INNOVATING LIFE & AUTO INSURANCE PRODUCT

BY ANALYZING FATAL CRASH RATES

A Major Qualifying Project submitted to the faculty of

Worcester Polytechnic Institute

In partial fulfilment of the requirements for the Degree of Bachelor of Science

By:

Chenbo Wang, Actuarial Science

Savan Ratanpara, Actuarial Science

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Report Submitted to:

Jon Abraham

Worcester Polytechnic Institute

Abstract

Online shopping for auto insurance is very common nowadays. What are some of the basic information that auto insurance companies have to know about you? Age, sex, license number, social – security for credit score, marital status, car you own, distance you'll be driving and from where, limits of coverage, etc. These are the factors that are considered in calculating the premiums. The three main factors that we analyzed for this project are Age, Gender and Location of driving. In this project we showed mathematically how these attributes about a driver and his/her history in driving, play a role in calculating auto insurance premiums. As young drivers are most likely to get into a fatal car crash and least likely to have a life insurance at an early age, we attempted to combine life insurance with auto insurance for the second part of this project. It insures any kind of debt that young drivers leave behind for their family in case of a fatal car accident.

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Introduction

One of the characteristics of Actuaries is to be able to look at the past and predict the future using statistical features. In auto insurance companies, Actuaries predict how likely it is for a particular driver to file a claim and the cost related to the claim. Based on the prediction of the cost, expenses and profit, the company charges a well calculated premium to the drivers. There was a time when just a few data points about the driver like age, driving history and location of driving was enough for an auto insurance company to underwrite an auto insurance policy. But in this era of competitiveness among insurance companies, more and more factors are taken into consideration in order to provide the most accurate premiums pinpointing the most precise risk factors.

The main purpose of this project is to show how various factors affect prices of auto insurance. The factors we considered are age, gender and the location of driving. There are numerous other factors that insurers look at as well; for example past driving record, marital status, credit score and even school grades of teenage drivers during the process of pricing an individual's insurance. In this project, a comprehensive analysis was performed on car crash patterns by age groups, gender and location of the car crash, in order to show the impact of these factors on the insurance rates.

From the analysis we concluded that young drivers in general are most likely to get into a car crash which helps to explain their high premium rates. So we decided to add low-cost life insurance to the auto insurance for young drivers. This insurance product is designed for the companies that they could potentially offer to its drivers. More than 30% of the population in the United States has no life insurance.

Data:

The fatal car crash data we used for this project is provided by National Highway Traffic Safety Administration. Another useful source was the Federal Highway Administration website, where we acquired the data on the total number of licensed drivers in the United States. We saw data on three main type of crashes: property damage crashes, injury related crashes, and fatal car crashes. Fatal car crash leaves the most damage in people's lives, emotionally and financially. Our project was based solely on fatal car crashes. We used Microsoft Excel as a tool for analysis of data. Data from year 1994 – 2011 was available to us. 2012 is still too recent, and therefore not available. Premium rates of Liberty Mutual were used in order to compare the results from our project.

While we just looked into fatal car crashes for our project, insurance companies look at all kind of crashes and all accidents for quoting purposes. Let's begin by looking into the first significant factor - namely age of a driver. For the most part, age determines the experience level of a driver, risk factors and driving abilities.

Factors

Age:

The legal driving age in most states is 16 and most teenagers get their first drivers license between the age of 16 and 18. Thus age of a driver is usually highly correlated to years of driving experience. The following graph shows the correlation between age (our proxy for experience) and the rate of fatal car crashes. Drivers with the least experience have the most fatal crashes while more experienced drivers in their 50's and 60's have the least fatal crash rates. As the driver gets significantly older; over the age of 75, the fatal crash rate tends to rise. We can see that these older driver get into a fatal car accident almost as often as very young drivers (the 20 year olds).

The analysis we performed should give an idea on what age groups are safer on roads and what age groups are riskier. As fatal car crash data was easily available for the project we decided to pick this factor in order to evaluate drivers. There are many other factors that come into play before making any final conclusion on what kind of drivers are risky.

Figure 1 provides information on what age groups are particularly risky compared to others. It is interesting to note that with the increase in population there has been a decrease in fatal crash rates from 2007-2011.

The percent range on the Y – axis may appear low, but this is a good thing, as it represents the proportion of fatal crashes occurring in each age group from 2007 to 2011. The crash rates are simply the number of drivers, involved in fatal crashes divided by the number of licensed drivers in its respective age groups. This is derived from statistical data obtained from the National Highway Administration.

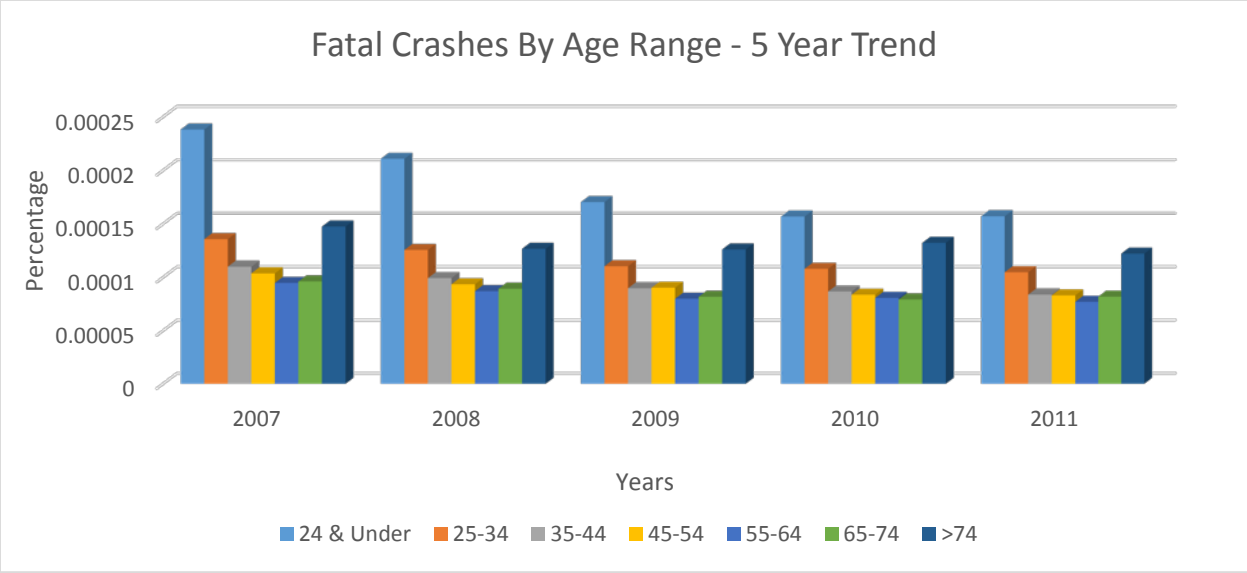

Figure 1: Fatal crashes by age range-5 year trend

Safe driving awareness and implementation of safety laws have enhanced safety levels. However, an uninsured driver must not use this reason to stay uninsured. All drivers are exposed to a certain risk while they are behind the wheel.

To check on our results we produced some quotes from one of the largest auto insurance company in the United States, Liberty Mutual. If premium rates were solely based on fatal crash rates teenagers should be priced the highest while age group of 55 – 64 years old drivers should be priced the least. Fortunately the prices reflected our findings. Of course, rates are not based solely on fatal crash rates; there are many other factors like property damage crash rates or injury related crash rates that are considered during the underwriting procedure. But the trend is still clear –younger drivers pay higher premiums than older drivers, and this is due at least in part to the information we show above regarding the rate of fatal crashes.

Following is the graph of the fatal crash rates by age groups compared with the graph of premium rates from Liberty Mutual in the state of Massachusetts. (Note that it is illegal to base auto insurance rates on age in Massachusetts and some other states. Auto insurance companies

doing business in these states will typically quote drivers based on their experience level, which as we discussed earlier is highly correlated to age – so this is how companies "get around" the rules prohibiting use of age in determining premiums).

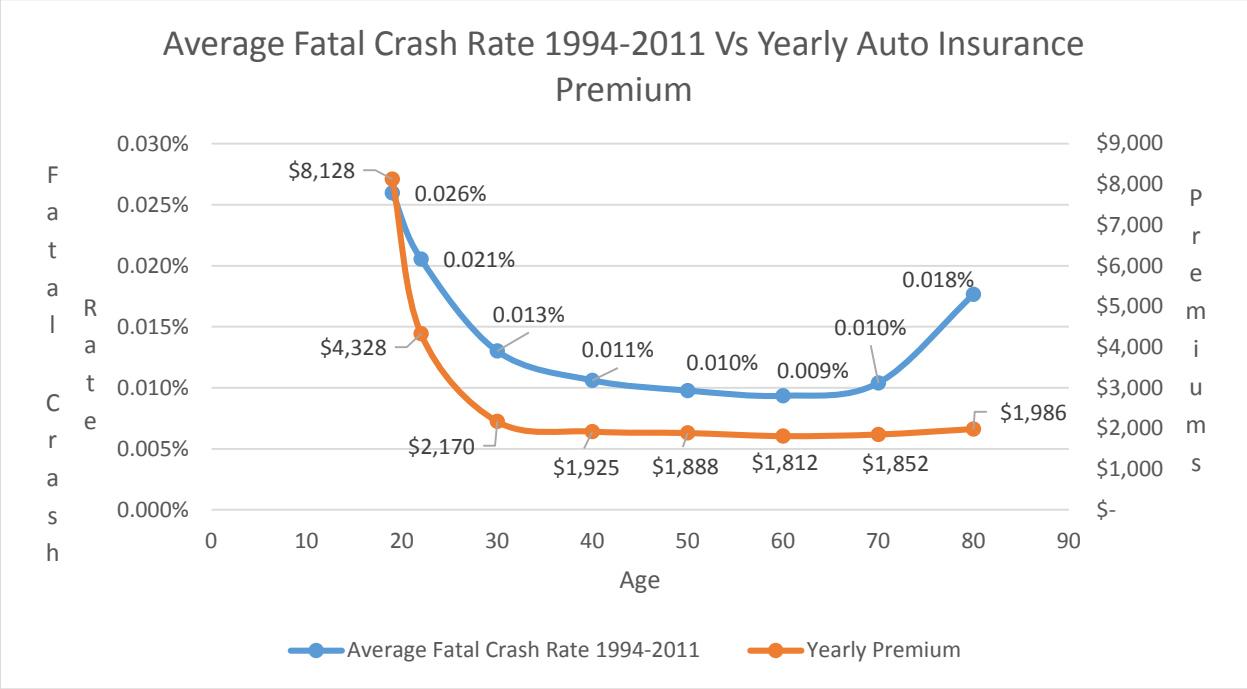

Figure 2: Average fatal crash rate 1994-2011 VS yearly auto insurance premium
Note: Premium rates are produced from the company Liberty Mutual Auto Insurance.

The age labeled on the X – axis is the mid age of the age groups we considered except the first two that are 19 and 22 years. These quotes were produced by setting the licensed age as 18 years old. The quote is based in Worcester, Massachusetts. Location is another important factor and we will discuss this in a later section. A 19 year old teenager who obtained his driver's license at the age of 18 has the highest premium of $8,128 while a 60 year old driver has the lowest premium of $1,812. This does correlate to the fatal crash rate but again fatal crash rate is just one out of many factors considered while calculating premiums.

To be able to calculate an X year old driver's fatal crash probability, we attempted to fit a fourth degree polynomial to the fatal crash rate curve and this is how it fits:.

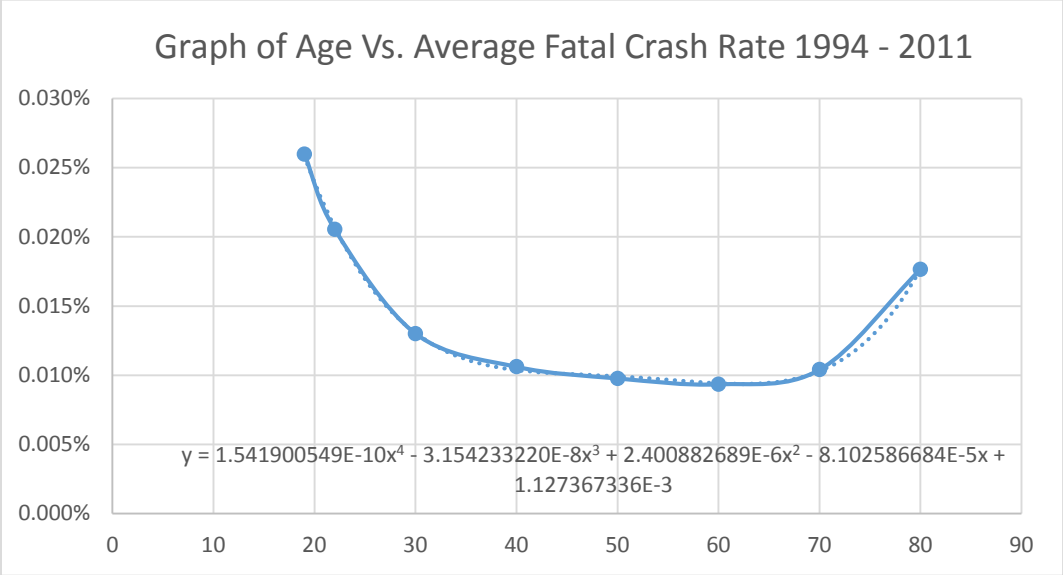

Figure 3: Graph of age VS average fatal crash rate from 1994-2011

Following are some test values to the formula we generated:

Age (X value)	Fatal Crash Probability (Y value)	Actual Values	Relative Error
22	0.021%	0.021%	0%
35	0.011%	0.011%	0%
60	0.009%	0.009%	1%
75	0.013%	0.020%	35%
85	0.026%	0.020%	30%

Table 1: Comparison of actual values with fourth degree polynomial values

Age is not the only factor insurance companies consider but it is quite evident that it is one of the important one. In many states teenage drivers under the age of 16 are required to have someone with a driver's license, age 21 years old and above, with them while driving. Young males are known for being more aggressive drivers. Texting and driving has been an issue among young drivers. Despite statistics confirming that distracted driving due to texting is

dangerous, 9 states still have no law putting a ban on this practice. While 41 states have outlawed the practice around year 2007, the evidence of the results is demonstrated on the next graph:

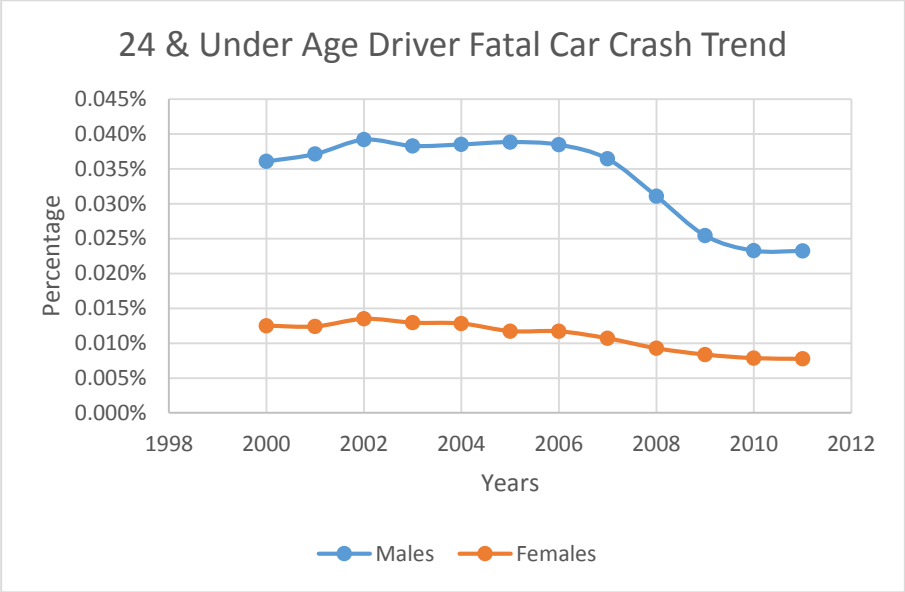

Figure 4: Young drivers fatal crash rate trend from 2000 – 2011

A ban on texting and driving may have resulted in the decrease in crash rates from 0.036% to 0.023% but there is not enough evidence to conclude. Safety features introduced in the technology of modern car building and comprehensive laws about young drivers may have also contributed to better driving.

Credit Score:

Studies have shown that drivers with good credit tend to be more responsible while driving and hence less likely to file a claim. Because of this correlation over 95% of auto insurance companies take into account the credit score of the driver during the process of underwriting. In fact, insurance companies examine high school grades of teenage drivers in order to provide lower rates to responsible teenagers. Because of the rise in competitiveness,

companies take into consideration as many factors as possible so they can provide the most precise premium rates for its drivers.

From year 2000-2011, on average about 13% of drivers involved in fatal crash carried an invalid license. This is quite significant. Among drivers carrying invalid licenses who got into an accident, over 50% had been previously convicted with either one or more than one of: speeding, DWI, crashes, license suspension or revocations. Driving history, credit score, school grades, etc. are some of the characteristics that can help insurance companies in assigning a driving to a particular risk set.

Driving experience plays an important role while pricing auto insurance, regardless of age. Older drivers tend to be more responsible drivers but without the experience they are all exposed to same risk. The rates used to compare the premiums were produced assuming the driver got his/her license at the age of 18. The insurance limits and types of coverage were kept constant while producing these rates.

The rates for male drivers are the same as the rates for female drivers in the state of Massachusetts as it is a law in MA that insurance quotes cannot be based upon sex (the same is true in four other states: Michigan, Montana, North Carolina and Pennsylvania). However, the statistics shows that male drivers are more likely to get into an accident than female drivers. In the next section we will look into how gender affects the auto insurance quotes.

Gender:

Gender is a non-driving related factor that is used by many insurance companies to underwrite their policies, be it health insurance or auto insurance. But if one insurer charged the same for both genders, that company would lose all its female customers to companies that made

a distinction in their pricing. We have statistical evidence that male drivers are more likely to get into an accident than female drivers, and so the auto insurance rates for males should be higher than females. Gender should be one of the core factors in calculating the premium based on our analysis on fatal crash rates. To demonstrate the difference, we looked into the fatal crash rates among male and female drivers from year 1994 – 2011. These crash rates are simply the number of male drivers involved in an accident divided by number of total males licensed in a particular year and likewise with the female fatal crash rates. The following table shows what we found:

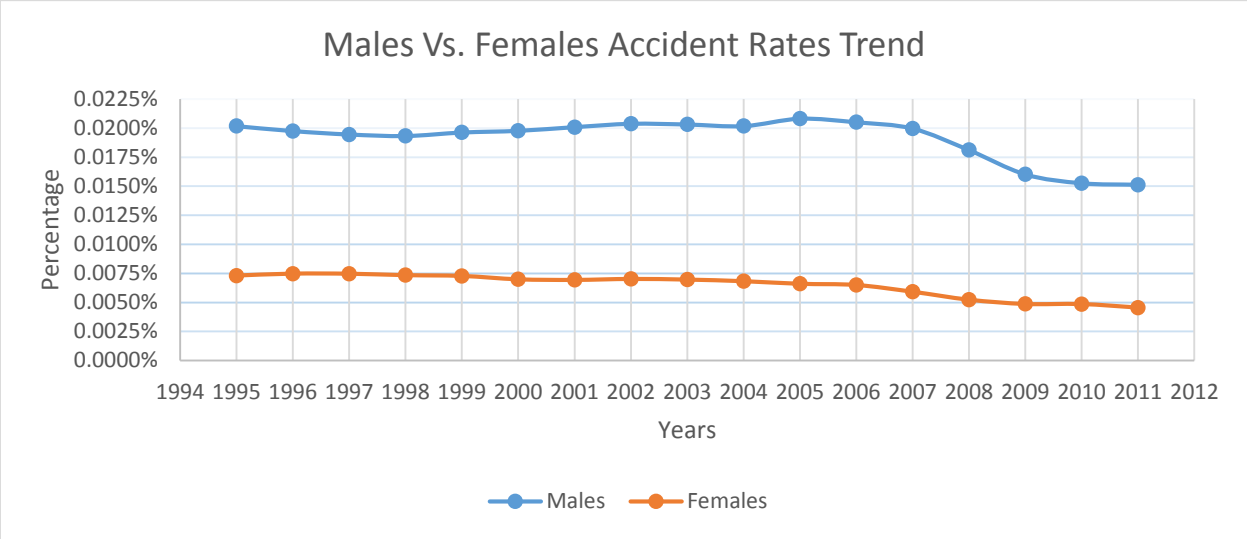

Figure 5: Comparison of Male vs Female drivers' crash rates between years 1995 - 2011

On average, male drivers have an accident rate about 0.0126% higher than female drivers, i.e., about 12,354 more fatal crashes among the male car driving population than females, each year. Our next graph looks into each age group of drivers and splits them between male vs. female drivers. The following graph shows the difference in crash rates between males

and females.

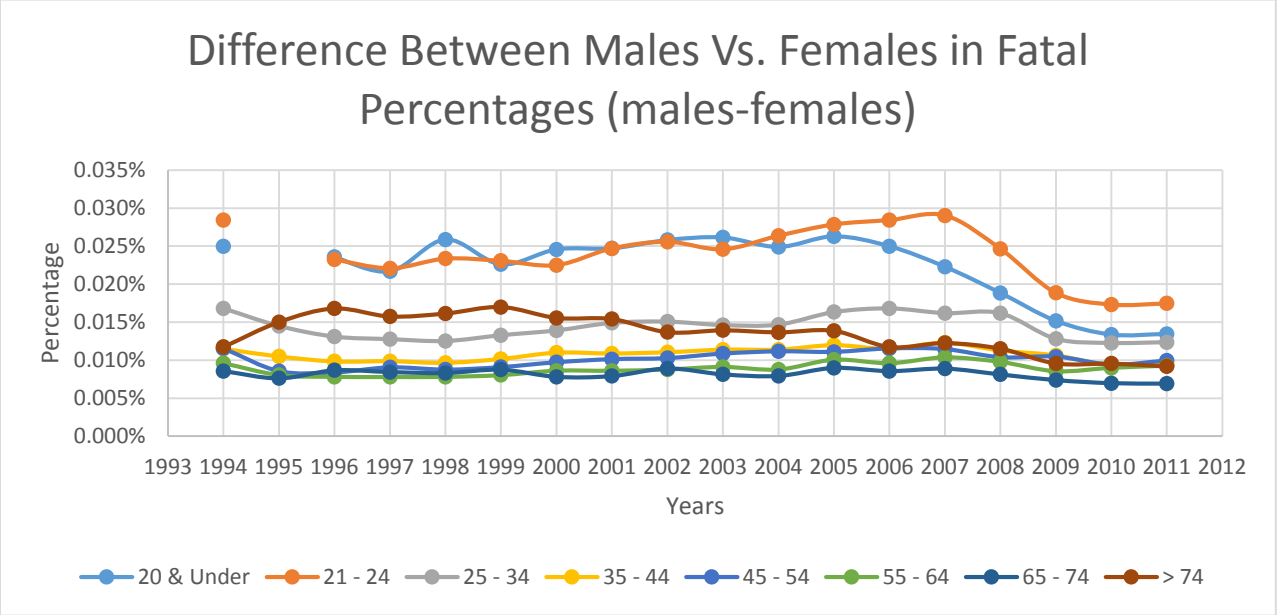

Figure 6: Difference of crash rates of female drivers from male drivers

The greatest difference between male and female drivers is among young and old drivers. Young drivers (below 24 years of age) and old drivers (above 74 years of age) have the highest fatal crash rate difference between male and female. As the population ages the differences get smaller. One reason that young males have much higher fatal crash rates than young females is alcohol-related impaired driving. Over 30 % of fatalities are due to alcohol-related car crashes. One out of every three alcohol related crashes involved a young driver below the age of 24. On average, among the male driver fatal car crashes, over 28% of crashes are alcohol-related with BAC (Blood Alcohol Concentration) of over .01, while over 24% with BAC level of .08 and above. This compares to female driver fatal car crashes, where over 15% of accidents were alcohol-related with drivers BAC level of over .01 and around 13% of accidents with BAC level of over .08.

Again to check on our results we compared the premium rates between males and females. This chart shows premiums in Connecticut, where it is legal for companies to quote auto insurance rates based on gender. Following is the graph of comparison of premiums between male and female drivers.

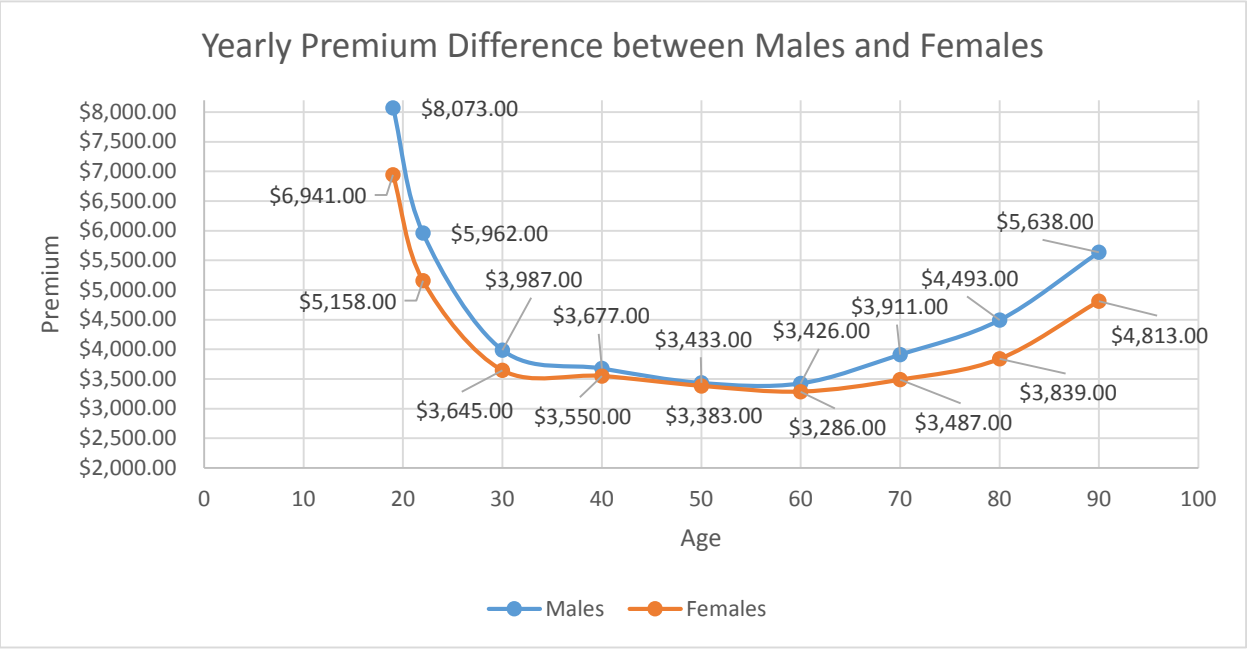

Figure 1: Difference in premiums between male and female drivers in the state of Connecticut

The premiums for male drives are about 14% higher than the premiums of female drivers in the state of Connecticut for young drivers of 24 years of age and below and for 74 years of age and above drivers. As noted earlier, Michigan, Montana, North Carolina, Massachusetts and Pennsylvania don't allow auto insurance rates to vary due to gender. Gender-based auto insurance rates is a sensitive topic. While Europe has banned gender based discrimination in auto insurance due to fundamental principles, it is difficult to imagine the United States adopting this law. Female drivers would end up paying more than they should while male drivers would pay less than they would.

We compared the difference in crash rates between males and females from these five states to overall difference between genders in the United States. All states except Michigan have higher difference than overall US over the course of twelve recent years.

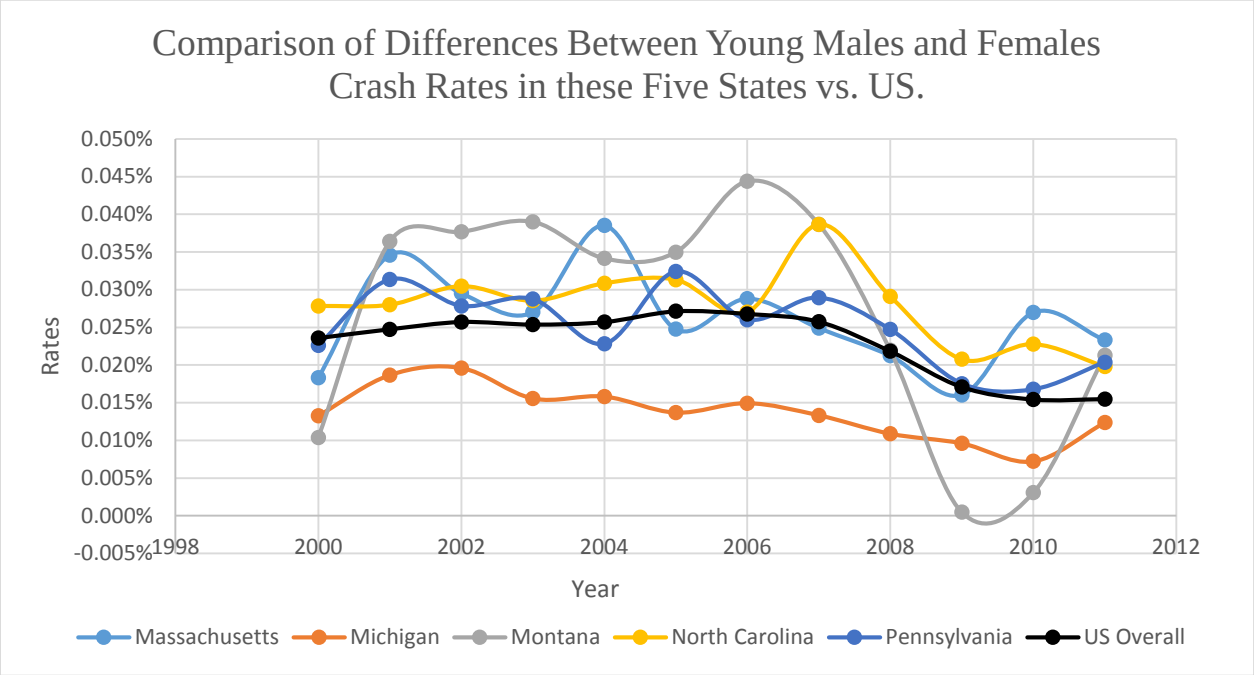

Figure 2: Comparison of Differences Between Young Males and Females Crash Rates in Five Stat

Drivers have raised questions on discriminative quotes among males and females most importantly because it is a non-driving related factor. However, we have significant evidence of the difference between the two genders and conclude that it is fair to quote female drivers lower than male drivers. Of course, other characteristics like bad driving history of a particular female driver may put them into a risky category and have higher premium than any male driver.

Again there are other factors than fatal car crashes that are considered while quoting auto insurance rates. Research has shown that married couples are less likely to get involved in a car crash than a single driver. It is very likely that married couples have many other responsibilities especially when they have kids. Repayment of house mortgage, school loans, car loans, etc. do put them into a responsible position and it is directly correlated to better driving.

Location:

Location of driving is another important factor. While fatal crashes mostly occur on freeways in rural areas, driving in big cities is just as risky but he it may be more risky in a way that you are more likely to get into a car crash generally but not necessarily a fatal crash. Many injury crashes and property damage crashes occur in urban areas due to distracted driving and high level traffic problems. Insurance companies take into the consideration where the car resides and how far is it going to be driven in a day and relate that to traffic fatalities trend around the location. Usually a class risk is assigned to the driver and based on that the monthly premiums are calculated.

We evaluated each state's fatal car crash rates and made an attempt to relate that to the auto insurance premium. We found some evidence that states with highest fatal crash rates have relatively higher premium rates. Perhaps determining fatal car crash rates in these states is helpful in predicting premium rates. Mississippi and West Virginia has the highest crash rates of almost 0.16 %. West Virginia have the highest fatal crash rates among the young drivers of 24 & under years of age. Mississippi had 445 fatal car crashes in the year of 2011 while California had the highest number of 1483 fatal car crashes. To normalize the car crashes we calculated number of fatal car crashes divided by total number of car drivers in its respective age group.

Smaller states like Rhode Island have very volatile crash rates as there is not a big population that lives there. So one or two crashes could have a big impact on the crash rates. This effect could be misleading. Later in the section we analyzed crash rates between rural area and urban area. States with high percentage of rural land and less of urban land have the highest fatal crash rate. Reason being lot of traffic is concentrated to the urban area hence more crashes.

Following is the graph of each state's fatal car crash rate in a descending order.

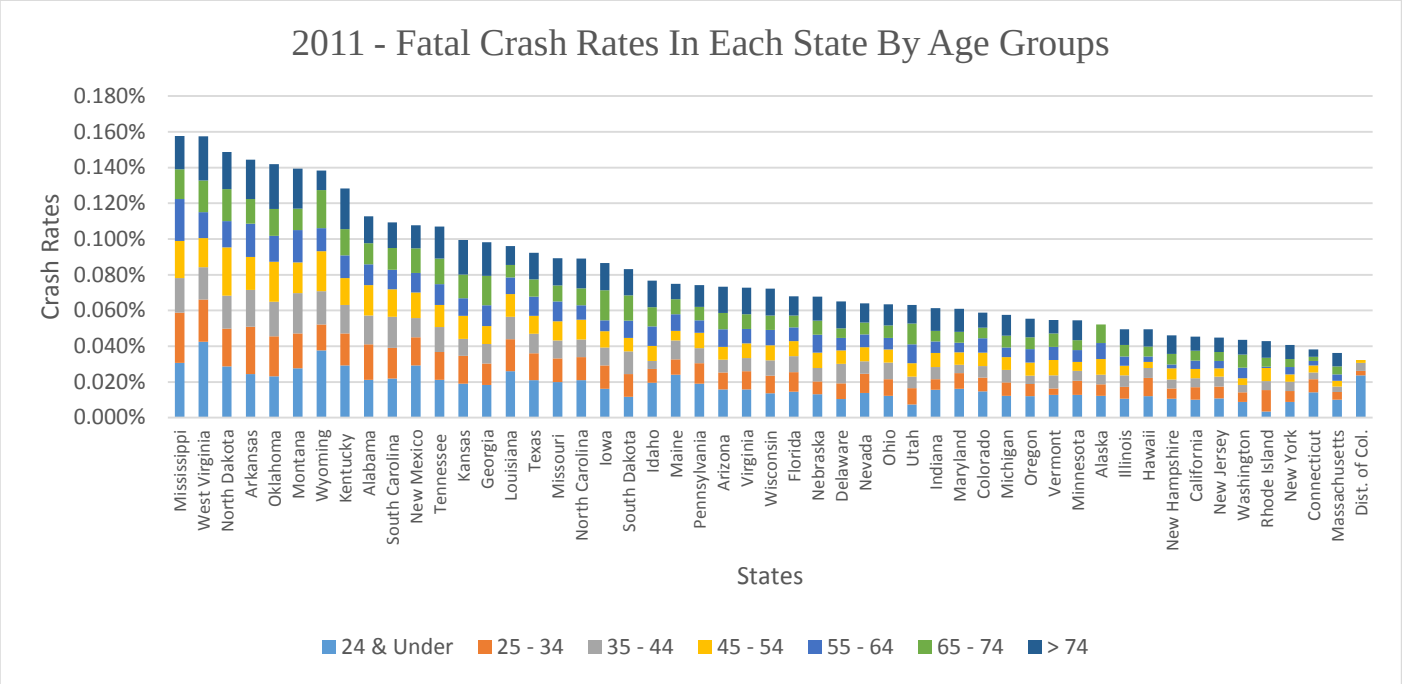

Figure 10: Comparison of Differences Between Young Males and Females Crash Rates in Five States

Some of the reasons for these crashes are reckless driving, speeding, drunk driving, weather conditions, car condition, distracted driving etc. Massachusetts and Connecticut had the lowest crash rate in the year 2011. California seen at the lower end of this graph is a surprise. California is the third largest state by area in the United States. If we look at the graph (following), almost half of California is covered by forest and according to US Census, 5% of California is urbanized while 95% is rural area.

It is very interesting to examine the states at left-most and right-most ends of the graph. One of the difference we found between the extreme end states is the difference in rural and urban land. States in the right-most end have the highest percentage of urban area whereas states at the left-most end have the highest percentage of rural area. Following is the table with information:

Top 5 States with most Crash Rates	Percent of land in Urban Areas	Percent of land in Rural Areas	Top 5 States with least Crash Rates	Percent of land in Urban Areas	Percent of land in Rural Areas
1. Mississippi	2.4	97.6	1. Massachusetts	38.3	61.7
2. West Virginia	2.7	97.3	2. Connecticut	37.7	62.3
3. North Dakota	.3	99.7	3. New York	8.7	91.3
4. Arkansas	2.1	97.9	4. Rhode Island	38.8	61.3
5. Oklahoma	1.9	98.1	5. New Jersey	40	60

Table 2: Comparison of Top 5 states with most crash rates

Urbanized area have higher job opportunities than rural areas so workers tend to commute to big cities and since top crash rate states like Mississippi, West Virginia, North Dakota, Arkansas and Oklahoma have the lowest percentage of urban areas, it has a high rate of commuters attracted towards big cities. As there would be more travelling from rural area to

urban area, fatal crashes are more likely to happen in these states than the ones that are more urbanized like Connecticut, Massachusetts, Rhode Island and New Jersey which is about 38% with New York being an exceptional case.

Observe the following graph of 2011's Rural vs. Urban fatalities due to car crashes. This is the graph of fatalities instead of car crashes unlike other graphs that we studied.

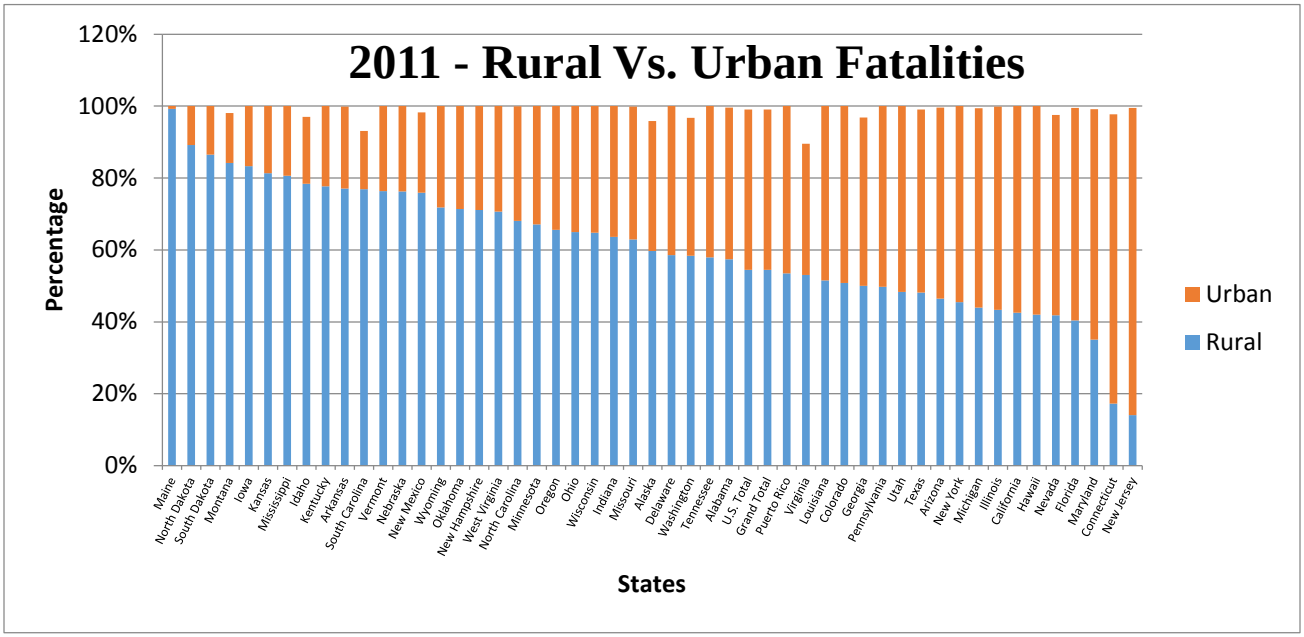

Figure 11: 2011- rural vs urban fatalities

STATES LEAST URBANIZED	Yearly Premiums for Males Aged 22	STATES HIGHLY URBANIZED	Yearly Premiums for Males Aged 22
1. Mississippi	$ 2783	1. Massachusetts	$ 4055
2. West Virginia	$ 2900	2. Connecticut	$ 7017
3. North Dakota	$ 3488	3. Washington	$ 4304
4. Arkansas	$ 2941	5. New Jersey	$ 4177
5. Oklahoma	$ 3230		

Tables 3: least urbanized states vs. highly urbanized states

States that are highly urbanized have higher premium rates however, most of the car crash fatalities occur in least urbanized states. It is interesting to know what other factors the

insurance companies consider while calculating these premiums. Most crash rates states have high rural land but least premium rates while least crash rate states are highly urbanized but high premium rates. Drivers living in urbanized states could be exposed to other risk factors like car theft, minor accident damages, vandalism, etc. These factors may outweigh the fatal crash rate in rural areas and thus have higher premium rates than the states that are least urbanized.

We have found out some factors that would be considered in pricing the auto insurance, and we made all the conclusions that are supported by the data. However, it is not hard to know that there are a large number of deaths caused by the car accident, and majority part is teenager. As we know, most of the teenagers do not have life insurance, and it will bring a big loss to the family if their young kids died in car accident. Therefore, we brainstormed a new product that might interest most of the clients, which is that we want to ask customer to use a few dollar to buy life insurance when they are buying Auto insurance. This insurance would cover death to fatal car accidents, and would not be very expensive.

Since it is a brand new product, we want to research more relative data to make sure if it would be implemented effectively. The website of Life Insurance Marketing and Research Association offers a lot of important information to us. It indicates that the Life Insurance Ownership/Coverage still remains low. There are thirty percent of U.S. households who have no life insurance at all; only 44 percent have individual life insurance. Also, the average amount of coverage for U.S. adults has declined to 167,000 in 2013, down $30,000 from the average coverage in 2004. Also, the most common reason given is that they have competing financial priorities. “Everyday expenses” such as energy costs, food, clothing and transportation. The second most common reason is that they think they could not afford the expensive life insurance.

And middle-income consumers are more concerned with reducing debt and having more money for retirement than other income groups.

The remaining 56 percent customer would be our potential customer in the future. They don't want to bring more financial pressure to their family if they die in an accident. Therefore, in the following section, we will introduce our idea in details, and use more data, statistics and algorithm to create our product with a reasonable and acceptable price.

Life and Auto Insurance

It is often the case when a driver, especially young one, passes away in a car crash and leave lot of debt behind for their family members to pay back. They are either student loans, car loans, liability for the damaged property or even a mortgage for their new homes. Likelihood of a driver dying in a car crash may be significantly low; below 1% on any day of the year but the thought of the possibility of dying in a car crash can intrigue drivers to buy this insurance. Usually one of the family member is required to co-sign the loan in which case if the person for whom the loan is borrowed could not pay the loan back for any reason the co-signer is liable for the repayment of the loan. According to the US census, every year over 32 million loan borrowers still have an outstanding balance. On average, each student take out $30,000 of loan to pay for their colleges.

Through this project we would like to design an insurance product that would insure any kind of debt that a driver leaves behind for their family in case of a fatal car accident. It would cover all the passengers involved in the car accident. Our goal is to offer this insurance for as low as under $15 per year. Our potential market would be any size auto insurance companies that are willing to buy our product and offer it to their drivers when they are being quoted a policy either online or in person.

Will there be a good turnover of drivers buying this insurance? It would depend on surveys, research and drivers. Unfortunately we did not have any capital to conduct a detailed survey or a research. But logically it would appeal to any type of driver who does not have a life insurance policy and are long distance drivers and obviously are in debt. College students usually don’t have life insurance and they are most likely to get into a fatal car crash according to our

analysis. Potential consumers could be young, responsible, in-debt drivers or adult drivers in their early or late 20's who are still paying off their student loan balance.

Passengers in car crashes:

For this project we would like to cover passengers that die in the car crash along with the insured driver. However there is very limited data available to calculate risk exposed to every passengers by the driver. In order to calculate risk we would need data on likeliness of a driver driving with passengers and get into a fatal car crash. Based on that conclusion we would be able to estimate expected number of passengers that die in a car crash.

Data and Analysis:

We used data from year 2004 to 2011 on fatal car crashes of both males and females of eight different age groups and projected fatalities for the year 2014 using natural log. All age groups had a clear pattern of decreasing crash rates along the years. We tried using linear equation as the correlation coefficient was higher than .90. But it eventually approaches zero fatalities in future years which is not realistic. Another projection technique we tried was using high degree polynomials in Microsoft Excel. We did find some good fit polynomial equation; however it gave us a negative number for fatalities for future years.

We decided on using natural log and linear relationship for the prediction of fatal car crashes in the year 2014. Using natural log of all the probabilities we got a linear pattern and we fit a linear equation over the linear pattern.

Following is the table consisting probabilistic values:

Years	Age 20 & Under	Natural Log of Probabilities
2004	0.000299762	-8.11252081
2005	0.000282172	-8.172993916
2006	0.000273595	-8.203860381
2007	0.000246704	-8.307319466
2008	0.000220825	-8.418138819
2009	0.000180221	-8.621328051
2010	0.000154136	-8.777672643
2011	0.000160893	-8.734768072

Table 4: Data of fatal car crashes from 1994-2011

Following is the graph of natural log values against years:

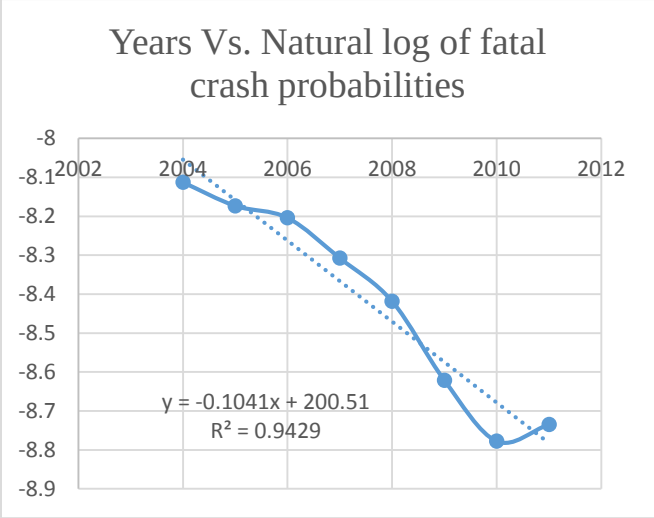

Figure 12: Year Vs natural log of fatal crash probabilities

Using the equation, y = -.1041(x) + 200.51 we get the natural log of fatal crash probability of year 2014 for age 20 & under drivers to be -9.1474 and to get the probability we calculated $e^{-9.1474} = .000106496$. A similar simulation for the rest of the age groups was conducted.

Following are the projected probabilities for the rest of the age groups for year 2014:

Age Groups	Age 20 & Under	Age 21-24	Age 25-34	Age 35-44	Age 45-54	Age 55-64	Age 65-74	Age >74
2014 fatal crash probabilities	.0106496	.000130753	.0000901712	.000074285	.000069708	.000069416	.00007195	.0001087

Table 5: projected probabilities for the rest of certain age group for year 2014

Now that we have the predicted probabilities for each age group, for a particular company we could predict the likelihood of the number of drivers getting into a fatal car crash. Based on this prediction we could calculate the amount of pure premium to be charged for each drivers. This premium would also mainly depend each driver's personal car crash history and other relevant factors.

Algorithm: In order to calculate the pure premium, we used basic probability concepts. Remember this algorithm is designed for insurance companies. Following is the simple logic we used to come up with pure premium:

*Probability of Fatal Car Crash **X** Amount of Insurance = Pure Premium*

This would give us the amount of premium to be charged to each insured driver. This amount does not include profit and expenses incurred. Following are the various amount of insurance that we could offer and its relative pure premium:

Age Groups	**20,000**	**35,000**	**40,000**	**50,000**	**60,000**	**75,000**	**90,000**
Age 20 & Under	3	4	5	6	7	8	10
Age 21-24	3	5	6	7	8	10	12
Age 25-34	2	4	4	5	6	7	9
Age 35-44	2	3	3	4	5	6	7
Age 45-54	2	3	3	4	5	6	7
Age 55-64	2	3	3	4	5	6	7
Age 65-74	2	3	3	4	5	6	7
Age >74	3	4	5	6	7	9	10

Table 6: amount of insurance that we could offer and its relative pure premium

As you can see these yearly pure premium rates are rounded up to the next whole number for sole purpose of adding profit and having an integer.

Let's take a look at an example:

A company XYZ agreed to buy our insurance product and offer it to their young driver population of over 250,000. Assuming 15% of these drivers decide to buy this insurance that would be 37,500 drivers. Since an average student is in debt of over $30,000, let's assume they buy the $35,000 insurance. Pure premium charged would be $5(Probability X Amount of Insurance). Adding a 50% profit and a 10% expense would bring the final price to $8/year which is very reasonable and appealing for a $35,000 insurance. In this case the company would make a profit of $93,750 every year. Obviously profit margin is very flexible so it could be raised as high as possible.

TVAR (Tail Value at Risk):

Insurance companies are always at a risk of unpredictable outcomes every year. Evaluating tail value at risk shows us how likely it is for the outcome to exceed the expected loss and put the company into trouble. There is an insurance for an insurance company known as Reinsurance. In the extreme case of overly losses Reinsurance companies cover the proportion of the loss or up to an amount of loss depending upon the coverage that the ceding company bought.

To evaluate tail value at risk we used Poisson distribution to calculate the likelihood of an event. Poisson distribution is used for a series of independent events and calculates the likelihood of certain number of events. Its parameters are:

$$\lambda = Expected\ Number\ of\ Success, \text{ N X p}$$

X = x success in X trials

The Probability Distribution functions is:

$$P(k) = \frac{\lambda^k * e^{-\lambda}}{k!}$$

Let's look back into the earlier example of company XYZ:

Number of insured drivers: 37,500

Probability of fatal car crashes: 0.0131 %

Expected Number of Fatal car crashes: .000131 * 37,500 = 5 = λ

For a $35,000 coverage, the company would need at least $175,000 to cover all the losses. But what if in a case of more than five fatal car crashes in a year. How likely is it that the company would face a larger loss than expected? Let's use Poisson distribution to answer this question. In this case, $\lambda = 5$ and k >5.

$$P(k > 5) = 1 - \left[\frac{5^0 * e^{-5}}{0!} + \frac{5^1 * e^{-5}}{1!} + \frac{5^2 * e^{-5}}{2!} + \frac{5^3 * e^{-5}}{3!} + \frac{5^4 * e^{-5}}{4!} + \frac{5^5 * e^{-5}}{5!}\right] = .4683$$

About 47% of the times, the number of fatal car crashes will increase the expected number of losses which in this case is 5. The company should definitely seek a reinsurance in this case.

Now let's calculate the probability of each number of fatal car crashes that exceeds 5:

Total Fatalities	Exceeds by	Probability of this event	Expected Loss	Probabilistic Loss
6	1	0.1462	35,000	5,117
7	2	0.1044	70,000	7,308
8	3	0.0653	105,000	6,857
9	4	0.0362	140,000	5,068
10	5	0.0181	175,000	3,168
11	6	0.0082	210,000	1,722
				29,240

Table 7: outcomes of the probability of each number of fatal car crashes that exceeds 5

The event that it would exceed the expected number of fatal crash by 2 is very likely. Around 10% of time the company would incur an expected loss of $12,425. Reinsuring this product would be very logical in this case. Non-Proportional reinsurance would cover any loss that exceeds the expectation. It may have a limit of coverage. There is a fixed amount of premium paid out to the Reinsured Company. Overall, after reinsuring the product, the ceding company can still profit from this product. It would be up to the Reinsurance Company to provide its insurance to this product.

Conclusion

There are two main parts in the project. First part is to use solid data, statistics and algorithm to figure out the main factors that are affecting prices of the car insurance. Based on the analysis of first part and the reality facts in the current period, there are many people who don't have life insurance. Therefore we brainstormed a new product that is to sell life insurance and auto insurance together to clients, especially young drivers.

As we all know, there are numerous factors that are considered by insurance company to set up an auto insurance price. In the project, we analyzed three main factors, which are age, gender, and location of driving.

Age correlates with driving experience. The least experience drivers have the most fatal crashes. As the driver gets older than 75, the fatal crash rate also tends to rise. Therefore, the premium of auto insurance is proportional to the driving experience and that experienced drive would get low premium. However, the insurance price would be relatively higher if driver gets significantly older. It well explains that insurance company would set 3 years driving experience as a level in pricing.

Gender is also a related factor that is used by many insurance companies. Most of the states in US are allowed to quote different rates based on gender. We have strong statistical evidence that the rates of male drivers getting into accidents are more than female drivers. We got a bunch of online quotes by different genders in each age group. It indicates that the premiums of male drivers are about 14% higher than the premiums of female driver in the state of Connecticut.

The premium would also depend on the location of driver living. Fatal crashes occur a lot in rural areas. Nevertheless, urbanized area have higher job opportunities than rural areas, it has more transportation across the cities. We compared the premium between five least urbanized states and five highly urbanized states, the result gives us that the premium is much higher in urban area than rural area. Overall, the factors of age, gender and location are directly and indirectly correlated to the premium, but there are still many other factors that are taken into consideration by auto insurance companies.

According to the result of our researching in the factors of age, we come up with a brand new idea. It is often case when a drivers, especially young driver, passes away in a car crash and leave lot of debt behind for their family members to pay back. Most of the young drivers do not have life insurance cover. So, we try to develop a new product that includes both auto insurance and life insurance. We used natural log and linear relationship for the prediction of fatal car crashes in the year 2014, and we came up with the 2014 fatal crash probabilities by different age groups from age 20 & under to age bigger than 74. Also, we set up 7 type's amount of insurance that we could offer and calculated its relative pure premium. Furthermore, in case of exceeding the expected loss, we would lose lots of money. Hence, we plan to reinsurance our product. We used Tail Value at Risk (TVAR) model to show how likely it is for the outcome to exceed the expected loss and put the company into trouble. To evaluate tail value at risk we used Poisson distribution to calculate the likelihood of an event.

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