

Public perceptions of road pavement conditions on Kansas Interstate 70

by

Katherine H. Geist

B.A., Kansas State University, 2017

A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF REGIONAL & COMMUNITY PLANNING

Department of Landscape Architecture and Regional & Community Planning
College of Architecture, Planning & Design

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2019

Approved by:

Major Professor
Gregory L. Newmark, PhD.

Copyright

© Katherine H. Geist 2019

Abstract

Poorly maintained road infrastructure is one of the most quickly growing infrastructure issues that America faces. This is due many different factors, including a lack of funding, old roads, general wear and decay, congestion, and many others. One of the biggest questions is how to combat this problem, to potentially save lives as this poor maintenance can lead to crashes, vehicle wear, etc. Another big question is whether or not citizens see this issue as a problem or not. This study involved surveying highway travelers to gauge their view on the quality of Kansas Interstate 70, to see what their opinions were on fixing this problem, and to inquire about their willingness to pay for these smoother roads. By getting to the root of the problem and speaking to those who deal with it firsthand, we will be provided with the best information that could lead to reversing it.

Table of Contents

List of Figures	vi
List of Tables	vii
Acknowledgements	viii
Chapter 1 – Introduction	1
1.1 - Research question	3
Chapter 2 – Background	4
2.1 - Road Funding.....	4
2.2 - Road pavement condition correlated with passenger comfort	9
2.3 - Willingness to pay	11
2.4 - Road wear & congestion	13
2.5 - Pavement smoothness	14
Chapter 3 - Methodology	16
Chapter 4 - Validity & implications.....	21
Chapter 5 - Analysis of survey data collected	22
5.1 - Details of data collection	22
5.2 - Predicted outcomes	22
5.3 - General data breakdown	23
5.3.1 - Patron consent to take survey	23
5.3.2 - Survey count breakdown by gender	24
5.3.3 - Average highway smoothness ratings by gender	25
5.3.4 - Kernel density plot of traveler birth years	26
5.3.5 - Traveler trip purpose	27
5.3.6 - Breakdown of traveler vehicle type	29
5.3.7 - Patron opinion of road pavement smoothness importance	30
5.3.8 - Total yearly days driven on I-70 vs. absolute difference in pavement smoothness ratings	31
5.4 - Road pavement smoothness	34
5.4.1 - Histogram of absolute difference in highway smoothness ratings	34
5.4.2 - Absolute difference in highway smoothness ratings by gender	36

5.4.3 - Vehicle type vs. highway rating absolute difference average	37
5.5 - Willingness to pay	37
5.5.1 - Kernel density plots of willingness to pay (in \$)	38
5.5.2 - Kernel density plot trends and implications	39
5.6 - Correlations	40
5.7 - Additional statistical tests	42
5.7.1 - T-test	42
5.7.2 - ANOVA (Analysis of Variance) test	43
5.7.3 - Chi Square test	44
Chapter 6 - Potential use of collected data	45
6.1 - Importance of public perception for the future of pavement smoothness	45
6.2 - Major conclusions of all data collected through this study	45
6.3 - Further research to advance this topic	45
Chapter 7 – Conclusions and final thoughts	47
Bibliography	49
Appendix A – Survey consent card	53
Appendix B – Survey	54
Appendix C - IRB approval letter	64

List of Figures

Figure 1 – Map of Interstate 70 in Kansas and the Kansas Turnpike	16
Figure 2 – Inset map of survey site and Kansas Turnpike study area	17
Figure 3 - Patron survey consent breakdown	23
Figure 4 - Total accepted survey count breakdown by gender	24
Figure 5 - Average highway smoothness ratings by gender	25
Figure 6 – Birth year kernel density plot	26
Figure 7 – Traveler trip purpose	27
Figure 8 – Frequency of traveler vehicle type	29
Figure 9 - Patron opinion of road pavement smoothness importance	30
Figure 10 - Yearly days driven on I-70 vs. absolute difference in highway ratings	31
Figure 11 - Histogram of absolute difference in highway smoothness ratings	33
Figure 12 - Absolute difference in highway smoothness ratings by gender	35
Figure 13 - Highway rating absolute difference based on vehicle type	36
Figure 14 - Willingness to pay for KS Turnpike pavement smoothness	37
Figure 15 - Willingness to pay for ideal pavement smoothness	37
Figure 16 – ANOVA test for vehicle type vs. KTA rating	42

List of Tables

Table 1 –Activities and costs per lane mile for counties in Ohio, courtesy of MRUTC 2011.....	6
Table 2 - Survey collection table.....	22
Table 3 – Correlation table.....	39

Acknowledgements

There are countless people that I could thank for their assistance with this project. First and foremost, I'd like to thank my major professor, Dr. Greg Newmark. He has spent countless hours assisting me from the initial conception of this study to its' final production. His suggestions and guidance have been invaluable to me and to the success of this study. You are one of the most driven and intelligent individuals I know; thank you. I would also like to thank my family for their unending support throughout the duration of this project. I have not always been the easiest to deal with when my stress level is through the roof. Thank you for loving me despite my crankiness! To Matthew, my rock, my fiancé, my biggest cheerleader: your unending patience with me is one of the biggest reasons that I love you. Thank you for holding me accountable and keeping me on track. I could not have done this without you! To my committee, Huston Gibson, PhD. and Prof. La Barbara James Wigfall, as well as our LARCP department head, Professor Stephanie Rolley, your guidance and expertise throughout this project has helped me to grow both as a student and a planning professional; thank you! To my KTA and KDOT contacts, you have had a huge impact on this study. From providing me with road data to meeting with me to provide advice, every email and phone call in between, thank you! To Shalin Hai-Jew, your Qualtrics expertise and time spent helping me figure out the nuances of my survey has meant more to me than I can put into words; thank you for helping me in every way that you could! And to my cohort, we did it! It has been an interesting ride over the past couple of years, but I could not have asked for a more supportive and intelligent group of people to learn with (and from)! Thank you, and I certainly hope our paths cross in the future.

Chapter 1 - Introduction

Every day, millions of Americans drive on the highways, interstates, and various roadways of our country. They are headed to work, running errands, picking up children from school, and thousands of other activities that require them to use an automobile to get from point A to point B. Well maintained roads are one of the keys to making sure that people can get where they need to go safely while also enjoying the ride and taking proper care of their automobiles. For many years, there has been a decline in the quality of American roads. This is so much so that the American Society of Civil Engineers deemed America's roads with a grade of "D" in 2017 (Engineers, 2017). America's comprehensive infrastructure grade was a between a "C" and a "D," which is an abysmal rating to receive. Road quality can affect everything from safety to economics (and everything in between), and instead of just being patched like a pothole, the problem needs to be solved.

The issues caused by poor construction and maintenance are multi-fold. These results can be weather related, a consequence of overuse, or an impact of varying vehicle type. All of these issues contribute to the condition of our highways, interstates, and roads. Many cities have their own "grading system" for their roads to determine which roads will be on the priority list for what will be fixed. While this can be an effective system, many more roads usually need fixing than a budget will have money for, leaving many roads difficult to drive on and in greater danger of becoming worse than they already are.

Each state in the America has at least 10% of their roads and highways that are classified as being in "poor/mediocre condition," with some states having as high as 73% of their roads

classified in this category (U.S. DOT, 2018). According to the U.S. Department of Transportation, funding is severely lacking across the board, and steps must be taken to correct this. One way it is proposed to fix this is to lobby the government to refrain from taking short-term steps to “correct” the infrastructure problems, and to try and implement comprehensive, long-term plans to truly eradicate some of the issues that roads are facing (U.S. DOT, 2018). Along with the roads, bridges across America are failing almost as quickly. Closely mirroring the road situation, each state has at least 10% of their bridges that are also failing or are in a serious state of disrepair. While bridges aren’t always immediately considered when discussing roads, some of the results of their failure can be much more catastrophic than any pothole on a regular highway. Since 2000, there have been at least 40 documented bridge failures in the United States (Equipment World, 2012). While that does not sound like very many, dozens of people were killed or injured due to these structural failures. This also is not to say that there were not underlying design causes or outside forces acting toward the failure of these structures, but had the failed bridges been more highly scrutinized during inspections on a biannual or annual basis, could these failures have been avoided? Hopefully the loss of life would not be as severe as it has been over the past 18 years as a result.

Based on the aforementioned information, what do Americans think of these numbers? According to a 2016 article, there were 1.3 million fatalities on the world’s roads in 2014 (Niroomand & Jenkins, 2016). Is it acceptable to sit by and let these issues move further along before they are addressed? While the facts mentioned previously are very important, the root of the study at hand is if patrons driving on these roads feel that their quality (or lack thereof) directly affects their health, safety, and wellbeing. Based on their opinions of this, would they be willing to pay to see the qualities in the road pavement increase?

Through this study, the goal is to gain insight into what the opinions of Kansas Interstate 70 constituents truly are, and if they are willing to pay a fee, what that fee would be. Currently, the approximate fee per mile on the Kansas Turnpike from Topeka to Lawrence is \$0.09. If a slight increase in this number (or to the miles included in the user fee realm) attributed to less crashes, better pavement smoothness, and a more comfortable and enjoyable user experience, would it be feasible to consider?

1.1 Research question

What are the public perceptions of road pavement smoothness on Interstate 70 and how much are Kansas patrons interested in an increased effort in road pavement maintenance and upkeep for an additional user fee to alleviate these issues?

Chapter 2 - Background

2.1 Road funding

Lack of available funding for new road construction and old road repairs/maintenance is a very large issue for infrastructure today. This has been an ongoing problem for decades, as the state of disrepair that many roads are in has been a continual process of neglect, conscious or not. According to a 2018 article, the need for infrastructure improvements tends to outpace the actual ability to fix the issues (Ozcan, 2018). To combat this, city governments and other entities have tried to find sustainable ways to fund road upkeep, with little to no success. While temporary fixes usually are not out of the price range, long-term substantial fixes often times exceed the budget provided, and therefore, the projects are pushed to the bottom of the list as other implementations take priority. This is evident in the research produced by the U.S. Department of Transportation. The study predicts what the next 10 years may look like in terms of cost, and the massive increase that may occur if things keep going in the direction that they have been for many years. It is interesting to note that the amount of funding for streets and roads is more than double its nearest neighboring category (electricity). Lack of funding seems to be common in infrastructure projects. As discussed in a recent article, "...failure of governments to finance necessary investments due to budget deficits and criticism on the inefficiencies attributed to public management and control initiated a tendency in favor of privatization of such services" (Ozcan, 2018).

While the future may look bleak, it could truly be an opportunity. Found in a Poister article, the productivity of the maintenance was directly increased by an increase in funding (Poister, 1983) As discussed in the paper by Gwilliam and Shalizi, usually the funding for roads

only adds up to between 10 and 20 percent of the overall yearly budget for a jurisdiction (Gwilliam & Shalizi, 1999). This seems odd, as roads are traversed daily by drivers who will always need them to get to work and home again, as well as everywhere else that they need to go. Road repairs are not often seen as vital unless there are massive potholes, or something else visible to the naked eye. Unfortunately, other problems could be lying beneath the surface, and would go undetected until something goes catastrophically wrong. According to the American Society of Civil Engineers, the U.S. has approximately an “\$836 billion backlog of highway and bridge capital needs” (Engineers, 2017). This is likely a result of many years of neglect and funding being put towards other projects.

How should these road pavement improvements be funded? An article written by I.G. Heggie and cited by Ozcan lays out all of the possibilities of where road funding can come from, including everything from congestion fees to gas taxes. While his suggestions are helpful to see the plethora of options for funding, money is not expendable, and most likely do not want to pay more for something that they already use at a minimal (or no) cost. For example, if someone travels a state highway daily to commute to work and does not have to pay a toll, the person would likely be very upset if tolls were put in to fund road repairs, even if it would benefit them. A report conducted by the Midwest Regional University Transportation Center noted that regardless of the increase in VMT (Vehicle Miles Traveled) on a yearly basis, state department of transportation budgets tend to stay the same, and that the disparities between the budget itself and the actual maintenance that needs to be done forces these agencies to make priorities, while neglecting other important projects (Midwest Regional University Transportation Center, 2011). As seen in the table below provided by MRUTC, there are very significant prices on different

road improvements that need to be done, even simply within the pavement sector. The table itself shows improvements from guardrail corrections to pavement improvements, specifically for the state of Ohio, in this example. The orange row that has been highlighted shows the different “pavement deficiency” issues that can be corrected, and the cost per lane mile. The red column that has been highlighted shows the average for specific Ohio counties there in 2006, compared with the Ohio statewide average to the left. It is very clear to see that these improvements vary greatly in cost, and yet, sometimes a simple patching job could be more expensive than getting to the root of the issue.

Table 7. Activities and costs per lane mile for counties in Ohio

Activity Group	Maintenance Activity		Statewide Average (\$2006)	County			
	Code	Description		Average (\$2006)	Std. dev (\$2006)	Probability %	Distribution
Guardrail	6230	End Assembly Installation and Maintenance	34.45	30.08	47.63	59	Johnson: $\mu=0.003, \sigma=1.00, 2.0690 + 0.5909 \ln((X + 0.0169) / (399.70 - X))$
	6233	Repair, Replacement, or Removal	161.21	164.93	139.58	97	No Fit
	6235	Crash Attenuator Repair or Replacement	23.77	18.24	39.15	19	Johnson: $\mu=0.072, \sigma=0.921, 1.8658 + 0.4306 \ln((X - 0.0393) / (265.16 - X))$
	6237	Concrete Median Barrier Repair, Replacement, Restoration, Removal	8.34	7.46	8.26	14	Johnson: $\mu=0.005, \sigma=0.945, 3.2354 + 0.9300 \ln((X + 0.2239) / (167.43 - X))$
	6333	Guardrail Betterment	28.62	24.97	63.57	27	Johnson: $\mu=0.032, \sigma=1.031, -0.8990 + 0.5100 \operatorname{Asinh}((X - 2.6384) / 1.1621)$
Pavement Deficiency	6120	Pavement Underseal/Fill Voids	2.23	2.298	1.81	4	Box Cox: $\mu=0.533, SC=0.834, \lambda = 0$
	6121	Pothole Patching	337.21	318.3	262.60	100	Johnson: $\mu=-0.033, \sigma=1.004, 2.6524 + 1.1335 \ln((X + 18.72) / (3029.60 - X))$
	6122	Surface Repairs	212.56	223	280.20	87	No Fit
	6123	Full Depth Repair	102.15	118.62	249.34	78	Johnson: $\mu=-0.006, \sigma=1.00, -1.6388 + 0.5871 \operatorname{Asinh}((X - 4.4339) / 3.6576)$
	6124	Fill and Seal Joints and Cracks	167.33	176.03	160.78	72	Box-Cox: $\mu=5.264, \sigma=1.847, \lambda = 0.341$
	6125	Surface Treatment	218.03	237.4	244.7	35	No Fit
	6126	Pavement Jacking	4.04	4.15	3.44	2	Box Cox: $\mu=0.596, \sigma=0.214, \lambda = -0.5$
	6127	Planning Bituminous Pavement	29.50	29.23	36.15	76	Johnson: $\mu=-0.0124, \sigma=1.000, 2.2019 + 0.7175 \ln((X - 0.3079) / (341.43 - X))$
	6129	Surface Paving	215.08	216.4	265.80	43	Gamma: $S=0.535, SC=404.06$
	6136	Partial Depth Repair	117.17	120.02	157.63	40	Johnson: $\mu=-0.0004, \sigma=0.961, 1.3218 + 0.4945 \ln((X - 0.2150) / (788.36 - X))$
Pavement Drop Off	6321	Roadway Betterment	31.72	34.33	60.03	30	Johnson: $\mu=-0.0177, \sigma=0.968, -1.4509 + 0.4380 \operatorname{Asinh}((X - 1.0177) / 0.4418)$
	6130	Spot Berming	186.75	191.47	171.12	100	Johnson: $\mu=-0.020, \sigma=1.026, 4.4614 + 1.3696 \ln((X + 25.73) / (4648.43 - X))$
	6131	Blading-Restore Unpaved Berm and/or Shoulders	308.46	331	257.73	100	Box Cox: $\mu=16.648, \sigma=7.36, \lambda = 0.5$
	6132	Repair Curbs and or Gutters	8.79	9.26	15.33	19	Johnson: $\mu=-0.054, \sigma=1.022, 2.2233 + 0.605 \ln((X + 0.0084) / (148.74 - X))$

Table 1. Activities and costs per lane mile for counties in Ohio, courtesy of MRUTC 2011

One consideration could be a public-private partnership, or privatization of roads in general. According to the Privatization Administration, “Public-Private Partnership (PPP, also sometimes called concession) schemes such as Transfer of Operating Rights (TOR) where the private party pays a fee to the government in exchange of operating an already running public infrastructure” (Privatization Administration, 2017). This would eliminate the need to create a completely new set of infrastructure (saving quite a bit of money) but provide the funding necessary and have proper operation standards in place. Privatization of roads (and infrastructure in general) has been a more common study in recent years, as federally-funded government budgets have, on the whole, gotten much smaller, especially in the infrastructure realm. One idea that Ozcan has in his article is that of transferring currently public roads over to the private sector for more adequate management, as the private sector typically has more substantial funds and less drive to garner political support. This thought ties in with the public-private partnership idea to some extent, believing that public infrastructure under privatization may in fact function better. This aspect is often applied to roads, in the form of user fees and toll roads, which will be discussed at length later in the report. Later in the article, Ozcan lists a few different reasons why he believes that privatization may be better than leaving infrastructure under the public realm.

“According to these theories, public sector operates inefficiently because: (i) its performance is not monitored enough since the real owners (citizens) are ambiguous, (ii) its agency costs are high since reward and punishment (carrot and stick) mechanisms for its managers are not well-defined, (iii) the politicians exploit the resources of public sector enterprises in accordance with their political interests, and (iv) it does not have the right organizational structure to succeed,” (Ozcan, 2018).

There is a warning towards the end of the article regarding when privatization should be used, how it should be sparingly, and for the right reasons. Ozcan says that privatization should be used solely if it will be “cost effective” (Ozcan, 2018).

The gas tax that has been in place for decades has been a constant source of income to repair and fund roads, and most people forget that it even exists, as cars need gas, and people need cars. Even if the gas tax was increased to a greater amount, people would still buy gas. If the aforementioned toll was implemented, the citizen would potentially try to find a new way to work if he or she did not want to pay the toll, regardless of how it would ultimately benefit both them and the state roadway system. Hensher, Ho, and Liu said in a 2016 article that it is a great possibility that once tolls, user fees, taxes, etc. begin to substantially effect patrons and their travel budgets, they will more likely than not be primarily interested in saving money instead of taking a faster way and paying a toll. It has been proven in many different infrastructure realms that if you are preemptive about repairs (or simply build strong, lasting infrastructure from the outset), less time and money will be spent having to fix them later on when they begin to wear out. This is one approach that would be helpful to consider in the road pavement discussion. By not cutting corners, not skimming through plans just to save a few dollars, and truly looking at infrastructure as a necessity that serves millions of Americans every day, lives could be saved, vehicles could be spared repetitive upkeep costs, and driving on America’s roads could be seen as a more enjoyable thing to do.

2.2 Road pavement condition correlated with passenger comfort

According to a study done on the correlation between vehicle vibration and user experience, passenger trip satisfaction directly correlates with a comfortable ride (Nahvi, Foulad, & Nor 2009). The same journal article states that “Analysis of road conditions parameters, such as the International Roughness Index (IRI), and their correlation with kurtosis and the vibration dose value (VDV) can give useful information about the effect of road roughness on passenger vibration comfort”. International Roughness Index is a major facet of the study that was conducted and is introduced in detail later in the literature review. A study done at the University of Michigan describes IRI as “...the IRI describes how much total vertical movement a standard passenger vehicle’s body would experience if driven over a 1-mile segment of the subject pavement at 50 mph” (*International Roughness Index (IRI)*, n.d.) Researchers have come up with a new way to measure passenger comfort in the form of an app called “Roadbounce.” Definitics Software Solutions, an India-based company, has spearheaded this initiative. According to an article on the app,

“It [the app] uses the phones built-in accelerometer and gyroscope sensors to measure the ride quality and thereby estimate the road roughness and variability. This data is stored in real-time with GPS location data. The vehicle speed, body frame, suspension type, and position of the phone in the vehicle are taken into account by the app to generate accurate and consistent readings.” (Davis, 2017)

This idea of using road bounce to scientifically generate user experience is similar to that of the International Roughness Index, although it takes into consideration additional factors, such as phone location and type of suspension. It also allows DOTs and/or vehicle manufacturers to get a technical reading on a specific vehicle or vehicle type while paving roadways, and to predict

what type of experience that users will have on the road they are testing. Currently the app is still being beta tested and used solely in India. The team that created Roadbounce are hoping to launch a social app so that users can share their experiences and data readings on social media and will therefore draw more attention to both the app, and the issues caused by poor roadways and maintenance.

2.3 Willingness to pay

Many authors have explored the willingness to pay for transportation amenities, including reduced travel time (Brownstone, Ghosh, Golob, Kazimi, & Van Amelsfort, 2003), reduced congestion, smoother roadway pavement, etc. As discussed in a 2016 article, “There may, however, be a limit on how much individuals are willing to outlay to save travel time, given personal budgets for specific expenditures and competing demands on their income” (Hensher, Ho & Liu, 2016). This idea does not negate the idea of willingness to pay, but rather, looks at how much people budget for transportation, and what user fees would look like as a part of it. In the same article, Sydney, Australia was discussed as a type of case study for patrons and their transportation habits. According to the study, it was very normal for residents there to spend upwards of “\$2,000 and \$5,000 per annum on tolls” to get back and forth to work and home (Hensher, Ho & Liu, 2016). This being said, it is possible that residents of areas that are already highly tolled likely may not be interested in additional tolls.

One of the most vital questions that could be answered through the survey that has been produced for this study is what the true opinion of patrons is regarding interstate pavement quality, and whether or not they would be willing to pay additional fees to help make it better. Even if the majority of the people surveyed are not willing to pay, the responses are still very relevant, as I will know their true perceptions and be made aware that user fees would be a less likely option for road pavement funding. The tollway on Interstate 66 just outside of Washington D.C. charged \$40 a trip for single-occupant cars December of 2017, and those using the interstate were outraged. The primary goal for this increase was to try and alleviate congestion, and to see if the toll would force more drivers to either go a different way, or to take different modes of transportation. One woman that drove on [Interstate 66] during this time said, “You

know, maybe \$5, I mean, just something more reasonable...But a daily commute of \$40 plus is extraordinary; it's extreme," (WAMU, 2017). While this is likely an outlier, it is interesting to note that road users are not completely against tolling but do see that a reasonable price for these tolls would increase their likelihood to be willing to pay. The results from the study done on Interstate 66 have shown a greater trend towards carpooling (in response to the high tolls) which has greatly lessened congestion, which was one of the initial goals of the Virginia Department of Transportation in considering this study (WAMU, 2017).

2.4 Road wear & congestion

Road wear can take many different forms and can have many different catalysts. These may include (but are not limited to): weather (ice/water in concrete roadways can cause fractures), overuse (roads that have been repeatedly used for many years without being properly maintained and are in need of replacement), and type of vehicle (vehicles that weigh more have a greater impact on the integrity of the roadway, i.e. tractor-trailers, garbage trucks, etc.). All of these issues contribute to the overall wellbeing (or dismay) of our highways, interstates, and roads. There is a direct correlation between the weight of a vehicle, and how much damage that will be done to a road surface. The average 9-ton big-rig outputs approximately 410 times more damage than an average car (Roads Minnesota, 2017). The severity of road wear also greatly influences user experience, paired with what type of vehicle is being driven. If a patron is driving in a compact sedan, their user experience of a pothole on the highway is far different than that of one driving a full-sized pick-up truck.

Congestion is another issue that can ultimately contribute to road wear (while also resulting in environmental and economic issues). Daily congestion at peak travel times (usually rush hour on the way to work, 7-9 AM and rush hour on the way home, 5-7 PM) can cause a strain on roadways due to the mass of vehicles putting all of their weight on the pavement below. This prolonged use of the roadways with vehicles moving at slow speeds can deteriorate the ground over time. Additionally, at slow speeds, cars engage with potholes more violently, resulting in more damage as the tires have time to fall completely into the hole and must come back out, and damage can be done to both tires and rims.

2.5 Pavement smoothness

International Roughness Index is going to be an important facet to the study. It is defined as “an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle, and thus the user” (Pavement Interactive, 2018). Since user experience (and further, perception) is the main info looking to be attained, the International Roughness Index numbers could prove to be a helpful source to back up the opinions given on the surveys received. IRI is typically measured in 1/10 of a mile increments, or 528’ segments of pavement. This allows for a smaller unit to be studied, while also having a substantial enough section that maintenance or replacement could be justified. According to a phone call with Rick Miller, a California Profilograph is the way that the IRI is first measured, less than 14 days after the pavement is surfaced. This allows for any abnormalities to be corrected prior to the opening of the stretch of roadway, making it easier on motorists and the construction workers. For post-construction checks on a monthly to yearly basis, a laser system is used to recover these measurements. The tool is attached to the bottom of a pick-up truck and drives at highway speeds to best emulate the user experience. The data is collected in real time and can be more quickly and easily analyzed than with the Profilograph. In the months after the initial analysis, the pavement logs provided by Rick Miller, the Pavement Engineer for KDOT, will be looked at. He has provided charts for a significant portion of I-70 regarding their IRI values, and in further studies, will be compared where the patrons surveyed stated that they entered the interstate to see where the “rough” places are believed to be.

There are a few different ways to gauge pavement smoothness, most falling under the umbrella of a “Pavement Management System” or PMS. With a pavement management system, there are different ways to try and provide the best maintenance and rehabilitation (M&R) based

on the predicted evolution of pavement quality (Meneses & Ferreira, 2012). A study done in Portugal looked at MODAT, or the Multi-Objective Decision-Aid Tool as being used for a PMS. This included a type of optimization model that aimed to minimize costs for pavement rehab while trying to make sure that the pavement quality stayed at a set standard. While doing the study, they considered three main points in their analysis. These included the minimization of agency costs (maintenance & rehab costs), the minimization of user costs, and the maximization of the residual value pavements at the end of the planning time-span (Meneses & Ferreira, 2012). According to the suggestion of the authors, they believe that MODAT could be used either annually or biannually to look at what needs to be done for maintenance and rehab of certain roads, and to look at more categories beyond the ones that are already considered in current road pavement maintenance methods. This could be helpful for many departments of transportation to look at, as it is a more widespread and holistic look at road pavement maintenance and the different facets that are affected by it.

Chapter 3 - Methodology

Drivers were to be surveyed to see what their personal observations are on the research question presented. To begin, the study site was considered. The first area chosen stretches between Kansas City, Kansas, and exit 183 in Topeka, KS. The KS Turnpike is a public user-fee funded highway, paid for by the tolls generated on its' various stretches and exits. The second study area chosen is Interstate 70 between the KS Turnpike Tollbooth at exit 183 westward towards the the Kansas/Colorado border. The maps provided below show the selected study site, as well as the entirety of Interstate 70 in Kansas being considered for this research.



Figure 1. Map of Interstate 70 in Kansas and the Kansas Turnpike, K. Geist

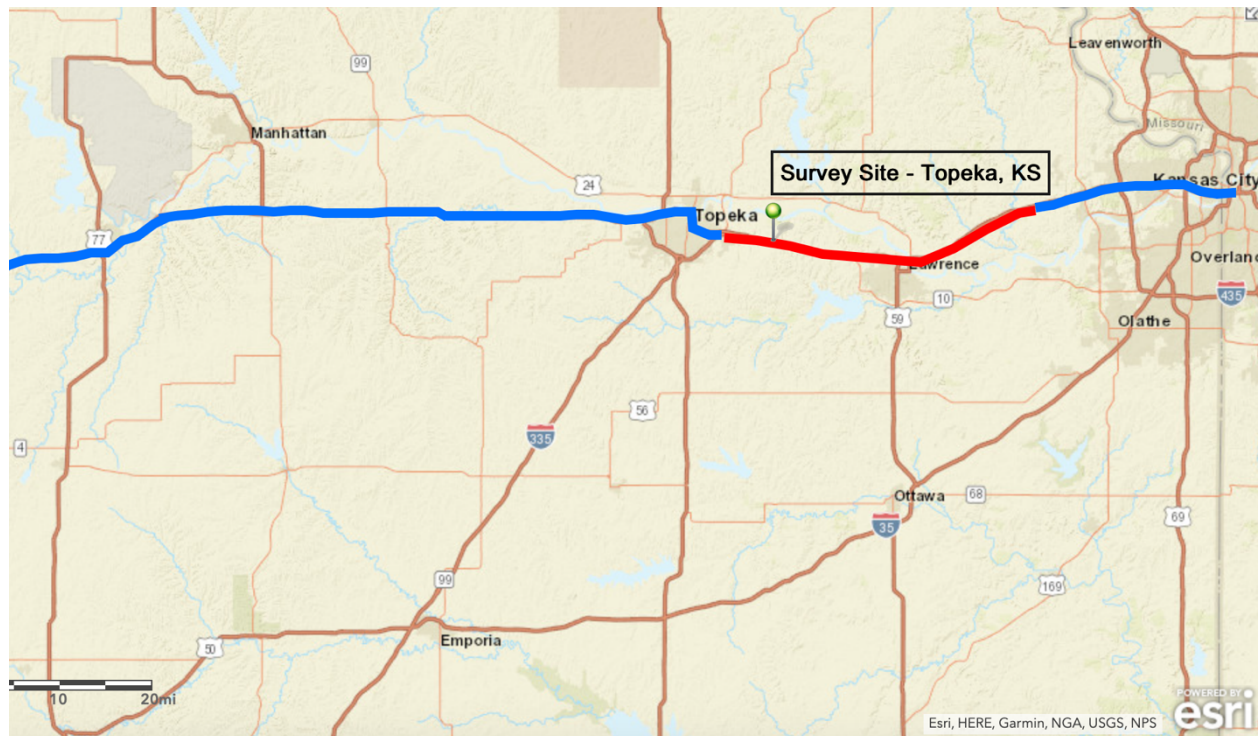


Figure 2. Inset map of survey site and Kansas Turnpike study area, K. Geist

For this study, a sample pool of 156 different drivers was surveyed to see what their opinions on the road pavement conditions of Interstate 70 were. Since this interstate is heavily trafficked, this number was not too high to successfully achieve. Instead of distributing a paper survey, surveyors were positioned at the Topeka rest area a couple of times a week in the March and April to conduct the surveys, gaining direct feedback as people came off of the road while their thoughts on the matter were fresh. Drivers were surveyed while they were pumping gas, so as to catch them at a time that they had a few minutes available and would not be doing anything else. This provided the opportunity to talk to people while they were stationary and allowed them to adequately comprehend and answer the survey questions. The first step to completing this methodology was receiving approval from the managers of the gas station and restaurant to conduct the survey, as these are their customers and was no solicitation occurring. As of September 29th and March 14th, the manager at the Topeka rest stop provided approval to do

repeated surveying, given that no soliciting was done and that the intentions of the study were made clear.

There were multiple types of variables in this experiment, as there are many different aspects to consider regarding the issue at hand. The drivers themselves, economic status, gender, trip purpose, road conditions, time of day, and type of vehicle were all relevant and deciding factors in what types of responses were received. While these are all important variables, some gave more deciding and pertinent information than others. The date and time of day when surveys were distributed was left to be an independent variable. One goal of the study was to survey patrons on every day of the week, as well as at multiple different times throughout the day. Morning, afternoon, and evening were all captured to see if drivers responded differently or had different trip purposes due to the time of day specifically.

The drivers are the second variable in this study. Drivers requested for the study were not preselected and it was desired to speak with a variety of ages of participants (only those over the age of 18). The only specification was that all patrons surveyed must be automobile drivers or motorcycle riders, and semi-truck drivers were not surveyed. This is due mainly to the fact that freight travel is very different from personal travel, and their opinions would likely be dissimilar to those driving passenger cars. The hope was that doing this study would give a broad scope of opinions, and people with different experiences and sensitivities would provide different reactions to things, therefore potentially altering their opinions. This is an independent variable, as the participants were not preselected, and there was no control over who came into the rest area. Along with this comes job type, predispositions, etc. that could have any effect on the results. As there was no prior knowledge of the subjects or their own biases and experience, this

helped to make sure that it was a truly random survey and that each person who came to the rest stop gas pump area was asked to complete it, regardless of race, gender, profile, appearance, etc.

The survey was conducted through Qualtrics, a surveying site licensed to Kansas State for student and faculty use. By the end of February, all questions were entered into the site, and the final copy of the survey was ready for use. There were 23 questions total, ranging from household size to stated preference, for more accurate analysis and findings. The final draft of the survey that was submitted to the IRB is in the appendix below. Each surveyor was provided with a tablet, and all helpers were thoroughly educated on survey procedure, and how the survey is set up. Small info cards were offered to those agreeing to be surveyed who wished to follow up with the study, should they wish to read the final product in May.

After all of the data was collected, it was categorized for making different conclusions and finding valid results. This included categories such as “people who would pay extra for roads if the pavement was well-maintained” or “people who claimed to be indifferent on the topic” or, could be graded on a scale and people could voice how they would rate the quality of the roads and how likely they would be to vote for paying extra money for them. Overall, the true results desired are what Kansas citizens believe the quality of the state and federal highways are, and whether or not they feel that this infrastructure issue truly is an impending problem, regardless of whether or not they know all of the facts regarding it. The people that this issue directly effects are the ones that use it regularly, so they are whose opinion is most strongly desired.

There are a few main points of analysis that were among the first considered. The first is willingness to pay compared with different sets of data, such as gender, household income, and other general demographic data. Even these simple delineations have very large implications for

how patrons respond to the survey, based on different biases and predispositions. A few other topics that were very relevant and helpful for analysis are the overall statistics of opinion on road quality, frequency of patrons' travel on the highway compared with response to any discomfort on the road, etc. These all helped to characterize and explain how Kansas patrons feel and gave more insight into why they may have answered the way that they did.

Chapter 4 - Validity & implications

There are some factors that could have interfered with the success of the methodology. As previously noted, biases and predisposition of drivers surveyed would potentially help the study, as it will give a wide range of opinions. On the other hand, it could have also potentially skewed the results if not managed correctly. As far as the testing of the roads is concerned, while one person may see a pothole as severe, another person may not even notice it, or the effect on their vehicle may be minimal due to what type it is (i.e. a truck may absorb any type of shock better as it is a bigger vehicle than a small sedan). This very well could have skewed the data; if people did not pay attention to the road conditions when they drive, they would not be able to give accurate data, and if they were overly alert to their conditions, it could be portrayed as being much worse than it truly is. These different possibilities more than likely had some impact on the final results of the study.

In terms of implications that were made from the research, one of the biggest was whether or not the conditions of the highways tested truly had an impact on the way people viewed roads, or whether it did not bother them, and they could not have cared less about it. The background research considered shows that roads are one of the most visible and heavily used (and overused) forms of infrastructure, so there was confidence that people would want to find solutions to better their road systems for their own safety, comfort, and the wellbeing of other travelers. One of the other implications that was anticipated was what the general public saw as a good way to pay for this road infrastructure. Asking this question as a part of the survey gave first-hand data on what people would truly be willing to pay for, instead of assuming or relying on prior experience with different funding methods that may be outdated or over utilized.

Chapter 5 - Analysis of survey data collected

5.1 Details of data collection

Date collected	Times collected	Successful surveys	Rejected surveys	Running total (successful)
3/15/19	2-4 PM	15	12	15
3/16/19	1:30-3 PM	17	11	32
3/31/19	4-5:30 PM	8	11	40
4/1/19	1-4 PM	23	16	63
4/2/19	5-6 PM	9	0	72
4/3/19	5:30-7:30 PM	15	3	87
4/4/19	6-7 PM	4	4	91
4/5/19	9AM-6PM	64	25	155
Total patrons successfully surveyed:	N/A	N/A	N/A	155
Total patrons approached:	N/A	N/A	N/A	238

Table 2. Survey collection table

5.2 Predicted outcomes

- Those that drive on Interstate 70 in Kansas on a regular basis likely won't have noticed as many abnormalities as those driving less, or for the first time.
- Those that have a higher household income will likely be willing to pay a toll if they aren't concerned about their financial situation as much.
- Most patrons will likely be in favor of a reduced or eliminated gas tax or reduced vehicle registration.
- Gender will be relatively unrelated to road pavement smoothness rating.
- Larger households will be less likely to want to pay a user fee than smaller households.

5.3 General data breakdown

5.3.1 Patron consent to take survey

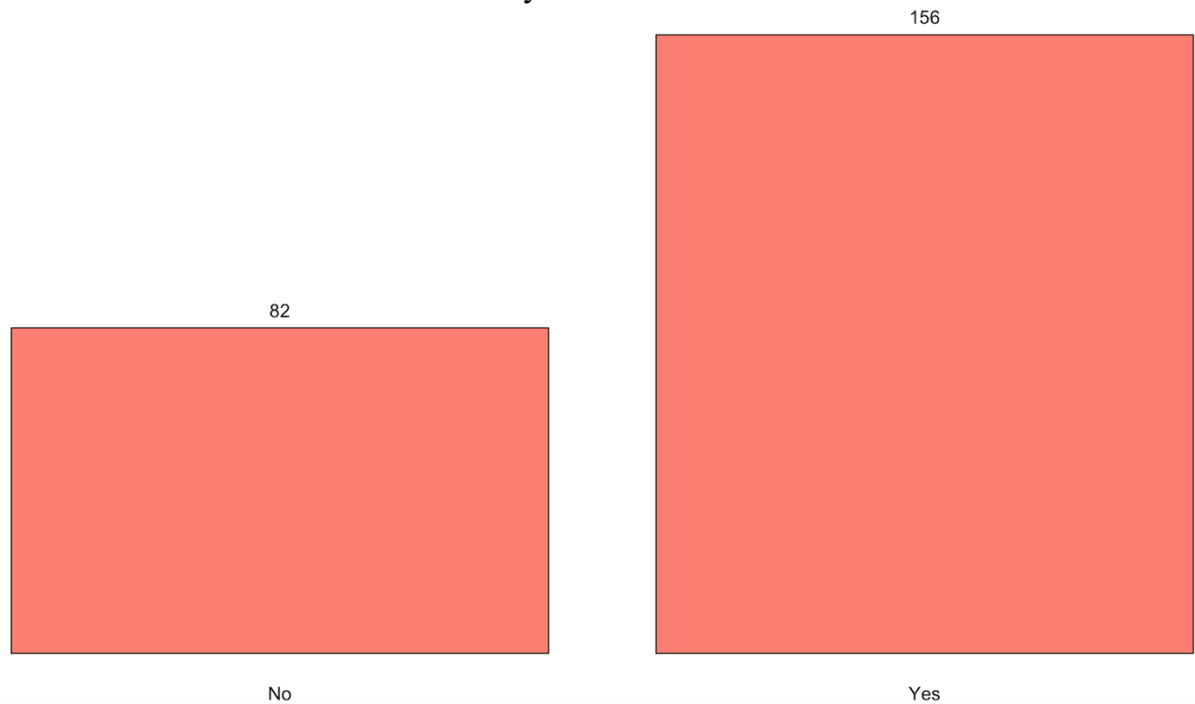


Figure 3. Patron survey consent breakdown

All patrons approached had the opportunity to either consent to taking the survey, or to decline. If a patron was approached and did not consent to the survey, they were thanked for their time, and the surveyor moved on. If a patron consented to taking the survey, the surveyor continued by further explaining the purpose of the study, who was conducting it, etc. For this study, a total of 238 people were approached during the survey period. Of those 238, 82 did not consent to taking the survey. 156 agreed to take the survey. This percentage breakdown is approximately 65.55% gave consent, and 34.45% did not give consent. Along with this, the majority of those surveyed traveled on both I-70 and the KS Turnpike. Approximately 71.05% of patrons said that they traveled on portions of both highways, while 28.95% said they solely drove on the KS Turnpike, and not on an un-tolled portion of I-70.

5.3.2 Survey count breakdown by gender

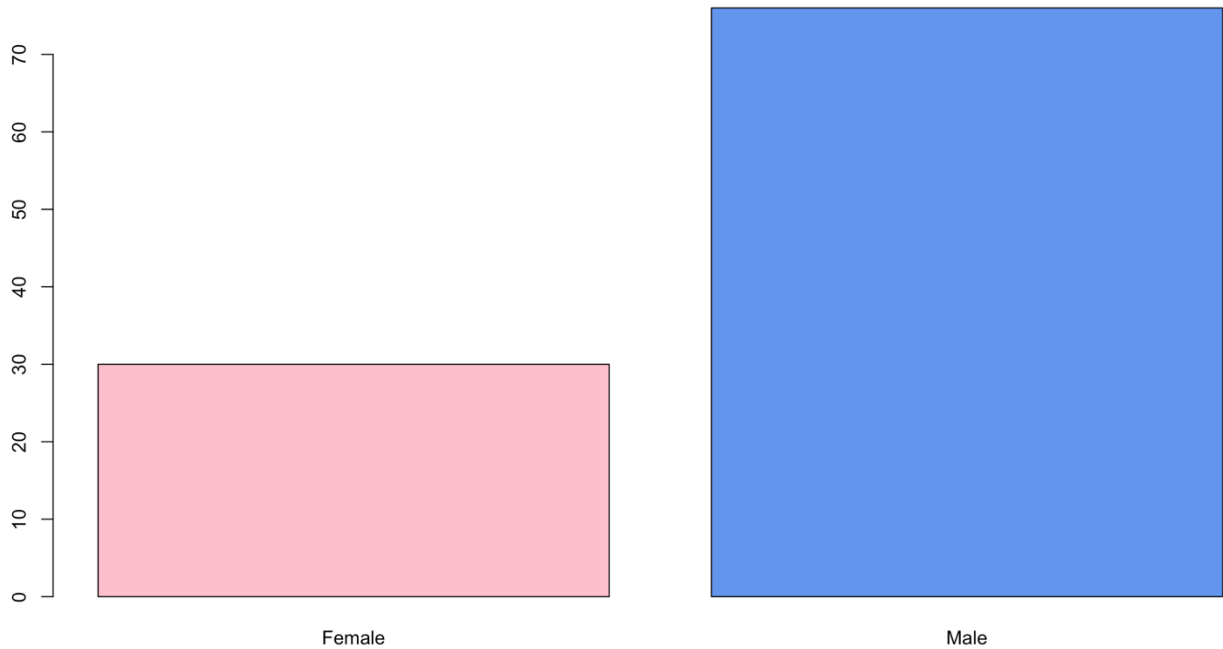


Figure 4. Total accepted survey count breakdown by gender

The above graph shows the breakdown by gender of those who agreed to take the survey. Approximately 70.97% of those surveyed were male, while 29.03% were female. This was not intentional, as all available patrons were approached. In a familial situation, many times the male was pumping the gas, while the female either watched over the children in the vehicle or went inside the gas station. This seemed to be a common trend throughout the surveying process. Overall, there seemed to be significantly more men than women during survey times at the rest area.

5.3.3 Average highway smoothness ratings by gender

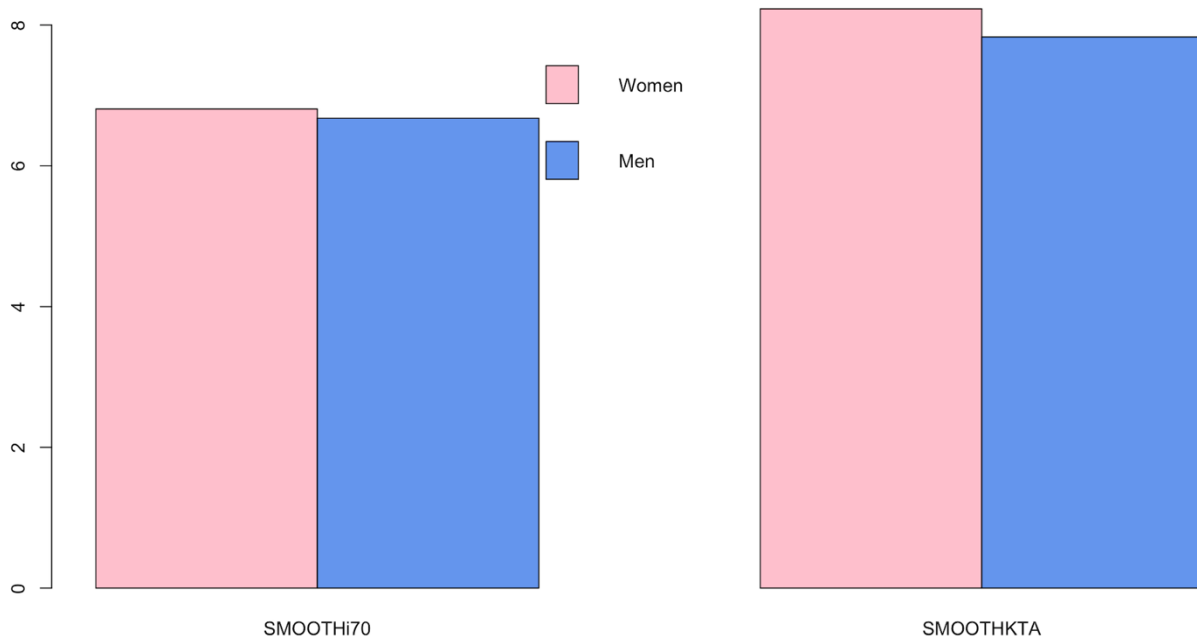


Figure 5. Average highway smoothness ratings by gender

The average highway rating breakdown shown on the previous page shows that according to this study, women tended to have a higher sensitivity to the roads, and therefore rated the roads higher than men did. This trend holds steady for both I-70 and the Turnpike. While both SmoothI70 (the rating provided for Interstate 70) and SmoothKTA (the rating provided for the KS Turnpike) are relatively close between genders, it is important to note which gender rated higher on average, and which scores were higher overall. Further studies are done on these variables in section 5.7, with other statistical tests such as a t-test, ANOVA, and Chi Squared.

5.3.4 Kernel density plot of traveler birth years

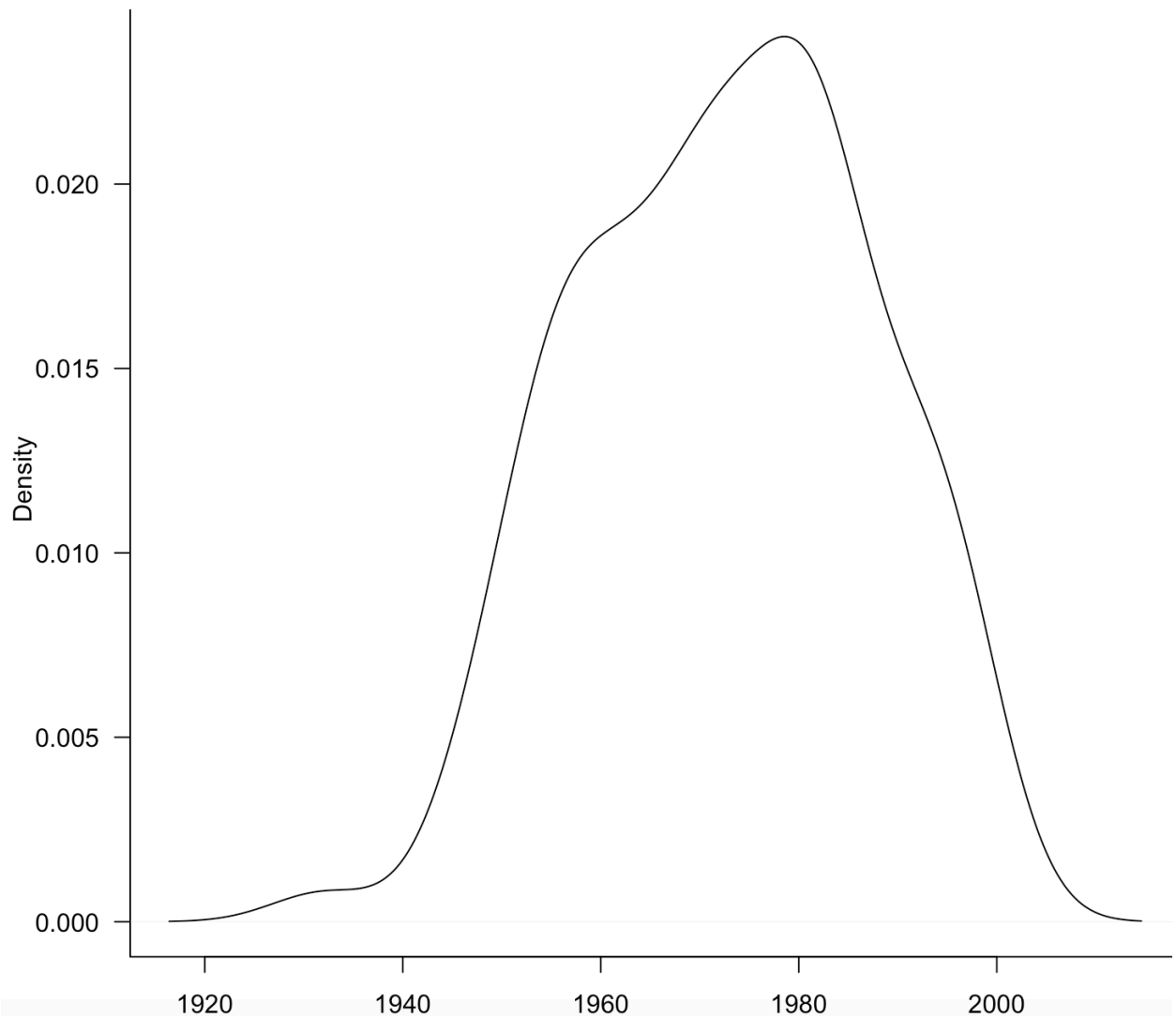


Figure 6. Birth year kernel density plot

The kernel density plot provided above shows the frequency of different birth years, and where the highest numbers were clustered. All people interviewed were born between the years of 1920 and 2000, with the highest frequency seen around the year 1980. This graph shows an initial peak from around 1958-1960, and an even stronger peak at 1980.

5.3.5 Traveler trip purpose

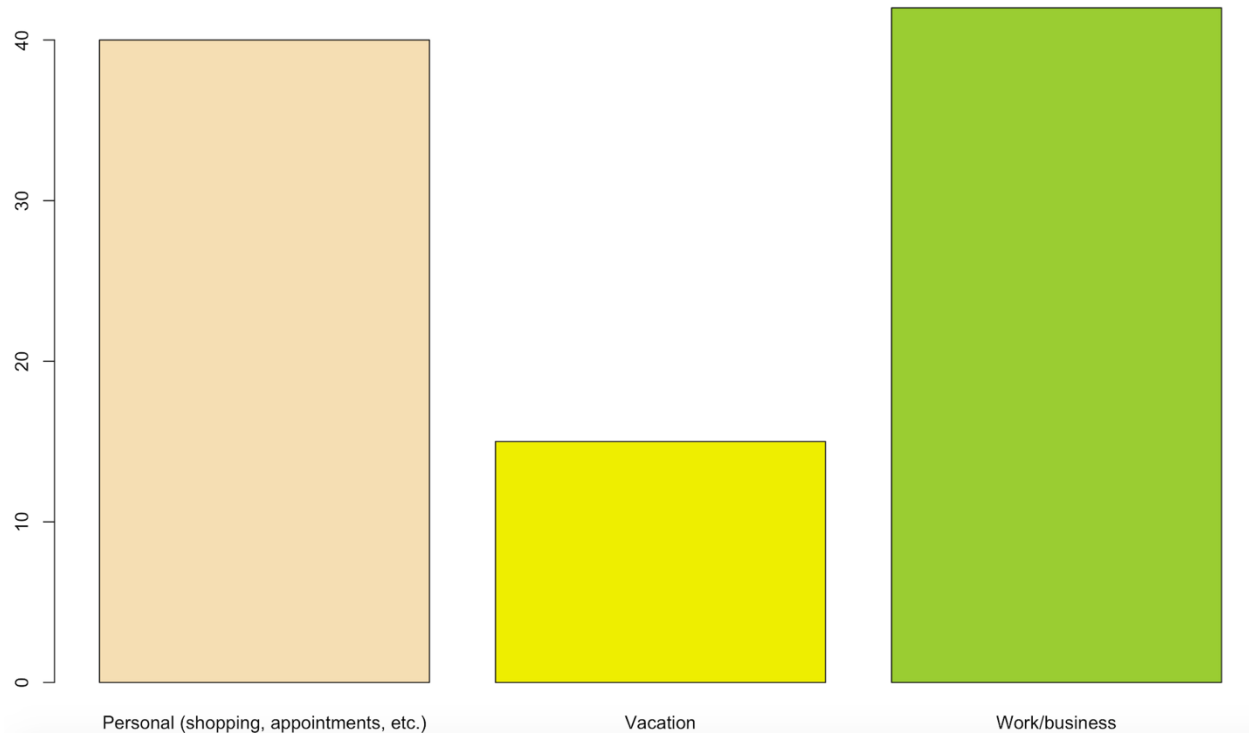


Figure 7. Traveler trip purpose

Traveler trip purpose was a prominent part of the study. There were three categories that a patron being surveyed could select from regarding the purpose of their trip on the highway the day they were surveyed. These included personal (shopping, appointments, etc.), vacation, or work/business. As seen in the figure above, there was a significant difference in the purpose breakdown. 43.81% of patrons noted that they were traveling on I-70 for personal reasons, 40.95% said that they were on the highway for work or business purposes, and 15.24% were on the highway for vacation.

The majority of patrons were either on work trips or doing personal errands. Less than 20% of people surveyed were on vacation. This was expected, as the survey times were in late March and early April. If the survey had been done earlier, it is likely quite a bit of the Spring Break traffic would have been caught, but as it was done later, this holiday specific traffic was

avoided. The times that surveys were taken is also pertinent. I was able to survey every day of the week to try and get all types of patrons, as well as significant times during the day (morning, afternoon, evening). This helped to get different types of demographics and trip purposes.

5.3.6 Breakdown of traveler vehicle type

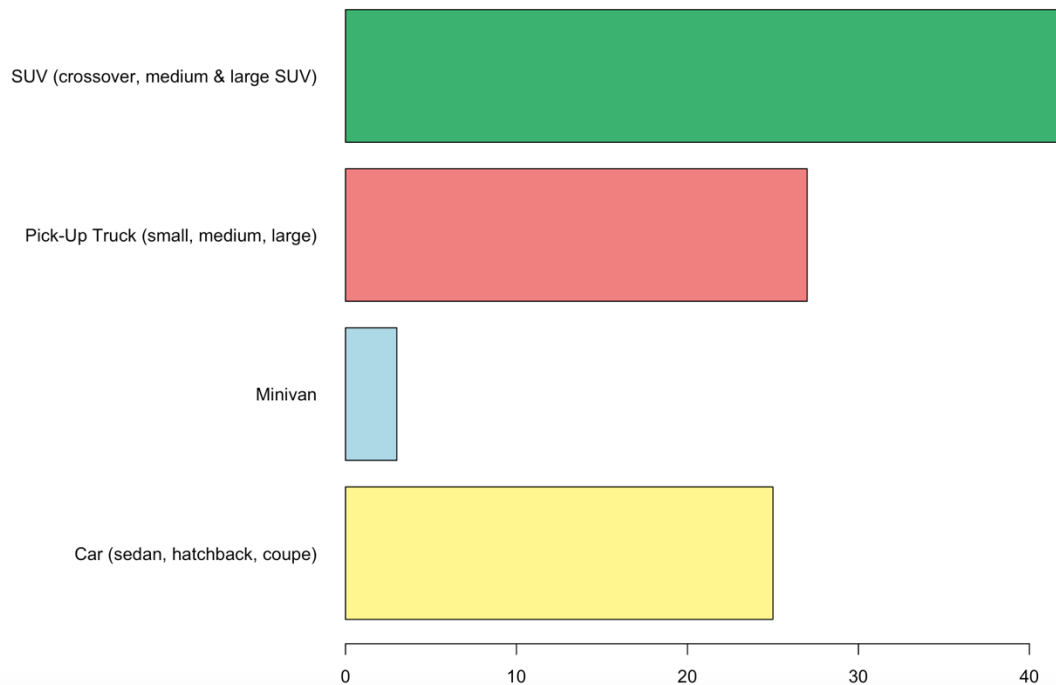


Figure 8. Frequency of traveler vehicle type

The above graph shows the overall frequency of vehicle type selected by those being surveyed. The options provided were SUV, pick-up truck, minivan, and car. Approximately 42.86% of travelers were in an SUV, ~27% were in a pick-up truck, ~25% were in a car, and 3.81% were in a minivan. These trends follow the predictions made, as the time of the year that surveys were conducted, vacation would be minimal, so families would likely not be traveling in minivans as frequently. Along with this, pick-up trucks and cars were fairly equal, likely based more on preference or job type than other factors. Lastly, SUV had the largest frequency by far. This fits with the predictions made, as SUV's are popular not only for families, but for couples, single people, etc. and while they aren't as economical as a car would be, still have the capacity to haul items and be relatively fuel efficient.

5.3.7 Patron opinion of road pavement smoothness importance

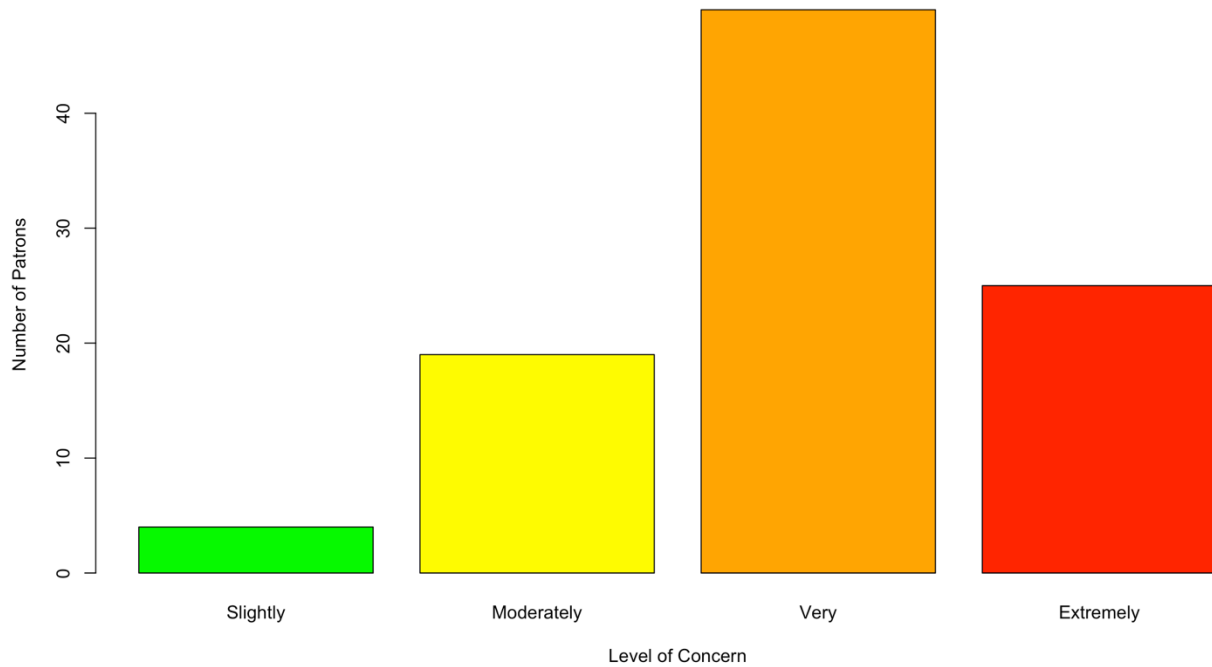


Figure 9. Patron opinion of road pavement smoothness importance

The above graph shows the frequency of patron opinions of the importance of road pavement smoothness. The provided categories were slightly important, moderately important, very important, and extremely important. On the following page, the percentages are provided to see where the biggest differences were. What does this breakdown mean? The people that were surveyed for this project seemed to really value road pavement smoothness as being an important part of their own personal driving experiences. Many patrons mentioned just how much they dislike potholes, uneven surfaces, etc. and that the lack of comfort and increased wear on their vehicle would be something that they would like to avoid if possible.

5.3.8 Total yearly days driven on I-70 compared with absolute difference in pavement smoothness ratings

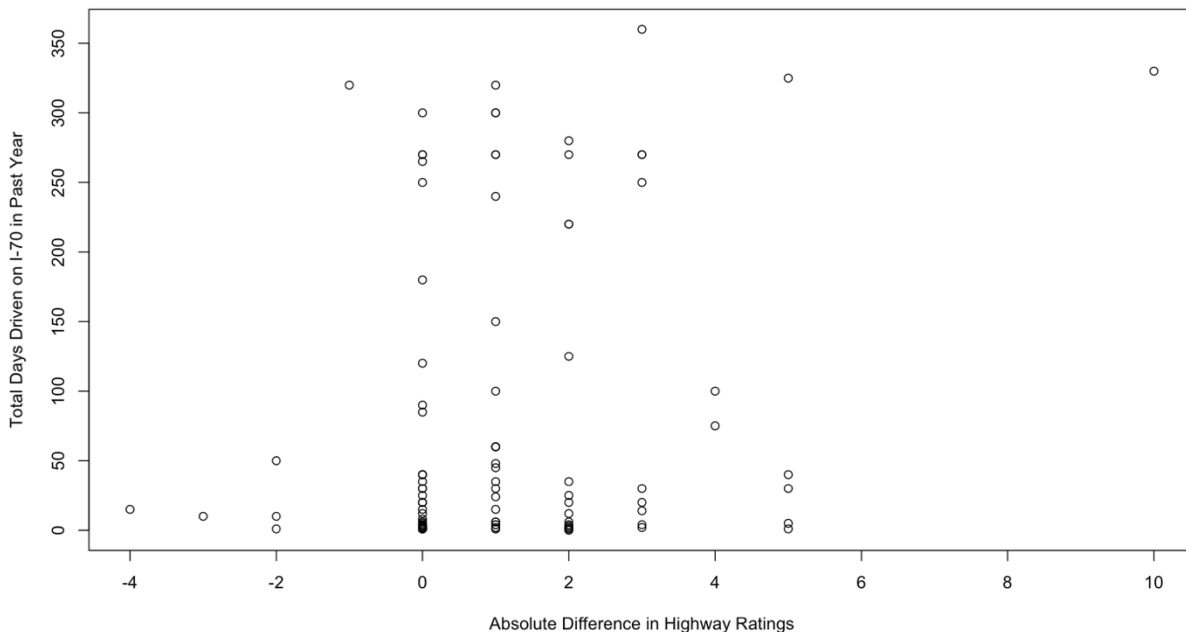


Figure 10. Yearly days driven on I-70 vs. absolute difference in highway ratings

It was initially predicted that this comparison, frequency of travel vs. amount of discomfort, would show much larger and more visible discrepancies than it does, ultimately. While those having driven on the road more frequently may not have noticed the different blemishes in the pavement smoothness, many people from across the country were interviewed while traveling through Kansas and had very good things to say about its highways. Multiple people ventured even to compare Kansas highways with other states such as Colorado, South Carolina, etc. and noted how highly they thought of Kansas roads, even though they didn't travel them often. It seemed that those who traveled the road more frequently actually had more issues with the differences in the roads, as they traveled them very often and were able to notice the issues over multiple trips. This was truly an opposite finding of what was expected initially.

A correlation was done with these two categories to see if there was any relationship between them, to hopefully back up what was seen in the scatterplot. The value for this correlation was 0.1345. This value shows that there was indeed a positive correlation. Though only a slight one, there was still a positive relationship visible between how many days patrons drove on I-70, and what their absolute difference in ratings were for both highways.

The outliers are important to note in this graph. Outliers can be seen in Figure 10 at -1, -2, -3, -4, and 10. As stated previously, the negative values correspond to when a patron believed that I-70 was of higher pavement smoothness quality than the KS Turnpike. The outlier at 10 is reflective of a patron who gave the KS Turnpike a rating of a 10, while giving I-70 a 0. The y-axis shows the number of days traveled on I-70 (on any portion of the highway, tolled or not) from 0 to 365. For many people surveyed, this was their first trip on this highway. The other majority travels on I-70 on a regular basis, which was predicted to greatly affect their results to this question.

It was predicted initially that this graph would show a large correlation. This correlation was predicted to show that those who drove the interstate more often may not see a large difference, as they have become attuned to the discrepancies in the road and do not notice those as much as someone who would be driving on the road for the first time the day they were surveyed. While this was the case in some of the people surveyed, there were also those who drove I-70 upwards of 320 days a year, and saw relatively large discrepancies, while some of those who were on it for the first time thought it had little to no difference from tolled to untolled pavement. The driving lengths also may have had an effect on what their ratings were. While some patrons were travelling from other sides of the country, others were simply

commuting for work as they do daily. Some patrons drove on different segments of pavement that may have affected their responses, while others did not.

5.4 Road pavement smoothness

5.4.1 Histogram of absolute difference in highway smoothness ratings

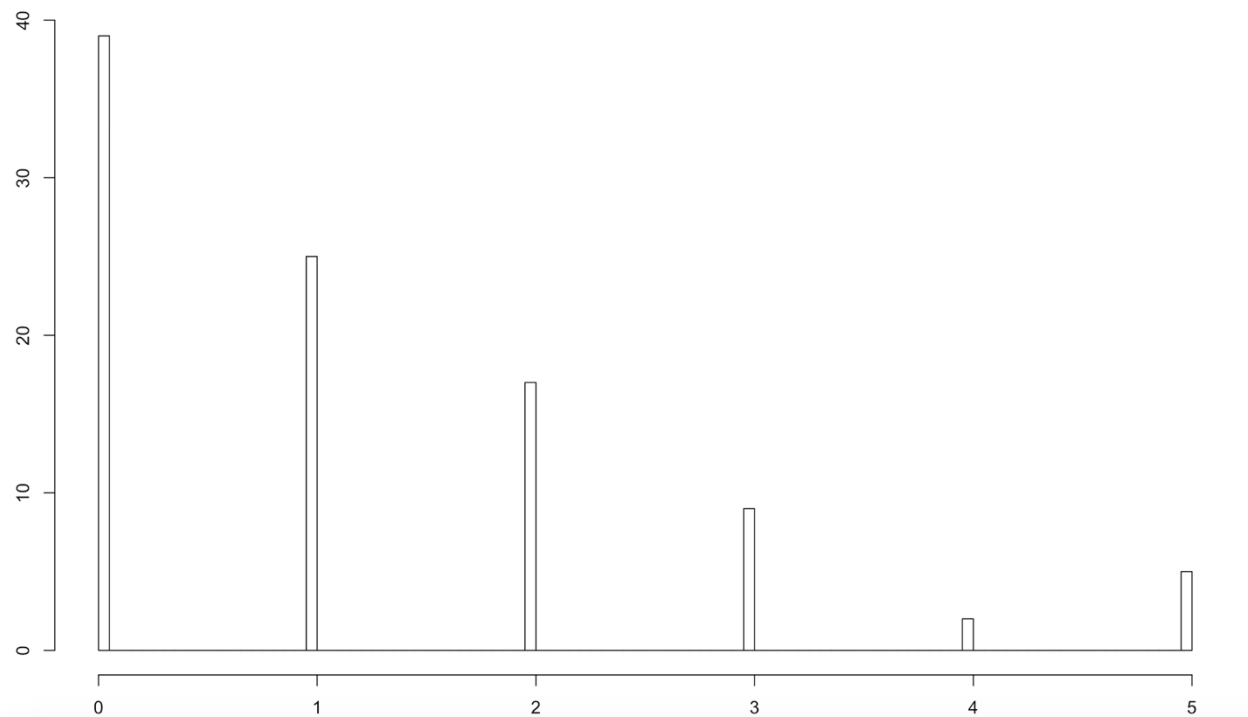


Figure 11. Histogram of absolute difference in highway smoothness ratings

The above figure presents a different way of looking at the absolute difference in highway smoothness ratings. The difference in the two ratings is important to look at, as it shows whether or not the patrons believed that there was a pavement quality discrepancy in the two roads, or whether they thought there was no difference. Along with this, the difference was predicted to greatly influence the willingness to pay aspect of the study. The largest bar on the histogram is seen at 0, with a frequency of approximately 38 responses. This shows that the majority of people saw no difference between the road pavement smoothness of Interstate 70 and the KS Turnpike. Moving down the histogram along the x-axis, the value increases to show which patrons believed that there were greater discrepancies between the two roads and their pavement smoothness. The smallest value seen was at 4, which had only a few responses. For

example, this would have occurred if a patron had rated I-70 at a 5 but believed that the KS Turnpike had a value of 9. The highest frequency was between 0 and 2, indicating that although some patrons saw a visible difference in the roads, the difference was relatively small. This was different than the predicted outcome, which was that patrons would see a distinct (and possibly significant) difference between the highways and their pavement smoothness.

One important thing to note is that there were negative outliers that were cut from the sample pool, as well as a very large outlier. These were cut as they were not reflective of the majority of responses and skewed the data rather greatly. The negative values reflected the answers of patrons who responded that they believed Interstate 70 had a higher pavement smoothness quality than the KS Turnpike. As stated previously, no opinion was considered incorrect, but since the number was so insignificant and was the opposite of the predicted outcome, those were left out. The values were incorporated into the graph shown in section 5.3.8, which is comparing days driven on I-70 and the absolute difference in ratings. They were kept for this graph as the numbers provide interesting conclusions that are helpful to note.

5.4.2 Absolute difference in highway smoothness ratings by gender

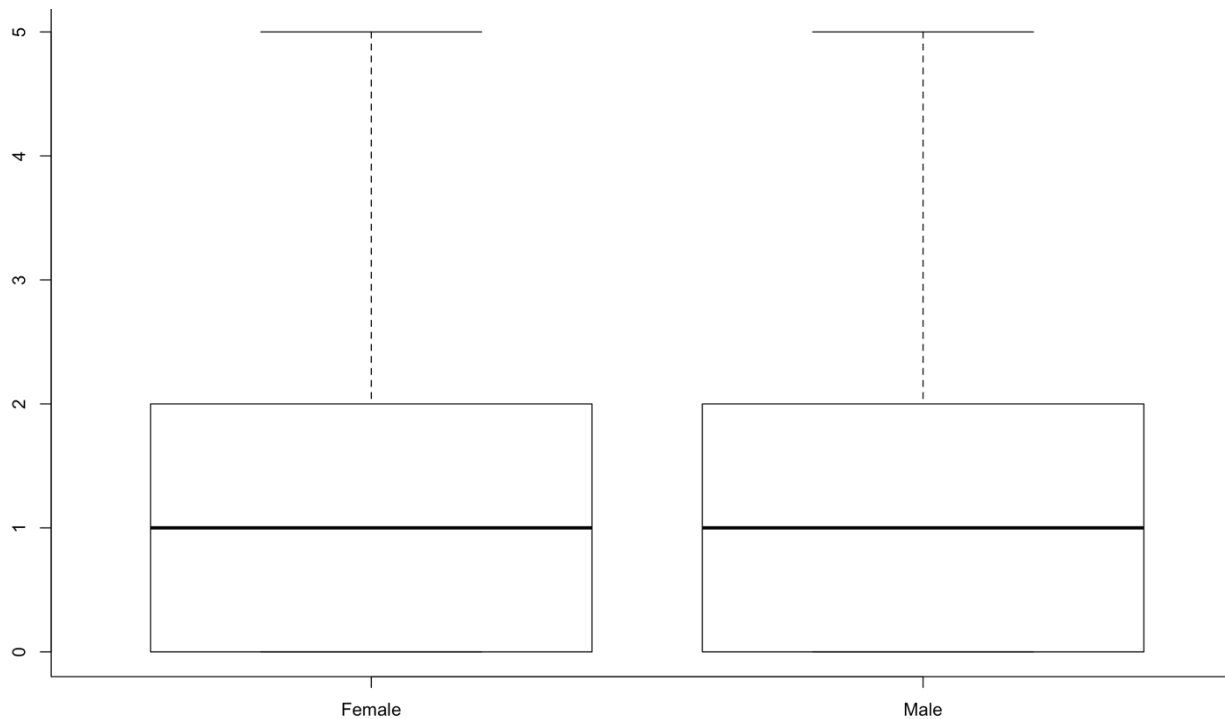


Figure 12. Absolute difference in highway smoothness ratings by gender

The graph above shows that in terms of the absolute difference of highway smoothness ratings for both men and women, they are virtually the same. The boxplot shows that the minimum absolute difference is 0, the median is 1, the maximum is 2, and there are outliers at 5 for both genders. The box distribution is relatively equal, implying that the data sets were likely very similar for the plots to have such a close relationship.

5.4.3 Vehicle type vs. highway rating absolute difference average

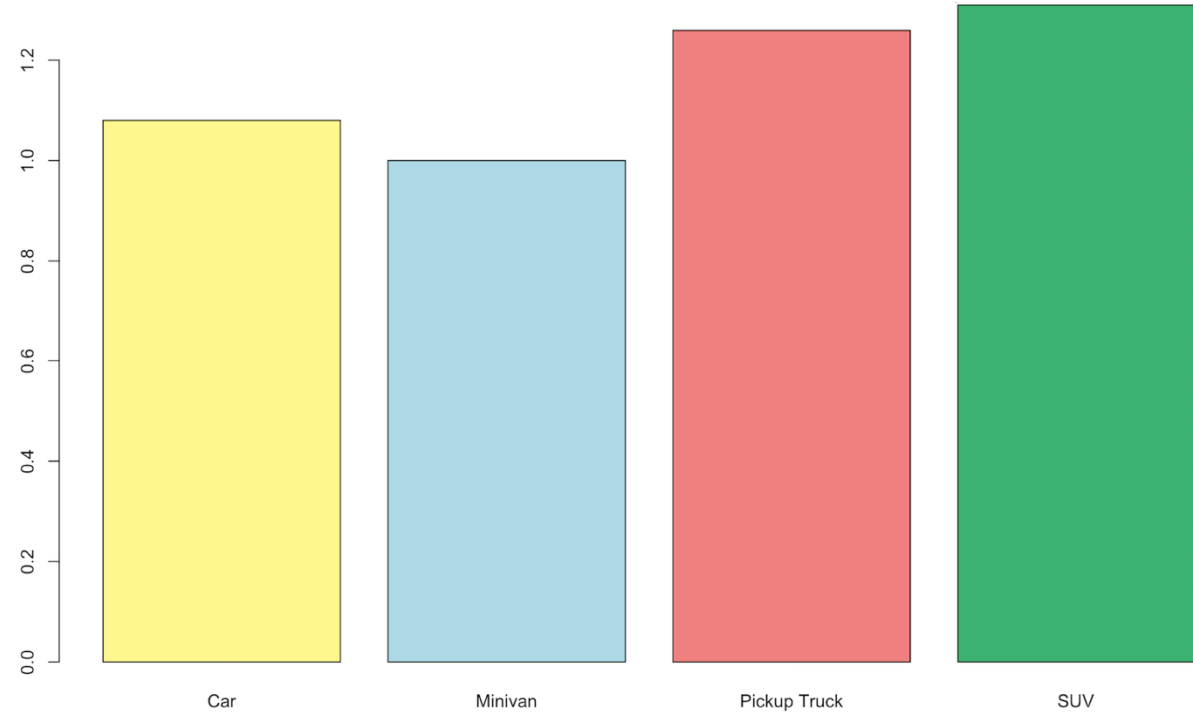


Figure 13. Highway rating absolute difference based on vehicle type

The above graph is another way of viewing absolute difference by vehicle type. The colors on this graph correspond to the vehicle colors in section 5.3.6. The y-axis shows the average in the absolute rating difference. If the difference in the averages was 0, that is seen at the bottom of the axis. If the difference was greater than that, the scale moves up the graph. The vehicle with the highest absolute difference in ratings was SUV, followed by pick-up truck and then car. Minivans had the smallest absolute difference, at a value of about 1. The difference is likely seen due to the type of axels on the vehicle. While SUV's and pick-up trucks are similar in terms of chassis, cars have a smaller wheel base, and may not feel bumps quite as strongly. Minivans are a different type of vehicle altogether, designed for comfort and safety, as their primary inhabitants are children and their parents.

5.5 Willingness to pay

5.5.1 Kernel density plots of willingness to pay (in \$)

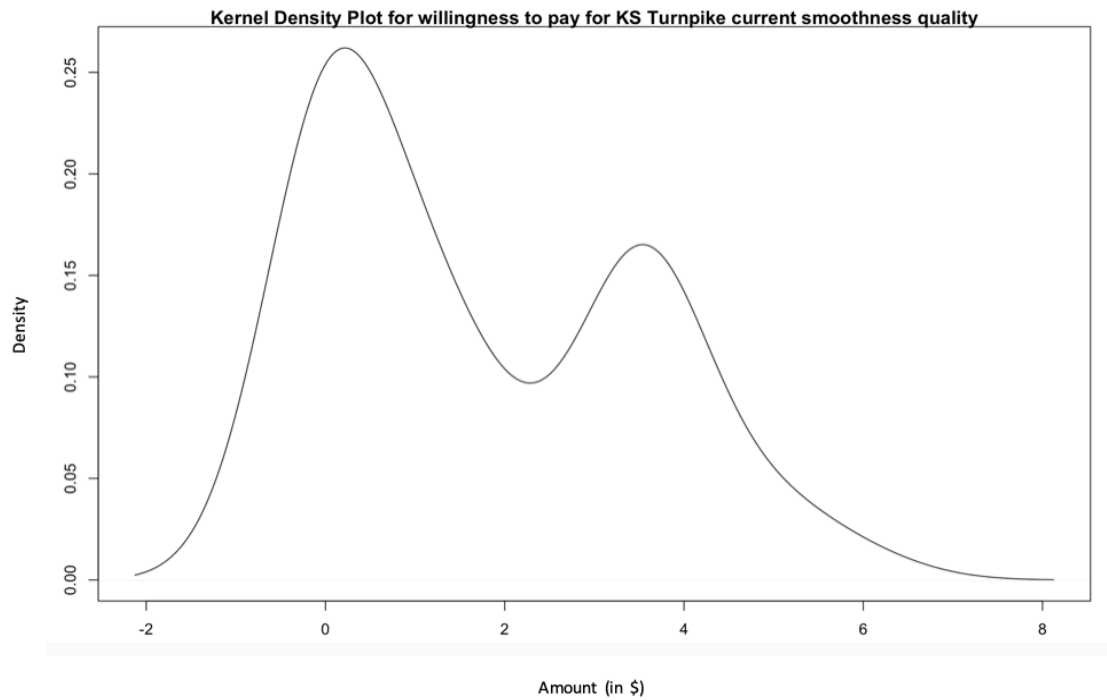


Figure 14. Willingness to pay for KS Turnpike pavement smoothness

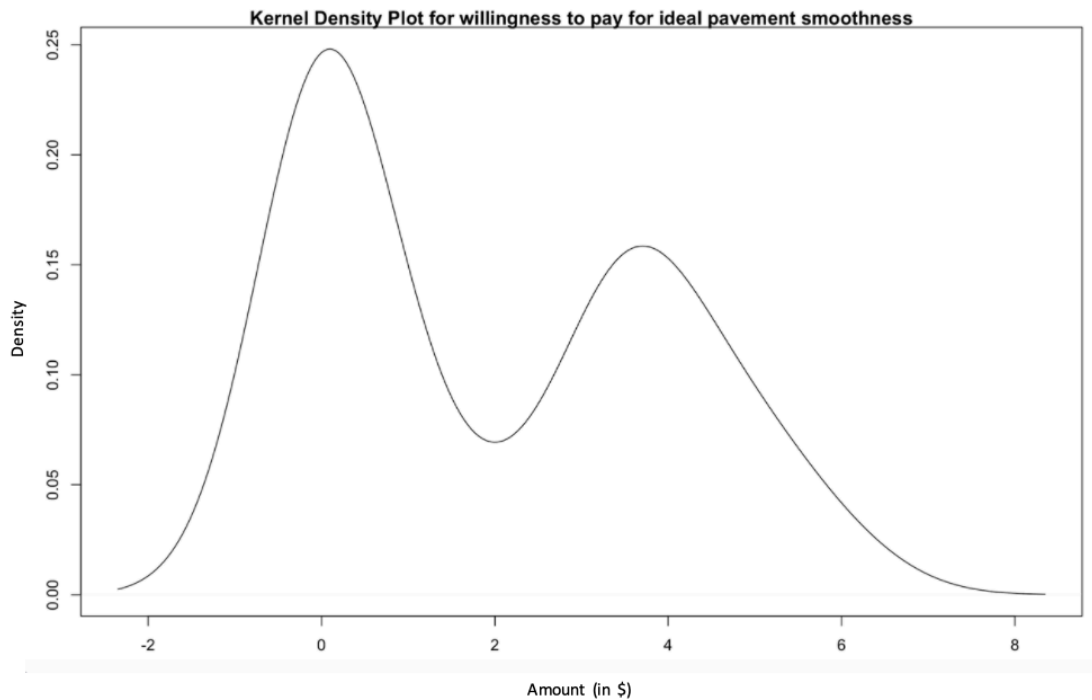


Figure 15. Willingness to pay for ideal pavement smoothness

5.5.2 Kernel density plot trends and implications

- Patrons are willing to pay for road improvements if it will truly make the roads better.
- The largest portion of patrons would not pay more than \$1 additionally to make these improvements.
- Some patrons are willing to pay upwards of \$5 for a significant increase in maintenance and upkeep, but that is a very small number.
- The distributions between the two willingness to pay histograms are very similar, indicating that across the board, people would be willing to pay for both Turnpike quality roads and for their ideal road pavement smoothness, but it is a small increase in the amount.

5.6 Correlations

	I-70 Rating	KTA Rating	Highway Ideal
Birth Year	-0.1624	-0.0735	-0.0504
Vehicle Year	-0.0817	-0.0045	-0.1144
I-70 Days	-0.0926	0.0314	0.0662

Table 3. Correlation table

The above tests were conducted to see whether or not there were variables that correlated with each other. Both positive and negative values have the possibility of showing some type of correlation, positive showing an upward, rightward trend in the data, and negative showing a downward, leftward trend in the data. Along with this, the values need to be of a certain significance to show any type of correlation. No correlation would be seen at 0, while upwards or downwards from there would show a correlation, be it negative or positive. In looking at the data provided in the table above, many comparisons show some type of correlation, while others show none. In terms of comparing birth year with the variables along the x-axis of the table, there is no clear correlation between the birth year of the patron surveyed with either their turnpike rating or their highway ideal. When looking at the birth year compared with the absolute difference in the provided ratings as well as their given I-70 rating, there are slight correlations seen. In terms of the absolute difference, there is a slight positive correlation seen. When comparing birth year and the provided I-70 rating, there is a slight negative correlation.

Vehicle year is a category that seems to have few visible correlations between the primary variable and the x-axis variables. The values are both positive and negative, but all are

smaller than -0.1 and 0.1, therefore there is likely no correlation present. The correlation with these variables that is the greatest is between vehicle type and the ideal highway rating, with a value of -0.1144. This shows a negative correlation, but a slight one, nonetheless.

5.7 Additional statistical tests

5.7.1 T-test

Three t-tests were done to compare different variables to show the differences in the mean, along with whether or not the means were statistically different. Each comparison was looking at the gender of the person surveyed against different variables such as the absolute difference in their highway ratings, their I-70 rating, and their KTA rating. The first t-test done was comparing gender and the absolute difference. The mean value found for the female section of those surveyed was 1.4230, while the male group had a mean of 1.1549. This means that the females surveyed had a higher absolute difference mean, therefore they tended to rate the KS Turnpike higher on average than the males did. The p-value for this test was 0.1219, meaning that it was a relatively low statistical significance.

The second t-test that was conducted looked at a comparison between gender and the I-70 rating provided. The female group had a mean rating for I-70 of 6.8077, while the male group had an average of 6.6761. These are extremely close mean values, therefore there doesn't seem to be much of a difference. The p-value for this test was 0.727, showing a relatively low statistical significance.

The third t-test compared gender and KTA ratings provided by those surveyed. This t-test showed the biggest result of the three conducted. The female group surveyed had a mean of 8.2308, and the male group had a mean of 7.8310. This is a difference of 0.3998, which is the greatest of the t-tests that were done. The difference in average means for this test shows that females, on average, rated the KS Turnpike at an 8 or higher, while males rated it between 7 and 8. From this, it can be deduced that females were likely more sensitive to the roadways on the whole, as well as recognizing a smoother ride on the Turnpike.

5.7.2 ANOVA (Analysis of Variance) test

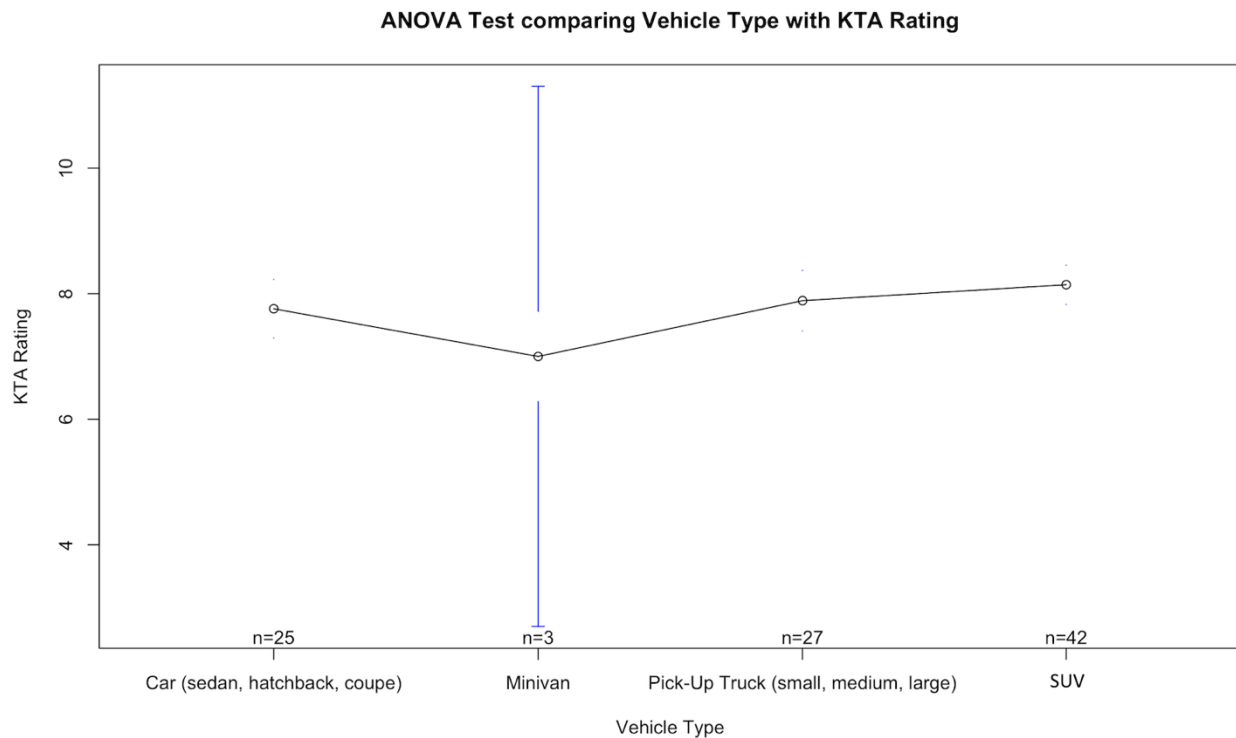


Figure 16. ANOVA test for vehicle type vs. KTA Rating

The above figure shows an Analysis of Variance test that was done to compare vehicle type with the rating provided for the KS Turnpike. Above each variable on the x-axis shows the number of responses corresponding to that number. Minivans show the greatest amount of variance, as their sample size was three patrons, and they likely gave significantly different ratings to show that much variance. From there, car and pick-up truck were relatively similar in their results. Their sample size was relatively identical, as well as their average Turnpike ratings. SUV has the highest rating, just higher than pick-up truck. A potential reason for no variance bars on the three variables other than minivan has to do with the greater sample size, as well as the likelihood that the ratings provided were very similar to each other.

5.7.3 Chi Square test

Two Chi Square tests were done with the collected data. These tests help to show further breakdowns of different variables being studied. The first test done was the opinion of importance of road pavement smoothness vs. gender. There were four categories of importance, including slightly, moderately, very, and extremely. The “slightly” category had few to no responses, so those were thrown out to make the data easier to analyze. From the three categories that were left, the distributions between genders were relatively similar. That being said, the conclusion can be made that there is no relationship between gender and importance of road pavement smoothness.

The second Chi Square test that was run looked at the importance of road pavement smoothness compared with trip purpose. Again, the “slightly” important category was eliminated, due to few responses. From there, the breakdown was very interesting. The largest trend was seen in the “very” column, where patrons on vacation, work/business, and personal outings all had the highest values. The highest seen was 52%, under personal. This was followed by work, and then vacation. The conclusion here is that those conducting personal business or going to work see the highest importance for road pavement smoothness on their trips, as likely their time is valuable, as is efficiency. Those on vacation either were not from the area or were not in a position to have needs such as a short commute or efficiency with their vehicle.

Chapter 6 - Potential Use of Collected Data

6.1 Importance of public perception for the future of pavement smoothness

Public perception data can be used for a few different things. While it isn't scientific data related to pavement smoothness or automobile crashes, it is factual data that represents the true opinions of patrons directly using the road. This can be very helpful for policy making, and future implementations related to roadways. Many times, patrons voice their opinions at outlets such as city council meetings, but the survey done in this study looks at specific questions that may not be addressed outside of a questionnaire like it.

6.2 Major conclusions of all data collected through this study

One of the first major conclusions from this study is that people are, in fact, passionate (to one extent or another) about the roadways that they drive on, and what their pavement quality is. The second conclusion made is that while some people notice discrepancies in the two roadways (I-70 and the KS Turnpike), others see the roads as being virtually of the same quality. A surprising third finding was that certain people surveyed believed that Interstate 70 was of higher quality than the KS Turnpike; this counteracted a previous prediction, that the privately-funded road would overwhelmingly fare better than the government-funded road would.

6.3 Further research to advance this topic

As previously discussed, comparing the International Roughness Index values of Interstate 70 in Kansas with the pavement valuations given would be telling of not only where the technical discrepancies lie, but where patrons feel the most uncomfortable. Studies similar to this one, but possibly in residential areas, on county highways, etc. would be quite valuable

because public perception seems to be overlooked quite often when considering infrastructure implementations; hopefully, considering public perception would change that, as the people giving the valuations are the ones that directly deal with these road pavement surfaces on a daily basis.

Chapter 7 – Conclusions and Final Thoughts

The biggest overall goal with this study was to not just see what hard, scientific data said about road pavement smoothness, but to get human perceptions of it. While the International Roughness Index is certainly a worthwhile measure of pavement surfaces, the humans that experience what the repercussions of those surfaces are were the major focus. Through the data collected in this project, it was quite clear what those opinions and relationships are. As expected, some patrons were extremely passionate about pavement smoothness, and were more than willing to contribute additional funds so that the required maintenance could be done. Others had no issues at all with the current state of the roadway, therefore they had no interest in paying additional fees.

There were many, many conclusions from this study. One of the biggest is that patrons are very interested in their opinions being heard. This does not only apply to road issues. More often than not, be it a positive or negative view of road pavement smoothness, most people surveyed had a justification for why they rated the roads the way they did. Along with this, a large number of patrons are willing to pay to increase road and pavement quality. While some of those surveyed were very firmly against the idea, this was met with a very high number of those who were open to user fees, for a number of different reasons. In terms of the correlations done, many correlations that were originally predicted to be strong and positive ended up showing little to no correlation, inciting that there was no strong relationship present between the variables tested in the specific correlation. Overall, one of the biggest conclusions was that patrons want better roads. Although this study was solely focused on interstate highways, many people emphasized just how poor road infrastructure in their specific towns has become as well. People are truly aware of how negative the situation has become regarding roadways and are not only

ready but willing to share their opinions and come up with a possible solution for lessening and hopefully eradicating many of the problems.

In looking back at the original research question, it does seem that it was answered.

“What are the public perceptions of road pavement smoothness on Interstate 70:

- a) Some people see I-70 and the KS Turnpike as being of the same quality.
- b) The majority of people surveyed see road pavement as being at least moderately important. No one said that they felt it was “not at all important.”
- c) Many patrons were relatively happy with the current level of upkeep on Kansas interstates.
- d) Common complaints outside of the road smoothness itself were that there are not enough roadside amenities, there is constant construction on the Turnpike, etc.

...how much are Kansas patrons interested in an increased effort in road pavement maintenance and upkeep for an additional user fee to alleviate these issues?”

- e) A large majority of people would be willing to pay some type of additional user fee to increase the pavement smoothness and quality levels of I-70.
- f) Many times, even out-of-state travelers were willing to pay the tolls, as they either have tolls in their home state, or view Kansas as having higher quality roads than surrounding states and wish others would take more initiative.

Bibliography

Abelson, P. W., & Flowerdew, A. D. J. (1975). Models for the economic evaluation of road maintenance. *Journal of transport economics and policy*, 9(2), 93-114. Retrieved from <http://www.econis.eu/PPNSET?PPN=372147089>

American infrastructure: Here's how bad U.S. infrastructure has become (2017). Retrieved from <http://fortune.com/2017/03/30/infrastructure-spending-funding/>

Association for Toll Interoperability. (2017). Full members. Retrieved from <http://www.tollinterop.org/about-ati/members-full-affiliate/>

Bad road design contributes to many fatal accidents. (2016). Retrieved from <https://www.slideshare.net/Cjwlaw/bad-road-design-contributes-to-many-fatal-accidents>

Barbaccia, T. (2012). Which U.S. bridges have failed? here's a list from january 1980. Retrieved from <https://www.equipmentworld.com/which-u-s-bridges-have-failed-heres-a-list-from-january-1980-through-this-yea/>

Brownstone, D., Ghosh, A., Golob, T. F., Kazimi, C., & Van Amelsfort, D. (2003). Drivers' willingness-to-pay to reduce travel time: evidence from the San Diego I-15 congestion pricing project. *Transportation Research Part A: Policy and Practice*, 37(4), 373–387.

Car registration in kansas. (2018). Retrieved from <https://www.dmv.org/ks-kansas/car-registration.php>

Davis, A. (2017). Roadbounce app measures road roughness and driving comfort - on the go!

Retrieved from <https://www.highways.today/2017/02/01/roadbounce-app-measures-road-roughness-driving-comfort-go/>

Engineers, A. S. of C. (2017). *Road Infrastructure | ASCE's 2017 Infrastructure Report Card*

(Vol. 2018). Retrieved from <https://www.infrastructurereportcard.org/cat-item/roads/>

Frequently asked questions. (2018). Retrieved from <https://www.artba.org/about/faq/>

Gwilliam, K., & Shalizi, Z. (1999). Road funds, user charges, and taxes. *The World Bank Research Observer*, 14(2), 159–185.

Heggie, I.G., 1999. Commercially managed road fund: managing roads like a business, not like a bureaucracy. *Transportation* 26 (1), 87–111.

Inflation calculator. (2015). Retrieved from <http://www.usinflationcalculator.com>

International Roughness Index (IRI). (n.d.). 1.

Kansas rest areas | roadside rest stops | maps. (2014). Retrieved from <http://www.kansasrestareas.com>

Kansas turnpike. (2018). Retrieved from <https://www.ksturnpike.com>

Kansas turnpike tolls to go up. (2018). Retrieved from <https://www.kfdi.com/news/kansas-turnpike-tolls-to-go-up>

Paul Koster, & Piet Rietveld. (2011). Optimizing incident management on the road. *Journal of Transport Economics and Policy*, 45(1), 63-81. Retrieved from <http://www.jstor.org/stable/25801414>

John A. Lapp. (1916). Highway administration and state aid. *The American Political Science Review*, 10(4), 735-738. 10.2307/1946831 Retrieved

from <http://www.jstor.org/stable/1946831>

List of bridge failures. (2018). Retrieved

from https://en.wikipedia.org/wiki/List_of_bridge_failures

Observer, 14(2), 159-185. Retrieved from <http://www.econis.eu/PPNSET?PPN=30862680X>

Open road tolling comes to kansas turnpike. (2017).

Poister, T. H. (1983). Monitoring the Productivity of a State Highway Maintenance Program. *Public Productivity Review*, 7(4), 324.

Privatization Administration, 2017. [http://www.oib.gov.tr/T%C3%BCrk%C3%A7e/](http://www.oib.gov.tr/T%C3%BCrk%C3%A7e/Kurumsal/Detay/%C3%96zelle%C5%9Firme_Y%C3%B6ntemleri/1488959781.html?)

[Kurumsal/Detay/%C3%96zelle%C5%9Firme_Y%C3%B6ntemleri/1488959781.html?](http://www.oib.gov.tr/T%C3%BCrk%C3%A7e/Kurumsal/Detay/%C3%96zelle%C5%9Firme_Y%C3%B6ntemleri/1488959781.html?), last access March 1, 2017.

Road and bridge data by state. (2016). Retrieved from <https://www.transportation.gov/policy-initiatives/grow-america/road-and-bridge-data-state>

Roughness - pavement interactive. Retrieved

from <https://www.pavementinteractive.org/reference-desk/pavement-management/pavement-evaluation/roughness/>

Schaper, D. (2017). Are \$40 toll roads the future?

. Retrieved from <https://wamu.org/story/17/12/12/are-40-toll-roads-the-future/>

Types of variables in statistics and research. (2018). Retrieved from

<http://www.statisticshowto.com/types-variables/>

U.S. DOT, O. of I. (2018). *Competitive Highway Bridge Program* (Vol. 2018). Retrieved from <https://www.fhwa.dot.gov/bridge/chbp/intro.pdf>

Utah Dept. of Transportation. Profilograph and pavement smoothness. Retrieved from <https://www.udot.utah.gov/main/uconowner.gf?n=200511230847451>

Appendix A - Survey consent card

Hello! We are assisting Katherine Geist, a Regional and Community Planning master's student at K-State, on surveys for her final project. She is currently conducting a survey to see *what the public perception of road pavement smoothness on I-70 is*. The survey results she is collecting are going to help shape the master's degree project. All data will be anonymous and no addresses, names, or other person-specific information will be collected. If you are interested in viewing the results of the study, please contact her at the email provided below and she will send you the link to the project when it is finished. Thank you for your time and consideration!

Katherine Geist | Kansas State University
kat.geist14@gmail.com

Please read the following statement set forth by the KSU Compliance Office and only continue with survey if you understand and agree that:

I understand this project is research, and that my participation is voluntary. I also understand that if I decide to participate in this study, I may withdraw my consent at any time, and stop participating at any time without explanation, penalty, or loss of benefits, or academic standing to which I may otherwise be entitled.

The following statement relates only to this survey:
Furthermore, any information and/or data collected as a result of this survey will be used solely for the purpose of the aforementioned research project and WILL NOT be used in any future research.

Appendix B – Survey

I-70 Survey MASTER COPY - 2

Survey Flow

Standard: Consent (2 Questions)
Branch: New Branch If If Do you consent to taking this survey? (This question to be answered by surveyor; if patron consen... Yes Is Selected
Standard: Participant Demographics (3 Questions) Block: General Introduction (3 Questions) Standard: SmoothI70 - Block (3 Questions)
EmbeddedData SmoothI70 = \${q://QID14/ChoiceGroup/SelectedChoices}
Standard: Smoothin KTA - Block 7 (1 Question)
EmbeddedData SmoothKTA = \${q://QID33/ChoiceGroup/SelectedChoices}
Standard: Public Perception - TOLLUP Block (2 Questions)
EmbeddedData TOLLUP = \${q://QID40/ChoiceGroup/SelectedChoices}
Standard: Public Preferences for Payments (2 Questions) Standard: Vehicle (4 Questions) Standard: Household Demographics (3 Questions)

Page Break

Start of Block: Consent

SURVTITLE

I-70 Survey

CONSENT Do you consent to taking this survey?

(This question to be answered by surveyor; if patron consents to taking survey, present them with the consent card that you have been provided with.)

☐ Yes (1)

☐ No (2)

End of Block: Consent

Start of Block: Participant Demographics

GENDER What is your gender?

(This question to be answered by surveyor.)

☐ Male (1)

☐ Female (2)

SLOC Where was this survey distributed?
(This question to be answered by surveyor.)

- ☐ Gas pumps (1)
 - ☐ Outside near gas station entrance (2)
 - ☐ Inside gas station (3)
 - ☐ Food court (4)
-

Q37 What year were you born?

Skip To: End of Survey If What year were you born? >= 2000

End of Block: Participant Demographics

Start of Block: General Introduction

JS

ENTER Where did you enter I-70 today?

Page Break

P2 IF RESPONDENT ONLY TRAVELED ON TURNPIKE, SELECTING 'YES' ON THE NEXT QUESTION WILL END SURVEY.

ONLYTPK Did you **only** drive on the Turnpike today? (If your answer is yes, you will be sent to the end of the survey.)

☐ Yes (4)

☐ No (5)

Skip To: End of Survey If Did you only drive on the Turnpike today? (If your answer is yes, you will be sent to the end of... = Yes

End of Block: General Introduction

Start of Block: SmoothI70 - Block

P1 The focus of this survey is public perception of road pavement smoothness on Interstate 70. This includes the sections that are both tolled (i.e. Kansas Turnpike) and not tolled. Please consider your drive on I-70 today as you answer the following questions.

Page Break

P3 The following two questions will ask you to rate your experience of the road smoothness along I-70 on a scale from 0 (roughest) to 10 (smoothest) for your trip today.

Page Break



SMOOTHi70 First, rate the roughness/smoothness of I-70 **before you got onto the Turnpike.**

- ☐ 0 (0)
- ☐ 1 (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ 6 (6)
- ☐ 7 (7)
- ☐ 8 (8)
- ☐ 9 (9)
- ☐ 10 (10)

End of Block: SmoothI70 - Block

Start of Block: Smoothin KTA - Block 7



SMOOTHKTA Now, rate the roughness/smoothness of I-70 on the Turnpike only.

- ☐ 0 (0)
- ☐ 1 (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ 6 (6)
- ☐ 7 (7)
- ☐ 8 (8)
- ☐ 9 (9)
- ☐ 10 (10)

End of Block: Smoothin KTA - Block 7

Start of Block: Public Perception - TOLLUP Block

Display This Question:

If SmoothKTA > $\$ \{e://Field/SmoothI70\}$

TOLL1 Earlier, you gave the portion of I-70 that you drove on before the Turnpike a smoothness rating of $\$ \{e://Field/SmoothI70\}$. How much would you be willing to pay to bring that portion of I-70 up to $\$ \{e://Field/SmoothKTA\}$, your rating of the Turnpike (in \$)?

Page Break



TOLLUP What is your **ideal roughness/smoothness rating for interstates** in Kansas?

- ☐ 0 (0)
- ☐ 1 (1)
- ☐ 2 (2)
- ☐ 3 (3)
- ☐ 4 (4)
- ☐ 5 (5)
- ☐ 6 (6)
- ☐ 7 (7)
- ☐ 8 (8)
- ☐ 9 (9)
- ☐ 10 (10)

End of Block: Public Perception - TOLLUP Block

Start of Block: Public Preferences for Payments

Display This Question:

If TOLLUP > \${e://Field/SmoothI70}

And TOLLUP != \${e://Field/SmoothKTA}

IDEALRATE Earlier, you gave the pavement smoothness of the Kansas Turnpike a rating of \${e://Field/SmoothKTA}. If the pavement smoothness was increased to your ideal rating of \${e://Field/TOLLUP}, how much would you be willing to pay (in \$)?

Page Break



ROADQUAL How important is road smoothness to your driving experience?

- ☐ Extremely important (5)
- ☐ Very important (4)
- ☐ Moderately important (3)
- ☐ Slightly important (2)
- ☐ Not at all important (1)

End of Block: Public Preferences for Payments

Start of Block: Vehicle



VEH What kind of vehicle brought you here today?

- ☐ Car (sedan, hatchback, coupe) (1)
- ☐ SUV (crossover, medium & large SUV) (2)
- ☐ Minivan (3)
- ☐ Pick-Up Truck (small, medium, large) (4)
- ☐ Motorcycle / Moped (5)
- ☐ Other (please list) (6) _____

Page Break

VEHYEAR What model year is this vehicle?

Page Break

TRIPPURP What is the purpose of your trip on I-70 today?

- ☐ Work/business (1)
- ☐ Personal (shopping, appointments, etc.) (2)
- ☐ Vacation (3)

Page Break

I70DAYS Roughly how many days in the last year did you drive on I-70?

(Do not count total trips - should ONLY include number of days)

End of Block: Vehicle

Start of Block: Household Demographics

HHSIZE How many people currently live in your household (including yourself)?

P4 The next question is related to household income, which can be a sensitive topic. The tablet
Page Break

will be turned to you so that the answer is anonymous. If you prefer not to answer, please select the arrow in the bottom corner of the tablet to end the survey immediately. Otherwise, choose the option that reflects your overall household income. After you have selected, please tap the purple arrow in the bottom righthand corner to end the survey.

HHINCOME What is your approximate yearly household income?

(Turn tablet to user, ask them to enter income, then select arrow button to end survey. Results will not be seen by surveyor.)

- ☐ Prefer not to respond (1)
- ☐ \$10,000-\$20,000 (8)
- ☐ \$21,000-\$30,000 (9)
- ☐ \$31,000-\$40,000 (10)
- ☐ \$41,000-\$50,000 (11)
- ☐ \$51,000-\$60,000 (12)
- ☐ \$61,000-\$70,000 (13)
- ☐ \$71,000-\$80,000 (14)
- ☐ \$81,000-\$90,000 (15)
- ☐ \$91,000-\$100,000 (16)
- ☐ \$101,000-\$199,000 (17)
- ☐ \$200,000+ (18)

End of Block: Household Demographics

Appendix C – IRB Approval Letter



University Research Compliance Office

TO: Dr. Gregory Newmark
Landscape Architecture/Regional and Community Planning
1093 Seaton Hall

Proposal Number: 9674

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: 03/05/2019

RE: Proposal Entitled, "Public Perception of Road Pavement Conditions on Kansas Interstate 70"

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §46.101, paragraph b, category: 2, subsection: ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.