

Behavioral Validation of Auto Insurance Rating Variables

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EXECUTIVE SUMMARY

This paper examines the behavioral drivers of auto insurance losses. Historically, auto insurers have estimated future losses—and determined rates—by examining the statistical correlation between a large combination of actuarially sound and independently predictive rating variables.¹ While the relationship between loss and many rating variables—such as driver age or driving record—are both intuitive and obvious and thus widely accepted, the relationship between loss and a number of other rating variables such as credit behavior, marital status, and education are less obvious or intuitive to some, even though most have been used by insurers for decades. For this reason, establishing the linkages between driver characteristics commonly used as rating variables and specific driver behaviors is critical to enhancing public understanding of why certain rating factors are so strongly predictive of loss outcomes.

Until recently, monitoring actual driver behaviors in real time has been impractical. In recent years, however, telematics technologies have proven instrumental in demonstrating that certain driver characteristic variables used in auto insurance pricing are strong predictors of both high-risk and low-risk driving behaviors and ultimately, costs.

Using telematics data, this paper demonstrates the association between two common risky driving behaviors—hard braking and hard acceleration—and loss across several commonly used rating variables: population density, education, occupation, marital status, and credit-based insurance scores. Because frequent hard braking and hard acceleration have both been proven to result in more costly claim outcomes, each of the driver characteristics associated with these behaviors discussed in this paper are strongly predictive of loss.

The findings in this paper also illustrate the importance of allowing insurers to maintain use of all actuarially sound rating variables. Restricting or prohibiting their use can adversely impact rate accuracy, fairness, and consumer choice.

¹ Actuarial standards of practice and insurance regulation require that insurers demonstrate a strong statistical correlation between loss outcomes and all rating variables used by the insurer. Behavioral or causal links are not required.

OVERVIEW: THE INHERENT COMPLEXITY OF AUTO INSURANCE UNDERWRITING

When the first automobile insurance policies in the United States were sold in the late 1890s, the premiums paid were determined largely by the vehicle's horsepower, a legacy of the industry's decades of experience insuring horse-drawn vehicles. In the nearly 125 years since, auto insurance pricing and underwriting have evolved continuously to reflect countless innovations in motor vehicle technology and design, massive investments in road and traffic management infrastructure, as well as the driving patterns and behaviors of the vehicle-owning public.

Today, America's nearly 230 million licensed drivers are behind the wheels of some 300 million registered motor vehicles, traversing the country's 8.8 million miles of public roadways and driving some 3.3 trillion miles each year.² As such, auto insurers of the 21st century face challenges unimaginable to insurers, drivers, and insurance regulators of the late 19th century. Foremost among those challenges is ensuring that auto insurance remains continuously available and affordable to the near quarter of a billion drivers who rely on that coverage to protect them against the potentially devastating financial consequences associated with accidents and injuries arising from the operation of motor vehicles.

Protecting hundreds of millions of drivers against the omnipresent threat of costly vehicle damage, property damage, bodily injury, and litigation is inherently complex. The number of circumstances that can give rise to auto insurance claims is literally infinite. To complicate matters further, policies are priced to reflect expected *future* costs—around which there can be considerable uncertainty arising from many sources. Insurance is one of few products that is sold before the actual cost of providing it is known.

MAXIMIZING ACCURACY IN AUTO INSURANCE PRICING

Because the population of drivers is large and diverse, the best—and fairest—way to manage the inherent complexity and uncertainty associated with auto insurance pricing is to use a large combination of actuarially sound and independently predictive rating variables. Using a large combination of variables related to driver characteristics, driving environment, vehicle characteristics and policy attributes maximizes pricing accuracy and assures that no single rating variable has a disproportionate impact on an individual's premium. This approach to pricing also allows insurers to offer their products to a broader range of consumers and to include incentives that promote safe and responsible driving behaviors.

Most drivers are familiar with many of the rating variables used by auto insurers today. The majority have been in use for decades because they have proven to be highly predictive of future losses. These factors fall into four major categories: (i) policy attributes, (ii) driver characteristics, (iii) driving environment and (iv) vehicle characteristics. Several commonly used variables within each category are shown in the table below.

Figure 1. Categorization of Rating Variables Commonly Used by Auto Insurers

CATEGORY	EXAMPLE VARIABLES
Policy Attributes	Number of Drivers, Number of Vehicles, Limits, Deductibles, Prior Lapse, Coverages
Driver Characteristics	Age, Gender, Credit Behavior, Marital Status, Occupation, Education, Driving Record, Moving Violations, Claims History, Miles Driven
Driving Environment	Territory (Location), Garaged or Street Parked, Repair Costs, Medical Costs, Weather Exposures
Vehicle Characteristics	Vehicle Age/Make/Model

2 Bureau of Transportation Statistics, Office of Highway Public Policy Information. Data are for 2019. Public roadway data are for "lane miles." Available at: <https://www.fhwa.dot.gov/policyinformation/statistics/2019/dv1c.cfm>.

INSURER USE OF DRIVER CHARACTERISTICS AS RATING VARIABLES

Most people have an intuitive understanding of why variables such as driving record, vehicle type, and distance driven are used to develop auto insurance rates. The causal links between a poor driving record, for example, and an above-average likelihood of filing an auto insurance claim are both intuitive and obvious. Moreover, society views higher premiums paid by risky drivers to be both fair and equitable.

Less obvious or intuitive to some is why certain driver characteristics such as credit behavior, marital status, and occupation are used by insurers, even though most have been employed by insurers for decades. The reason is that these variables—just as with all variables—have been demonstrated to be strong predictors of future loss. Actuarial standards of practice and state insurance regulators mandate that all rating factors used by insurers comply with stringent requirements documenting strong statistical correlations between rating variables and loss outcomes.

Certain driver characteristics, such as age, are widely recognized and accepted as predictive of loss. Teen drivers, for example, are nearly three times as likely to be involved in a fatal automobile accident—and 24 percent of fatal crashes involving drivers under the legal drinking age of 21 involve alcohol.^{3,4} The strong predictive power of certain other variables related to driver characteristics, such as education, occupation, marital status, and credit standing is not as widely recognized by drivers.

To bridge that gap and increase understanding of how such variables are related to loss outcomes, some insurers have in recent years turned to telematics—technologies which allow insurers to monitor driver behaviors in real time. To be sure, researchers have for decades studied driver behaviors that historically contributed to motor vehicle accidents, injuries, and deaths, typically relying on data after-the-fact from accident reports or from driver surveys.⁵ Research suggests that a multitude of behaviors contribute to automobile accidents and injuries, including alcohol use, failure to use seat belts, distracted driving, propensity to speed, and a general disregard for traffic rules. While telematics cannot monitor every risky driving behavior, the technology can capture data on several specific behaviors that allow insurers, drivers, and regulators to observe direct linkages between the effects of these behaviors on claim costs and the impact on premiums.

ESTABLISHING THE LINK BETWEEN DRIVER CHARACTERISTICS AND DRIVER BEHAVIOR

Telematics has proven instrumental in demonstrating that certain driver characteristic variables used in auto insurance pricing are strong predictors of both high-risk and low-risk driving behaviors and ultimately, costs.⁶ In the analyses that follow, hard braking and hard acceleration—two common risky driving behaviors—are used to demonstrate strong correlations between several driver-related characteristics and losses. Frequent hard braking and hard acceleration have been proven to result in more frequent accidents. Hence, each of the driver characteristics associated with these behaviors discussed in this paper are strongly predictive of loss.

3 Insurance Institute for Highway Safety (IIHS). Fatality Facts 2019: Teenagers. Highway Loss Data Institute; March 2021. Available at: www.iihs.org/topics/fatality-statistics/detail/teenagers.

4 National Highway Traffic Safety Administration (NHTSA). Traffic Safety Facts 2019: Young Drivers (Report No. DOT HS 813 130). U.S. Department of Transportation; June 2021. Available at: <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813130>.

5 See, for example: Norris, F., Matthews, B., and Riad, J. "Characterological, situational, and behavioral risk factors for motor vehicle accidents: a prospective examination." *Accident Analysis and Prevention*, v. 32, issue 4 (July 2000), pp. 505-515. Available at: <https://www.sciencedirect.com/science/article/pii/S0001457599000688>.

6 The telematics data referenced in this paper were based on national data using billions of miles driven by voluntary telematics participants. Experience was captured from January 2017 through June 2019.

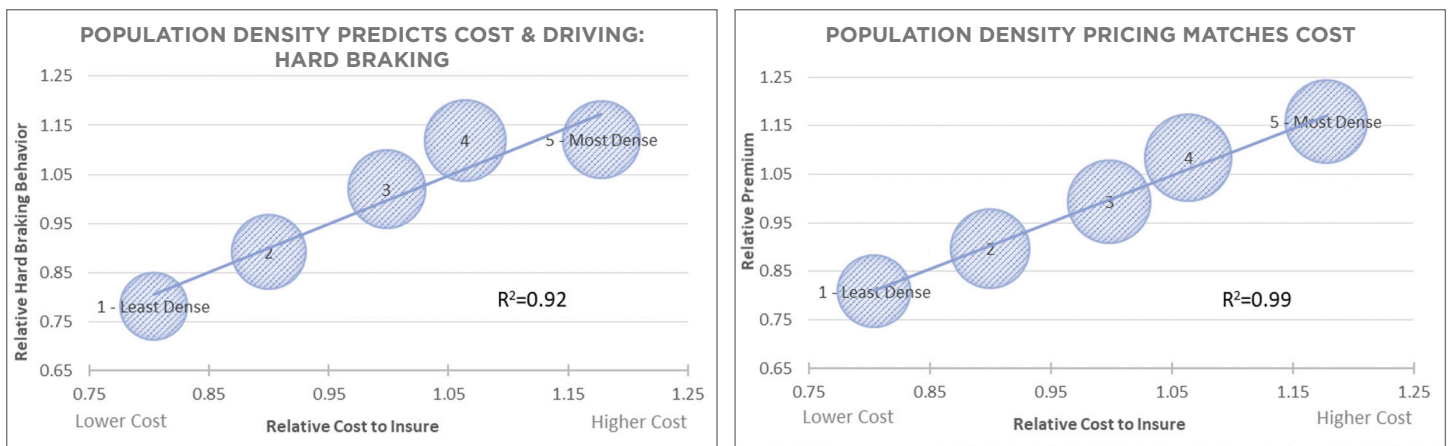
POPULATION DENSITY

Telematics data prove that population density is a highly accurate predictor of insurance cost. Population density can be viewed as a variable that reflects territory (e.g., urban versus rural). Risk factors across territories can vary tremendously. Examples include traffic density, theft and vandalism rates, weather, motor vehicle repair costs, medical costs, and litigiousness.

As shown in the panel at the right below, drivers in areas where population density is the highest are associated with insurance claim costs that are approximately 20 percent higher than the overall population of drivers.⁷ Conversely, drivers in areas with the least population density tend to have claim costs that are 20 percent below the overall population of drivers.

The panel on the left demonstrates one reason why this is the case: drivers in areas with high population density are far more likely to engage in hard braking behaviors. Indeed, drivers in areas with the highest population density engage in hard braking behaviors approximately 10 percent more frequently than the overall population of drivers, while those in low density areas engage in hard braking approximately 20 percent less frequently than the overall driver population. The telematics data therefore demonstrate that population density (territory) is strongly predictive of auto insurance claims costs, in part because hard-braking behavior—a proven determinant of accidents—is far more prevalent in high-density areas and far less prevalent low-density areas.

Figure 2: Population Density, Hard Braking, Claim Cost and Premiums



EDUCATION

Education is another driver characteristic that is highly predictive of loss. The association between claim costs and education can once again be demonstrated using telematics data.

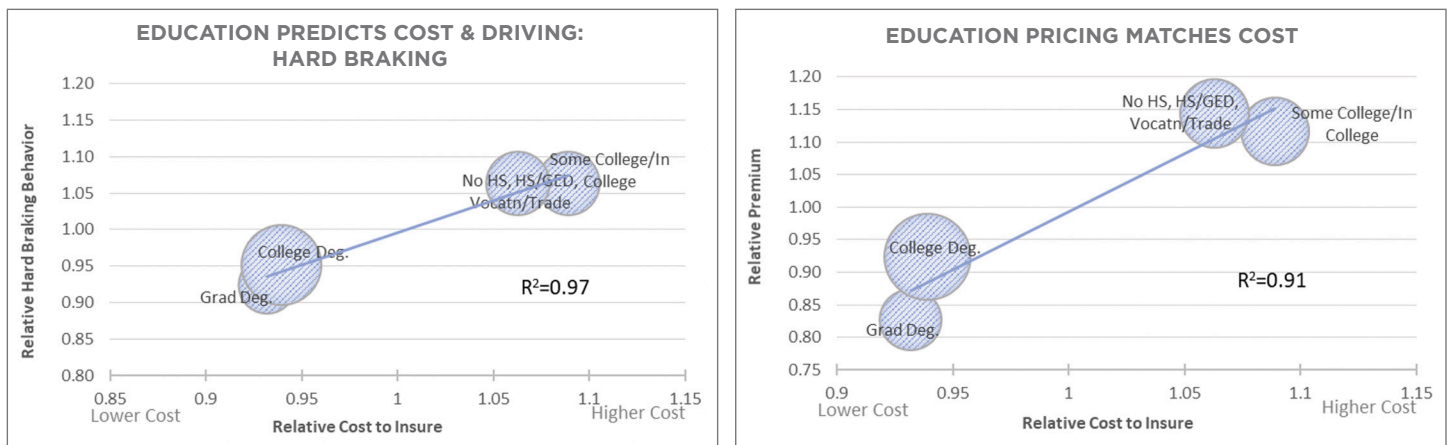
As shown in the panel at the right below, drivers with lower levels of educational attainment are associated with insurance claim costs that are approximately 5 percent to 10 percent higher than the overall population of drivers. Conversely, drivers with higher educational attainment have claim costs that are at least 5 percent to nearly 20 percent below the overall population of drivers.

The panel on the left, employing telematics data, demonstrates a very clear association between educational attainment and hard-braking behavior. Drivers with high degrees of educational attainment engage in hard-braking behaviors at least 5 percent less frequently than the overall population of drivers, while those with

⁷ The term “population of drivers” in this paper refers to all drivers whose telematics data were collected for analysis as described in footnote 6.

lower educational attainment engage in hard braking approximately 5 percent more frequently than the overall driver population. The telematics data therefore demonstrate that educational attainment is strongly predictive of auto insurance claims costs, in part because hard-braking behavior—again a proven determinant of accidents—is far more prevalent among drivers with lower educational attainment and far less prevalent among drivers with a high degree of educational attainment.

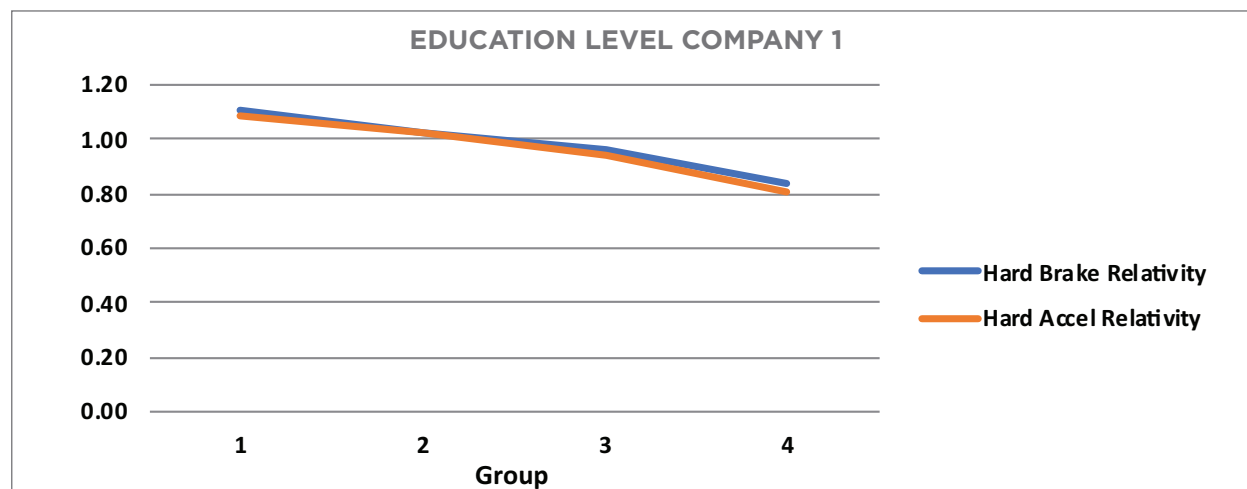
Figure 3: Education, Hard Braking Behavior, Claim Cost and Premiums



Hard acceleration is another risky driving behavior that is correlated with education and loss. Specifically, lower levels of educational attainment are associated with an increased frequency of hard acceleration behaviors which ultimately lead to higher relative costs. A separate analysis of data collected from several auto insurers, displayed in the charts below, illustrates this relationship between hard acceleration, education, and cost while also confirming a similar relationship with hard braking behaviors.⁸

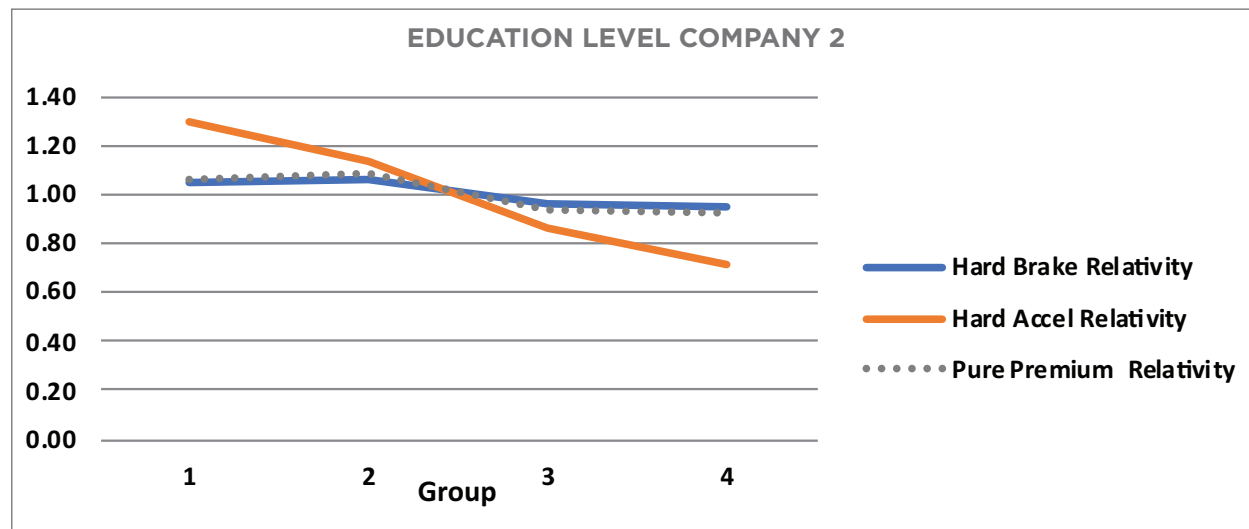
The direction of less desirable to more desirable driving habits (more hard brakes and accelerations to fewer hard brakes and accelerations) follows the same direction as the increase in level of education (education attainment increases by group level with Group 4 consisting of drivers with the highest level of educational attainment).

Figure 4A: Relationship between Education and Hard Braking and Hard Acceleration Behaviors, and Premiums



⁸ Data are derived from a request by the American Property Casualty Insurance Association (APCIA) to its member companies to compare usage-based insurance relativities (hard braking and hard acceleration) to education, occupation, and credit-based insurance score (CBIS).

Figure 4B: Relationship between Education and Hard Braking/Hard Acceleration Behaviors, and Premiums



Like the earlier charts, the direction of less desirable to more desirable driving habits (more hard brakes and accelerations to fewer hard brakes and accelerations) follows the same direction as the increase in level of education (education attainment increases by group level with Group 4 consisting of drivers with the highest level of educational attainment).

OCCUPATION

Occupation is a driver characteristic used by some insurers that has also been found to be highly predictive of loss. The association between claim costs and occupation can once again be demonstrated using telematics data.

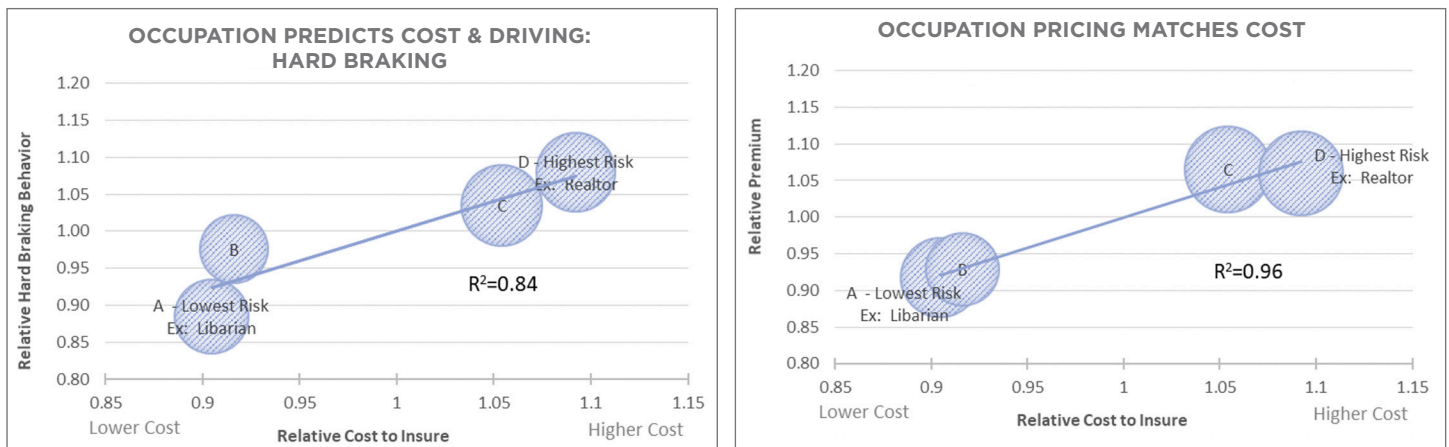
As shown in the panel at the right below, drivers with certain occupations are associated with insurance claim costs that are approximately 5 percent to 10 percent higher than the overall population of drivers. Conversely, drivers with other occupations have claim costs that are 5 percent to 10 percent below the overall population of drivers.

The panel on the left, employing telematics data, demonstrates a very clear association between certain occupations and hard braking behavior. Occupation is predictive because it reflects vehicle usage and the regularity of commutes. For example, realtors generally drive more frequently and often to areas they aren't as familiar with compared to a schoolteacher who tends to drive the same route to and from school every day. School teachers thus benefit from the use of occupation as a rating factor.

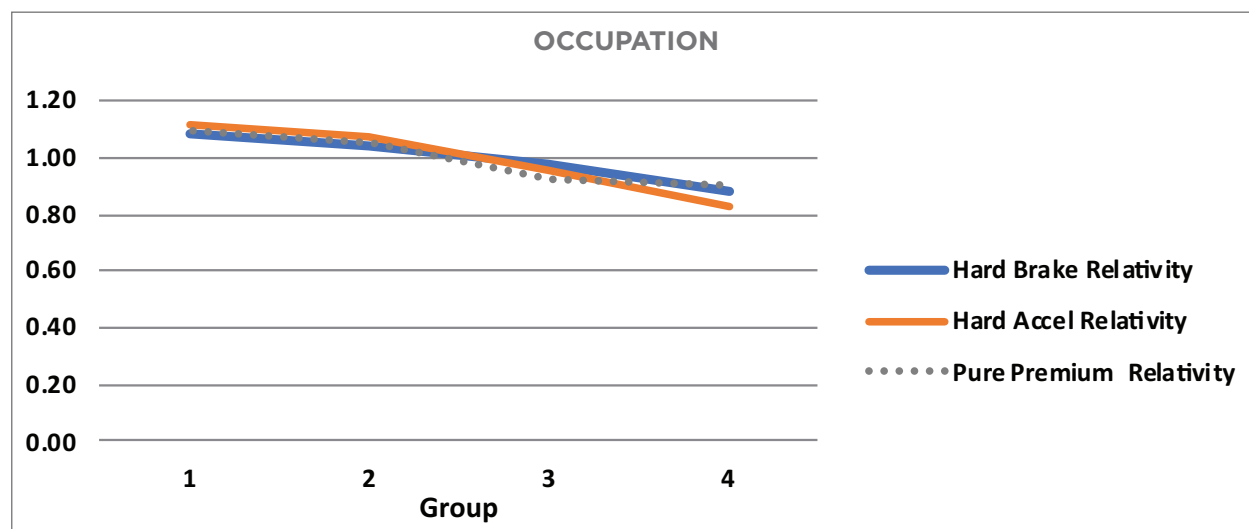
It is important to note that the occupational risk groups are not based on income. They are based on actual claim costs. Low-income and high-income occupations exist within each risk group. Additionally, U.S. Census data shows that each risk group is represented by people from every race and ethnicity. For example, data from one insurer show that:⁹

- Bank tellers benefit from lower rates compared to psychologists
- Teachers benefit compared to financial advisors
- Enlisted military benefit compared to pharmacists
- Firefighters benefit compared to dentists
- Receptionists benefit compared to veterinarians

⁹ Specific occupational comparisons may differ across insurers and states.

Figure 5: Occupation, Hard Braking Behavior, Claim Cost and Premiums

As the chart below illustrates, hard acceleration behaviors are likewise correlated with occupation and loss. Specifically, occupational groupings (Groups 1 and 2) that produce higher levels of loss are far more likely to engage in both hard acceleration and hard braking behaviors.¹⁰

Figure 6: Relationship between Occupation, Hard Braking/Hard Acceleration Behaviors, and Premiums

Like the earlier charts, the direction of less desirable to more desirable driving habits (more hard brakes and accelerations to fewer hard brakes and accelerations) follows the same direction as the risk associated with occupational groupings (Group 4 consists of drivers with occupations at the least of risk of accidents).

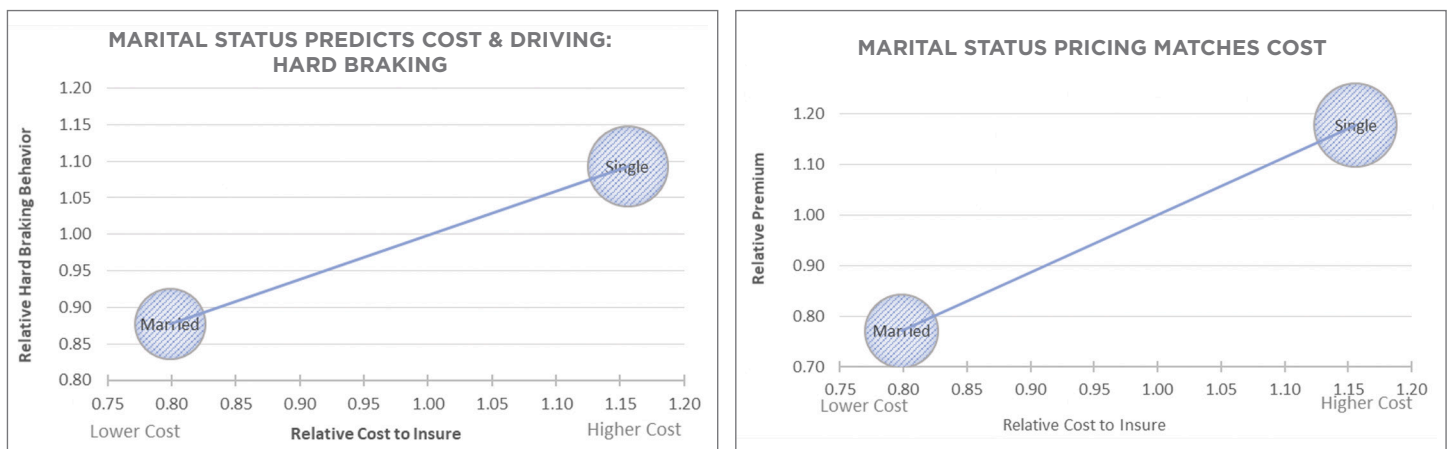
¹⁰ Data are derived from the same analysis of data described in footnote 7.

MARITAL STATUS

Marital status is a driver characteristic that is used by many insurers because it is highly predictive of loss. As shown in the panel at the right below, married drivers are associated with insurance claim costs that are approximately 20 percent lower than the overall population of drivers. Conversely, single drivers have claim costs that are approximately 15 percent above that of the overall driver population.

The panel on the left, employing telematics data, demonstrates a very clear association between marital status and hard braking behavior. Married drivers engage in hard braking behaviors approximately 10 percent to 15 percent less frequently than the overall population of drivers, while single drivers engage in hard braking approximately 10 percent more frequently than the overall driver population. The telematics data therefore demonstrate that marital status is strongly predictive of auto insurance claims costs, in part because hard braking behavior is far more prevalent among single drivers than married drivers.

Figure 7: Marital Status, Hard Braking Behavior, Claim Cost and Premiums



CREDIT-BASED INSURANCE SCORES

A driver's credit-based insurance score (CBIS) is a variable used by most auto insurers today. The widespread usage of CBIS by insurers began more than 20 years ago because it was demonstrated to be a consistent and highly accurate predictor of loss. Insurer use of CBIS has been extensively studied by insurers, regulators, the federal government, and academics. Every serious and reputable actuarial study on the issue, including a seminal study in 2007 by the Federal Trade Commission (FTC)¹¹, has reached the same conclusion: there is a high correlation between insurance scores and the likelihood of insurance claims.

The FTC study, specifically, concluded that:

- Credit-based insurance scores effectively predict the number of claims consumers file and the total cost of those claims.
- The use of CBIS is likely to make the price of insurance better match the risk of loss that consumers pose.
- As a result of the use of scores, higher-risk consumers, on average, pay higher premiums and lower-risk consumers pay lower premiums.
- Scores permit insurers to evaluate risk with greater accuracy, which may make them more willing to offer insurance to higher-risk consumers for whom they otherwise would not be able to determine an appropriate premium.
- Scores also may allow insurers to grant and price coverage more efficiently, producing cost savings that could result in lower premiums.¹²

¹¹ Federal Trade Commission, Credit-Based Insurance Scores: Impacts on Consumers of Automobile Insurance. (July 2007). Available at: <https://www.ftc.gov/news-events/press-releases/2007/07/ftc-releases-report-effects-credit-based-insurance-scores>.

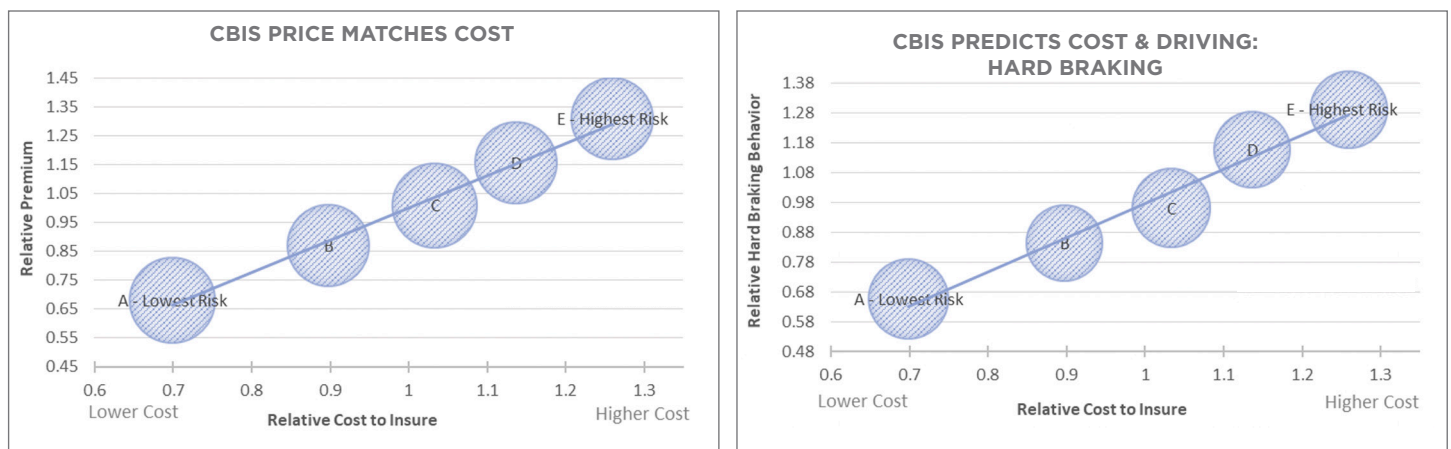
¹² The FTC study also found that credit-based insurance scores are not a proxy for race or ethnicity.

In the years since the FTC study, telematics technologies have advanced to the point where linkages between credit-based insurance scores and certain driving behaviors can be statistically established.

The panel at the right below shows that hard braking behaviors are strongly associated with the higher risk drivers (those with a lower CBIS). The cost to insure the highest risk drivers (as measured by pure premium) is approximately 28 percent higher than for the overall driver population. Conversely, the cost to insure drivers with the strongest CBIS is about 30 percent less than the overall driver population. The telematics data therefore demonstrate that credit-based insurance scores are strongly predictive of auto insurance claims costs. Again, this finding has been corroborated in many independent studies over the past two decades.¹³

The panel on the left shows that CBIS (as measured by pure premium) closely tracks the premium charged by the insurer, as well as hard braking.

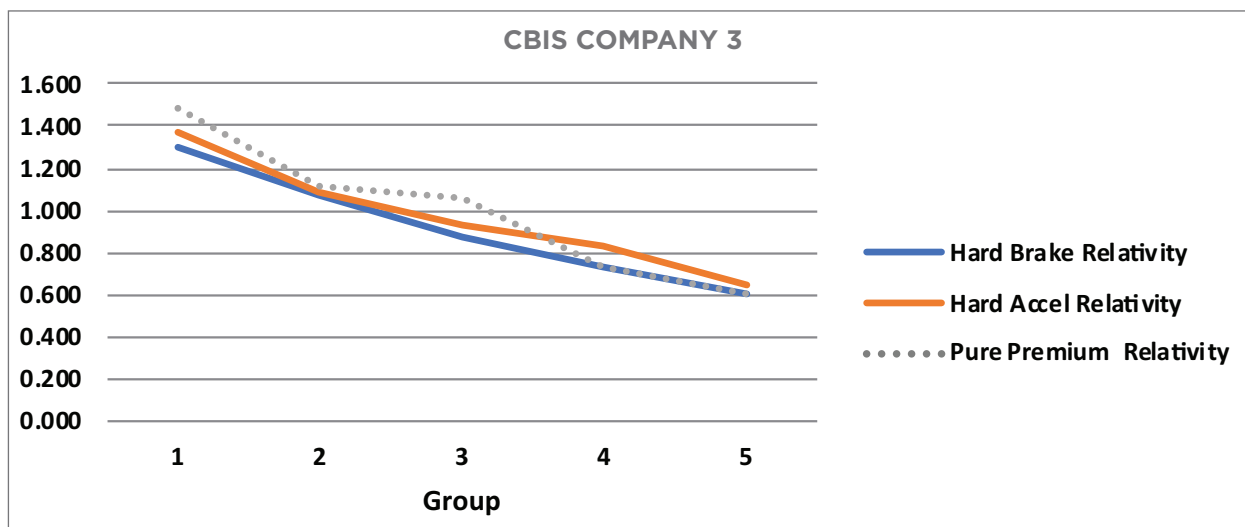
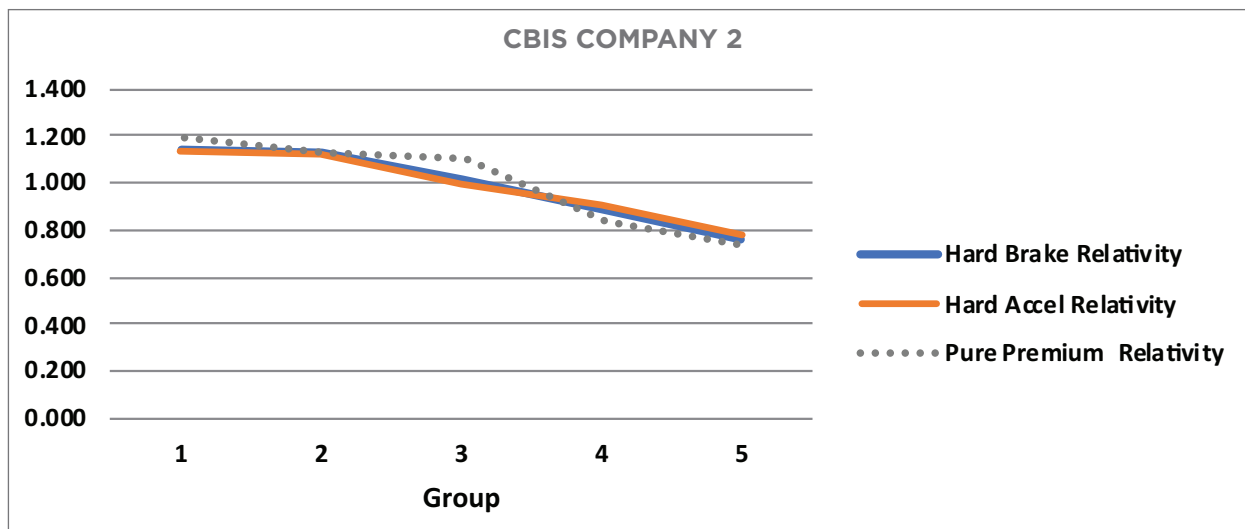
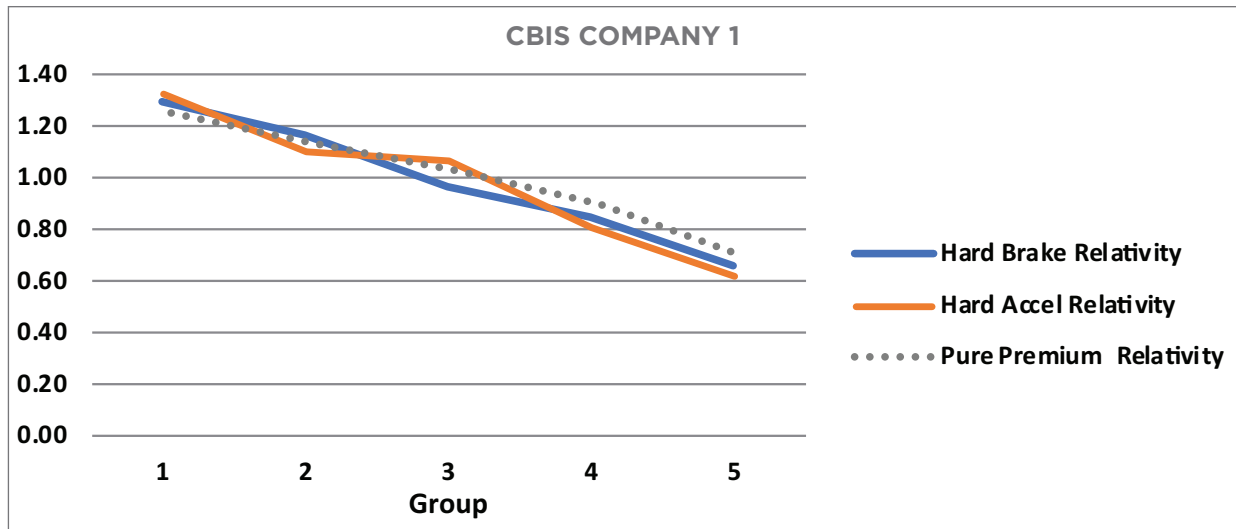
Figure 8: Credit-Based Insurance Score, Hard Braking Behavior, Claim Cost and Premiums



CBIS=Credit Based Insurance Score

The predictive power of credit-based insurance scores is consistent across companies. The experience of three different companies, each representing a large number of drivers, in the charts below illustrates a clear pattern between credit-based insurance scores, risky driving behaviors (hard braking and hard acceleration), and losses generated. In each chart, Group 1 reflects the CBIS associated with the highest risk of loss, and Group 5 reflects the highest CBIS associated with the lowest risk of loss. The direction of less desirable to more desirable driving habits (more hard brakes and accelerations to fewer hard brakes and accelerations) follows the same direction as the increase in CBIS.

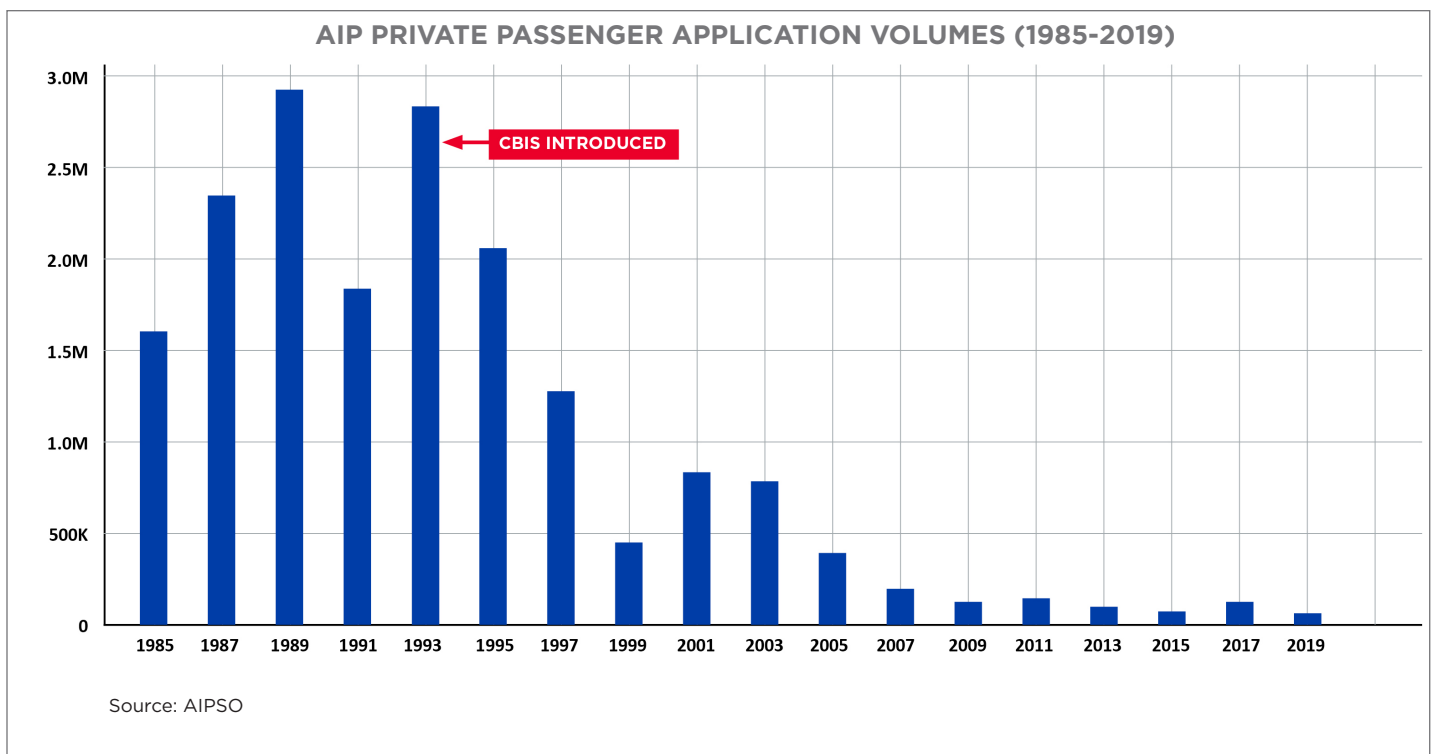
13 See, for example: Vermont Department of Financial Regulation, A Study of Credit-Based Insurance Scoring for Motor Vehicle Insurance—Impact and Limitations. (December 2016). Available at: <https://legislature.vermont.gov/assets/Legislative-Reports/Credit-based-Insurance-Scoring-Report-12-15-16.pdf>; Texas Department of Insurance, Use of Credit Information by Insurers in Texas. (December 2004). Available at: <https://www.tdi.texas.gov/reports/documents/creditrpt04.pdf>, and Powell, L., Risk-Based Pricing of Property and Liability Insurance. Journal of Insurance Regulation, v. 30, no. 4 (2020). Available at: <https://content.naic.org/sites/default/files/inline-files/JIR-ZA-39-04-EL.pdf>.



CREDIT-BASED INSURANCE SCORING ALSO BENEFITS THE RISKIEST DRIVERS

Among the key findings of the FTC's credit-based insurance scoring study is that scores permit insurers to evaluate risk with greater accuracy which, in turn, may make them more willing to offer insurance to higher-risk consumers for whom they otherwise would not be able to determine an appropriate premium. In other words, the use of credit-based insurance scores can increase competition among insurers for high-risk drivers, resulting in more options and lower premiums. One vivid illustration of this effect is the dramatic decline in applications to state auto insurance plans (AIP), which are state-run high-risk pools for motorists who cannot find coverage in the market. As displayed in Figure 9, in 1985 approximately 1.6 million drivers across 25 states applied for coverage through AIPs and by 1989 that number had soared to nearly 3 million. When credit-based insurance scores were introduced in 1993, applications began to decline. By 2019, the latest year for which data are available, there were just 160,000 applications in those states, a decline of 95 percent from its 1989 peak.

Figure 9: Auto Insurance Plan Private Passenger Application Volumes, 1985 – 2019



SUMMARY

For more than a century, auto insurers have collected and analyzed data related to the many and diverse risks arising from the ownership and operation of motor vehicles. Today, with some 230 million drivers and 300 million registered vehicles on America's highways and byways—collectively driving more than three trillion miles each year—the business of analyzing and pricing those risks is necessarily more complex than ever. Telematics technologies are a recent innovation that allow insurers to better manage and understand these risks through the direct observation of actual driving behaviors that contribute to motor vehicle accidents—and how these behaviors are linked to driver characteristics proven to be predictive of loss.

Frequency of hard braking and hard accelerating—both proven causes of vehicle accidents—are just two examples of specific driver behaviors that can be captured using telematics. The analyses presented in this paper demonstrate the linkages between these behaviors and several rating variables long used by insurers to estimate future losses. While all rating variables used by insurers are strongly predictive of loss, the use of telematics data allows—for the first time—insurers, drivers, and regulators to observe direct linkages between the effects of these behaviors on claim costs and the impact on premiums.

The bottom line is that a better understanding of specific driver behaviors giving rise to loss leads directly to improved rate accuracy, increased competition, and more consumer choice. Preserving insurers' ability to employ proven, strongly predictive rating variables associated with these behaviors is an essential element in the continuation of the industry's century-plus long commitment to ensuring the availability and affordability of auto insurance for the millions of drivers who depend on that protection each and every day.

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