driving in highways is much more fuel efficient than driving in urban area. (Graham Smith , 2015)

If safe driving is efficient driving or vice versa, driving in highways is safer than driving in urban area, however this statement seems not right.

In 2015, the rate of crash deaths per 100 million miles travelled was 2.6 times higher in rural areas (more highways) than in urban areas (1.84 in rural areas compared with 0.71 in urban areas). From 1977 to 2015, the rate decreased by 58 percent in rural areas (from 4.35 to 1.84) and 70 percent in urban areas (from 2.35 to 0.71).

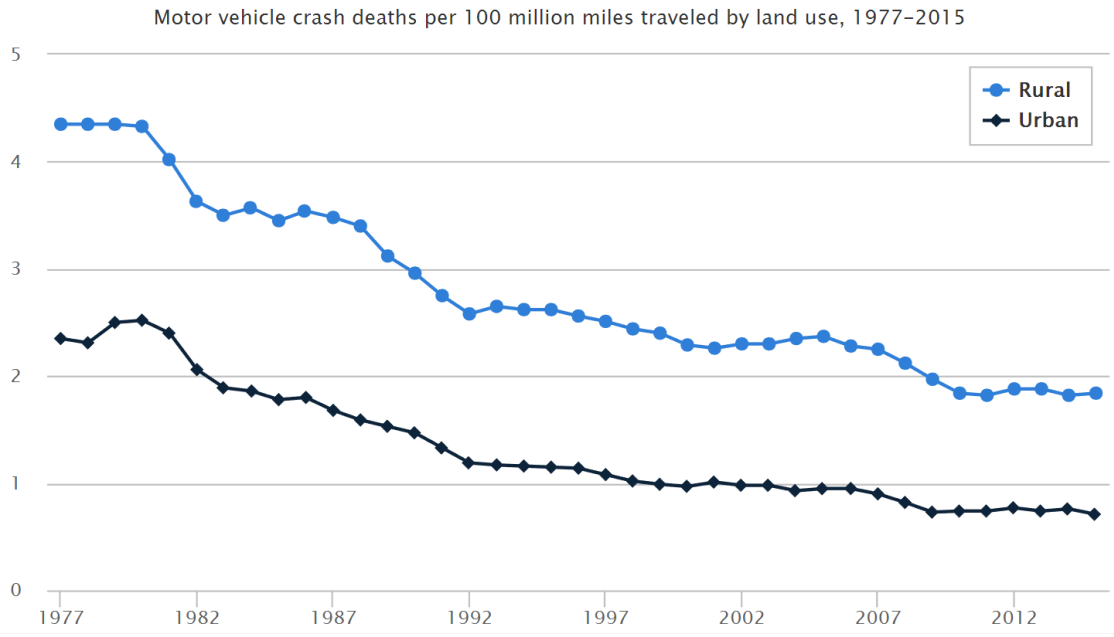

Figure 2.1

(Insurance Institude for Highway Safety , 2015)

The table below shows that driving in rural (highways) has higher death rate which 6845 in rural and 5402 in urban for cars and minivans.

Motor vehicle crash deaths by vehicle type and land use, 2015

	Rural		Urban		Total*	
	Deaths	%	Deaths	%	Deaths	%
Cars and minivans	6,845	52	5,402	41	13,116	100
Pickups	3,095	69	1,159	26	4,467	100
SUVs	2,716	60	1,567	34	4,560	100
Large trucks	421	70	155	26	600	100
Motorcycles	1,915	41	2,299	49	4,693	100
Pedestrians	1,160	22	3,704	69	5,376	100
Bicyclists	214	26	492	60	817	100
Total*	17,114	49	15,362	44	35,092	100

**Total includes other and/or unknowns*

Figure 2.2

(Insurance Institude for Highway Safety , 2015)

2.3 The driving characteristics with safety and efficiency

1. Glide in neutral gear on downhill road

Most of the people feel that put the car in neutral gear during downhill may save fuel, however, it is not really save fuel but waste fuel compare to putting normal gear. Most of the surveyor in various forum and websites have the same comments that in modern computerized automobiles, the engine can cut off fuel if there is low load or no load on the engine. If the car stay in gear and let off the gas pedal while the engine speed is above idle, as would typically be the case on a long downhill, the engine will cut off fuel to combustion chambers so that you are using no gas. Because the car is in gear, the wheels will keep turning the engine so that it doesn't stall. (Gary Richard, 2014)

If the car is in neutral, the wheels will not turn the engine, so the engine has to send fuel to the combustion chambers to maintain idle RPM so that the engine doesn't stall. (Gary Richard, 2014). Therefore, it is really un-efficient to glide in neutral compare to glide in gear on downhill road, (Brian Su, 2013) shows the experiment that gliding in gear is more fuel efficient than gliding in neutral.

If the driver has to accelerate or quickly change lanes to avoid unsafe road conditions, the last thing the driver will think of is whether the vehicle is in gear. With the car out of gear, drivers and passengers are more at risk when it comes to reacting quickly, this action is very dangerous. (Gary Richard, 2014)

2. Smooth and gradual acceleration or braking

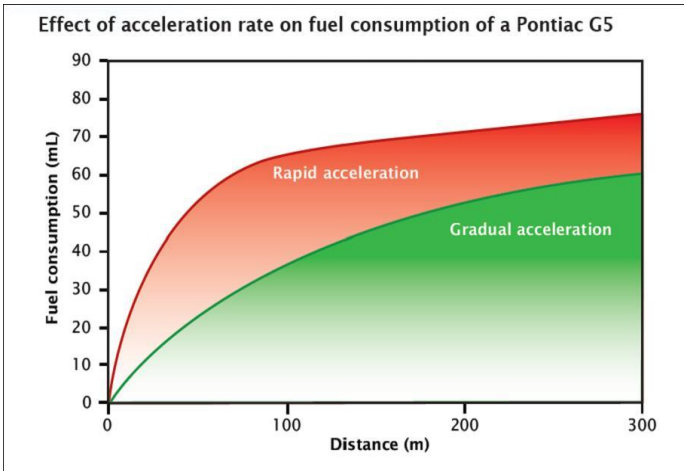

Figure 2.3

(Government of Canada, 2016)

During acceleration fuel efficiency generally improves as RPM increases until a point somewhere near peak torque (brake specific fuel consumption). However, accelerating to a greater than necessary speed without paying attention to what is ahead may require braking and then after that, additional acceleration. Experts recommend accelerating quickly, but smoothly to save fuel. (Anne Eisenberg, 2001) (Ashley Langer and Shaun McRaey, 2014)

Generally, fuel efficiency is maximized when acceleration and braking are minimized. (Ashley Langer and Shaun McRaey, 2014)

So a fuel-efficient strategy is to anticipate what is happening ahead, and drive in such a way so as to minimize acceleration and braking, and maximize coasting time. However, if one driver need to practice smooth and gradual acceleration or braking, the distance of the driver car between the car in front have to keep a distance which is long enough to practice smooth braking and acceleration by coasting. Therefore the practice of smooth and gradual braking and acceleration may leads to safety.

3. Maintaining an efficient speed

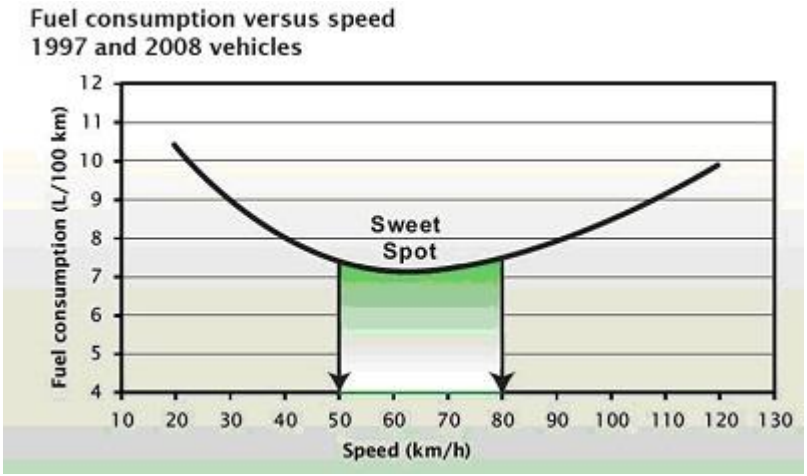

Figure 2.4

(Government of Canada, 2016)

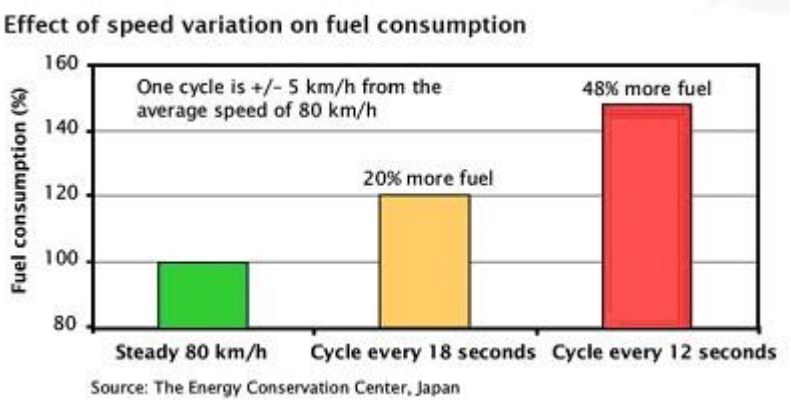

Figure 2.5

(Government of Canada, 2016)

Since fuel efficiency is maximized when acceleration and braking are minimized, maintaining an efficient speed is an important factor in fuel efficiency. Optimal efficiency can be expected while cruising at a steady speed, at minimal throttle and with the transmission in the highest gear. (Ashley Langer and Shaun McRaey, 2014) The optimum speed usually reported to be between 35 mph (56 km/h) and 50 mph (80 km/h). (Government of Canada, 2016)

Road capacity affects speed and therefore fuel efficiency as well. Studies have shown speeds just above 45 mph (72 km/h) allow greatest throughput when roads are congested. Individual drivers can improve their fuel efficiency and that of others by avoiding roads and times where traffic slows to below 45 mph (72 km/h). Communities can improve fuel efficiency by adopting speed limits or policies to prevent or discourage drivers from entering traffic that is approaching the point where speeds are slowed below 45 mph (72 km/h) (European Environment Agency, 2011) (C. Beckx , 2011) (World Record Academy, 2015) (Ina Andersen, 2015)

In the US, the speed at which fuel efficiency is maximized often lies below the speed limit, typically 35 to 50 mph (56 to 80 km/h); however traffic flow is often faster than this. The speed differential between cars raises the risk of collision.

However maintaining constant speed may generally safe in urban as it lengthen the distance between driver and the cars in the road due to the prevention of acceleration and braking in order to maintain constant speed.

4. Select the correct Gear

Engine efficiency varies with speed and torque. For driving at a steady speed, drivers cannot choose any operating point for the engine—rather there is a specific amount of power needed to maintain the chosen speed. For a turbo diesel too low a gear will move the engine into a high-rpm, low-torque region in which the efficiency drops off rapidly, and thus best efficiency is achieved near the higher gear. In a gasoline engine, efficiency typically drops off more rapidly than in a diesel because of throttling losses. Because cruising at an efficient speed uses much less than the maximum power of the engine, the optimum operating point for cruising at low power is typically at very low engine speed, around or below 1000 rpm. This explains the usefulness of very high "overdrive" gears for highway cruising. For instance, a small car might need only 10–15 horsepower (7.5–11.2 kW) to cruise at 60 mph (97 km/h). It is likely to be geared for 2500 rpm or so at that speed, yet for maximum efficiency the engine should be running at about 1000 rpm to generate that power as efficiently as possible for that engine (although the actual figures will vary by engine and vehicle). (Julian Edgar, 2012) (Augustine C. Osigwe, Ph.D, 2016)

If one is driving manual transmission car, if the gear is not properly selected, it may cause accident due to the unexpected slow acceleration during pick up. Therefore select the correct gear is important on safety while driving.

5. Drive slowly

Normally optimum fuel efficient speed is from 35 mph (56 km/h) to 50 mph (80 km/h). Drive slower than 35 mph (56 km/h) may not be fuel efficient. However, if driving 35 mph (56 km/h) and 50 mph (80 km/h) in highway is consider slow as most of the vehicle drive faster than 80km/h in highway. (Government of Canada, 2016) Therefore, drive slowly in urban area may not too efficient but drive slowly in high way is efficient. Furthermore, the need to brake is sometimes caused by unpredictable events. At higher speeds, there is less time to allow vehicles to slow down by coasting. Kinetic energy is higher, so more energy is lost in braking. At medium speeds, the driver has more time to choose whether to accelerate, coast or decelerate in order to maximize overall fuel efficiency. Also, at higher speeds wind resistance plays an increasing role in reducing energy efficiency. (Augustine C. Osigwe, Ph.D, 2016) (Peter Valdes-Dapena, 2008)

However, drive slower may reduce the risk of accident as slower driving, driver can control and handle the vehicle better. It is safe to drive slowly.

6. Coasting or gliding

Coasting dissipates stored energy (kinetic energy and gravitational potential energy) against aerodynamic drag and rolling resistance which must always be overcome by the vehicle during travel. Using stored energy (via coasting) for these purposes is more efficient than dissipating it in friction braking (Augustine C. Osigwe, Ph.D, 2016). When coasting with the engine running and manual transmission in neutral, or clutch depressed, there will still be some fuel consumption due to the engine needing to maintain idle engine speed. While coasting with gear, the vehicle actually using no fuel, therefore is very efficient to practice coasting. (Brian Su, 2013)
However, to practice coasting or gliding, the driver have to keep a length of distance from the car in front, thus it leads to safety.

7. Tyres kept at proper pressure

Underinflated tires wear out faster and lose energy to rolling resistance because of tire deformation. The loss for a car is approximately 1.0% for every 2 psi (0.1 bar; 10 kPa) drop in pressure of all four tires.
Operating a vehicle with its tires underinflated by 8 psi (56 kPa) can reduce the life of the tires by 10,000 kilometres and increase the vehicle's fuel consumption by four percent (Natural Resources Canada, 2017). However overinflated tires are rigid and stiff causing the tire's contact patch (the amount of rubber that meets the road) to be reduced. That leads to a "harder" ride as well as uneven tread wear. The most common type of uneven tread wear due to overinflation is referred to as "center wear." Exactly what it sounds like, the center of the tire will be smooth and worn down while there will be more tread on the sides of the tire. Due to the rigidity of an overinflated tire, it can be more easily damaged by everyday road hazards such as potholes and imperfections in the road (P.I. Stores , 2017) (Central Avenue Automotive, 2013) . Underinflated tires do not hold their shape and are flatter to the ground. Therefore, more of the tire comes in contact with the road, causing the shoulders of the tire to wear prematurely. That is referred to as "shoulder wear." There will be a strip of normal tread down the center of the tire while the shoulders of the tire will be smooth and worn down. Underinflated tires are more flexible when they

roll, leading to increased rolling resistance and therefore a decrease in fuel economy. It's surprising how much of an impact a little air in your tires can have on your safety while driving. The National Highway Traffic Safety Administration found that poorly inflated tires were three times more likely to be the cause of an accident than properly inflated ones. A little more air can save a lot of damage. (Augustine C. Osigwe, Ph.D, 2016)

Worryingly for motorists, during the time of the study, 66% of passenger cars were found to have incorrectly inflated tires on their cars. In some informal studies, that number has risen to 80%. Therefore kept the tires pressure properly may leads to safety.

8. Regular service and maintenance

Wheel alignment, fuel evaporation while parked, and high engine oil kinematic viscosity, all reduce fuel efficiency. Poor wheel alignment may increase the friction between the road and the tyres. High viscosity of engine oil may increase friction of the piston inside the engine and thus increase the burden of the engine. Therefore, frequent car maintenance may leads to fuel efficiency. (Rogers Concepts, 2017)

To maintain safety and reduce the cost of car repair, it is important that you have your car inspected regularly. Regular mechanical inspection should be done and not just a visual inspection of your automotive, since many components of your car cannot be inspected visually. Have regular car service and maintenance is important to avoid car breakdown on road which may cause road accident.

9. Momentum drive at junctions

It is similar as practicing coasting or gliding. It is a behaviour of driving while turning without braking or accelerating. It is lead to fuel efficiency compare to braking or accelerating while turning. However it is dangerous, the car may turn over if the speed of the car is too fast while turning without braking.

10. Running across red light

It is very efficient as it skip the process of the drive cycle which are brake, stop, idling, and accelerate to pick up. Coasting toward a stop sign or red light helps you conserve fuel and save money. It's not only a fuel-efficient driving habit; it's also easier on your tires and brakes, which helps you save on maintenance and repair costs. However, while running across traffic at the instant the traffic lights yet to turn red from yellow, the driver may accelerates more to cross the red light. This may leads to sharp acceleration which is not fuel efficient. However, running across red light is still consider as fuel efficient if the driver did not have sharp acceleration. (Ashley Langer and Shaun McRaey, 2014)

However, it is very dangerous, most of the road accident was because of running across of red light. The severity of running across red light may cause death. It is too high risk to do so.

11. Running across stop sign

It is almost the same as running across red light. However the time taken for idling is lesser compare to waiting a traffic light. It is also very dangerous to do so.

12. Practice illegal U turn

It may skip unnecessary routes and shorten the travelling distance, therefore it save fuel and time. However it is dangerous to do so as it may cause accident as it gives unexpected driving behaviour to other driver.

13. Plan your routes

While going across town or across the country, combine several errands in one outing, and plan the route to avoid heavy traffic areas, road construction, hilly trerrain, etc. With a little organization can group "town tasks" into fewer trips, saving time and fuel expense. However it seems no strong relation to safety, however it has a little leading to safety because it avoid heavy traffic areas, road construction, hilly trerrain, etc.

14. Tailgating/ Drafting

Drafting occurs where a smaller vehicle drives close behind a vehicle ahead of it so that it is shielded from wind. Aside from being illegal in many jurisdictions it is often dangerous. Scale-model wind tunnel and Real-World tests of a car ten feet behind a semi-truck showed a reduction of over 90% for the wind force (aerodynamic drag). The gain in efficiency is reported to be 20–40%.

Up to 10 ft @ 55 mph, the efficiency kept increasing. At its maximum, efficiency was up by 40%. At a distance of 2 ft, efficiency dropped because of the difficulty in keeping the car exactly 2 ft away from the big rig. Regardless, drafting does increase fuel efficiency. (Episode 80: Big Rig Myths, 2007) (Gaffney, 2007)

However drafting increases risk of collision when there is a separation of fewer than three seconds from the preceding vehicle.

15. Looking ahead and surroundings

Driver who stay focus while driving and looking ahead surroundings may not have strong relation to efficiency, however looking ahead while driving may avoid unnecessary braking and acceleration which may leads to a little improvement of fuel efficiency. It is really important for driver to stay focus to avoid accident.

16. Smooth and progressive steering

It does not have any relation to efficiency however it is dangerous if one practice sharp turning and steering because accident may happed due to unexpected driving behaviour.

17. Giving signal when turning/shifting lanes

It does not have any relation to efficiency however it is dangerous if one do not give signal when turning and shifting lane because accident may happed due to unexpected driving behaviour.

18. Putting both hands at 10-10 position while driving

It does not related to efficiency however related to safety because driver may handle and control the vehicle better when emergency happened.

19.Using of smart phone while driving

It seems have little relation to efficiency because if driver use smart phone while driving may not be focus on the road which may cause unnecessary braking and acceleration. It increase the risk of accident due to driver not focus on the road.

20. Fasten seat belt while driving

Base on Alma Cohen, the mandatory seat belt law reduce the death rate in road accident but the average speed increase due to the psychological effect that driver feels safe when fasten seat belt and thus drive faster. Psychologically it seems not fuel efficient as the speed increase after practicing seat belts, however practically or physically it does not have any relation to efficiency. It is consider safe to fasten seat belt as in reality it reduce the death rate in road accident. (Alma Cohen and Liran Einav, 2003)

According to a national daytime observational survey of motorists in 2015, safety belt use among front seat occupants was 87 percent in rural areas and 89 percent in urban areas. Unrestrained vehicle occupants are more likely than restrained occupants to be fatally injured in a crash, so belt use is much lower among fatally injured occupants. In 2015, 47 percent of fatally injured passenger vehicle occupants 13 and older were belted in both rural and urban areas. (Insurance Institude for Highway Safety , 2015)

Safety belt use among fatally injured passenger vehicle occupants 13 and older by land use, 2006-2015

	Rural						Urban					
	Belt used		Unbelted		Unknown		Belt used		Unbelted		Unknown	
	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%
2006	7,247	40	9,740	54	1,102	6	4,832	43	5,389	47	1,132	10
2007	7,219	41	9,216	53	1,092	6	4,594	43	4,912	46	1,160	11
2008	6,271	41	8,287	54	899	6	4,007	43	4,334	47	895	10
2009	6,059	42	7,534	52	819	6	3,727	45	3,735	45	847	10
2010	5,701	43	6,709	51	801	6	3,825	46	3,598	43	882	11
2011	5,510	43	6,527	51	770	6	3,567	45	3,474	44	824	10
2012	5,643	43	6,669	51	786	6	3,749	46	3,529	43	866	11
2013	5,714	45	6,184	49	846	7	3,778	47	3,273	41	911	11
2014	5,565	46	5,871	48	729	6	4,031	48	3,382	41	932	11
2015	5,802	47	5,841	47	813	7	3,818	47	3,272	41	982	12

Figure 2.6

(Insurance Institude for Highway Safety , 2015)

21. Open a window

Rolling down the windows increased drag in the form of air resistance and thus consider as un-efficient driving characteristic. However it do not have strong relation to safety.

22. Overtaking

Overtaking involve sharp acceleration which is not fuel efficient. Also, it increase the risk of accident while overtaking, however proper lane shifting and over taking by giving signal may reduce the risk of accident.

23. Stopping at T-junction

Stop at T-junction is not fuel efficient as it need to stop, idle and pick up which is more time consuming and more fuel is used compare to coasting across the T-junction (Augustine C. Osigwe, Ph.D, 2016) . However it is safe to stop at T-junction to avoid accident.

24. High usage of air-conditioning

Using air conditioning requires the generation of up to 5 hp (3.7 kW) of extra power to maintain a given speed. A/C systems cycle on and off, or vary their output, as required by the occupants so they rarely run at full power continuously.
Air conditioning can increase a vehicle's fuel consumption by as much as 20 percent (Government of Canada , 2016). However it seems like do not have any relation with safety.

25. Excess weight

Drivers can also increase fuel efficiency by minimizing transported mass, i.e. the number of people or the amount of cargo, tools, and equipment carried in the vehicle. On a typical vehicle, every extra 100 pounds increases fuel consumption by 2% (Union of Concerned Scientists, 2017). Remove items such as salt, sand and sports equipment from your vehicle before setting out. The less weight in the vehicle, the less fuel the engine will need. Consider that the fuel consumption of a mid-size car increases by about one percent for every 25 kilograms of weight in the vehicle. On the other hand, the greater the mass of the vehicle, the greater the risk as the inertia of the

vehicle is greater, the effort to stop the car during emergency is harder. Is dangerous is the vehicle is in excess weight.

26. Aggressive driving

Rapid acceleration and harsh braking reduce fuel economy by as much as 33 percent at highway speeds and 5 percent in town, according to the EPA. (Sean M. Lyden, 2013). "Jack-rabbit" starts and hard braking can increase fuel consumption by as much as 40% (Eartheasy, 2014). The proper way is to accelerate slowly and smoothly, then get into high gear as quickly as possible. (Augustine C. Osigwe, Ph.D, 2016)
Moreover, aggressive driving is very dangerous according to a 2016 study by the AAA Foundation for Traffic Safety, almost 80 percent of drivers across the country admitted to expressing some form of significant anger, aggression, or road rage in the past year. The study also revealed that aggressive driving is a factor in a staggering 56 percent of all traffic fatalities. (Tyler Therriault, 2016)

27. Speeding over limit

NEW YORK (CNNMoney.com)--Traveling faster makes the job even harder. More air builds up in front of the vehicle, and the low pressure "hole" trailing behind gets bigger, too. Together, these create an increasing suction that tends to pull back harder and harder the faster you drive. The increase is actually exponential, meaning wind resistance rises much more steeply between 70 and 80 mph than it does between 50 and 60. Every 10 mph faster reduces fuel economy by about 4 mpg, a figure that remains fairly constant regardless of vehicle size. (Peter Valdes-Dapena, 2008) (Government of Canada, 2016) (Augustine C. Osigwe, Ph.D, 2016)
Furthermore, is dangerous to speed over the limit as the faster the speed, the larger the impact when crush, the higher the death rate.

28. Put the car in Idling

Energy biggest loss is from idling, or when the engine is in standby, which explains the large gains available from shutting off the engine. (Environmental Defense Fund, 2009) The estimated fuel consumption of an idling engine is 0.6 litres / hr per litre of engine displacement. This means that an idling 3.5 litre engine consumes more than 2 litres of gas per hour. Letting your engine idle 30 minutes a day for two winter months burns a full tank of gas without ever moving a kilometre. (Eco Mobile , 2008) (K P Tiwari, 2013)

Therefore, put the car in idling is very un-efficient practice. However put the car in idling did not cause any dangerous to driver or passenger as the car does not move. So it is no relation to safety.

2.4 Safe Driving

Safe driving could be define as driving which protected from or not exposed to danger or risk; not likely to be harmed or lost uninjured; with no harm done.

Safe driving may also be define as defensive driving. The standard Safe Practices for Motor Vehicle Operations, ANSI/ASSE Z15.1, defines defensive driving skills as "driving to save lives, time, and money, in spite of the conditions around you and the actions of others." This definition is taken from the National Safety Council's Defensive Driving Course. (National safety council, 2017)

In this research, the level of safety on each of every driving characteristics are measure by 2 factors which are the chance of the driving characteristics leads to accident and the seriousness of the accident if the accident happened due to the practice of the driving characteristics.

2.5 Efficient Driving

Efficiency from various dictionary was define as (especially of a system or machine) achieving maximum productivity with minimum wasted effort or expense. Preventing the wasteful use of a particular resource. Efficiency may also describe as the ratio of the output to the input. However in term of driving efficiency, the input will be the amount of petrol and time, while the output will be the distance travel. (Dictionary & Vocabulary , 2017) (Investopedia, 2017)

In this research, efficiency in driving characteristics may not be measure directly from the fuel consumption rate [km/litre] of the vehicle. This is because different vehicle has different weight, shape and type of engine. Therefore, an assumption was first approach on the level of efficient driving which is measure by the amount of improvement in fuel economy after the driving characteristics were practiced. Whereby most of the factor which effect efficiency in driving are the level of idling, acceleration, braking, and speed.

2.6 The Correlation and the mathematical method

2.2.1 Correlation definition

Correlation is a statistical relationships involving dependence, though in common usage it most often refers to the extent to which two variables have a linear relationship with each other. Familiar examples of dependent phenomena include the correlation between the physical statures of parents and their offspring, and the correlation between the demand for a product and its price. However, in this project, the approach will be the correlation between safe driving and efficient driving.

- Correlation is Positive when the values increase together, and
- Correlation is Negative when one value decreases as the other increases

Types of correlation patterns

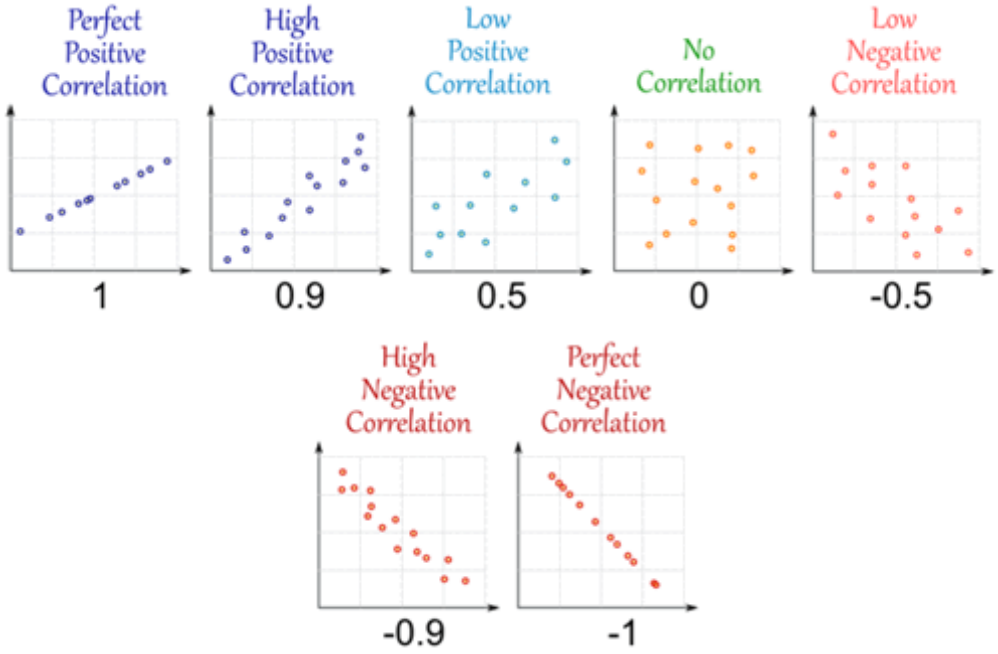

Figure 2.7

Correlation can have a value:

- 1 is a perfect positive correlation
- 0 is no correlation (the values don't seem linked at all)
- -1 is a perfect negative correlation

The value shows how good the correlation is (not how steep the line is), and if it is positive or negative.

2.6.2 The correlation's mathematical method and calculation

The Correlation

One of the method in calculating correlation factor is Karl Pearson's method. It calculate correlation between sets of data is a measure of how well they are related. The most common measure of correlation in stats is the Pearson Correlation. The full name is the Pearson Product Moment Correlation or PPMC. It shows the linear relationship between two sets of data. In simple terms, it answers the question, *Can I draw a line graph to represent the data?* Two letters are used to represent the Pearson correlation: Greek letter rho (ρ) for a population and the letter "r" for a sample.

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\,n\Sigma x^2 - (\Sigma x)^2\,][\,n\Sigma y^2 - (\Sigma y)^2\,]}}$$

r = +/-0.5 consider as large effect

r = +/-0.3 consider as medium effect

r = +/-0.1 consider as small effect

The P-value

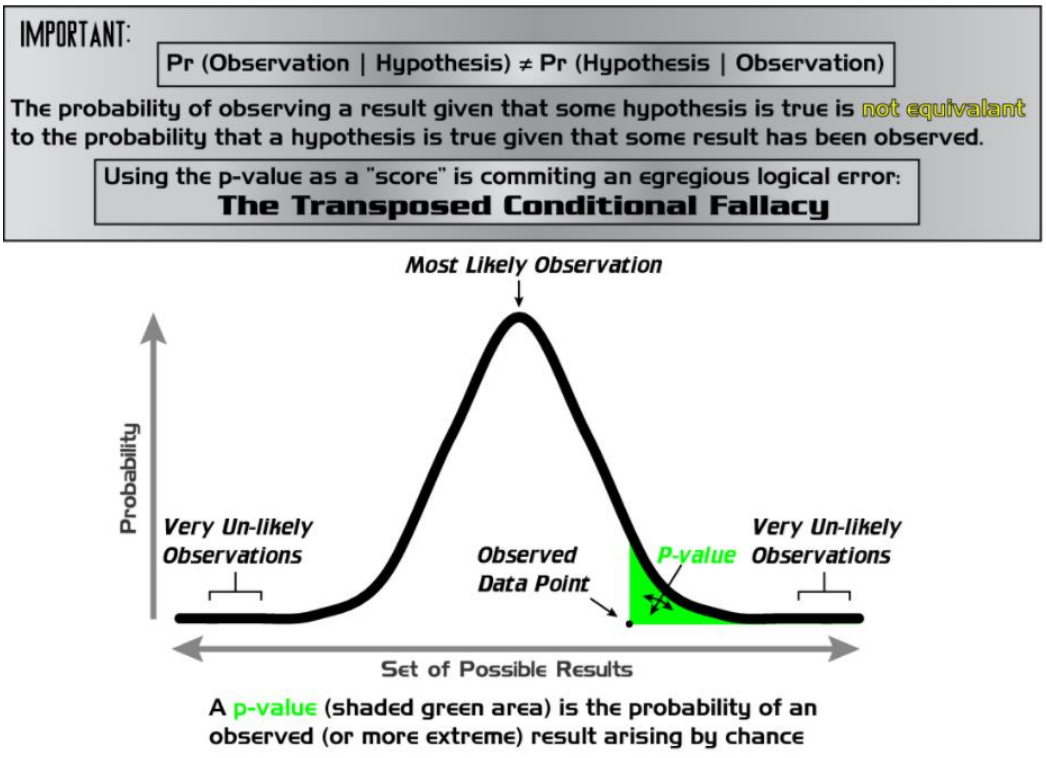

Figure 2.8

Confidence in a relationship is formally determined not just by the correlation coefficient but also by the number of pairs in your data. If there are very few pairs then the coefficient needs to be very close to 1 or –1 for it to be deemed 'statistically significant', but if there are many pairs then a coefficient closer to 0 can still be considered 'highly significant'. The standard method that statisticians use to measure the 'significance' of their empirical analyses is the p-value. Suppose we are trying to determine if the relationship between safe driving and efficient driving of people is significant; then we start with the 'null hypothesis' which, in this case is the statement 'safety and efficiency of people are unrelated'. The p-value is a number between 0 and 1 representing the probability that this data would have arisen if the null hypothesis were true. A low p-value (such as 0.01) is taken as evidence that the null hypothesis can be 'rejected'. Statisticians say that a p-value of 0.01 is 'highly significant' or say that 'the data is significant at the 0.01 level'. However in this project the relation may said to be significant if p-value is less than 0.05. (Quantitative Specialists, 2014), (Norman Fenton and Martin Neil, 2012).

2.6.3 Correlation may not be causation

Correlation does not imply causation just because two trends seem to fluctuate in tandem, this rule posits, that doesn't prove that they are meaningfully related to one another. Correlations between two things can be caused by a third factor that affects both of them. There might be a third factor that was responsible for the correlation between safe driving and efficient driving. As a seasonal example, just because people in the UK tend to spend more in the shops when it's cold and less when it's hot doesn't mean cold weather causes frenzied high-street spending. A more plausible explanation would be that cold weather tends to coincide with Christmas and the new year sales.

(Am J Pol Sci, 2012)

2.7 Difference between qualitative and quantitative research method.

Qualitative Research is primarily exploratory research. It is used to gain an understanding of underlying reasons, opinions, and motivations. It provides insights into the problem or helps to develop ideas or hypotheses for potential quantitative research. Qualitative Research is also used to uncover trends in thought and opinions, and dive deeper into the problem. Qualitative data collection methods vary using unstructured or semi-structured techniques. Some common methods include focus groups (group discussions), individual interviews, and participation/observations. The sample size is typically small, and respondents are selected to fulfil a given quota. (Susan E. Wyse, 2017)

However in this research, the qualitative method were to study each of every driving characteristic on the safety and efficiency through expert's observation, opinions and comments to give idea for potential quantitative research later.

Quantitative Research is used to quantify the problem by way of generating numerical data or data that can be transformed into useable statistics. It is used to quantify attitudes, opinions, behaviours, and other defined variables – and generalize results from a larger sample population. Quantitative Research uses measurable data to formulate facts and uncover patterns in research. Quantitative data collection methods are much more structured than Qualitative data collection methods. Quantitative data collection methods include various forms of surveys – online surveys, paper surveys, mobile surveys and kiosk surveys, face-to-face interviews, telephone interviews, longitudinal studies, website interceptors, online polls, and systematic observations. (Susan E. Wyse, 2017)

However in this research, the quantitative method were to generate data from the respondents through online survey forms/questionnaire. The data were used for statistical data analysis.

Chapter 3: Methodology

3.1 Qualitative Research Method

1) The major key characteristic of safe driving and efficient driving was analysed and listed down. Which were based on the overall opinion from different experts and researchers discussion that shows in literature review.
2) Ranking for both safe and efficient driving characteristic for two group which are Urban and Highway was arranged. The reason of separating two group, Urban and Highway, is because some of the driving characteristic is absent in highway however present in Urban. Which are, running across red light, running across stop sign, momentum drive at junction, practice illegal U-turn, Smooth and progressive Steering, stop at T-junction, put the car in Idling and plan the route before driving.
3) Weightage for each of every characteristic was arranged and a graph for safety vs efficiency was plotted
4) The correlation between safety and efficiency was calculated and analysed.

3.1.1 (a) Major Key Characteristic of safe driving

Positive

1) Stop at T-junction
2) Drive slowly
3) Select the right gear
4) Fasten seat belt while driving
5) Giving signal when turning/shifting lanes
6) Smooth/gradual braking
7) Smooth/gradual acceleration
8) Tyres kept at proper pressure
9) Put both hands at 10-10 position while driving
10) Smooth and progressive Steering
11) Regular service and maintenance
12) Overtaking
13) Looking ahead and surroundings

Negative

1) Use smart phone while driving
2) Practice illegal U turn
3) Running of red light
4) Running of stop sign
5) Revving
6) Aggressive driving
7) Tailgating
8) Momentum drive at junctions
9) Cruise/Glide at neutral on flat/down hill road
10) Speeding over limit
11) Excess weight
12) Coasting or gliding

3.1.1 (b) Major Key Characteristic of Efficient Driving

Positive

1) Smooth and gradual acceleration
2) Smooth and gradual braking
3) Select the right gear
4) Running of red light
5) Running of stop sign
6) Practice illegal U-turn
7) Tyres kept at proper pressure
8) Drive slowly
9) Momentum drive at junctions
10) Cruise/Glide at neutral on flat/down hill road
11) Maintaining an efficient speed
12) Regular service and maintenance
13) Coasting or gliding
14) Plan your routes