Miss-and-run: Factors contributing to two-vehicle phantom vehicle crashes in Florida

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ABSTRACT

Objective: Phantom vehicle crashes (PVCs), or miss-and-run crashes, are a topical issue in car insurance coverage because of controversies over testimony and compensation. However, no peer-reviewed literature has examined the perceptions and deliberations involved in this infrequent type of car crash. A novel taxonomy of roadway traffic crashes is proposed in this study on the basis of whether physical collisions did occur (hit or miss) and whether the perpetrators stayed at the crash scene (stay or run). In this way, this study poses the issue of PVCs within the scope of traffic safety research and aims to investigate the statistically significant factors that are likely to induce PVCs.

Methods: A binary logistic regression method was adopted to model the probability and occurrence of 2-vehicle PVCs (TV-PVCs) in Florida. Data derived from the Crash Analysis Reporting system in 2012–2014 consisted of 45,319 2-vehicle crashes, of which 1,376 (3.04%) were confirmed as positive TV-PVCs. Sixteen factors with 50 variables on crash information, roadway characteristics, and environmental conditions were included in the original consideration of the TV-PVC model.

Results: The results indicated that a 2-vehicle crash is more likely to be a PVC when the crash happens on weekends, on roadways with no traffic control or speed control, full access control; on curving and sloping roadways; on roadways of National Highway System; and in low-density areas. A TV-PVC is less likely to occur on dry roads, in daylight, or at intersections or driveways. Moreover, alcohol involvement in a 2-vehicle crash is associated with hit-and-stay crashes than PVCs, and uninsured motorists are more likely to be the victims of PVCs because they tend to avoid physical collisions due to the potential self-paid loss.

Conclusions: Several conclusions for better understanding the occurrence of PVCs are proposed for traffic management departments and car insurers. Cautious driving behavior including concentrated attention and deliberate lane changes should be encouraged for motorists to engage in appropriate levels of driving freedom, and drunk driving should be strictly supervised to keep motorists behind the wheel conscious. Car insurance is encouraged to compensate for economic loss resulting from roadway crashes. Road monitoring systems with well-performing illumination devices are recommended to help drivers provide potent testimony for compensation claims.
Whether physical collisions occur among those involved in the crash

| Categories | Yes (hit) | No (miss) |
|------------|-----------|-----------|
| Whether the perpetrators stay at the crash scene | H&S crashes | M&S crashes |
| | H&R crashes | Phantom vehicle (M&R) crashes |

*H&S crashes and M&S crashes may be the most frequent and the most rarely recorded events in police accident records, respectively.

(hit-and-runs). However, sometimes the vehicle responsible for causing an accident may not actually be directly and physically involved in the crash (Carbone 2016) and can be absent from the accident scene; these are usually termed *phantom vehicle crashes* (PVCs) or *miss-and-run accidents* (Rasansky 2013). For instance, a run-off-road crash that results from avoiding a head-on collision may be caused by a car A in the opposite direction, who illegally drifts over the center line of the highway into your lane to try to pass another car B in front of it; A then veers away (Online Auto Insurance 2015). Car A, the phantom vehicle in this case, does not make any physical contact with you or other crash-involved vehicles but is still the perpetrator that principally caused the accident.

On the basis of the analysis above, the present study innovatively classifies road traffic crashes into 4 categories using 2 perspectives; that is, whether the (1) crash parties have a physical collision with other vehicles (for vehicle–vehicle crashes) or objects (for single-vehicle crashes) and (2) perpetrators or at-fault vehicles stay at the crash scene for the police or just flee (intentionally or unintentionally). According to this taxonomy, any crash must exclusively fall into one of the 4 categories shown in Table 1; that is, hit-and-stay (H&S) crashes, miss-and-stay (M&S) crashes, hit-and-run (H&R) crashes, or phantom vehicle (miss-and-run, M&R) crashes. The PVCs in this study refer to a peculiar type of roadway traffic accident involving phantom vehicles that make no physical contact with the crashed vehicles and are absent from the crash scene. In a PVC, it may be cumbersome for authorities to affirm the technical responsibility of the crash and for the insurer (if have) to quantify the financial reimbursement.

PVCs endanger public interests in multiple respects. For example, analogous to hit-and-run crashes, the escape of phantom vehicles can delay the identification and emergency rescue of victims, which increases injury severity and the mortality rate. Although there are some modes of evidence available to prove that phantom vehicles were at fault in the crash, insurance companies often receive dishonest claims. The Association of Certified Fraud Examiners (2009) declared that fraud involving PVCs is one of the most common schemes that cheaters used to defraud automobile insurance companies. When phantom vehicles are responsible for crashes, proving liability and collecting full financial compensation is crucial, especially in a 2-vehicle (i.e., the victim’s vehicle retained at the scene and the at-fault one missing from the scene) crash (Baron & Herskowitz 2014).

To the best of our knowledge, no previous peer-reviewed study has specialized in the analysis of the determinants of PVCs in the domain of traffic safety or the insurance industry. Therefore, the primary purpose of this study is to pose the issue of PVCs to the academic field of traffic safety and to investigate the risk factors involved in 2-vehicle PVCs to ensure motorists’ personal safety and provide suggestions concerning PVC-related insurance controversies. The effects of various crash-related factors on the propensity of a positive PVC to occur are examined so that some characteristics of PVCs can be identified to better understand this type of crash; proper countermeasures can then be taken to prevent injuries and economic loss to motorists from occurring in these incidents.

### Literature review

The issue of PVCs initially appears in the automobile insurance industry with some evidence of sporadic legislation and some homepages or websites belonging to traffic crash attorneys or law offices. As a postaccident measure to ease the economic burden that road traffic crashes impose on society and households, drivers may consider purchasing automobile insurance, which is a contract signed between an automobile insurance company (insurer) and the car owner (insured) to cover physical damage or losses resulting from collision, theft, or other unfortunate events (Hsu et al. 2016). In legal terms for insurance purposes, a *phantom vehicle* is defined as one that causes bodily injury, death, or property damage to an insured but involves no physical contact with the insured or the vehicle the insured is occupying at the time of the accident (Washington State Legislature 2017) or, shortly, a traffic crash in which the perpetrator vehicle leaves the scene after causing another vehicle to crash without actually contacting the other vehicle (Wright 1977). Some PVC victims may even be accused of fabricating a story in order to blame someone else for their crash, and many may not even try to seek compensation for their property damage and injuries (Rasansky 2013). This means that if a PVC victim cannot provide credible evidence, it is troublesome to clarify the causality concerning the event to the insurer (if insured) for insurance compensation. Generally, modes of credible evidence that could legally be presented to prove that someone is a victim of a PVC usually include (1) video data from a Vehicle Data Recorder, (2) video from an authoritative or public camera installed in proximity to the incident site, and (3) testimony from witnesses to the incident.

In addition to the aforementioned lack of legislative clauses and legal websites, little literature involving PVCs can be reviewed in the academic research field. In a recent case-control-based analysis of highway safety (Gross 2013), any observation from *phantom* or *hit-and-run* crashes was excluded from the data set. As one type of automobile insurance fraud, phantom vehicle frauds are related to insurance issued for fake, nonexistent vehicles (Abdallah et al. 2016). Therefore, this study contributes to the current literature on the issue of PVCs from the perspective of academic research and by exploring the risk factors for the occurrence of PVCs to achieve a preliminary understanding. Compared
to the scant PVC-related literature mentioned above, studies of another rare crash type, hit-and-run crashes, have received more academic interest. To provide some insights on the discussion of PVCs in this study, Table 2 presents almost all hit-and-run-related studies in the past 10 years.

### Methodology

To investigate the risk factors affecting the propensity for a PVC to occur, the data set derived from the Crash Analysis Reporting (CAR) system of the Florida Department of Transportation was used in this study. The key variable driver action code classified and coded drivers’ postcrash actions into 4 classes: Not applicable (0), phantom (1), hit-and-run (2) and all other drivers (3). To specifically tackle the phantom (miss-and-run) behavior of drivers in a crash, driver actions coded as not applicable (0) and hit-and-run (2) are excluded in this study, so that the dependent variables are exclusively dichotomous; that is, PVCs or non-PVCs. As mentioned before, this study focuses on 2-vehicle PVCs (TV-PVCs), which are defined as those crashes involving one positive phantom (i.e., miss-and-run) vehicle and just one other crashed and retained vehicle. The descriptions of all variables used in the TV-PVC model are shown in Table A1 (see online supplement), including 1,376 positive TV-PVCs (30.04%) of the 45,319 2-vehicle crashes from 2012 to 2014 with 50 independent variables derived from 16 factors.

An important task before developing the model is the selection of appropriate factors. Two considerations were jointly taken to select the factors. Firstly, given the comparable crash-causing mechanism between the PVCs and hit-and-runs, the selection of variables referred to the existing hit-and-run-related studies in Table 2, and the hit-and-runs were found to be associated with the crash- and environment-related factors considered in this study. Secondly, the CAR system used in this study basically contains information classified as person, vehicle, and crash that are reserved in 3 separate sub-data sets, and other promising factors that might be associated with the occurrence of PVCs (e.g., insurance conditions) were also included in the original model.

In this study, whether a crash is a PVC or not is a binary variable. Sophisticated techniques—for example, the mixed logit model—may provide us with in-depth insights into the data; however, they usually rely on the quality of data sets. Failure of convergence when conducting the mixed logit model in this study hints that it may be inappropriate for this data set involving infrequent events like PVCs. On the other hand, to treat the skewness or nonsymmetry of the events (i.e., the PVCs) in this study, a skewed logistic (scobit) model and likelihood ratio tests (Nagler 1994; Tay 2016) were developed to identify significant factors contributing to a PVC and to investigate its significant difference from a standard logistic model. The likelihood ratio test of the scobit model ($P = 0.8878$) indicates that it is not significantly advantageous over a standard (binary) logistic model. Given that almost all of the hit-and-run studies in the past 10 years utilized a binary logistic regression model as a dominant and highly efficient method (see Table 2), a binary logistic regression model is a suitable, cost-effective method and was adopted to model significant variables affecting the occurrence of a PVC in this study. Specifically, the logit is the natural logarithm of the odds $p/(1−p)$ that the dependent variable is 1 (a PVC) as opposed to 0 (not a PVC). The probability $p$ of a PVC is expressed as (Washington et al. 2011)

$$Y = \logit(p) = \log \left( \frac{p}{1-p} \right) = \alpha + \beta x,$$

where $\alpha$ is the intercept term of the model, $\beta$ is a vector of the coefficients to be estimated, and $x$ is a vector of the explanatory variables. In this study, independent variables related to the crash and the vehicle are dichotomous (present $= 1$, absent $= 0$). When an independent variable $x_i$ increases by one unit as all other factors hold constant, the odds increase by the factor $\exp(\beta)$, which is called the odds ratio (OR) and ranges from 0 to positive infinity. The odds ratio indicates the relative amount by which the odds of the outcome (PVC) increase (OR $> 1$) or decrease (OR $< 1$) when the value of the corresponding independent variable increases by one unit.
Results and discussion

Simple correlation tests between selected variables were conducted before doing a regression, and strong correlations were found between variable interstate and full access control ($r = 0.79$) and no access control ($r = -0.77$). To avoid potential multicollinearity, the factor road system identifier was omitted while other detailed factors that depict roadway conditions like traffic and access control type were retained. Data were analyzed using Stata (Ver. 14.0). After the full model was estimated, the variables that were not significant were excluded to conduct the final logistic model for high estimation efficiency. Lacking previous peer-reviewed studies on PVCs, the following results and analysis are comparable to the existing findings of studies on hit-and-run crashes, whose crash-causing mechanism is analogous to that of PVCs.

The estimation results of the final TV-PVC model are shown in Table 3. Overall, the final model fits the data quite well: with very small $P$ values (.0000), relatively large pseudo-$R^2$ values (0.1468), and a high area under the receiver operating characteristic curve value (0.8016). The statistically significant independent variables that better explain TV-PVCs in Florida at a 95% confidence level ($P = .05$) include weekends, no traffic control, straight–level, straight–sloping, curving–level, dry, daylight, intersection, driveway, alcohol, insured, National Highway System (NHS), full access control, low-density and other areas, among which the variables weekends, no traffic control, full access control, and low-density areas may be related to high levels of driving freedom.

As a whole, a PVC is found to be significantly affected by the conditions in which the motorists can drive at will with fewer restrictions or disturbances. For instance, the estimation result showed that a 2-vehicle crash that happened on a weekend (OR = 1.350, $P = .007$) was more likely to be a PVC than if it occurred on a weekday. Similar results involving hit-and-run crashes were found to be more likely to occur on weekends than on weekdays (MacLeod et al. 2012; Tay et al. 2010), probably because drunk driving is more likely to occur on weekends (Tay et al. 2009). With regard to traffic control types, relative to a crash that happens on roadways with a stop sign, those 2-vehicle crashes that occur on roadways with no traffic control (OR = 2.752, $P = .000$) were found to correlate significantly with TV-PVCs; this also implies that a driver’s freedom to drive without external restrictions would probably increase the likelihood of a PVC occurring. As with the access-control type of road, a fully access-controlled roadway (OR = 2.539, $P = 0.000$) was found to be significantly related to the occurrence of a PVC, relative to a non-full access-controlled roadway. A fully access-controlled road is usually associated with a high posted speed and frequent lane-changing behaviors; thus, a tiny perception–reaction time would be left for victims while perpetrators could swiftly leave the scene. Further evidence comes from land use types. Relative to the variable CBD and high-density areas, a 2-vehicle crash is more likely to be observed as a phantom one when it occurs in low-density areas (OR = 1.746, $P = 0.000$). High-density areas allow less freedom for perpetrators (i.e., the potential phantom motorists) to flee from the scene whether intentionally or unintentionally and more chances for them to be made aware of what is happening by victims or witnesses.

| Variables Coefficient | Odds ratio | $P$ value |
|-----------------------|------------|-----------|
| cons                  | -2.471     | 0.084     | .000     |
| Day of week (base: Weekdays) | 0.300 | 1.350 | .007 |
| Traffic controls (base: Other controls) | 1.012 | 2.752 | .000 |
| No control            | 0.879      | 2.409     | .000     |
| Speed control         | 0.932      | 2.539     | .000     |
| Road alignments (base: Curving–sloping) | Straight–level | -0.836 | 0.433 | .002 |
|                       | Straight–sloping | -1.122 | 0.326 | .000 |
|                       | Curving–level  | -0.897    | 0.408    | .035    |
| Road surface conditions (base: Non-dry) | Dry | -0.227 | 0.797 | .50     |
| Lighting conditions (base: Non-daylight) | Daylight | -0.449 | 0.638 | .003 |
|                       | Site locations (base: Other locations) | Intersection | -0.446 | 0.640 | .003 |
|                       | Driveway     | -0.917    | 0.400    | .009    |
| Alcohol/drug (base: No violation) | Alcohol | -1.871 | 0.154 | .000 |
| Accident insurance (base: Uninsured) | Insured | -1.044 | 0.352 | .000 |
|                       | Federal highway systems (base: Non-NHS) | NHS | 0.614 | 1.847 | .000 |
| Access controls (base: Non-full access control) | Full access control | 0.932 | 2.539 | .000 |
|                       | Land use types (base: CBD and high-density) | Low-density | 0.557 | 1.746 | .000 |
|                       | Other lands   | 0.392     | 1.480    | .001    |

*Other areas refer to those land use types excluding CBD and high density areas or low density areas.

Table 3. Final logistic regression estimation results of 2-vehicle PVCs. A

A traffic operating characteristic curve value (0.8016; Hosmer-Lemeshow $\chi^2(8) = 5.73$.)

References

- Jiang et al. 2016
- MacLeod et al. 2012
- Roshandeh et al. 2016
- Tay et al. 2009
- Tay et al. 2010
- MacLeod et al. 2012
- Roslandeh et al. 2016

These results suggest that poor lighting conditions are conducive to a perpetrator running from the crash scene because of an unintentional driving interaction or few witnesses and difficulties of recognition.
Roadway surface type usually affects braking distance by different friction coefficients. Inferior roadway materials might be associated with a poor driving environment, and drivers could be more inclined to lose mechanical operability when reacting to abrupt driving disturbances like cutting in. However, the findings of the present study did not show supportive evidence that surface type would have a significant contribution to PVC. As with the crash site location, relative to 2-vehicle crashes occurred at nonintersections or ramps, the results indicated that crashes at intersections or on driveways are less likely to involve a miss-and-run phenomenon. Possible reasons could be that motorists usually drive cautiously at intersections and driveways, more pedestrians and witnesses exist at intersections, and fewer PVCs in driveways could be expected to be reported to the police.

For almost all existing hit-and-run-related studies, alcohol involvement in a crash is found to be highly relevant to hit-and-run behavior. However, the present study implied a contemporary outcome for the occurrence of a PVC versus hit-and-stay crashes. The model results indicated that, relative to no alcohol, alcohol involvement in a 2-vehicle crash is 84.6% more likely to result in a hit-and-stay crash than a PVC (OR = 0.154, \( P = .000 \)). This is logical because in a 2-vehicle crash, there would be a higher probability of a drunk driver incurring a physical hit than a precise miss.

Regarding car insurance, the results indicated that for a 2-vehicle crash, being insured is associated with the occurrence of hit-and-stay crashes (OR = 0.352, \( P = .000 \)). Because the insurance condition of the phantom vehicle is probably hard to track, this result also implies that an uninsured vehicle would indeed be more likely to be the victim of a PVC. In other words, when encountering an emergency, uninsured motorists have the propensity to avoid physical collisions due to the potential self-paid loss than insured motorists, who would be compensated by insurers if a hit crash occurred, which provides some empirical evidence on the clarification of PVC-related insurance controversies.

Other variables such as roadway median, roadway surface types, injury severity levels, and so on did not significantly affect the occurrence of a TV-PVC in this study, implying that the effects of these variables on the occurrence of a TV-PVC need to be examined in further studies.

In conclusion, PVCs are generally a topical issue in the practical application of car insurance coverage because of the controversies and the difficulties involved in testimony and compensation, but no previous peer-reviewed study has examined this topic either in the field of car insurance or injury prevention. The objective of this article was to perform an exploratory analysis of significant factors that are more likely to induce 2-vehicle PVCs and to academically propose this infrequent type of crash to further understanding.

By examining the impact of 50 variables on the occurrence of PVCs in Florida, this study found that a 2-vehicle crash would be more likely to be a PVC when the crash happened on a weekend, on roadways with no traffic control strategies or curving and sloping alignments, on roadways belonging to the NHS, on roadways with full access control, and in low-density and other areas. In contrast, the probability of a TV-PVC would decrease if a 2-vehicle crash happened on dry roads, in daylight conditions, at intersections or driveways, when alcohol is involved, and when the staying party is insured. Note that the results of this study suggested that when compared with hit-and-stay crashes, alcohol was found to have a negative influence on the occurrence of TV-PVCs. In addition, an uninsured vehicle would more likely be the victim of a TV-PVC than an insured one, which provides some evidence on the clarification of PVC-related insurance controversies.

To decrease the occurrence of PVCs and avoid or clarify the controversies in testimony and compensation of traffic crashes, several countermeasures are proposed according to the findings of this study. First, cautious driving behavior, including concentrated attention and deliberate lane changes, should be encouraged, because the results showed that those conditions that encourage drivers to engage in high levels of driving freedom (such as weekends, roadways with no traffic control strategies, or full access control) were significantly associated with the occurrence of TV-PVCs. Second, alcohol involvement was proved to have a negative effect on TV-PVCs but will increase the likelihood of hit-and-stay 2-vehicle crashes (as well as hit-and-runs). More alcohol checkpoints should be employed to ban drunk driving because the fact that alcohol is highly related to serious injury severities and fatalities has long been verified by numerous studies (Behnood et al. 2014; Hobday and Meuleners 2018; Stephens et al. 2017). Furthermore, installing automobile video recorders and improving road monitoring systems with well-performing lighting systems for real-time surveillance would unquestionably help drivers or victims to replay the course of the accident and provide potent testimony for compensation claims. In the future, the effects of further factors that account for miss-and-run behavior should be considered in greater detail.

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