An STS Thesis Prospectus

An Analysis of the Popularity of Sport Utility Vehicles Despite their Negative Environmental Implications.

Peer Reviews and Comments:

Over the course of developing this topic, I have gotten invaluable feedback from my peers, Professor Gorman, and the course teaching assistants. For this I am extremely grateful.

- Professor Gorman suggested that while actor network theory was a good framework to approach this subject from, I did not do enough to address how I would use it. As a result, I restructured the format of the prospectus to include an objectives and methods/approach section where I specifically address this subject
- Emily Flynn recommended that I define "a time of environmental consciousness" and show that we are currently in that time. For this I added a section outlining the significance of the environmental problem and how the car buying public is contributing to it. She also brought up the point that some people may actually need larger vehicles for work, to which I decided to add in ethical frameworks as another sts topic worth discussing on when it would be ethical to use an SUV. I also tried to elaborate more on targeted advertising per her request.

Introduction:

For my STS thesis I intend to use Actor-Network Theory (ANT) and various ethical frameworks to examine the rise in popularity of the sport utility vehicle (SUV), despite their negative environmental implications, in a time of environmental consciousness. To do this, I will first examine the development of the automobile as a whole, using ANT to study how certain actors, namely the US consumers and government, shaped automakers decisions and the automobile market. Special attention will be payed to the similarities and differences between the changes to the US automobile market as a result of the 1973 Oil Crisis, and the US automobile market's progression through the current Environmental Crisis.

Problem/Significance:

It is widely accepted that humanity is at an environmental crossroads. The effects of climate change are already becoming observable; shrinking glaciers, increased droughts, and more extreme weather are becoming the new norm.[1] Environmental scientists predict that if the current rate of carbon dioxide emission continues, the long-term effects of climate change could be irreversible.[1] Despite this troubling fact, worldwide emissions continue to increase. Transportation emissions make up a significant portion of overall carbon emissions and are also a sector that has seen a recent increase in emissions.[2] While this is due in part to an increase in vehicle miles travelled, an increase in the proportion of Sport Utility Vehicles (SUVs) and crossovers, relative to passenger cars, has been negating the effects of improved fuel economy of newer vehicles.[3] So many new vehicle sales are going to the SUV segment that companies like Ford are discontinuing their passenger car lineups in favor of SUVs. This is a problem because

normal Americans, many of whom do care about the environment, are contributing to a greater carbon footprint than they could if they were to just switch to a compact or midsize car.

Background Information:

A new development for the late 1800's was motorized personal transportation, or the first automobiles. Prior to this, transportation within cities and was either on foot, or by trolley, bicycle, or carriage. Those in small towns were less fortunate, as they lacked trollies and railroad stations and would have to have to travel by horse or carriage to the nearest railroad station. While there were several attempts at creating a four-cycle internal combustion engine, Nikolaus Otto was the first to successfully build one in 1861. By 1876, he had developed his final iteration of the engine and its power cycle, the Otto cycle, is has been the basis for all four stroke engines over the past almost 150 years.[8] The introduction of compact versions of the internal combustion engine using the Otto cycle is then what made automobile possible. Karl Benz is credited with the invention of the modern car with his "Motorwagen" in 1885[9], and another German firm, Daimler, was soon to follow. These initial automobiles bared more of a resemblance to a horseless carriage than a car however and the scale of production was relatively small, keeping these vehicles out of the hands of the masses.

Henry Ford is responsible for streamlining the production of mass-produced cars with his moving assembly line in 1913[10]. With a new car coming of the line every 15 minutes, coupled with the high wages of employees, these cars were now becoming accessible to the average person. This set the stage for both rapid automotive growth, as well as rapid technological development within the industry. Consumers provided demands for features such as: comfort, performance, reliability, versatility, and very importantly price. In return, the car manufacturers

used what resources they had to meet and exceed these demands in order to win over the consumers. Existing actors would rely on their more established resources to iteratively advance technologies with quality and reliability as their main focus. Conversely newer actors would try to introduce higher risk ideas to try and gain the public's attention, for example Cadillac's introduction of independent suspension. This combination of new and old actors allowed technology to advance quickly in both breadth and understanding of what it took to make a quality automobile. Even worker safety considerations were made, with worker specialization reducing the number of injuries. The only actor that didn't have a say was the environment.

The period following World War II saw both the size and power of automobiles increase dramatically. By the early 1970's luxury cars such as the Lincoln Continental were easily topping 20ft long and approaching 6000lbs in weight. In the power department, some sports cars were reaching over 400 horsepower coming from engines over seven liters. Little regard was paid to efficiency or the environment; gas prices were low and single digit fuel economies were common. Then the oil crisis of 1973 was the straw that broke the camel's back. This crisis was a result of the Organization of Arab Petroleum Exporting Countries (OPEC) declaring an oil embargo on the United States and other countries in support of formation of Israel[11]. This raised the global price of oil by almost 400% globally, and even more in the US[11]. While this had widespread economic and political implications, it finally forced a society content with excess to look in the mirror and see their dependence on fossil fuels. Very quickly, the large cars, or "land yachts, of the 1960's were replaced with smaller more fuel-efficient cars. Imported cars from Japan gained popularity as they had been making exclusively small cars for years, and the American auto industry rushed to catch up. Fuel rationing was enacted were even numbered license plates could only get gas on even numbered days and odd numbered plates on odd

numbered days. Corporate Average Fuel Economy (CAFE) standards were enacted by Congress in 1975[12], which set requirements on the weighted average fuel economy for all cars and light trucks that a company sell. Companies that cannot meet these standards receive a penalty based on how many vehicles they sell and how far under the standard they are. Since the inception of CAFE standards, average fuel economies have risen steadily until recently. The EPA also instituted the Clean Air act which began the use of catalytic converters to reduce tailpipe emissions to combat smog and air pollution.

The post Oil Crisis goals of increased fuel efficiency and reduced emissions were achieved in two primary ways: downsizing and technological developments. Cars were reduced in both physical size and engine displacement which yielded dramatic improvements on fuel economy. While initially performance suffered dramatically, technologies adapted from the World War II aerospace industry, such as fuel injection and turbocharging, began to become mainstream, and performance figures improved rapidly while fuel economy improved as well. Fast forward to modern times and average car sizes are increasing rapidly despite the widely accepted problem of climate change. Even more disturbing is the increasing market share of SUVs and more recently crossovers. Why is this the case? They are what consumers want. This is interesting how people that would consider themselves considerate of the environment, would make the conscious choice to drive an SUV over a car despite the additional environmental toll. Part of the reason is that technology has gotten good enough that vehicles of this size are able to get over 20 miles per gallon on average, whereas 15 years ago they would be getting 15 miles per gallon[13]. Because the consumers see this fuel economy as “good enough,” especially when comparing with the cars they are used to from the past. While this is a feat of technology, the same technology applied to modern average cars yields over 30 miles per gallon[11] and even

higher for compact cars. With the proportion of new vehicles that are SUVs or crossovers has increasing so rapidly, the average nationwide fuel economy has actually begun to stagnate[3,13].

A second reason is safety. Vehicles in general have been increasing in size to increase safety. This size is to accommodate crumple zones and additional electronics; however, dimensions have expanded beyond what is necessary for safety. This is because of the perception of safety. People feel safer when they are higher off the ground because they can see over other motorists. They also feel safer having more mass in a collision. The problem with this is it creates an arms race of vehicle sizes. If everyone else's vehicle is the same size as yours again, you have to get an even bigger one. Now people that drive conventionally sized cars are disadvantaged because they have little visibility and are more likely to be fatally injured by the high proportion of significantly larger vehicles on the road[15,16]. Furthermore, this bigger is safer mentality is fundamentally flawed. SUVs and crossovers are more likely to roll over[15], have more kinetic energy to dissipate in a collision with a fixed object. Additionally, SUVs and crossovers are more likely to be in a collision due to increased braking distances, reduced maneuverability, and more blind spots. However, the government wrongly encourages consumers to buy larger vehicles in the name of safety. The Highway Data Loss Institute goes as far as to recommend that teens and new drivers

Another reason why consumers feel the need to buy SUVs and crossovers is the illusion that they can go anywhere in them. Even though most people will not seriously off road their vehicles, the freedom to do so if needed is appealing. Once automakers realized this, they targeted their marketing on this go anywhere mentality, pushing vehicles that are no more off road capable than an all-wheel drive passenger car. Automakers are fine with catering to the consumers folly because larger vehicles command higher prices and more profits. So few people

are buying new cars, companies like Ford are discontinuing their entire line up of cars in exchange for all crossovers and SUVs. In addition to being more expensive, more raw materials are required as well, further increasing their toll on the environment.

Objectives:

My first goal in the writing of this thesis is to clearly define the automobile and provide a brief history of development to put my research questions into context. I plan to focus first on the development of the passenger car as the original basis of the automobile and then on the SUV as a divergence from the passenger car. I will then define each vehicle individually and discuss the similarities and differences between the two in terms of their utility, safety, and relative environmental impact. After these facets of the topic are properly explored, and the topic is introduced, my thesis will be modelled around answering the following research questions:

1. Which actors have been most responsible in development of the automobile up to this point, and how, if at all, has this relationship changed over time?
2. What factors have shaped public perception of SUVs and caused the paradigm shift away from passenger cars? (targeted marketing, economic, societal)
3. Which ethical frameworks could be applied to SUVs and their implications on the environment and road safety?

By answering these questions, I hope to show the effects the underinformed consumer can have on a global scale and how the US automakers irresponsibly encourage poor consumer choices and regressive government policy.

Approach/Method:

For my first research question I plan to use actor network theory to observe the relationships between the US automakers, the US government, US consumers, and the environment. Attention will be payed to points in history where automakers have had more say in influencing public policy and at which points has public policy forced unavoidable changes in the auto industry. Additionally, I will attempt to find a time where the environment as an actor has had primary consideration by the rest of the network based on its own merit, and not due to some secondary motivation like in the 1973 Oil Crisis. Finally, I will attempt to see whether it is the consumer's buying power, or the automaker's market influence that is the leading cause of SUV dominance.

For my second research question, I will focus on the consumer and try to determine what caused them to widely accept the SUV as the vehicle of choice. I will use the marketing strategies presented to them as the beginning of my search to see what perceived benefits are most appealing to them. From this I will try to determine which societal factors push people towards liking these attributes and whether or not the American way of life reinforces these societal factors. Are certain cultural values to blame? Is it the infrastructure surrounding Americans and their vehicles that is contributing? Or is it simply a matter of jumping on a bandwagon? These are all sub-questions I hope to answer within my second research question

Finally, I would like to discuss the ethics of the SUV as a consumer choice, and what this choice says about the consumers themselves. Using various ethical frameworks as a basis for analysis, is there any merit in the SUV as a mainstream vehicle, or should they have remained as the utilitarian work vehicles they evolved from. Has mainstream adoption of SUVs made them

less useful for their original purpose? Is there any justification for using 5000 pounds of metal to transport one person to work when a motorcycle can transport an entire family in India? Is recommending a vehicle that increases one's safety by endangering others, and ethical decision? By answering these questions, I hope to show the shortcomings of the SUV as a consumer choice and show how these consumers need to become more educated on the implications of their buying power to guide the market towards a more safe and sustainable future.

Resources

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Technical Prospectus: Production of Gasoline via Molten Salt Gasification of Electronic Waste

With increasing pressures towards addressing mounting waste in the US, many scientists are turning towards new ways to utilize waste in energy producing processes. Researchers from the International Telecommunication Union (ITU) estimate that about 44.7 million metric tons of electronic waste (e-waste) was generated worldwide in 2016. Only 20% of this amount was recycled through appropriate channels (Baldé et al., 2017). Developing a process to utilize productively e-waste is therefore highly desirable. E-waste is made up of a mixture of various metals; namely copper, aluminum, iron, and nickel, as well as various plastics, resins and ceramics (Flandinet et al., 2012, p. 485). We will research how to convert e-waste into synthesis gas (*syngas*) which can later be treated and converted into gasoline. Syngas is typically processed from natural gas; thus, this project has the environmental advantage of replacing a non-renewable feedstock with a non-degradable one, solving two issues in sustainability.

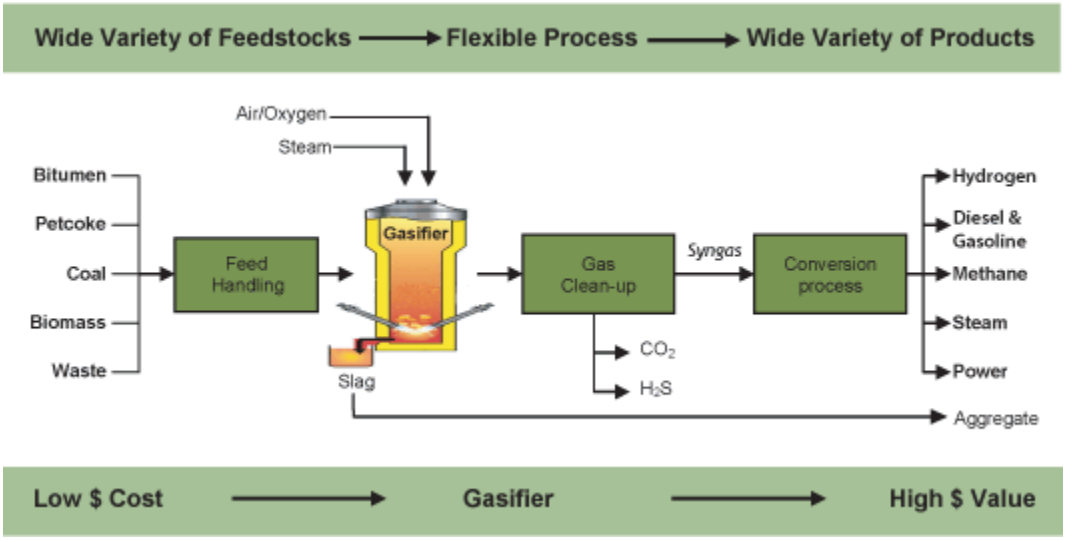

Figure 1: An Illustration of the Gasification Process of Waste into Syngas. (Bhat, N. 2016)

Syngas is a mixture of hydrogen, carbon monoxide, and carbon dioxide, typically produced using methane from large natural gas reserves. Syngas is used for a variety of

processes, including diesel production, methanol production, and hydrogen synthesis, for the Haber-Bosch process used to irrigate most of the world's crops (Sartipi, et al., 2013). We will model the gasification of syngas with molten salts..

The first challenge is breaking down the e-waste into syngas. Gasification is a common method of converting organic waste into syngas; however, traditional gasification might not handle the metals in e-waste without additional processing. Our process must separate out any potential contaminants and produce high yields of clean syngas. Thus, we propose gasifying the e-waste using molten salt, which exhibits excellent heat transfer properties, a high operating temperature range, and does not require metal to be separated before gasification. Kinetic data for a eutectic mixture of lithium, sodium, potassium carbonates (LNK) molten salts reacting with e-waste has been published, supporting its viability (Salbidegoitia et al., 2015).

Once the e-waste converts into syngas, the syngas will be processed into gasoline. Historically, the Fischer-Tropsch process, pioneered in the 1920s, converted syngas into fuel. Recent developments in catalyst technology improved the process' selectivity towards gasoline-grade hydrocarbons, reducing the need for hydrocracking (Sartipi, S., et al., 2013). Another mechanism converts the syngas into methanol, then into dimethyl ether, then into gasoline through a series of fluidized bed reactors (Primus Green Energy, 2019). Gasoline is a profitable product critical to society, and its production from waste may be an environmentally friendlier alternative to conventional petroleum extraction.

We will analyze our system through a collection of material and energy balances, while using MATLAB to solve the kinetic and thermodynamic equations that define our process. Our process will be simulated with *Aspen Plus V11*, which will guide our economic and unit operation analysis. We will determine if this process is energy-efficient. If the energy costs are

high, then it may cost the environment more in burning fuel to run the process than it saves by recycling waste. The project will evaluate both the economic and environmental viability of producing gasoline from syngas generated from e-waste.

Sources

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