

The Affects of Economic Forces on Motor Carrier Safety: Labor economics and fatigue

Fatigue in Transit Operations Transportation Research Board

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Competition as a key latent safety factor

- Freight and passenger transport is a business activity
 - Cannot separate fatigue management from work and business process
 - Do not focus on the technology but rather on industrial organization
 - Focusing on technology and engineering ignores economic forces — and competition — driving the work process
 - Competitors will do whatever they must to make a profit
 - Without regulatory limits to competition:
 - Shippers will make carriers do whatever it takes to be lowest cost providers
 - Carriers will make operators do whatever it takes to reduce cost
 - With regulatory limits
 - Carriers can compete on safety and service
 - Safety management can become a strategic advantage
 - Risk-shifting and subcontracting to least powerful people pushes competition to the bottom of the food chain
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Original U.S. Regulation

- “Cutthroat competition” in trucking began in the 1920s and led to serious safety problems
 - State and local authorities could not cope with growing safety problems created by inter-state trucking
- Motor Carrier Act of 1935 limited competition and improved safety
 - Enforcement originally rested with Interstate Commerce Commission (ICC) but shifted to U.S. Department of Transportation (DOT) in the 1960s
 - Unionization grew from less than 10% in the early 1930s to 60-90% in the 1970s and has returned to less than 10%
 - Collective bargaining brought order to a fragmented industry and compensation to middle-class standards
 - Worker protections at unionized carriers spilled over to protect non-union workers at non-union firms and in exempt sectors



U.S. Regulatory Liberalization

- Administrative deregulation in 1977 increased market competition
 - Motor Carrier Act of 1980 removed most existing economic regulation of inter-state trucking
 - Market entry eased; transparency ended
 - MCA of 1980 favored rate discrimination; shippers gain bargaining power
 - Collective ratemaking ended; cutthroat pricing returns
 - Intra-state deregulation mandated in 1995; ICC closed
 - Federal Motor Carrier Safety Administration (FMCSA) of the DOT now is the major regulatory barrier to cutthroat competition
 - Hours of work (which limits labor market competition)
 - Truck and driver health and safety standards
 - Motor carrier safety regulation
 - DOT doesn't want this job
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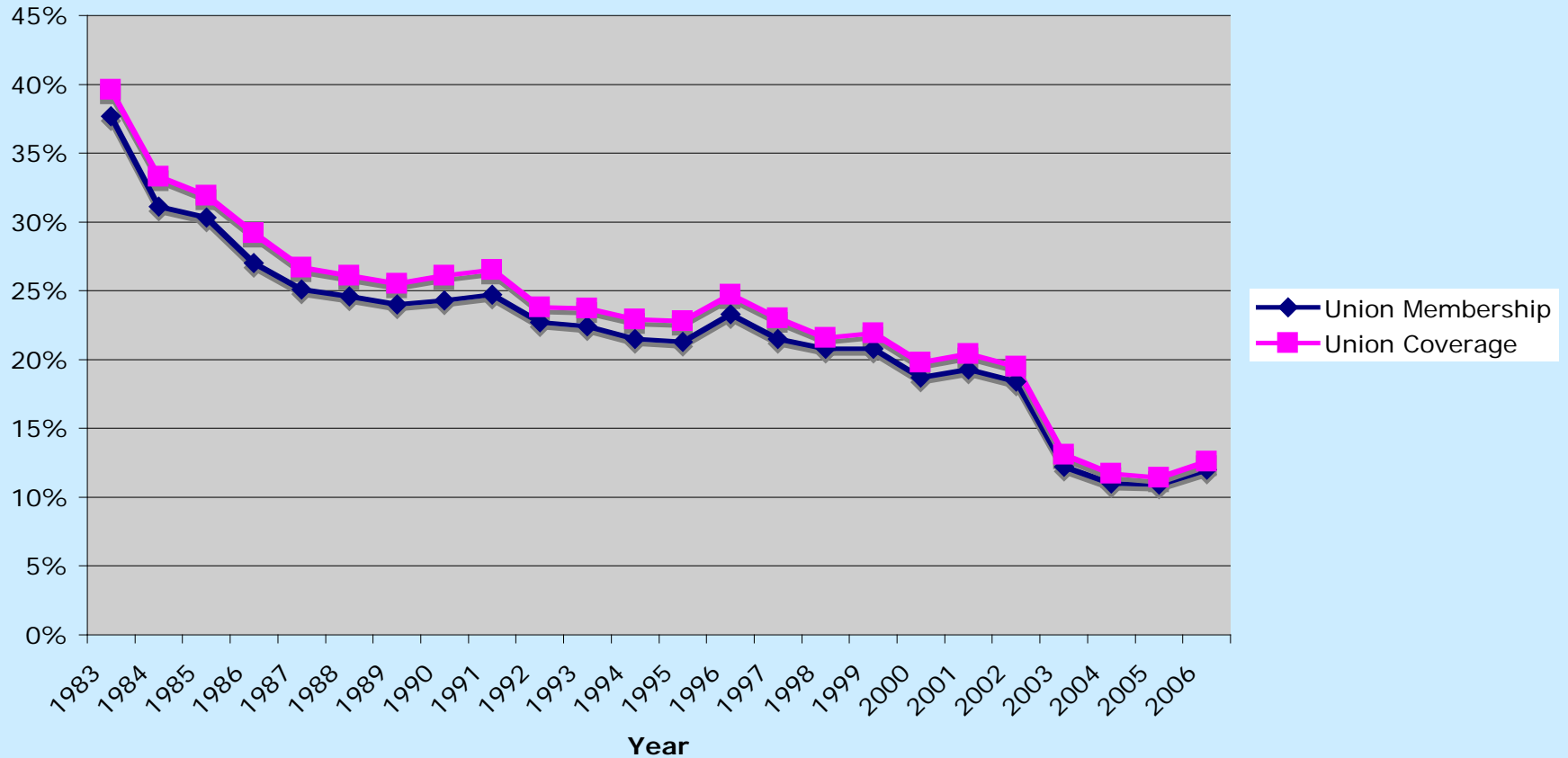


Carriers Now Compete on Price

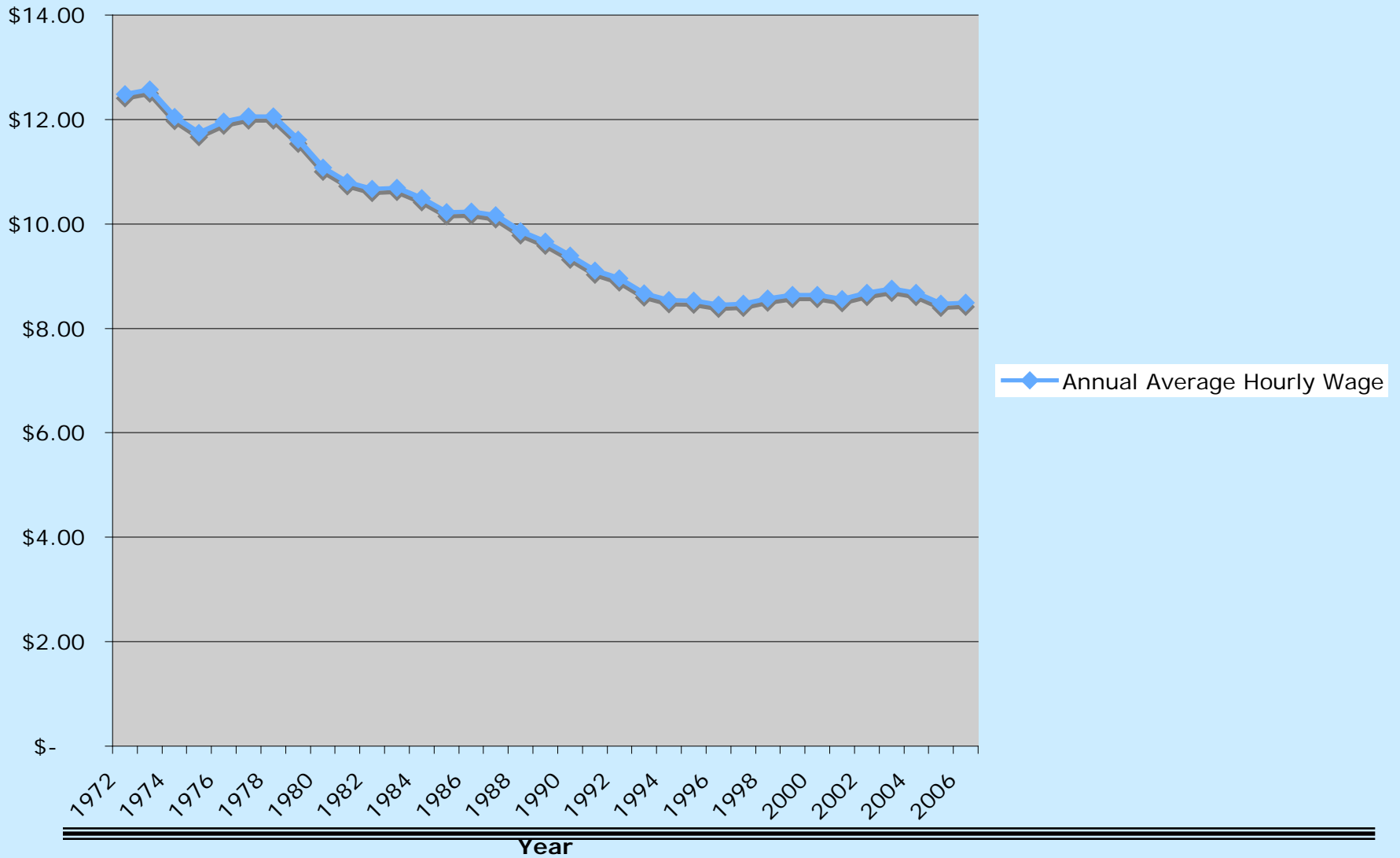
- **Primary determinant of freight transport pricing is cost**
- Carriers must continuously reduce cost
 - Shippers view freight transport as a commodity - a “cost-center”
 - Shippers’ goal is to keep cost low
 - Cost caused industry to restructure completely in 3 years
 - Lower trucking cost enabled increased trade and longer supply chains
- **Rapid change in cost factors changed industrial organization**
 - Trucking rapidly segmented based on shipment size
 - Truckload carriers need no consolidation terminals
 - Truckload carriers need no local pickup and delivery networks
 - A few common carriers survived as less-than-truckload carriers; the rest failed
 - Non-union specialized and contract carriers created booming truckload sector
- Probably 1/4 of cost-savings came from restructuring
- Probably 3/4 of cost-savings came from lower compensation
- **Does low compensation lead to safety management problem?**



Union Density in Truck Transportation Industry



Super Sector: Transportation and Warehousing



UMTIP Driver Survey

- Survey conducted in 1997-1998 in Midwest truck stops, focusing on over-the-road drivers
- Drivers average \$745 per week and 65 working hours/week
 - \$11.46 per straight time hourly wage
 - CPS data for same period shows 21.4% of all drivers worked more than 60 hours/week
- Mean mileage rate was 28.6¢/mile
- Unionized drivers earn an average of 38.6 ¢/mile
 - Only 9.8% of OTR employee drivers unionized
 - Almost no owner-drivers are union members
- At the mean, truckers drove 113,843 miles
- On average, 25% of working hours were unpaid non-driving time
- Total annual working time about 3,250 hours, assuming drivers had 2.25 weeks off for vacation and holidays



Other Features of This Labor Market

- Pervasive subcontracting and as many as 500,000 carriers
 - Perhaps 300,000 owner-drivers (no accurate measures exist)
 - 75% of owner-drivers leased to motor carriers
 - 25% operate on their own authority (actual owner-operator drivers)
- Common law treats all of them as independent contractors and hence they may not organize (not true in Canada or Australia)
- Marginal cost pricing in transportation leads to cobweb (“cutthroat”) pricing and destructive competition
 - Teamster drivers earn average of about \$50,000/year, mostly in LTL
 - Non-union drivers average about \$36,000/year, mostly in TL
 - Owner-drivers net about \$21,000/year on average
 - Most have no health insurance and none have pensions
 - 2004 DOT regulations raised drive time to 11 hours/shift and allow drivers to re-set their weekly clock to allow an 84-hour workweek



Trucking Industry Benchmarking Program / OOIDA survey of owner-operators in 2003-2004

Summary of
cases selected according to
421 total cases of which 83 are missing

NetProfit&WagesFromTruckingOps
OneTruck

Total Cases	421
Count	338
Mean	\$21,266.70
Median	\$17,988.50
StdDev	\$37,163.10
PopStdv	\$37,108.10
Min	\$-14,9571.00
Max	\$301,400.00



Three Studies Show How Pay Drives Safety

- Using driver level data from J.B. Hunt, we determined the probability of driver crashes using 11,540 drivers and 93,000 driver-month observations
- Using carrier level data from the National Survey of Driver Wages, we determined the extent to which compensation factors predict carrier crash rates
- Using the UMTIP random survey of over-the-road drivers, we determined that driver pay predicts safety outcomes



Study 1: Effect of pay level in one firm

The Problem

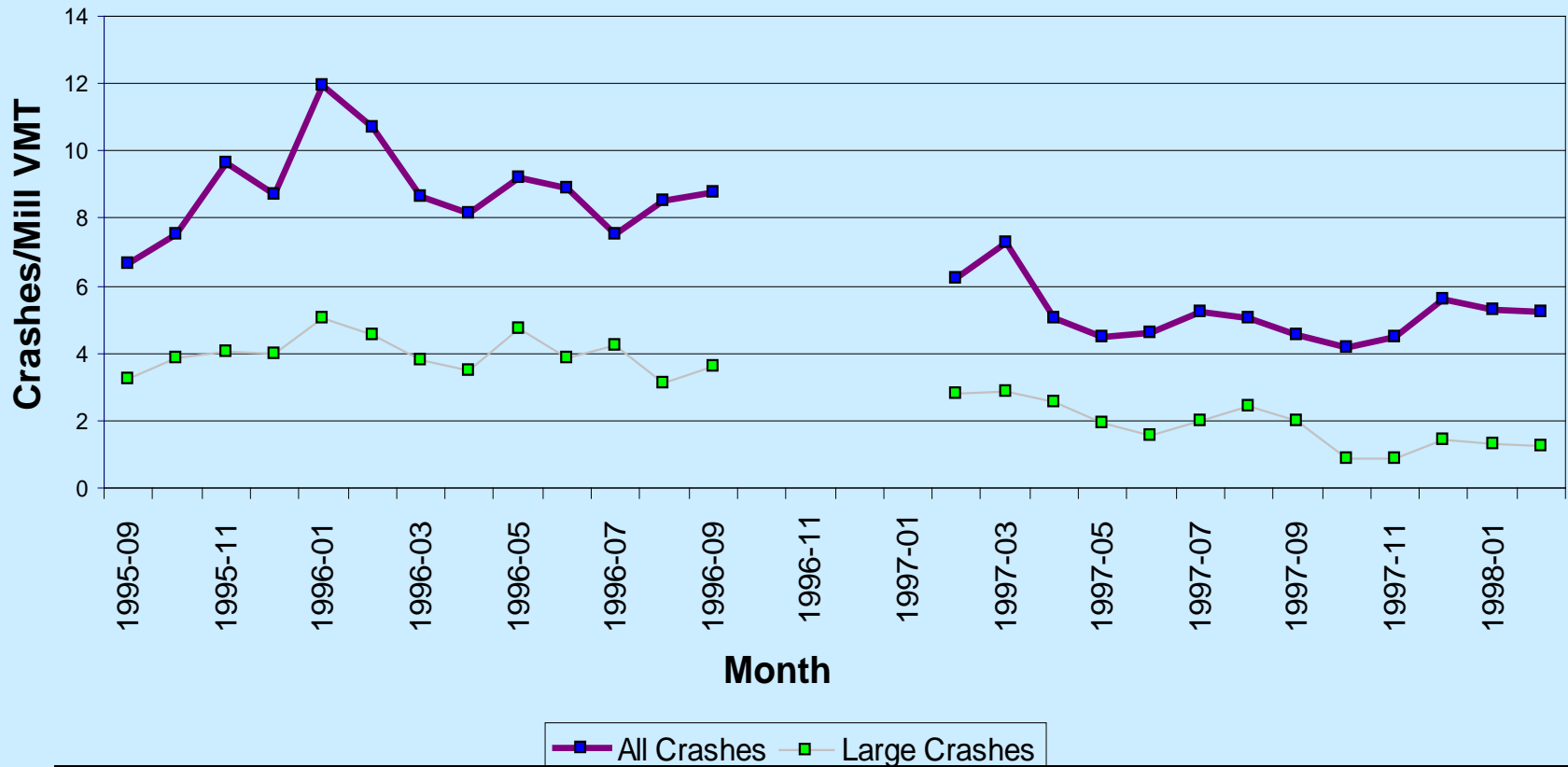
- J. B. Hunt: The nation's second largest truckload carrier in 1995
 - 96% driver turnover
 - Carrier experienced driver safety and driver reliability problems

The Solution

- Raised wages by 38% in one major move
- Closed down training schools & hired experience
- Focused on driver retention



Higher Pay, Lower Crash Rates



Pay Level Findings

- **Overall, every 10% more driver pay related to 40% lower crash probability**
- At the mean, every one cent more in first observed pay leads to **11.1% lower crash probability**
- At the mean pay rate of 34 cents per mile, every 10% higher first observed pay is associated with a **34% lower crash probability** (human capital?)
- A **10% pay increase** is associated with a **6% lower crash probability** (incentive?)
- At the mean, each **year of tenure** reduces crash by **16%**
- **Higher pay reduces turnover and increases age, experience, and unmeasured characteristics**



**Study 2:
The Effect of Compensation
Level and Method
for 102 Truckload Carriers**

Data Sources:
National Survey of Driver Wages
UMTIP Survey of Carriers
SAFER System



Carrier Level Descriptive Statistics

VARIABLE	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
CRASHES	63.87	101.20	1	660
MILEAGE PAY	\$0.286	.026	.230	.380
UNPAID TIME (hrs/mi)	.004	.004	.870 E-4	.017
RAISE	\$0.007	\$0.005	\$0.00	\$0.040
SAFETY BONUS	.490	.502	0= No	1= Yes
PRODUCTION BONUS	.284	.453	0= No	1= Yes
HEALTH INS	\$166.84	69.803	\$0	\$368.30
LIFE INS	\$15,505.00	10991.00	\$0	\$52,000
PAID TIME OFF	\$773.56	\$302.27	\$250	\$2,000
GOVERNOR SPEED	.765	.426	0= No	1= Yes
MILES PER RUN	905.85	472.77	400	3,800
MILES PER YEAR (MILLIONS)	127.53	238.88	1.5	1,106.0
FLAT BED	.206	.406	0	1
VAN	.510	.502	0	1
POWER UNITS	682.94	1035.8	24	7193



Negative Binomial Regression Results

VARIABLE	ESTIMATE	T-STAT.	ELAST
Mileage Pay Rate	-1.83 ***	-2.68	-.52
Unpaid Time (Hrs/Mile)	24.63 ***	5.68	-.10
Raise	-8.72 *	-1.89	-.06
Safety Bonus	-0.10 ***	-3.56	-.10
Production Bonus	-0.05	-1.60	-.05
Driver Pay Health Insurance (\$100)	0.05 ***	2.00	.08
Value of Life Insurance (\$1,000)	-0.04 ***	-3.08	-.06
Paid Time Off (\$1,000)	-0.04	-0.61	-.03
Governor Speed	-0.19 ***	-6.14	-.19
Total Compensation Effect			-.92

Log-likelihood: -454.996

Restricted Log-likelihood: -4648.659

Likelihood Ratio Statistic: -8387.326

Chi-Square Statistic 465.016

Significance Level: 0.000

Significance Level: 0.000



Overall Compensation Effect

- For every **10% more** that they compensate drivers, carriers have a **9.2% lower crash rate**
- Significant components include
 - **Mileage rate** for drivers with 3 years experience (**5.2%**)
 - Drivers' anticipated **annual pay raise** (**0.6%**)
 - Amount of **unpaid non-driving time** per mile driven (**1.0%**)
 - **Safety bonus** (**1.0%**)
 - Amount of **money driver pays for family health insurance** (**0.8%**)
 - **Amortized value of life insurance** provided by carrier (**0.6%**)



Study 3

Effect of Pay Level on Safety: Individual Driver Level Data

Sloan Foundation Trucking Industry Program
UMTIP Truck Driver Survey

- Based on 1,000 drivers surveyed in 1997-98
- Regression results based on 247 of these who are mileage employee drivers working in the for-hire trucking industry



Mean Compensation Variables

Mileage Rate	\$0.295
Unpaid Time (minutes/mile)	.227
Paid Days Off	14.71
Employer Paid Health Ins	85.0%
Late Penalty	62.8%
Safety Bonus	57.9%
On Time Bonus	26.7%
Yearly Earnings	\$38,848



Workplace Variables

Crash	13.8%
Yearly Miles	121,378
Weekly Hours	62.1
Non-Driving Work Hours	18.3%
Night Driving Hours	21.2%
Union	9.3%
Large Firm	68.8%
Private Carriage	13.0%
Drybox	66.4%
OTR	72.9%



Probit Regression Estimates

(significant variables only)

Variable	Estimate	St. Err.	t-statistic	Elasticity
Mileage Rate	-4.85	2.44	-1.990**	-18.7%
Paid Days Off	-.309	.144	-2.15**	-6.3%
Large Firm	-.493	.261	-1.889*	
Total Pay Effect				-25.0%

N = 247

Log-likelihood: -85.706

Restricted Log-likelihood: 98.967

Chi-Square Statistic: 26.522

Significance Level: .380



Driver Survey: Effect of Pay on Safety

At the mean pay rate, for every 10% more that drivers earn, their probability of having a crash is 25.0% lower

Significant components include

- For every 10% higher mileage rate that driver earns, the probability of a crash is 18.7% lower
- For every 10% more paid days off, the probability of a crash is 6.3% lower



Three Studies' Overall Effects

- Mileage rate alone accounts for 4:1 safety effect at J.B. Hunt
 - Compensation alone accounts for 0.92:1 safety effect for 102 TL carriers
 - Compensation alone accounts for 2.5:1 safety effect for surveyed drivers
 - Conservative conclusion:
 - Higher driver pay is strongly associated with reduced crashes (2:1)
 - At the mean, 10% higher pay leads to 20% safety improvement
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Human capital and incentives may not be independent

- Better jobs go to those with best overall record.
 - For beginning drivers, hiring depends on factors other than commercial truck driving.
 - Subsequent performance on the job determines future opportunities
 - Drivers are careful not to damage their record in order to maintain their labor market position.
 - This explains “efficiency wage” phenomenon
 - Further incentives include defined-benefit pensions, which act as performance bonds.
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Study 4

Large Truck Crash Causation Study

- Strength: Comprehensive study of about 1,000 truck crashes
 - Weaknesses
 - Data quality on compensation too poor to analyze
 - Asked the wrong questions or asked the right questions wrong
 - Researchers misunderstood and miscoded the respondents' answers
 - Data quality on work pressure is excellent
 - Dependent Variable: Assigned Critical Reason for crash
 - Logistic regression included all usable questions on the economics of the workplace
 - Results
 - **Work pressure and fatigue are strong crash predictors**
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ANOVA for Total Work Pressure

ANOVA

Analysis of Variance For WorkPressureTotalD_m

2284 total cases of which 828 are missing

Source	df	Sums of Squares	Mean Square	F-ratio	Prob
Const	1	34.1545	34.1545	1063.5	² 0.00 01
NewPosition_m	1	18.3945	18.3945	572.75	² 0.000 1
EXPWorkSchedule_m	1	34.6929	34.6929	1080.2	² 0.000 1
SelfInducedIllegal_m	1	11.5645	11.5645	360.08	² 0.000 1
SelfInducedOther_m	1	37.4595	37.4595	1166.4	² 0.000 1
OtherPressure_m	1	14.0881	14.0881	438.66	² 0.000 1
UnpaidLoading_m	1	8.22071	8.22071	255.97	² 0.000 1
OtherRelations_m	1	17.5968	17.5968	547.91	² 0.000 1
RotatingShift_m	1	25.9495	25.9495	807.99	² 0.000 1
Quotas_m	1	1.53774	1.53774	47.881	² 0.000 1
ExtraLoads_m	1	3.02502	3.02502	94.190	² 0.000 1
Demoted_m	1	3.28185	3.28185	102.19	² 0.000 1
UnscheduledExtensions_m	1	12.3810	12.3810	385.51	² 0.000 1
ShortNoticeTrips_m	1	17.5236	17.5236	545.63	² 0.000 1
FillInTrips_m	1	8.48526	8.48526	264.21	² 0.000 1
Error	1441	46.2793	0.032116		
Total	1455	464.845			



Logistic Regression for Fatigue

Analysis of Variance for Fatigue

2284 total cases of which 1443 are missing

Source	df	Sums of Squares	Mean Square	F-ratio	Prob
Const	1	2689.17	2689.17	2569.1	² 0.000 1
WeekLongest	1	6.32530	6.32530	6.0429	0.0142
LastWeekHours	1	12.1454	12.1454	11.603	0.0007
HoursWorked	1	29.7852	29.7852	28.455	² 0.000 1
SleepInterrupted	3	7.78982	2.59661	2.4807	0.0598
RotatingShift	1	8.35335	8.35335	7.9803	0.0048
Error	833	871.935	1.04674		
Total	840	932.593			



Work Pressure & Fatigue Leads to Crashes

Source	df	Sums of Squares	Mean Square	F-ratio	Prob
Const	1	21.9168	21.9168	21.569	² 0.000 1
IDRSafetyBonus	1	15.7409	15.7409	15.491	² 0.000 1
ClassYears	1	11.7438	11.7438	11.558	0.0007
OverDispatchD	1	4.08679	4.08679	4.0220	0.0454
DisciplinedLateD	1	0.889669	0.889669	0.87556	0.3498
WorkPressureTotalD	1	5.38650	5.38650	5.3011	0.0217
IDROnTimePerformance	1	1.05566	1.05566	1.0389	0.3085
Fatigue	1	23.5280	23.5280	23.155	² 0.000 1
White	1	1.33912	1.33912	1.3179	0.2514
GVETruck	1	0.418244	0.418244	0.41161	0.5214
RotatingShift	1	0.376679	0.376679	0.37071	0.5429
MileagePayThisTrip	1	2.14369	2.14369	2.1097	0.1469
Error	595	604.588	1.01611		
Total	606	674.987			



Economic Forces Drive Safety

- Nobody drives a CMV for fun
 - This is an industry
 - Operations must make money
 - Deregulation has made all operations competitive
 - All studies show that economic competition underlies commercial vehicle safety
 - This effect is latent
 - Applies to trucking, motor coach intercity bus, airlines, as well as transit
 - Fatigue, lack of maintenance, overwork, bad judgment (driver/pilot error), design flaws are proximate causes but not common cause
 - No solution will last that does not deal with economic forces
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Policy Suggestions

- Engage the US DOT and the US Department of Labor to work together
 - DOT cannot regulate compensation and employment relationships, but DOL can
 - DOL cannot regulate transportation safety per se, though it could regulate working time
 - Chain of responsibility regulation to make everyone in the supply chain jointly responsible for safety
 - Look more closely at subcontracting and subcontractors
 - Worker misclassification as contractors is destroying the employment relationship
 - Misclassification denies workers protection and leads to widespread tax shortages
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Further Resources Available by Request

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Studies:

<http://www.clas.wayne.edu/unit-faculty-detail.asp?FacultyID=595>

<http://myprofile.cos.com/mbelzer>

Benchmarking:

<http://www.ilir.umich.edu/TIBP/>

