

Insuring Vehicles as they Transition from Human-Driven towards Autonomous:

An Actuarial Literature Review

Abstract

Car accidents remain a major global problem, especially for young people, despite efforts to improve road safety. Auto insurers play a critical role by offering protection against these risks, but their pricing models must accurately reflect changing realities while following regulations. Historically, insurance pricing was simple and mostly based on basic driver and vehicle factors. However, the rise of advanced vehicle technologies, changing driver behaviors, and increasing claim costs are forcing insurers to reconsider how they assess risk and set premiums. New challenges such as distracted driving, rising repair expenses, and emerging cybersecurity risks further complicate this landscape. At the same time, evolving technologies like telematics and AI-driven dynamic pricing offer opportunities for more precise risk assessment and fairer premiums. This paper explores the historical background, current crisis, and the urgent need for integrating technology into auto insurance pricing models to meet today's challenges and future demands.

History of Traditional Pricing

No one would think it would happen to them individually, but collectively, car accidents are more common than we would expect. We all know someone that has been involved in an accident [9]. Moreover, "thousands of deaths occur each day, and road traffic crashes remain the leading killer of children and youth aged 5–29 years" [11]. This has been such a global issue that the United Nations has advised participating nations to cut these risks in half before the end of the decade [10].

It is important for auto insurers to develop pricing models that can help these victims of tragedy be sufficiently prepared for such accidents, in addition to providing financial incentives to reduce such exiting risks in the first place. The consumer trades the small cost of the policy for the certainty that an uncertain risk will not cripple them. It is the insurers' duty to accurately quantify such uncertainty of these risks, but they must also navigate within the state governmental regulations, which require insurers to obtain approval for rate increases based on loss trends and cost projections. [14] This might lead to confusion especially given that teams of data scientists and actuaries must also avoid unfair discrimination. [20]

As cars transition with additional technological advancements, insurers must consider all this new information to update their prior beliefs about the quantification of the drivers' risk. "Carriers face a diverse range of regulators and organizations influencing insurance regulation... In this complex environment, carrier liabilities might shift rapidly based on changes in requirements by any one of those agencies. Proactive engagement with regulators is essential for insurers to develop insurance products and adopt operational practices in line with technological advancements" [5]. This is important, especially in recent times as cars have become ever more technologically sophisticated.

Historically, on the other hand, these pricing models were simple, and only took into account basic risk factors,

namely the price of the car, and the geography associated with it. Cars have not even been around for a very long time, but as early as 1922, actuary A.L. Kirkpatrick recognized the driver "is by far the greatest hazard to be considered in automobile underwriting." Unfortunately, "there has been no satisfactory solution presented for getting the information which will enable the underwriter to determine which drivers are good risks and which are bad." [1] Insurers typically use other factors such as demographic variables related to the driver of the vehicle. [2]

Moreover, these traditional insurance premiums are set using a cost-plus model. "The cost-plus model is an actuarial pricing model that assesses the risk premium and adds a percentage to cover direct and indirect costs, including a small profit margin" [21]. In general, insurers typically rely on underwriting rules and third-party data integrations to predict potential loss. [22]

Essentially, historical pricing models are focused on basic characteristics of the driver. If we can understand the reasoning behind historical pricing models, then we can better understand how models should adapt with the integration of new technologies, safety features, and even self-driving capabilities that are gradually being incorporated into the traffic of today's treacherous roads.

The Shift of Vehicles and Insurance

Today, risk factors incorporated into existing pricing models include driver's age, years of experience, gender (in some states), marital status, driver record, history of claims, vehicle make and model, location, credit-score, length of time with the company, number of vehicles being insured, and the type of coverage. [2] Most of these factors are related to the driver, and few are related to the vehicle itself. Another study concluded that crash and near-crash risk for individual drivers is associated with critical incident rate, demographic, and personality characteristics. [13] The predominant belief is that the liability is on the driver - as it is the driver's responsibility to ensure the safety of the vehicle while in control of the vehicle - perhaps because human factors constitute the dominant risk factor recognized in the literature and are the leading cause of road crashes; 95 % of total road crashes (Singh, 2015). [10]

It is important to consider the recent changes occurring today that might impact the predictive utility of these traditional factors. There are two main types of changes occurring concurrently: changes related to vehicles and changes related to the auto insurance industry itself. First of all, vehicles are becoming more expensive, so it becomes more costly to insure. Especially considering supply shocks and labor shortages caused by the recent COVID-19 epidemic. "Since 2019, the price of new vehicles in the U.S. has soared by 22%, making replacing the aging vehicle fleet more expensive and driving up auto insurance premiums" [14].

Even though vehicles are becoming more expensive, they are also becoming safer as technology results in a reduction in driving risks. Specific features like "front crash prevention, lane departure warning, blind spot detection, adaptive headlights, park assist and back over prevention are boosting vehicle safety, according to "Crash Avoidance Technologies," on the Insurance Institute for Highway Safety (IIHS) website. Electronic stability control, which became standard in 2012, lowers the risk of a

single fatal vehicle crash by about half and the risk of fatal rollover by as much as 80 percent” [3].

Even though vehicles are also becoming safer, the number of driver-distractions is rising. In addition, these safety features risk drivers becoming overly dependent and decrease the level of driver engagement necessary to react swiftly to road hazards. In other words, “manufacturers are producing safer cars while also boosting driver distraction with in-car access to mobile technology and infotainment systems” [3]. Moreover, Fifty percent of respondents to the NSC’s “Distracted Driving Public Opinion Poll,” released in March 2016, believe infotainment dashboards and hands-free technology must be safe if the auto manufacturers installed them. [3]

This is how things have changed to where they are today, but in order for a competitive insurance firm to strategically foresee risks, they must anticipate how things will be in the future. “Self-driving cars have been stuck in a slow lane for years. But if the incoming Trump administration rolls back regulation, they will shift up a gear. Motor insurers should buckle up. Depending on how rapidly the technology is adopted, it could boost their fortunes or run them off the road” [6]. Additionally, “market participants optimistic about the pace of innovation expect that by 2030, roughly half of new vehicles will be electric, nearly all new vehicles will be connected, and some (maybe one in six) will have Level 3+ autonomous-driving capabilities—such as self-driving without constant human supervision” [5]. These become important factors for the auto insurance industry to consider, in addition to how their own market is changing.

According to this article from Coughlin Insurance Services, these industrial changes can be described as “undergoing significant upheaval, exacerbated by a crisis stemming from rising claim costs, increased repair expenses, and regulatory hurdles. As of 2024, auto insurance rates have seen a stark increase. Some states have witnessed a 22% jump in premiums year-over-year—the highest since 1976. This surge is part of a broader trend that has seen rates climb by over 43% in the past few years alone” [16]. An additional issue they face is that auto accident rates have increased, with collisions often being more severe. This rise in claims severity directly impacts the amount insurers must pay out, putting upward pressure on premiums. [8] Along with their own crisis, they also face challenges with the “dramatic shifts brought on by technological advancements. These developments have fundamentally altered how coverage is priced and provided, presenting both challenges and opportunities for consumers” [16].

Some critics might argue that rising premium costs relate to the insurance company’s shift in profits in the competitive economy. However, “increases in auto insurance costs are correlated with rises in loss costs, rather than changes in insurer profits. This suggests that economic downturns or periods of increased accidents can lead to higher premiums” [4]. Especially considering the economic ramifications of the covid-19 epidemic.

These rising costs could even facilitate a positive feedback loop in which more drivers are unable to afford insurance, so there is an increase in uninsured drivers. This places the burden on insured drivers that have to now pay even higher premiums due to the risk associated with the increase of uninsured drivers. According to this article from J.P. Morgan Asset Management, “the cost of auto insurance has rendered it unaffordable for many, leading to a rise in uninsured motorists,

from 11% of drivers in 2019 to 14% in 2022 (the latest available data). This shift burdens insured drivers with higher premiums to cover the risks posed by the uninsured” [14].

Traditionally, “in 2009, when Towers Watson began its annual predictive modeling survey, 76 percent of personal auto carriers were using predictive modeling for underwriting/risk selection and/or rating/pricing. By 2015, virtually all — 97 percent — reported the same, according to Willis Towers Watson’s “2015 Property & Casualty Insurance Predictive Modeling Survey,” released in February 2016” [3]. In addition, the increasing amount of available real-time data and computational power to handle complex actuarial models allows the nature of auto insurance pricing to become ever more sophisticated [2].

However, this complexity comes at a cost to maintain, updating with new factors and technology. Sometimes it is easier for insurance companies to keep their models simple using traditional risk factors with their pricing models. On the other hand, complex pricing methods like telematics, might have more benefits than drawbacks, where “telematics programs monitor individual driving behaviors, enabling insurers to offer personalized pricing. Drivers who maintain safe habits benefit from reduced premiums, creating a win-win for both insurers and customers” [8].

The Existing Crisis

“The latest WHO global status report on road safety 2023 shows that, since 2010, road traffic deaths have fallen by 5% to 1.19 million annually” [11]. Even though progress has been made to make the roads safer, driving safety remains one of the world’s highest, persistent global health risks, especially considering that vulnerable populations pay a higher price in part, due to a rising risk of death for pedestrians and cyclists.

Other vulnerable populations also suffer from non-representative risk factors used to quantify risk. Specifically, insurers are using generalized, and often, discriminatory non-driving factors such as occupation, ZIP codes, education, credit score and even homeownership status to “assess” drivers’ risk. [17] In addition, “traditional insurance-pricing policies do not penalize dangerous driving behaviors and ignore the strong correlation between driving behavior and accidents” [12]. This would give even more challenges to drivers that suffered from loss of jobs in the COVID-19 pandemic given that “drivers with poor credit get 75% higher rates on average compared to those with good credit, irrespective of their driving behavior” [17]. Moreover, the Insurance Information Institute claims that machine learning holds potential to shift the way actuarial pricing models are developed, but “research has shown these tools also can amplify any biases in the underlying data. [20] As mentioned, this could increase the number of uninsured drivers, raising costs for those that are insured. A decade of rate increases hasn’t turned the tide. Across the U.S., auto insurance rates increased by 11% [22].

While premiums are rising, the cost of claims is also rising. “Modern vehicles equipped with advanced safety systems and technologies like sensors and cameras are safer but far more expensive to repair” [7]. Also relating to the rising claim costs, it is important to consider that “despite newer vehicles featuring advanced safety technologies, car fatality rates increased by 10% from 2019 to 2022 (the latest available data). This rise in severe incidents has increased costs associated with repairs,

replacements, and legal liabilities. [14] Part of this might even be because of the how the COVID-19 pandemic made us even more addicted to our cell phones and “today, every mile driven is more dangerous for drivers, and thus more costly and unpredictable for auto insurers” [17].

This is all despite the increasing integration of new safety features that are supposed to make roads safer and reduce fatalities, at least, in theory. It might be important to note that one could make a counterfactual: It could be a lot worse without these safety features. This would be an effective counterfactual, if it wasn't for the safety features themselves that contribute to the additional hazards due to the additional signals and distractions. Additionally, “despite cars getting safer, our driving is getting more dangerous. Since the new safety devices don't make your car “driverless,” there is still a lot of room for driver error” [9].

Another concern with these new safety features is for them to properly integrate into the driving experience such that the driver can find them intuitive and safe to use. Take lane-departure warnings, for example, which “suffer from high error rates and user pushback, with drivers who find them nonintuitive or intrusive often deactivating them” [5]. Also, according to a survey, some respondents indicate that they were more comfortable looking away from the road because of the LDW system. [9].

One of the final predominant issues, among others, are the emergent threats as cars transition towards autonomy and integrated technology that reduces the driver's engagement and role in driving safely. This article from Coughlin Insurance Services in 2024 describes such emergent threats as cybersecurity and data privacy, which have emerged as significant concerns: “Insurers are investing heavily in robust cybersecurity measures to protect sensitive customer data from breaches. For consumers, understanding the privacy policies of their insurers and the security measures in place is crucial” [16].

In conclusion, the existing crisis of the industry is prefaced firstly, with traffic hazards remaining a leading global health issue, where vulnerable populations pay a higher price both during a traffic hazard, and within holders of an insurance policy itself. Additionally, non-representative factors are being used, and there are rising claim cost and premium costs, due to safety features that even cause the very thing they are trying to prevent. Finally, new risks need to be accounted for that incorporate cybersecurity and data privacy risks as safety features become more dependent on real-time data and digital technology.

The Importance of Integrating New Technology and Accurate Pricing and Possible Solutions

The auto industry is experiencing a rapid shift, and insurers must adapt to these new safety technologies by considering the role these changes play in accurate pricing models. It is important to implement risk-based pricing with a deep understanding of the underlying mechanisms that could either create or inhibit safety. [5] According to Marty Ellingsworth, an executive managing director at J.D. Power, “risk-based pricing accuracy requires new levels of analysis that... [consider] both the technology patterns that arise from individual features installed on vehicles that create ‘defensible

space’ and a dynamic understanding of the value of a vehicle over time” [18]. Moreover, there are many benefits of risk-based pricing according to Dale Porfilio, FCAS, MAAA, Chief Insurance Officer, Triple-I, because “the price reflects risk, helps align premium paid with risk assumed, expands availability of coverage and promotes a competitive marketplace.” [20]

This is especially important considering that there are more developments of online tools that consumers can use to shop around for a better insurance policy. According to Lexis-Nexis Risk Solutions “A shocking 41% of auto insurance policyholders shopped for auto insurance in 2023” [22]. Today, insurers can use real-time data to develop dynamic pricing models. “Customers and prospects have come to value speed, personalization, and flexibility in their dealings with carriers. No aspect of this relationship is more important than pricing, and the presentation of policy options tailored to consumers” [23].

According to Barbara Schwarz, with 35 years of experience in the P&C insurance industry, “dynamic pricing AI algorithms leverage this wealth of information to create predictive models that go beyond traditional actuarial methods” [21]. In addition, “when the premium is set too high for safe drivers, the expected loss ratio from that group is naturally lower. Conversely, when premiums are set too low for risky drivers, the expected loss ratio is much higher” [24]. Essentially, insurers without telematics and other real-time risk-based models will lose out to auto insurers whose more sophisticated pricing. “Their lack makes carriers “sitting ducks” for attack by the competition” [23]. Something needs to change in the industry [22].

One of the obstacles to adoption of these new pricing models is the predominant trust in traditional methods. There is more data that shows the traditional methods do work, so insurers could be hesitant to adopt more complex models. “Critics of U.S. auto insurer pricing practices have expressed concerns that certain rating factors, such as credit-based insurance scores and the geographic location of the customer's residence, discriminate against lower-income drivers and minority groups. Triple-I explained that eliminating any rating factor – for whatever reason – forces those with less risk to overpay for auto insurance and allows those with greater risk to pay less than they should for auto insurance” [19]. In addition, the costs of adopting telematics are an issue, along with data privacy concerns. “Entry costs, such as technology development, hardware purchases, and advertising, can be a significant obstacle for smaller companies. In addition, the population is increasingly wary of sharing individual data, and a problem of social acceptability could arise” [25].

Conclusion

The auto insurance industry is facing a complex crisis driven by persistent road safety risks, rising claims, and outdated pricing methods that don't fully capture modern driving realities. Vulnerable groups suffer disproportionately due to non-representative risk factors and systemic biases. Meanwhile, advances in vehicle safety technologies create new risks like driver distraction and cybersecurity threats. Although traditional pricing models have served insurers for decades, they are no longer sufficient in a world where cars and driving behaviors are rapidly evolving. To survive and remain competitive, insurers must embrace dynamic, data-driven pricing approaches that

incorporate real-time driving behavior and new risk factors. Despite concerns around data privacy and implementation costs, these innovations hold promise for more accurate, fair, and adaptable insurance products that better align premiums with true risk. Without such change, insurers risk losing customers and facing increased financial pressures in an increasingly complex risk environment.

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