Paying for Safety:
An Economic Analysis of the Effect of Compensation on Truck Driver Safety

Executive Summary

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This report examines the link between truck driver pay and driver safety. It establishes a relationship that is important for policy purposes because it suggests that low driver pay, which we expect is linked to low but unmeasured human capital, may be an important predictor of truck driver safety. The study uses three different data sets at three different levels of analysis to demonstrate this link. The study also includes an estimation of the truck driver labor supply curve, an important contribution to understanding drivers' (and carriers') preferences for balancing income and work time. One model includes the entire population of drivers at a very large truckload motor carrier and uses survival analysis (also known as duration modeling) to measure individual crash probabilities over time while controlling for individual and work characteristics. Another model uses a cross section of more than 100 truckload carriers to link driver pay with safety performance across firms. The third model uses a representative sample of individual drivers across all firms engaged in over-the-road operations to demonstrate the effect of driver pay in predicting crashes.

Previous Research

Research has shown that:

- Over-the-road drivers ordinarily are paid on a piecework basis;
- Real pay levels for trucking industry personnel have declined over the past two decades; real pay levels have declined relative to employees in other industries;
- Benefits availability and level of benefits have declined, and deferred compensation in the form of pensions has declined;
- Unionization has declined, further reducing compensation;
- The trucking industry has been increasingly competitive and firms and drivers are under great pressure to deliver loads just-in-time and quickly.

Theory

We expect driver compensation to predict safety outcomes because:

- Employee earnings levels affect the quality of drivers attracted to the job;
- Employee expected earning levels also determine the quality of the drivers attracted to the job; both earnings levels and expected earnings affect employee behavior;
- Employee pay methods affect employee behavior;
- Turnover, a likely independent predictor of safety, is related to compensation.

Economic theory would lead us to predict that low pay levels would be associated with low human capital and lower human capital would be associated with inferior performance outcomes. We hypothesize that low human capital is associated with unsafe driving, since higher quality workers can be expected to perform better in their jobs and since safe driving is an important attribute of high performing truck drivers.

Data

Study 1

Data for the cross-sectional analysis of the truckload sector come from the following.

Executive Summary Table 1

Data set	Variable	Year
National Survey of Driver Wages	Mileage pay	1998
	Raise	
	Safety bonus	
	Production bonus	
	Health insurance	
	Life Insurance	
	Paid time off	
	Length of run	
	Governor Speed	
National Motor Carrier Directory	Power units	
MCMIS	DOT reported crashes	1998
UMTIP firm-level survey	Unpaid non-driving time	2000
	Power units	
	Miles	

The National Survey of Driver Wages, for which the shorthand term "Signpost" is used throughout this report, is a privately collected but purchasable dataset which covered 198 truckload (TL) firms (mostly general freight but including some specialized carriers) in 1998. While this dataset is not representative of the population of TL firms, as only those carriers willing to provide data to Signpost are included, it does cover a large part of the TL sector and is cited widely as an authoritative source of driver wage information. We conducted our own survey of Signpost firms to develop a measure of unpaid non-driving time, since Signpost declined to collect this information systematically on the presumption that drivers simply are not paid for this time (which we found not to be true). The UMTIP firm-level survey collected information on firm pay method and level for non-driving time and supplements Signpost. The Motor Carrier Management Information Systems data set is a data file maintained by the U. S. Department of Transportation.

Study 2

Data for the individual firm driver-level study come from truckload carrier J.B. Hunt over two periods of 13 months each. The dataset included observations on 11,540 individuals for one to 26 months; a total of 92,528 person-months were observed. Drivers were observed at Hunt before and after a major wage increase. Hunt raised wages in an effort to reduce crashes and turnover, so the wage increase was accompanied by other efforts designed to achieve these goals, such as a promise to send drivers home within two weeks of a request. These data are proprietary and not available to the public.

Elements of the dataset include:

- Age
- Gender
- Race (white and non-white)
- Marital status
- Base pay (cents/mile)
- Pay increase from period 1 to period 2
- Miles driven per month
- Dispatches per month
- Driving season (Winter)
- Hiring date
- Tenure with firm
- Prior moving violations (only for a subset of the data)
- Driving experience prior to hire (only for a subset of the data)
- Crash occurrence
- Date of termination, if employee is terminated during observed periods

Study 3

Data for the individual driver study come from the University of Michigan Trucking Industry Program. Drivers were selected using a stratified random sample of truck stops (stratifying on size of truckstop proxied by number of parking spaces) in Michigan, Ohio, Indiana, Illinois, and Wisconsin and randomly selecting drivers at each truck according to a carefully developed sampling design. Data were collected in two "waves," one during the summer of 1997 and another during four seasonal periods beginning in the spring of 1998 and continuing to the winter

of 1998/1999. Data are proprietary and not available to the public. All of the information is self-reported.

- Crash during the past year
- Yearly Miles
- Mileage Rate
- Unpaid Time
- Paid Days
- Health Insurance
- Late Penalty
- Safety Bonus
- On Time Bonus
- Tenure
- Experience
- High School Grad
- Weekly Hours
- % Non-Driving time
- % Night Driving
- Union Membership
- Firm Size
- Type of trailer used

Findings

Truck Driver Labor Supply Curve

An important component of this study involves modeling the labor supply curve for truck drivers. Using the UMTIP driver survey data we demonstrate a classic backward-bending labor supply curve, which is predicted but rarely found in other data because of institutional and other limitations on actual work practice. In the case of over-the-road truck drivers, whose hours are not constrained by the Fair Labor Standards Act and whose maximum hours enforcement agencies find very difficult to regulate, we see a full backward-bending curve within the range of valid observations.

While such a curve theoretically represents drivers' preferences in trading labor and leisure, our institutional knowledge leads us to think that driver and firm preferences are not independent. That is, this curve represents the joint choice by drivers to work more or less hours depending on their rate of pay as well as the firms' choice (at various levels of pay) to ask or require drivers to work more hours or, alternatively, to limit their hours. We would expect firms paying lower wages to require drivers to work more hours (take more runs) and that drivers working for lower wages would tend to want to take more runs (work more hours) to reach their target earnings (they would collaborate with firms to work more hours). Firms which pay higher wages tend to be unionized, and union wages and bargaining power give workers a higher rate of pay (and less need to work longer hours to reach target earnings) and greater leverage with the firm to refuse extra work.

- At 20 cents per mile, drivers have a positive economic incentive to work 48.9 hours.
- At 25 cents per mile, drivers have a positive incentive to work 60.1 hours.
- At 31.4 cents per mile, drivers - on average - choose to work 65.1 hours per week.

Above this pay level drivers' preference for more work hours declines.

- At 37.8 cents per mile, the drivers' preference for work declines to 59.9 hours per week
- At 42.1 cents per mile, the drivers' preferred work level drops to 50.6 hours.

This finding demonstrates conclusively that increasing driver pay decreases the likelihood that drivers will work more hours. This finding is entirely consistent with prevailing economic theory with respect to the labor - leisure tradeoff.

Safety Study 1: Firm-level cross sectional analysis

- Average pay is $0.286 per mile for drivers with three years experience.
- The average driver works 0.004 hours of unpaid time per mile driven, or 3.6 hours of unpaid time per trip with an average reported trip length of 906 miles.
- The average expected annual raise in driver pay is $.0007 per mile.
- 49% of firms pay a safety bonus.
- 28.4% of firms pay a production bonus.
- The average driver pays $166.84 monthly for health insurance.
- The average amortized value of a driver's available life insurance policy is $15,505.
- The average driver receives $773.56 per year in paid time off.
- The average run is 905.85 miles.
- 20.6% of all firms primarily use flat bed trailers.
- 51.0% of all firms primarily use van trailers.
- The average carrier has 683 power units.
- 76.5% of carriers use governors to limit truck speeds.

We ran a negative binomial regression to predict the number of crashes in each firm as a function of various pay variables and other carrier characteristics. The results are highly significant, with most compensation variables except "pay raise" significant at the 0.01% level (pay raise is significant at the 10% level; paid time off is not significant). Incentive variables produce uneven results: "safety bonus" is significant, while "production bonus" is not.

We converted the estimates to elasticities to explain most clearly the effect of each of the independent variables. If we sum up all of the compensation effects tested in this model, we find that compensation and crashes are inversely related on nearly a 1:1 level. To be specific, for every 10% more in average driver compensation (mileage rate, unpaid time, anticipated annual raise, safety bonus, health insurance, and life insurance), the carrier will experience 9.2% fewer crashes.

Safety Study 2: Individual driver level study at one firm

A pay raise by a major TL carrier gave researchers an ideal scenario for a quasi-experimental research design. How much does driver pay predict safety? What is the effect of a major pay increase on safety?

Table 2 shows the raw effects of the pay raise on demographic and occupational factors.

Executive Summary Table 2: Before and After Descriptive Data

	Before the raise	After the raise
Age	38.0	41.6
Female	3.6%	2.0%
White	72.9%	78.2%
Non-married	53.6%	43.7%
Base pay (dollars/mile)	$0.262	$0.336
Percent pay raised		10%
Miles per month	9,155	9,190
Dispatches per month	15.6	16.2

The variable "percent pay raised" substantially understates the increase because all drivers did not receive a pay raise. Drivers who were hired at a low rate during the first period and who were retained under the new regime received pay raises, while drivers who were hired during the first period and who did not remain after the pay raise are not in the dataset. In addition, drivers who were hired at the higher rate in the second period also did not receive a raise. Among drivers receiving a pay raise, the average increase is 38%.

Both driver pay rate and the pay increase have statistically significant effects on the probability of observing a crash each month. All predictors are significant at the 0.01% significance level except marital status, season, and the interactive effect of age and time observed, which are significant at the 0.05% confidence level. Other covariates that were not statistically significant include gender, number of dispatches and time of hire (before or after pay raise).

The key findings are, controlling for the other effects in the model:

- Driver crash risk decreases with age until the driver reaches 41 years of age, when the effect changes direction. A driver that is 20 years old has a crash risk similar to the crash risk of a driver 62 years of age, all other characteristics held equal.
- Non-married drivers are safer.
- Higher pay rates are associated with greater driver safety.
- Pay increases are associated with greater driver safety.
- The more miles drivers drive the safer they are (probably reflecting miles on Interstate highways).
- Longer driver tenure contributes to safety.
- Drivers are safer in winter.
- The interaction of driver age and driver base pay over time also significantly contribute to higher safety outcomes.
- There are unmeasured attributes, perhaps at the driver or at the operations level, that suggest that crash risk decreases over time, even after controlling for the variables described above.

What does this mean in terms of elasticities? The results show that *at the mean*, for every penny in a *driver's base pay rate*, the risk of crash is 11% lower; in percentage terms, *at the mean* a 10% higher *driver base pay rate* (hiring rate or the rate at which the drivers were paid before the pay increase, which generally is the hiring rate) leads to a 34% lower probability of

crash. The effect is not linear, so this elasticity will change above and below the mean. In addition, *for every 10% raise in driver pay that occurred while we observed the drivers*, there is a 6% reduction in crash risk. However, this effect cannot be attributed solely to the pay raise, since individuals getting the pay raise tend to be, on average, more safe than other individuals. These crash effects are independent of the demographic changes that resulted from the pay increase.

We ran a further analysis on the drivers who worked for Hunt during the second period (after the pay raise). For these drivers we have prior driving experience measures, and thus together with tenure at the firm, we can construct a measure of total driving experience. As with age, we found that the relationship between total driving experience and crash risk is quadratic: as experience increases, crash risk is lowered, but at a decreasing rate. Evaluated at the mean experience for the sample (5.2 years), this suggests an elasticity of -4.94; at the mean, 10% more experience leads to a 49.4 percent lower probability of crash. However, this decreasing effect of experience rarely is observed in the data since experience is associated with lower crashes for the first 18 years of a driver's experience.

Overall, we conclude from these analyses that higher driver pay is associated with a lower probability of crash. Conventional economic theory supports the assertion that pay is a proxy for human capital. Most of this human capital is unmeasured: we simply have no good measures in conventional data sets nor in our own data sets to calculate this effect, so it remains captured by proxies such as pay, race, and other factors. In addition to serving as a proxy for human capital, and consistent with our other studies, we also find that a pay increase appears to have an "incentive" effect that results in safer driver behavior. The causal underpinnings of such behavioral outcomes are a matter for further research. For the purpose of public policy, however, it may not make any difference for safety outcomes whether higher pay results from the sorting effect or from the incentive effect: the consequence is still greater highway safety.

Safety Study 3: Individual driver level; random sample of all drivers

Our final analysis is based on our driver survey. While this survey included 1,000 drivers, we narrowed our analysis to "employee" drivers who are paid a mileage rate. This excluded hourly drivers and owner-operators, as well as company drivers and owner-operators whose earnings are based on a percentage of revenue. We did this to reduce the noise in the data and develop a consistent measure.

The drivers in the sample look similar to drivers in other studies, including the two other studies included in this report. The average driver earns $0.295 per mile, drives 121,380 miles per year, receives 14.7 paid days off, and works 62.1 hours per week. We found that 85% have health insurance, 26.7% receive an on-time bonus, 57.9% get a safety bonus, and 62.8% will suffer a penalty if they pick up or deliver a load late. Surprisingly, the average driver has worked for his current employer nearly 4 years and has more than 14 years of experience. Drivers put in a great deal of non-driving time (18.3% of their time) and work more than 20% of their hours during the night. Only 9.3% of over-the-road drivers we surveyed are union members (we probably undersampled this group because they are somewhat less likely to stop at truck stops and do not fuel on the road).

A probit regression was used to estimate the likelihood that a driver reported having a crash during the past year. While some individual statistics are significant, our overall model is not significant because the data set has so much "noise." While this may be disappointing, the fact that we achieved very strong results on the two pay variables (pay rate and paid time off, both

significant at the 0.05 level) supports our hypothesis that driver pay strongly predicts truck driver safety. Measured at the mean value of all characteristics, a 10% increase in the mileage rate from $0.295 to $0.324 is estimated to reduce the probability of a crash from 13.8% to 10.86%, which is a 21% decrease in this probability. Similarly, increasing the number of paid days off also reduces the estimated crash risk. A 10% increase in the number of paid days off decreases the crash risk from 13.8% to 12.79%, which is a 7% decrease.

Conclusion

This study demonstrates that driver pay has a strong effect on safety outcomes. These results are consistent with economic theory because we expect that carriers pay drivers according to their market value, and that value is determined by their personal employment history, driving record, training and education experience, driving skills, temperament, and other unmeasured factors. Since very few of the drivers studied in our datasets are union members, we expect that the differences in safety outcomes are likely due to different individual characteristics for which they are paid differentially. Firm size probably is associated also with greater driver safety, as two of the three data sets suggest (though the results are ambiguous because the trend does not appear to be linear), and firm size has shown to be an independent predictor of employee pay rates.

It is difficult to come up with a single summary estimate of the effect of driver pay, as elasticities vary across datasets and model specifications, but conservatively we can say that the relationship between safety and pay probably is better than 2:1. Higher pay produces superior safety performance for firms and for drivers. The precise driver-level study of Hunt suggests this relationship may be as high as 1:4 while the cross-sectional study of Signpost carriers shows that even with an imprecise pay variable, the relationship between safety and pay rate is 1:0.5 and the relationship between safety and compensation is 1:0.92 – a ratio of nearly 1:1. Clearly truck driver pay is an extremely strong predictor of driver safety.