Evaluating the Injury Risk Associated with All-Terrain Vehicles: An Application of Bayes’ Rule

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Abstract

This article discusses several technical and conceptual issues relating to the regulation of All-Terrain Vehicles (ATVs). Qualitative response models are used to analyze a survey of injured persons and a survey of the general population of users. Because the latter did not distinguish injured and non-injured persons, an application of Bayes’ rule is used to make inferences about the relationship between the two injury categories, and to consistently estimate injury risk. The article concludes with a discussion of the problem of risk awareness and some policy implications.

Driving all-terrain vehicles (ATVs) has been an enjoyable leisure activity for many Americans. ATVs are three- and four-wheeled motorized vehicles that are intended for off-road use on various types of non-paved terrain.\(^1\) Concern about the safety of ATVs grew during the 1980s as the level of injuries rose. In 1985, for example, there were about 85,900 ATV-related injuries requiring hospital emergency-room medical treatment out of a population of approximately 3,500,000 drivers (a 2% injury rate).\(^2\) In that same year 250 individuals were identified explicitly as being killed in ATV accidents.\(^3\)

The U.S. Consumer Product Safety Commission (CPSC) initiated a regulatory proceeding in 1985 to evaluate the hazards of ATV use, and to determine what, if any, regulatory actions should be taken. A lawsuit was eventually filed through the Department of Justice against the major ATV manufacturers (and distributors).\(^4\) The government’s complaint alleged that although ATVs appear to be relatively safe to drive, they are actually complex machines that require a high degree of skill for safe operation. The result, according to the CPSC, has been a relatively high risk of injury to ATV users, especially those who are young and inexperienced.

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On March 14, 1988, a Final Consent Decree was reached between the Department of Justice and the ATV manufacturers. Without admitting fault, the manufacturers agreed to provide extensive safety warnings to both past and prospective owners, to develop a media safety-awareness campaign, and to implement a nationwide training program. In addition, the manufacturers agreed to stop selling the three-wheeled vehicles and to develop a voluntary performance standard to make ATVs safer.

The ATV case raises a number of intriguing statistical and policy issues concerning safety regulation. How can one statistically estimate the effects of user and vehicle characteristics on the likelihood of injury? Is the provision of information of the type included in the Consent Decree likely to alter the public's awareness of the risks associated with the use of ATVs?

Section 1 of this article briefly introduces the ATV product market. Section 2 contains the central portion of the article, an analysis of the statistical issues involved in measuring the effects of various factors on accident injuries. In this section, qualitative response models are applied to the results of a survey of injured persons and a separate survey of the general population of users. Since the latter did not distinguish between injured and noninjured persons, an application of Bayes' rule is used to make inferences about the relationship between the two injury categories and to consistently estimate injury risk. Section 3 includes some comments concerning the public's awareness of the risks associated with the use of ATVs and the regulation of ATVs.

1. The market for ATVs

The number of ATVs shipped grew substantially during the 1970s and early 1980s (about 12,000 were shipped in 1972, 200,000 in 1980, and 650,000 in 1984). Shipments peaked in 1984 and have declined steadily since then. At the same time, the proportion of ATVs with four wheels has grown substantially. The first four-wheeled vehicles were sold in 1983, and they made up only about 10% of all sales. The proportion increased, however, to about 60% in 1985 and over 90% in 1987. Engine sizes have also increased in recent years. In 1986, about 22% of ATVs in use had engines of 250 cc or more; by 1989 the percentage increased to about 32%.

An active market exists for used ATVs. A survey conducted for the CPSC in 1987 indicated that by 1986 almost half of ATV sales transactions were in the used market. Approximately 80% of the ATVs purchased used were bought from individuals, and about 20% were purchased from franchised or nonfranchised motorcycle dealers. Word-of-mouth and newspaper ads are the primary methods employed by individuals to sell used ATVs, and these methods accounted for about 70% of total sales.

The used market appears to be well functioning. The survey results indicated that about 76% of used ATVs were sold in less than one month, and about 51% were sold in less than one week. Moreover, the reported sales prices averaged only about 7% less than the reported initial asking price.

Many ATV riders are young; in 1985 14% were under age 12; another 13% were 12-15 years of age. In total, 48% were under the age of 25. In addition, about 68% of the riders were male, and many were inexperienced (36% had less than two years of experience). About 6% were trained in an organized training program or by dealers; 50% were taught by a relative or friend; and the remainder were self-taught.

2. A statistical analysis of ATV injuries

In an ideal world, the analysis of ATV injuries would be accomplished by surveying a stratified random sample of the population of ATV users, some of whom would have received injuries. However, because only about 2% of the riders were injured in 1985, the CPSC relied on two totally distinct surveys. The “Injury Survey” contains detailed information about riders, vehicles, and accidents, based on a sampling of 277 emergency room treated injuries from across the nation. The “Exposure Survey” contains detailed information about riders and vehicles, based on a sample of 1,350 drivers drawn from a national representative consumer mail panel. The mail panel is not a probability sample, but is balanced to match U.S. statistics on five demographic variables. (The data are discussed in more detail in the appendices.)

A plausible approach to modeling the probability of a serious ATV injury would involve a probit or logit specification in which rider and vehicle characteristics of noninjured riders (from the Exposure Survey) and injured riders (from the Injury Survey) are compared. Let

\[ y = \text{the propensity of an ATV user to have an accident leading to a serious (emergency room) injury} \]
\[ x = \text{a vector of user and vehicle characteristics} \]
\[ \beta = \text{a vector of coefficients} \]

The statistical model assumes that accidents are random events that occur when the unobserved propensity to have an accident \( y \) is greater than a threshold value, \( \alpha \). Specifically, define the observable variable \( z \), which indicates whether or not an accident has occurred, as follows:

\[ z = \begin{cases} 
0 & \text{if } y \leq \alpha \\
1 & \text{if } y > \alpha 
\end{cases} \]

The probit model, for example, is given by

\[ \text{Prob}(\text{Injury}) = \Phi(y) = \Phi(z) \]

where \( \Phi \) represents the cumulative normal probability function. (With a logit model, \( \Phi \) would represent a cumulative logit probability function.) An estimate of the parameter vector \( \beta \) is obtained by maximizing the likelihood function \( L' = \text{IIProb}(z) \).

The data were initially evaluated with a logit model. Unfortunately, the Exposure Survey did not determine whether or not respondents had been injured. Since approximately 2%
of all ATV riders had been injured and treated in emergency rooms during 1985, the
direct analysis of responses from the two surveys will generate inconsistent logit parameter
estimators. (The comparison between the characteristics associated with injury vic-
tims and those not injured will be tainted because some of those labeled as noninjured
had in fact been injured.)
Fortunately, it is still possible to make statistical inferences about the relationship
between $y$ and $x$; this was done using a probit specification of the regression model.
Intuitively, it is possible to find out about unusual characteristics of the injured population
by means of an appropriate comparison of the two survey samples. The approach essentially
involves a general application of Bayes' rule—one infers information about the characteris-
tics of those who are uninjured from information about the general population and from
information about those who are injured. Suppose, for example, that the average experience
in the population of users is estimated to be two years, while the average for the injured
sample is only six months. Given prior information about injury rates, it is possible to
estimate the average experience for the population of noninjured riders.

To see how the probit model is estimated, let

$$f(x, y) = \text{the probability density function of } x \text{ and } y,$$

$$F(x, y) = \text{the corresponding probability distribution function.}$$

The initial (inconsistent) approach to parameter estimation is obtained by assuming that
all those in the Exposure Survey were not injured. In that case, the likelihood associated
with noninjuries is given by

$$g_1(x) = \int_{-\infty}^{\infty} f(x, y) dxdy.$$  

Similarly, the likelihood associated with injuries is given by

$$g_2(x) = \int_{-\infty}^{\infty} f(x, y) dxdy.$$  

The likelihood function to be maximized is

$$L = [\Pi g_1(x_i)][\Pi g_2(x_i)],$$

where the first product is taken over the Exposure Survey and the second over the Injury
Survey.

However, the appropriate likelihood function for those people in the Exposure Survey
(in which $z$ is not known) is

$$f_1(x) = \int f(x, y) dy.$$  

The likelihood function for those in the Injury Survey is the conditional distribution of $x$
given $z = 1$. This is calculated as the ratio of the joint density of $x$ and $z$ evaluated at $z = 1$,

$$f_1(x)\int_{-\infty}^{\infty} \frac{f(x, y)}{f(x)} dy = f_1(x)F_1(x)$$

to the marginal probability of an accident,

$$F_2 = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y) dxdy.$$  

Thus, the likelihood of each observation in the second sample is

$$f_2(x) = f_1(x)F_1(x)/F_2(x).$$

The overall likelihood function to be maximized is, therefore,

$$L = [\Pi f_1(x_i)][\Pi f_2(x_i)],$$

where the first product is taken over the Exposure Survey and the second over the Injury
Survey.

$L$ was maximized on the assumption that the joint distribution of $(x, y)$ is multivariate
normal. The important explanatory variables are listed in Table 1. Table 2 presents a
comparison of the consistent maximum-likelihood estimated parameters (maximizing $L$)
with the estimates obtained using the initial (inconsistent) procedure (maximizing $L'$).
Each of the vehicle and driver characteristics are highly statistically significant, with
signs that were generally expected based on causal evidence. The probability of an
ATV-related injury is higher for those drivers who 1) are younger; 2) are less experi-
enced; 3) are male; 4) are tall;5 and 5) have relatively low weight. The probability is also
higher when the vehicle being driven 1) is three-wheeled;\(\frac{10}{10}\) has been substantially
modified;11 and 3) has a large engine size.12 Finally, accident probabilities increase,
other things equal, for vehicles 1) that tend to be used in recreational as opposed to
work-related activities; and 2) that are used more often.

<table>
<thead>
<tr>
<th>Table 1. Variable definitions</th>
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<tbody>
<tr>
<td>AGE</td>
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<tr>
<td>DAYS</td>
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<tr>
<td>EXPERIENCE</td>
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<td>WHEELS</td>
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<td>SEX</td>
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<td>HEIGHT</td>
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<tr>
<td>WEIGHT</td>
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<tr>
<td>WORK</td>
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<tr>
<td>MODIFICATIONS</td>
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<tr>
<td>ENGINE</td>
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</tbody>
</table>
The two sets of coefficients are similar—they have the same signs in all cases. Nevertheless there are some differences in the results, as is apparent in Table 3, which shows the average annual probability of an injury accident for various combinations of vehicle and user characteristics. Each of the risk estimates is obtained by evaluating the probability of an accident for a typical driver who uses the ATV 11.7 days per month without modification, and who uses it for recreation only. The calculations for adult males are based on a 5’9”, 165 lb individual; for females, on a 5’4”, 125 lb individual; and for children, an 11-year-old, 4’8”, 77 lb child.

Note the substantial variation in accident probabilities that are suggested by the consistent maximum-likelihood estimates. For example, in part A of Table 3, one can see that the probability of an accident increases from 1.29% for a 25-year-old male driving a four-wheel 200 cc engine ATV to 3.36% for a three-wheel vehicle, and to 12.92% for an inexperienced male driving a three-wheel vehicle. In part B, the probability of an experienced 25-year-old male being injured driving a three-wheel ATV increases from 1.29% with a 110 cc engine to 4.65% with a 250 cc engine. Finally, part C shows that the probability of an 11-year-old male child with some experience being injured driving a 125 cc ATV increases from 2.22% when he is driving a four-wheel vehicle to 3.22% when driving a three-wheel vehicle.

3. Implications of the statistical results

The statistical analysis suggests that differences in users, vehicles, and use characteristics correlate with differences in accident rates. Many of these differences are statistically significant, since a change in patterns of use and/or a change in the vehicles being used can substantially lower the number of injury accidents. 

Table 3. Comparison of initial and consistent parameter estimates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial</th>
<th>Consistent</th>
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<tr>
<td>AGE</td>
<td>-0.24</td>
<td>-0.014</td>
</tr>
<tr>
<td>DAYS</td>
<td>0.048</td>
<td>0.048</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>-1.000</td>
<td>-1.000</td>
</tr>
<tr>
<td>WHEELS</td>
<td>0.645</td>
<td>0.648</td>
</tr>
<tr>
<td>SEX</td>
<td>0.882</td>
<td>0.850</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>0.064</td>
<td>0.050</td>
</tr>
<tr>
<td>WEIGHT</td>
<td>-0.010</td>
<td>-0.008</td>
</tr>
<tr>
<td>WORK</td>
<td>0.015</td>
<td>0.011</td>
</tr>
<tr>
<td>MODIFICATIONS</td>
<td>-0.995</td>
<td>-0.733</td>
</tr>
<tr>
<td>ENGINE</td>
<td>0.005</td>
<td>0.004</td>
</tr>
</tbody>
</table>

3.1. Awareness of risks

From a policy perspective, it is important to ask to what extent differences in accident rates are the result of actions by informed or uninformed individuals. A lack of information can distort the ATV market along a number of dimensions. First, some uninformed individuals will purchase ATVs when they would not do so with complete information. Second, some consumers might buy the wrong type of ATV, presumably one that...
Table 3 (continued).
C. Engine size, experience, and wheels (child)

<table>
<thead>
<tr>
<th>Engine size (cc)</th>
<th>Child (11 yrs), male, experienced, 3-W</th>
<th>Child (11 yrs), male, experienced, 4-W</th>
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<tr>
<td>Initial Risk Estimates</td>
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<tr>
<td>70</td>
<td>2.30</td>
<td>.92</td>
</tr>
<tr>
<td>110</td>
<td>2.79</td>
<td>1.13</td>
</tr>
<tr>
<td>125</td>
<td>3.02</td>
<td>1.21</td>
</tr>
<tr>
<td>185</td>
<td>4.07</td>
<td>1.65</td>
</tr>
<tr>
<td>200</td>
<td>4.37</td>
<td>1.78</td>
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<tr>
<td>225</td>
<td>4.95</td>
<td>2.02</td>
</tr>
<tr>
<td>250</td>
<td>5.59</td>
<td>2.30</td>
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<tr>
<td>Consistent Risk Estimates</td>
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<td></td>
</tr>
<tr>
<td>70</td>
<td>2.22</td>
<td>.80</td>
</tr>
<tr>
<td>110</td>
<td>2.94</td>
<td>1.10</td>
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<tr>
<td>125</td>
<td>3.22</td>
<td>1.22</td>
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<tr>
<td>185</td>
<td>4.75</td>
<td>1.92</td>
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<tr>
<td>200</td>
<td>5.16</td>
<td>2.12</td>
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<tr>
<td>225</td>
<td>6.06</td>
<td>2.56</td>
</tr>
<tr>
<td>250</td>
<td>6.94</td>
<td>3.01</td>
</tr>
</tbody>
</table>

is inherently more risky than they would otherwise choose. (Indeed, it is possible that safer models might not be produced at all.) Third, some individuals will not use their ATVs in as safe a manner as they would if they were well informed.

It is difficult to determine precisely how well individuals were informed about ATV risks in the early to mid-1980s, but the CPSC believed that a substantial proportion of users were not well aware of risks (see, e.g., the Final Consent Decree referenced in note 5). ATVs were relatively new products for most new users and had handling characteristics unlike other existing types of recreational vehicles such as trail bikes, bicycles, dune buggies, or snowmobiles. ATVs also appear to be safe vehicles; their three- and four-wheeled configuration and rugged construction give them a stable and sturdy appearance that belies the fact that they have unexpected handling characteristics and require a high degree of skill and attentiveness for safe operation.15

Underestimation of risks can, in principle, be corrected through the sales process and/or through the media. Whether and to what extent these corrections actually occur depends on one’s view as to how individuals process risk information. Suppose, as Viscusi and Magat (1987) suggest, that individuals are Bayesian decision makers, calculating their posterior probabilities of injury by updating their priors to account for new public and private information. Priors presumably are determined on the basis of individuals’ information relating to their own experiences with ATVs. As a result, advertisements about risk along with warnings at the time of sale will add to that store of knowledge; on balance, such advertisements should improve individuals’ risk assessments, but could lead to some individuals overestimating and others underestimating risk.16

In the case of ATVs, there is little hard evidence that safety was stressed in ATV advertising prior to the Consent Decree, or that the potential additional risks of three-wheeled vehicles was publicized.17 An exception is the negative publicity that ATVs received during the 1985–1987 period in such television programs as “Sixty Minutes” and “20/20,” and in five hearings held by the CPSC. In any case, the 1986 exposure survey of the CPSC reported that about 41% of riders had not heard or read about any ATV safety problems.

The only objective evidence that consumers were not aware of the risk differential between three- and four-wheeled ATVs prior to the Consent Decree comes from the used-ATV market. The Consent Decree stopped the sale of new three-wheeled ATVs, but did not create any impediments in market for used ATVs. Used three-wheeled ATVs were priced about $260 less than four-wheeled ATVs for the three months prior to the stop-sale. However, the price differential increased to about $475 during the three-month period following the stop-sale.18 One plausible interpretation of these results is that prior to the stop-sale, some consumers were buying riskier ATVs than they would have if they had been better informed.

An alternative view is based on the literature that indicates that individuals overestimate low-probability events that are brought to their attention (see, e.g., Slovic et al. (1978); Viscusi (1987)). From this perspective, it is possible that once ATV risks were publicized, there was an overreaction on the part of the public. Nevertheless, the used-ATV market data are consistent with the interpretation that the stop-sale provided risk information to consumers that reduced the relative demand for three-wheeled ATVs.

Whatever one’s interpretation, there is little doubt that the statistical results also reflect the risk-taking propensities of some classes of drivers. Thus, the probability that a male driver will have an injury accident is approximately twice that of a female driver. Assuming that males and females are equally well informed, this suggests that males have higher risk-taking propensities than do females. The same argument can be made for young drivers 15–25 years of age. It is unlikely, however, that the relatively high risk for young children can be attributed solely to risk-taking behavior, since children under the age of 12, because of inadequate strength, cognitive abilities, and motor skills,19 are not generally able to operate ATVs safely.

It is interesting to note that a majority of the settlement provisions in the ATV case were aimed at improving information. They included the following:

1. More stringent age recommendations. The adult-sized models are not recommended for children under age 16; ATVs intended for children 12–15 years of age are limited to the less powerful models with less than 90 cc; no ATVs are recommended for children under the age of 12.20
2. An agreement by manufacturers to provide free training courses for purchasers and their families, and to focus on children’s safety especially. Purchasers are given a $50 rebate or a $100 savings bond to encourage them to attend the training course.
3. An agreement by manufacturers to conduct a media campaign directed at informing ATV owners and users of the hazards of using ATVs.
4. An agreement by manufacturers to provide warning labels on newly manufactured ATVs, including a special warning directed at children.

3.2. Policy issues

A final note of caution concerning ATV regulatory policy seems warranted. Whether these policy prescriptions are appropriate cannot be answered in this article, or for that matter in any analysis that does not evaluate the link between regulatory solutions and private tort litigation. One can conceive, for example, of an ideal tort system that would resolve some or all of the inefficiencies associated with the informational problems just discussed. In such a system, the governing rule would be strict liability.\textsuperscript{21} If all individuals who are harmed bring suit and receive compensatory damages, the manufacturers of ATVs will internalize the costs of injuries, and the price of new ATVs will reflect the risks of injury and death. Under such an arrangement, manufacturers will take the efficient level of precaution, and activity levels will be right on average.\textsuperscript{22}

Unfortunately, our actual tort system is far from this ideal. For one thing, not all of those injured do bring suit: one expert has indicated that ATV cases worth less than $50,000 are rarely filed.\textsuperscript{23} In fact, tort awards are often substantially below what is necessary to induce appropriate safety incentives. (And the application of punitive damages in a few, often arbitrary, cases is not likely to correct for the fact that not all suits are brought.) In addition, many of those suits that have been filed have been settled on the understanding that settlement terms will not be made public.\textsuperscript{24} Finally, legal and court costs make product liability suits an expensive safety-generating mechanism. Within such a framework, it is unlikely that the tort system on its own will generate sufficient deterrence.\textsuperscript{25}

As Viscusi (1988) has suggested, however, the tort system in combination with the regulatory process can lead to overregulation, at least in cases in which product liability lawsuits generate additional regulation. To complicate matters, in most situations compliance with governmental regulations does not ensure immunity against private tort suits.

To what extent do a less than ideal tort system and a regulation-induced, but untested, attempt by manufacturers to inform individuals about risks complement each other? This remains an intriguing question for further study. The CPSC has reserved the right to regulate ATVs further, should such regulation be deemed necessary. Only time, a new statistical study of injury accidents, and an evaluation of ATV-related tort litigation will give us some answers.

Appendix 1: Data adjustments

The Injury Survey was conducted by the CPSC's Directorate for Epidemiology from May 1, 1985 through July 15, 1985. Observations for the Injury Survey came from the CPSC's National Electronic Injury Surveillance System (NEISS), which is based on a national sample of hospital emergency rooms. The Exposure Survey was conducted by Market Facts, Inc, from March 11, 1986 through April 10, 1986.

Since the Exposure Survey was conducted about 10 months after the Injury Survey, adjustments were made to the data to make valid comparisons between the two surveys. To avoid bias from changing sales patterns or driver characteristics in the interval between the two surveys, exposure observations were excluded if the driver had no experience at the time of the Injury Survey or if the ATV had been purchased after the Injury Survey was completed.

Unfortunately, CPSC was unable to add back to the data observations for ATVs that had been retired or for riders who had stopped riding during the interval between surveys. Since the older vehicles being retired tended to have three wheels, three-wheeled ATV exposure may have been underestimated, and hence risk overestimated. However, the impact of this factor is likely to be minimal. Approximately 82% of the ATVs in use at the time of the Injury Survey had three wheels. Based on industry scrapage rates,\textsuperscript{26} about 6% of the ATVs in use during the Injury Survey would have been retired prior to the exposure survey, and about 92% of the retired units would have had three wheels. Based on these estimates, three-wheeled ATV exposure would have been underestimated by about 0.64% (i.e., \[\frac{(0.82 - 0.92)(0.94 - 0.82)}{0.94}\]). In addition, a sensitivity analysis was conducted by increasing the relative weight of three-wheeled ATV observations in the exposure data. The results of the analysis were not altered.

Since the Exposure Survey gathered information only from ATV-owning households, accidents involving borrowers were also excluded from the analysis. The results are therefore applicable to drivers from ATV-owning households.

Appendix 2: Maximum-likelihood estimation

The multivariate normal distribution of \((x, y)\) is given by

\[
f(w) = \frac{1}{\sqrt{(2\pi)^d}} \exp\left(-\frac{1}{2} (w - \mu)^T \Sigma^{-1} (w - \mu)\right) = \phi(w; \mu, \Sigma),
\]

where \(w = (x, y)^T\), \(E(w) = \mu\), and \(\text{Var}(w) = \Sigma\).

Let the first \(n\) observations be associated with the Exposure Survey and the second \(m\) observations with the Injury Survey. Then the log-likelihood function for the entire data set is given by

\[
L(\beta, \mu, \Sigma; x) = \sum_{i=1}^{n} \log\phi(x_i; \mu_x, \Sigma_{xx}) + \sum_{j=1}^{m} \log\phi(x_j; \mu_y, \Sigma_{yy})
+
\log\left[1 - \Phi\left(\frac{\alpha - \mu_y - (x_i + n - \mu_x)\beta}{\sqrt{\Sigma_{yy} - \beta^2 \Sigma_{xx}}}ight)^{1/2}\right]
- \log\left[1 - \Phi(\alpha - \mu_y)\right].
\]

The model was estimated using the normalizations \(\mu_y = 0\) and \(\Sigma_{yy} = 1\). The actual estimates that were used are linearized estimates based on the final Newton-Raphson
step from initial consistent estimates. The initial estimates were computed as follows: \( \mu \) and \( \Sigma \) parameters were obtained by maximum-likelihood from the exposure sample. Estimates of \( \beta \) were obtained using maximum-likelihood estimation for the injury sample, treating the initial estimates as population values. A Lagrange multiplier test for distance from the maximum was approximately 3, indicating near convergence.

Notes

1. ATVs are characterized by large, low-pressure tires, a motorcycle-type seat, and handlebars for steering. Engine sizes range from about 50 to 500 cubic centimeters (cc) of displacement, and the weights of vehicles range from about 100 to 600 pounds. Suggested retail prices for new ATVs currently range from about $1500 to over $4000, and the expected product life is about seven years.

2. Based on survey data collected by the National Center for Health Statistics in the mid-1970s, about 59% of medically attended injuries of the type sustained in ATV accidents are treated outside of hospital emergency rooms.


6. The voluntary standard that was accepted by the CPSC in October 1988 includes requirements for footrests, mechanical suspension systems, and control switches. In addition, it includes some stability requirements, performance requirements for service and parking brakes, and speed limitations for models of less than 90 cc. See the U.S. Consumer Product Safety Commission, "Approval of Voluntary Standard for All-Terrain Vehicles," Federal Register 54, 1407-1428 (1989).

7. Further details are given in the appendixes to this article. Paul Ruud took primary responsibility for the econometric development and for the computer programming.

8. The taller the driver, the higher the driver-vehicle combination's center of gravity, and the greater the potential for ATV instability.

9. Lighter drivers may have less control over the ATV.

10. The triangular configuration of the three-wheeled ATV makes it more prone to tipping.

11. Major modifications, usually undertaken by sophisticated riders, include the installation of different tires or wheels, a special exhaust system, and engine high-performance kit, etc.

12. ATVs with larger engines are capable of greater accelerations and higher speeds than those with smaller engines.

13. One estimate places the actual cost, assuming an average (nonfatal) injury rate of 2%, at approximately $440 million in 1985.

14. If the decision to engage in the activity is well informed, one must ask whether it is appropriate to restrict choices (e.g., for children) or to create alternative incentive structures that reduce social costs associated with hospitalization, morbidity, mortality, and environmental damage.

15. This skill is required in part because ATVs have solid rear axles connecting two highly frictional rear wheels; this structural configuration gives ATVs a tendency to move straight ahead, which must be overcome before the vehicle can respond to the driver's steering commands.

16. Viscusi (1985) suggests that his Bayesian approach is more appropriate than an alternative approach by Lichtenstein et al. (1978) that would rule out the possibility of information causing individuals to overestimate risk. However, there is evidence that brings the use of Bayes's rule into question. See, for example, Tversky and Kahneman (1982).

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17. Masis (1988) analyzed ATV advertising from 1980-1987 by evaluating 39 television commercials and 281 print ads in 31 periodicals. The only safety theme that appeared was that the safe operation of ATVs is primarily associated with wearing proper equipment.

18. The data are from the National Automobile Dealer Association appraisal guides. See Rodgers (1989) for a more complete hedonic price analysis of the used ATV market.


20. The Consent Decree does not prohibit the sale of ATVs less than 70 cc, which had been permitted for children under the age of 12. However, no such ATVs are currently produced.

21. Strict product liability has become the norm in American law. To be successful in a product-liability suit, the plaintiff must show the product to be defective in 1) manufacturing; 2) design; or 3) the failure to warn the users of the product's dangers. Failure to warn is arguably relevant in many ATV injury cases. To the extent that moral hazard is a concern, a rule of strict liability with a contributory negligence defense would be more appropriate.

22. Not all users are equally informed about risk. Therefore, even under this ideal tort system, individual choices concerning the purchase and use of ATVs will not necessarily be the efficient.

23. Even though all those injured do not bring suit, it should also be pointed out that not all injuries are due to product defects.

24. On the basis of an informal discussion with an expert who has appeared in ATV litigation, we estimate that about 1500 ATV cases have been filed. Of those, 1000 have been disposed of, with approximately 90% settling. Of those cases going to trial, plaintiffs won about one quarter. In one recent case, $5 million in punitive damages was awarded. Of the cases that settled, approximately 40% were in the range of $50,000 to $250,000, for 40% were in the range of $250,000 to $1 million, and 20% were over $1 million.

25. However, see Shavell (1984), who argues that neither regulation (imperfect information) nor liability (a probability less than one of being sued and paying compensation) is the proper way to compensate the other party. He supports the view that it is often advantageous for both means of controlling risk to be used. One important advantage arises when the harms generated vary among individuals, but a single regulatory standard applies. In this case Shavell shows that it can be efficient to set a lower than optimal (first-best) standard. Those individuals that meet the standard but generate substantial harms will be deterred by the possibility of liability. See also Shavell (1974) and Viscusi (1989) for further discussion of issues relating to regulation and liability.


References


