Article

ELRR

The Economic and
Labour Relations Review
1–21

DOI: 10.1177/1035304617728440
journals.sagepub.com/home/elrr
SAGE

Why do long distance truck drivers work extremely long hours?

Michael H Belzer
Wayne State University, USA

Stanley A Sedo
University of Michigan, USA

Abstract

While other research has shown that higher paid truck and bus drivers are safer, this is the first study showing *why* higher paid drivers are safer. We estimate the labour supply curve for long-haul truck drivers in the United States, applying two-stage least squares regression to a national survey of truck drivers. We start with the standard model of the labour supply curve and then develop two novel extensions of it, incorporating pay level and pay method, and testing the target earnings hypothesis. We distinguish between long-haul and short-haul jobs driving commercial motor vehicles. Truck and bus drivers choose between long-distance jobs requiring very long hours of work away from home and short-distance jobs generally requiring fewer hours. The labour supply curve exhibits a classic backward bending shape, reflecting drivers' preference to work until they reach target earnings. Above target earnings, at a 'safe rate' for truck drivers, they trade labour for leisure, working fewer hours, leading to greater highway safety. Drivers work fewer hours at a higher pay rate and likely have less fatigue. Pay rates also have implications for driver health because worker health deteriorates as working time exceeds 40 hours.

JEL Codes: I14, J28, J33, J88, L92, M55

Keywords

Compensation, labour markets, labour supply curve, labour/leisure tradeoff, long-distance truck drivers, pay methods, pay rates, piece rates, truck driver safety, working hours

Corresponding author:
Michael H Belzer, Department of Economics, Wayne State University, 2074 Faculty Administration Building, 656 W. Kirby Street, Detroit, MI 48202, USA.
Email: Michael.H.Belzer@wayne.edu

Introduction

More than a decade and a half after the creation of the Federal Motor Carrier Safety Administration (FMCSA) within the US Department of Transportation (USDOT), trucking safety remains important public policy. While fatalities in truck crashes declined from 0.363 per 100 million vehicle miles travelled (VMT) to 0.138 fatalities per 100 million VMT between 1975 and 2014, on average, 11.4 people die every day in truck crashes (FMCSA, 2014: Table 1). The truck fatality trend follows the passenger vehicle trend closely: automobile fatalities declined from 3.25 to 1.05 per 100 million VMT (FMCSA, 2014: Table 5). Because of the difference in mass, truck–car crashes are more likely to involve high negative consequence for automobile passengers. While fatal truck crashes declined by 28% from 2001 through 2010 and fatal truck crashes declined by 48% per million VMT, fatal crashes have risen 8% per million VMT since then (FMCSA, 2014: Figures 1 and 2).

Larger and heavier trucks, increased congestion and just-in-time (JIT) delivery have all been considered as possible explanations for the number of crashes and deaths related to trucking (National Academies of Sciences, Engineering, and Medicine, 2016: 34). Research has also focused on nighttime driving, driver fatigue and increases in longer truck trips. Little effort, however, has focused on the effects of competition on freight rates and compensation on truck driver working hours. This study explains how compensation influences work hours in the trucking industry, in turn, influencing safety outcomes.

Previous research on commercial safety has focused on the immediate mechanisms influencing certain driver behaviours, taking an engineering or behavioural approach. The engineering approach examines road configuration, vehicle dynamics and safety technologies. Behavioural studies focus on speeding, driving long hours and fatigue rather than on economic motivations, as if truck drivers speed and drive long (and often illegal) hours just because they are greedy or because they have a preference for speeding and other reckless behaviour. This research shows how driver compensation influences long work hours and tests the target earnings hypothesis theoretically and empirically, providing a rational explanation for why they work long hours.

Literature

Yellen (1984) hypothesises that an employer paying higher than average wages will discourage workers from shirking by imposing a high cost of job loss on workers. Such an ‘efficiency’ wage can help employers elicit greater effort from workers, while reducing monitoring costs. In addition to compensation level, payment type can influence behaviour. ‘Piecework’ rates in trucking provide an alternative incentive for workers to increase their effort (Prendergast, 1999). While the efficiency wage argument appeals to the worker’s long-run interest to maintain employment, the piecework system creates a short-run incentive to increase production by paying the most productive workers higher earnings, leading to longer hours than for other similarly situated workers.

Piecework pay has been the norm in long-haul trucking for decades (Levinson, 1980) and in road transport more generally for hundreds of years (Gerhold, 1993). Most intercity drivers in both truckload (TL) and less-than-truckload (LTL) trucking are paid by the mile or by the load, rather than hourly (Burks et al., 2010). In North American trucking,

length-of-haul (mileage) often is the sole determinant of compensation. Drivers frequently wait long periods for their loads and in many cases, must load or unload their own freight. This non-driving time generally goes underpaid or unpaid, relative to driving time; the tension between piecework pay and speed limits encourages drivers to work unusually long hours in order to reach earnings targets (Belzer, 2000).

While these compensation practices may elicit more work effort from drivers, they may create incentives encouraging behaviours, negatively influencing safety-related outcomes and attract workers with few labour-market alternatives. Such behaviours may include speeding, taking safety shortcuts, neglecting safety inspections, working illegally long hours and neglecting repairs; TL drivers regularly work between 90 and 100 hours per week, even though the legal limit is around 60. Drivers may work these long hours simply by recording unpaid non-driving labour off duty, and electronic logs may be set to record driving only when a truck exceeds 15 miles per hour, thus allowing the driver to work (and drive) while remaining logged off duty (Viscelli, 2016). In addition, FMCSA regulations changed in 2004, reducing the effectiveness of the 70-hour-per-8-day-week working time limit (designed to give over-the-road truck drivers a longer weekly break) by allowing truck drivers who reach their 70-hour limit to re-set their weekly hours to zero after taking a 34-hour break (the '34-hour restart'). This allows drivers to log as many as 84 hours in a 7-day week (Saltzman and Belzer, 2007). While long hours may provide short-run economic benefit to individual drivers or carriers, in the long run, they lead drivers to supply excessive labour to the marketplace for a fixed number of workers, reducing wages and encouraging illegal and dangerous hours of work.

The National Transportation Safety Board, US Department of Transportation (1990), called for a review of trucking industry structure, operations and conditions that may create incentives for drivers to violate hours-of-service (HOS) regulations and use drugs. A 1995 study raised questions about the influence of pay policies on truck driver fatigue and suggested a possible link between compensation method and fatigue-related crashes (National Transportation Safety Board, U.S. Department of Transportation, 1995).

Research has shown that pay levels may motivate long driving hours and illegal substance use, contributing to fatigue (General Accounting Office, US Congress, 1991; Hensher et al., 1991; National Academies of Sciences, Engineering, and Medicine, 2016: 34–36). Forty-five percent of respondents to a New York State survey thought hourly pay would reduce driver drowsiness (McCartt et al., 1997). Focus groups believe per-mile compensation limits income and encourages cheating (Cadotte et al., 1997; Mason et al., 1991). Piece rate systems, when coupled with enforceable HOS regulations, limit the income opportunities of drivers (Chatterjee et al., 1994).;

Monaco and Williams found that occupational characteristics, not demographics or education, predict truck crash rates. A probit analysis of the University of Michigan Trucking Industry Program (UMTIP) driver survey data determined that higher driver pay rates and hourly pay predicted a lower probability of drivers' involvement in a crash during the previous year or their having had a logbook violation over the previous 30 days. Those paid a percentage of revenue – a combination of revenue miles hauled plus the market value per mile of that freight movement – had the highest rate of HOS violations and crashes (Monaco and Williams, 2000).

While scholars have documented the safety consequences of long work hours in many industries and particularly in trucking, theoretically grounded, empirically validated

studies have been lacking. Similar problems have beset research on health consequences of long hours. Dembe et al. (2005, 2006, 2007) conducted a number of studies using the National Longitudinal Survey of Youth in the United States and found a strong association between long and irregular work hours and occupational injury and illness, as well as negative employment consequences. A study of medical interns showed that exceptionally long hours were associated with fewer 'attentional errors' (Lockley et al., 2004). Several Australian studies have shown the association between long work hours and safety and health problems in long-distance trucking (Mayhew and Quinlan, 2006), as well as in short-haul trucking (Williamson et al., 2009), and the same has been shown in the US (National Academies of Sciences, Engineering, and Medicine, 2016). However, research has not shown clearly why long-haul drivers work such extremely long hours. We argue, here, that truck drivers who choose long-haul work do so to achieve earnings targets they probably could not reach any other way.

Theory

We divide our theoretical discussion into three parts. First, we discuss a standard model of labour supply, modified to account for the particular constraints faced by a long-haul driver paid by distance. This model allows us to specify the economic incentive effects of piece rates compared with time rates. Second, we consider a series of models, stylising the employment relationship somewhat differently than our basic model. These models capture different aspects of the complex causal structure of jobs than our standard model. These models differ from our standard one because they represent situations in which the employee receives a higher net wage than that offered by the next best alternative. Third, we consider a model that describes how unpaid time can create an incentive for drivers to work in excess of the HOS regulations.

The standard model of the labour supply curve

The standard model implicitly assumes that we observe an equilibrium in which straightforward economic factors such as differences in the productivity of employees, or in the positive or negative non-pecuniary rewards of the particular job, explain pay differences. Given the high turnover in trucking, we start with a model that assumes workers are indifferent between the current job and the next best alternative. HOS regulations allow drivers 14 hours between the start and end of a shift. After 14 hours, drivers must take at least 10 hours off before resuming driving. Since the individual consumes both leisure time and income, we measure leisure time on the horizontal axis and income on the vertical. An hourly worker can choose a point anywhere on the budget constraint represented by the line segment A–B. However, those willing to work at least 6 days per week, away from home for weeks, may earn higher income. The segment C–D–E represents this constraint. To earn the higher annual income offered by long-haul trucking, drivers must work the long hours the job requires. Drivers can choose jobs with more time off (such as short-haul) but lower income. The indifference curve that passes through point C shows those workers who are indifferent to taking the lower income of hourly employment and the higher pay and longer hours of long-haul trucking. In this case, no rents are earned, since workers are indifferent between working in the trucking industry and

working as hourly production workers in another industry. However, those workers who wish to work even more hours can choose to do so and will choose a point such as D in trucking – a point that exceeds the legal limit.

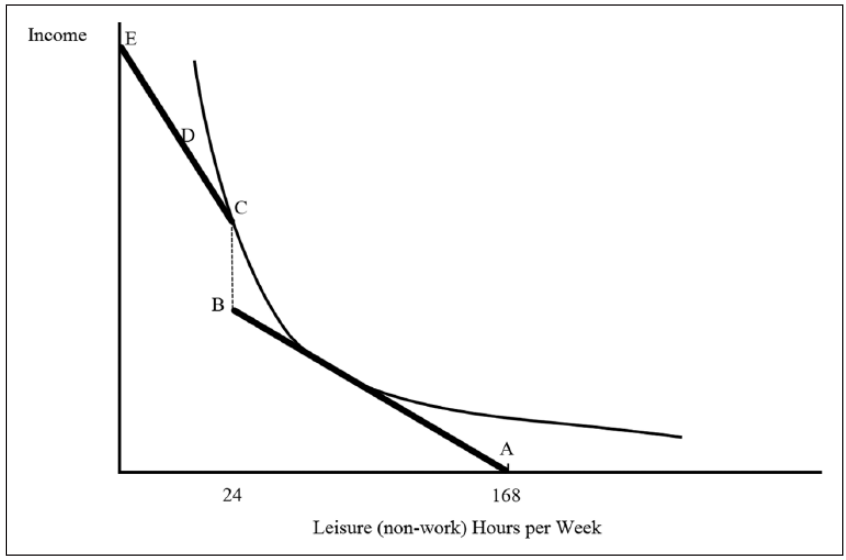

Figure 1. The standard labour supply model.

Extensions of the standard model: Pay level

While this model explains why some workers choose employment in long-distance trucking, it does not address the relationship between the level of pay and driver behaviour. Why might higher mileage rates induce workers to become more safety conscious? The efficiency wage gives workers the incentive to work more safely when behaviour is difficult to monitor directly. For example, a firm concerned about the number of crashes and violations might pay above market wages to its drivers to encourage safety for at least two reasons. First, drivers failing to meet the firm's safety requirements lose these above market wages, causing them to focus on safety. Second, efficiency wages would attract safer drivers to the firm since these drivers would be rewarded for safety, while reducing turnover. Efficiency wages, thus, reduce crashes and violations. As long as the value of reduced crashes and greater productivity is greater than the cost of paying the efficiency wage, the rational firm will pay efficiency wages.

Another example involves regulation. The 40-hour standard workweek (and time-and-one-half for overtime) prescribed by the Fair Labor Standards Act (FLSA) in the United States does not apply to safety-related employees of interstate trucking companies (Belzer, 2000). While the FLSA's minimum wage requirements do apply, because truck drivers self-report non-driving labour and because low pay rates in trucking give truck drivers an incentive to work unusually long hours, a regulatory requirement to pay drivers for all of their work time might create an incentive to work fewer hours. Even

with electronic logbooks, drivers systematically violate the HOS maximum labour time regulation because non-driving labour time requires self-reporting and drivers' economic incentives run counter to long-term safety and health policy (Viscelli, 2016).

Workers also might have a 'target' income, and higher compensation might induce them to be more safety conscious than they would be otherwise (Camerer et al., 1997). Drivers who cannot reach this target income without violating HOS regulations have an incentive to exceed them. A higher mileage rate would allow these drivers to reach their target income after fewer hours of work.

This incentive can exist even if the target income hypothesis is not true, since higher incomes mean a higher level of utility. As long as the additional utility from income is greater than the disutility of working, offset by the threat of detection and the expected cost of paying the fine for violation or losing their job, drivers have an incentive to work additional hours. On the other hand, higher pay rates can reduce this incentive, regardless of whether the target income hypothesis is applicable, if their current job is better than the alternative. If drivers have a target income, higher pay rates will allow them to satisfy these targets without increasing their hours to dangerous levels.

Extensions of the standard model: Method of pay

For those drivers without target earnings, higher pay also reduces the incentive to work additional hours as long as the income effect of this increase is larger than the substitution effect. However, if the substitution effect is larger, a higher pay rate would lead to greater hours worked. This ambiguous theoretical prediction provides the basis for a testable hypothesis regarding the actual response of drivers to changes in pay rates. Figure 2 shows the case where a higher pay rate leads to fewer hours worked. In this

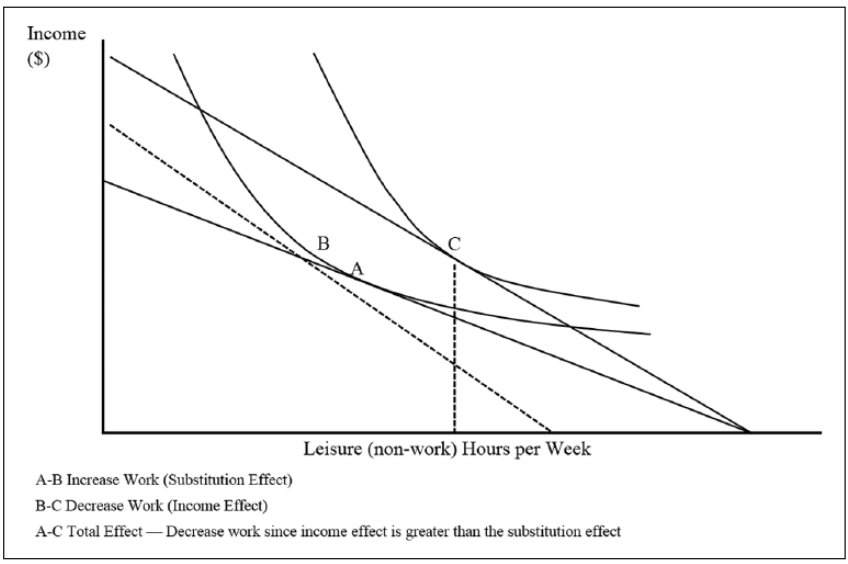

Figure 2. Extension of the standard model.

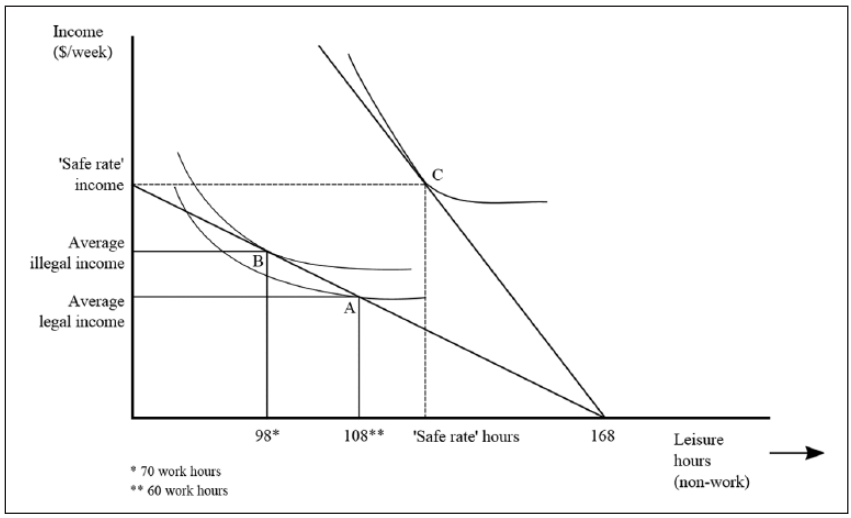

Figure 3. Method of pay.

instance, the substitution effect of greater compensation rates causes the driver to increase hours worked from A to B, while the income effect reduces these hours from B to C. Since the reduction in hours worked due to the income effect is larger than the increase due to the substitution effect, the net effect is to reduce hours worked. In this case, however, workers may make more money for fewer hours of work. Therefore, a higher driver pay rate can reduce the incentive to work beyond the HOS regulations, regardless of whether the target income hypothesis holds true, leading to greater safety performance.

The common practice to either underpay or pay nothing for non-driving time also influences driver behaviour. Unpaid time spent loading, unloading, and waiting represents a significant proportion of working time, according to results from the UMTIP Drivers Survey as well results from a National Institute for Occupational Safety and Health (NIOSH) survey (Chen et al., 2015). Drivers who are unpaid or underpaid for non-driving labour have an incentive to underreport this unpaid time to conserve driving hours.

Figure 3 shows hours of leisure, measured from left to right, and working hours, measured from right to left on the horizontal axis; compensation appears on the vertical. Assuming legal logging, for a given amount of unpaid time (U*), drivers have a certain limited amount of legal driving and working time, indicated by the vertical line through point A. This determines a driver's maximum level of income. If at this point the compensation for an additional hour of driving is higher than the marginal rate of substitution of money for time, then drivers would prefer to work more hours. They can do this by not reporting some of the time spent unloading, which allows drivers to spend more time on the road. This incentive exists even if there is some compensation for non-driving labour time, as long as it is less than the amount paid for driving.

The fact that most drivers are either paid by the mile or earn a percentage of revenue creates an incentive for drivers to violate the HOS regulations. Drivers earn the same

amount for a given load, regardless of the hours worked. If traffic, weather or other delays cause the trip to take extra time, drivers have a strong incentive to work additional hours to reach target earnings.

Payment by 'percentage of revenue' compounds the piecework earnings problem. If the supply of trucks and drivers is loose, competition for freight also drives down rates. Since it is hard to verify non-driving delays, drivers may work extra hours without fear of detection. The ease with which drivers hide non-driving hours by logging off duty heightens the competition and squeezes drivers to work more for lower effective rates. This problem remains significant even when carriers adopt electronic logbooks. While the electronic logbook reliably records when the truck is moving, it does not show what the driver is doing when the truck is stopped; this requires driver self-report.

While point B shows fewer hours worked than point A', it represents more total hours, since the total reported hours, offset by those not reported, are at point B. Point A' indicates the utility maximising point for 'desired' hours worked. Since these delays are difficult to verify, drivers may work extra hours without fear of detection. With FMCSA's permissive regulations regarding logging non-work labour time, incentives for truthfulness remain weak even when drivers use electronic logbooks.

The tradeoff between pay rate and work hours

Many studies have found a relationship between fatigue and crash rates. Lin et al. (1993) use 1984 data from an LTL firm to show that accident rates increase with the number of continuous hours driven, while McCartt et al. (1997) provide similar results from a survey of truck drivers in New York State. Beilock (1994) used a survey of drivers at Florida inspection stations to show that tight schedules induced drivers to either violate speed limits or violate the HOS regulations. In a similar study, Hertz (1991) estimated that 51% of observed drivers violated these regulations. A 2010 NIOSH survey showed that violations continue at a high rate even after HOS regulations were relaxed substantially (Chen et al., 2015). Since HOS regulations were created to reduce driver fatigue, it is important to determine the factors creating an incentive for drivers to violate these regulations (National Academies of Sciences, Engineering, and Medicine, 2016).

Methods

We establish the applicability of the labour/leisure tradeoff in trucking by estimating a labour supply curve. The truck driver labour/leisure tradeoff establishes a foundation for understanding the extent to which industrial work-process organisation and driver compensation contribute to truck drivers' propensity to work much longer hours every week than typical non-driving production workers, and by extension, the tendency to accumulate fatigue resulting from chronic long hours.

Labour supply curve estimation

We estimate the determinants of the number of driver weekly work hours – particularly, the relationship between mileage rates and work hours. Since it is reasonable to assume

that hours might be determined in part by some of the same random components that influence mileage rates, we cannot estimate this relationship directly. We use a two-step procedure, first estimating the mileage rate for each driver, and then using the fitted values of the mileage rate to estimate the weekly hours equation.

We estimate each equation using ordinary least squares (OLS). The general form of the model can be written as

$$\text{Rate}_i = \beta_1 + \beta_2 X_{i2} + \beta_3 X_{i3} + \ldots \beta_K X_{iK} + \varepsilon_i$$

where Rate_i is the mileage rate for the ith driver, Xs represent characteristics of the driver and job that are relevant to determining the mileage rate and βs are the parameters to estimate. The term ε summarises the random components and unobserved characteristics of the individual driver and job.

We divide the variables used to estimate the mileage rate equation into two groups. The first summarises the human capital characteristics of the individual driver: experience, tenure, education, union status, race, age and marital status. We use other family income to measure the importance of driving income relative to overall household income. We include the squares of experience and tenure to allow for a non-linear relationship between these variables and the mileage rate. We also allow for an interaction between race and union status, which allows the union premium to differ by race. Finally, we use drivers' previous violation record as a proxy for individual skill and performance levels.

We expect the mileage rate to correlate positively with experience and tenure; a negative second-order term would indicate that this premium decreases as mileage rates increase. While in most occupations we would expect a high school degree to raise the wage rate, this may not hold for truck drivers because of the low formal education requirement of truck driving. Previous research suggests that unionised and white workers would also earn more than other drivers. We hypothesise that unions would raise the mileage rate of non-white drivers by more than that of white drivers, as the earnings discrimination literature suggests that unions often have an equalising effect on the wages of non-white workers. Finally, we expect that those drivers with a previous moving violation would earn a lower mileage rate.

The second group of variables captures characteristics of the firm and job. Previous research has documented that larger firms pay higher wages, *ceteris paribus*. Private carriage firms (vs. for-hire firms) and firms that haul primarily dry boxes (vs. temperature-controlled trailers, flat beds, and tankers e.g.) might be expected to pay different mileage rates, but we cannot predict the direction of these differences in advance. Drivers with longer trips probably earn lower mileage rates since they spend a greater percentage of their time driving (and hence, waste less time performing unpaid non-driving labour). Finally, we also include the amount of unpaid time and paid time off, although we cannot determine the direction of these influences in advance. Firms requiring a substantial amount of unpaid time for loading, waiting or other activities may or may not be compelled to compensate by paying a higher mileage rate, depending on the labour-market pressure for drivers. Similarly, more paid holidays and longer vacations might compensate for a lower

mileage rate, or they could be complementary aspects of 'good' jobs that offer better compensation generally.

Data

Data used to estimate the labour supply curve were obtained from a survey of drivers collected in 1997–1998 by UMTIP (Belman et al., 2004). The sample includes all full-time employee drivers paid by the mile. The estimation is based on a sample of 233 employee drivers for whom complete information was available. These drivers reported working an average of 64.49 hours per week with a minimum of 25 and a maximum of 126. Drivers earned an average of USD0.286 per mile with a range from USD0.13 to USD0.485; on average, they had 13.66 years of experience and average company tenure of 3.46 years. While the data are 20 years old, the work process and pay systems in trucking have not changed enough to make them obsolete, and the economic motivations underlying truck drivers' work hours have not changed, so the econometric test of the foregoing theory remains valid. Because they were collected at the individual level, the data remain the most robust data available as of this writing. While not identical, the hours of work averages and distribution revealed in this survey in the late 1990s are consistent with more recent surveys, including one conducted by the FMCSA, US Department of Transportation (2005; 61.4 hours per week) and one conducted by the NIOSH in 2010 (60 hours per week; Chen et al., 2015). Indeed, the 2010 NIOSH truck driver survey, conducted using a similar truck-stop design, shows that more than 20% of all drivers worked more than 75 hours per week, which is entirely consistent with the 1997 UMTIP survey used here and far greater than the stated legal limit of 60 hours per 7-day week.

Several variables are categorical. Union members accounted for 8% of the sample, 86% were white and 25% had had a moving violation in the past year, while 33% worked in a 'medium'-sized firm (between 100 and 500 workers) and 34% worked in 'large' firms with more than 500 workers. Fourteen percent of drivers worked in the private carriage segment of the market and 65% hauled dry boxes. This sample may be biased towards larger for-hire firms because these drivers more likely are employees and because private carriage represents roughly half of all trucking, but the implications for this study are unknown.

The average miles per dispatch was 858 with a standard deviation of 619.75; we attribute the extent of variation to the wide variety of operations in the trucking industry. On average, drivers spent about 0.23 minutes in uncompensated activities per mile driven. Given the average of 858 miles per dispatch, this means that the median trip included about 197 minutes of uncompensated labour time. At the other end of the spectrum, the median driver received 13.7 paid holiday, vacation and sick days per year, with a minimum of zero and a maximum of 35.

Drivers' average age was 42.18% and 69% were married. The variable 'other income' is the measure of total family income less the income earned from driving. This included income earned by other family members or by the driver in other occupations. The mean value was USD46,980 with a standard deviation of USD18,880. Finally, 22% of driving

Table 1. Summary statistics, UMTIP driver survey of piece work drivers, n = 233.

Variable	Variable definition	Mean	SD	Minimum	Maximum
Weekly hours	Hours worked in the week preceding the survey	64.49	18.11	25	126
Mileage rate	$/mile	0.286	0.055	0.13	0.485
Experience	Years of experience as a driver	13.66	10.12	1	43
Tenure	Number of years worked with current firm	3.46	4.58	0.083	30
HS education	1 if driver completed high school, 0 otherwise	0.83	0.37	0	1
Union	1 if driver is a union member, 0 otherwise	0.08	0.27	0	1
White	1 if driver is white, 0 otherwise	0.86	0.35	0	1
Age	Age of driver	42.18	9.51	22	64
Married	1 if driver is married, 0 otherwise	0.69	0.46	0	1
Other income (USD1000)	Other family income	46.98	18.88	0	120
Moving violation	1 if driver received a violation in the past year, 0 otherwise	0.25	0.43	0	1
Medium firm size	1 if firm has between 100 and 500 drivers, 0 otherwise	0.33	0.47	0	1
Large firm size	1 if firm has more than 500 drivers, 0 otherwise	0.34	0.48	0	1
Private carriage	1 if firm is private carriage, 0 otherwise	0.14	0.34	0	1
Dry van	1 if driver pulls primarily dry vans, 0 otherwise	0.65	0.48	0	1
Miles per dispatch	Number of miles in the average dispatch	858.01	619.75	144.14	3500
Unpaid time per mile	Average amount of unpaid time per mile driven, in minutes	0.23	0.4	0	3
Paid days off	Number of paid holidays, sick and vacation days per year	13.7	8.4	0	35
% Night driving	Percentage of driving hours between 11:00 pm and 7:00 am	0.22	0.21	0	0.75
% Non-driving	Percentage of time spent in activities other than driving	0.19	0.17	0	0.89
Last home	Number of days since the driver was at home	8.46	12.74	0	90

UMTIM: University of Michigan Trucking Industry Program; HS: higher secondary.
Pay rates in current US dollars, 1997–1998.
USD1.00 in 1997 was the equivalent of USD1.50 in 2016.

occurred at night (between the hours of midnight and 6:00 am) and 19% of the typical driver's time was spent in non-driving activities. The typical driver last slept at home 8.46 days prior to the interview.

Results

Mileage rate estimation

Table 2 reports the results of the mileage rate equation. Returns to tenure and experience were statistically significant at the 5% level, as was the squared value of tenure. This means that an additional year of tenure at the mean (3.46 years) added 1% to the average mileage rate. However, an additional year of experience (holding tenure constant) had a negligible effect. Union members could expect to earn almost USD0.10 per mile more than non-union drivers, and this estimate was also significant at the 5% level. The returns to education were insignificant. White workers could expect to earn USD0.016 per mile (5.7%) more than others. The interaction of race and union status was not significant, indicating that the union premium was similar for all drivers, regardless of race.

Firm-level characteristics offered a great deal of insight into differences in driver compensation. Drivers working for large firms earned significantly more than those in smaller firms, similar to what research on firm size has shown generally (Bayard and Troske, 1999; Brown and Medoff, 1989). In addition, workers with more paid time off earned higher mileage rates, indicating that 'good jobs' reward workers not just by paying higher wages but with other forms of compensation as well. Drivers with longer dispatches earned less per mile than those with shorter dispatches. However, neither of these raised mileage rates substantially.

Table 2. Mileage rate equation.

Variable		Estimate	Standard	
			Error	t
Constant		0.241***	0.016	14.918
Experience		0.002**	0.001	2.133
Experience^2		–4.1E–05	0.000029	–1.437
Tenure		0.004**	0.0017	2.049
Tenure^2		–0.00011**	0.000054	–1.972
HS degree		0.000574	0.008	0.076
Union		0.097**	0.057	1.726
White		0.016**	0.008	1.858
Union by white		–0.04	0.058	–0.695
Previous moving violation		0.007	0.007	1.051
Medium firm		0.013**	0.006	2.065
Large firm		0.026***	0.009	3.164
Private carriage		–0.020	0.010	–1.900
Dry van		–0.008	0.007	–1.221
Miles per dispatch		–0.00002***	0.000006	–3.276
Unpaid time		–0.010	0.008	–1.192
Paid days off		0.001**	0.0004	2.071
Sample size	233	Dependent variable	Mileage rate	
R^2	0.385	Rbar-squared	0.340	
Residual SS	0.431	Std error of est	0.045	
F(16, 216)	8.457	Probability of F	0.000	

* = .10; ** = .05, and *** – .001.

Weekly hours estimation

The weekly hours equation can be written as

$$\text{Hours}_i = \gamma_1 + \gamma_2 * W_i + \gamma_3 W_i^2 + \gamma_4 Z_{i4} + \ \ldots \gamma_K Z_{iK} + \varepsilon_i$$

where Hours_i are the weekly hours of the ith driver, and W_i is the fitted wage of the ith driver from the regression estimates described above. The Zs represent characteristics of the driver and job that influence the number of hours worked, while ε_i captures the random components of the hours worked not included in the explanatory variables.

To estimate the weekly hours equation, we must provide instruments that include variables in the mileage rate equation but do not determine hours of work. We hypothesise that experience, education and race will influence wages, but not hours. Finally, we do not include the size of the firm and the type of trailer in the hours equation.

We included both the fitted wage and its square in the regression. This allowed the influence of the wage rate to decrease and even allowed for the possibility of a 'backward bending' supply curve where higher wages can cause a decrease in hours worked. Other variables included in the regression were age (and its square), marital status and other income. We also considered characteristics of the firm and job that might influence hours worked. These include the percentage of night driving, the percentage of time spent in non-driving activities, the amount of unpaid time and paid days off, as well as union status, length of dispatch, private carriage and tenure. Finally, the variable 'last home' is a measure of how long it had been since the driver had slept at home.

We report the results of the hours equation in Table 3. First, weekly hours were not estimated as precisely as the mileage rate in part because the reported hours may be measured with error, relative to the explanatory variables. Weekly hours are reported for the most recent week, but it is possible that weekly reported hours worked may have over- or under-estimated the hours worked in a typical week. As long as these differences are not systematic, they do not bias the parameter estimates, but do make them less precise, as reflected in the results.

Weekly hours tended to increase with age, *ceteris paribus*, until the driver was about 44.6 years old, at which point they declined. Married drivers tended to work almost five fewer hours per week, suggesting that married drivers may be more willing than non-married drivers to trade personal time for labour once they have met their earnings targets, but this is significant only at the 10% level. Finally, we need to interpret the results on non-driving time. The variable 'unpaid time' measures the amount of unpaid time per mile driven. The estimate suggests that drivers who were not paid for their non-driving time tended to compensate by working longer hours, as hypothesised. The non-driving time variable measures the percentage of time that a driver spends in activities other than driving. While the negative coefficient may seem surprising, in conjunction with unpaid time, we interpret this variable to measure the effect of at least partly compensated non-driving time. We therefore are not surprised that drivers with more paid non-driving time may work fewer hours, while those who have more unpaid non-driving time may work more.

Table 3. Weekly hours of work equation.

Variable		Estimate	Standard Error	t
Constant		–116.29**	52.88	–2.199
Fitted rate		776.75**	370.8	2.095
Fitted rate^2		–1266.30**	637.3	–1.987
Age		3.119***	0.849	3.674
Age^2		–0.035***	0.001	–3.578
Married		–4.853*	2.548	–1.905
Other income (USD1000)		0.021	0.067	0.348
% Night driving		9.241	5.598	1.651
% Non-driving time		–21.820**	9.788	–2.229
Unpaid time		11.066***	3.441	3.216
Union		10.842	9.372	1.157
Miles per dispatch		0.0007	0.002	0.313
Private carriage		–4.082	3.464	–1.178
Tenure		–0.365*	0.201	–1.820
Last home		–0.006	0.125	–0.045
Sample size	233	Dependent variable	Hours per week	
R^2	0.164	Rbar^2	0.111	
Residual SS	63611.8	Std error of est	17.082	
F(14, 218)	3.061	Probability of F	0.000	

* = .10; ** = .05, and *** – .001.

We interpret the mileage rate results as follows. The fitted value of the mileage rate and its square is significant at the 5% level, showing an overall positive influence of wages on hours for most drivers. The positive relationship between mileage rates and hours continues until the mileage rate reaches about USD0.307 per mile, at which point we estimate that further increases in the mileage rate begin to reduce weekly hours. This relationship is described in Figure 4. Note particularly the predictions of hours worked relative to the HOS regulations current at the time of the survey. For low mileage rates, increasing the mileage rate led to an increase in hours worked. The mean rate of USD0.286 provides an estimate of about 69.2 hours worked per week, with a slight increase to almost 69.8 hours for rates above the mean, up to USD0.307 per mile. However, after this point, further increases in the mileage rate led to fewer work hours, supporting the target-earnings hypothesis. Once drivers earn a high enough rate and are already working long hours, they use further mileage rate increases to 'buy' more time off rather than purchase more goods and services. It is insightful to observe that the point at which the estimated pay-rate curve crosses the 60-hour legal limit was USD0.395 per mile in 1997 dollars. In 1997, J.B. Hunt Trucking, one of North America's largest TL carriers, raised truck driver compensation to an average of USD0.37 per mile in a successful effort to reduce turnover and driver crash rates (Rodriguez et al., 2006). In recruiting efforts at the time, Hunt described itself as offering union-level pay rates without the union. Our estimates predict that for USD0.37 per mile, drivers would reduce their

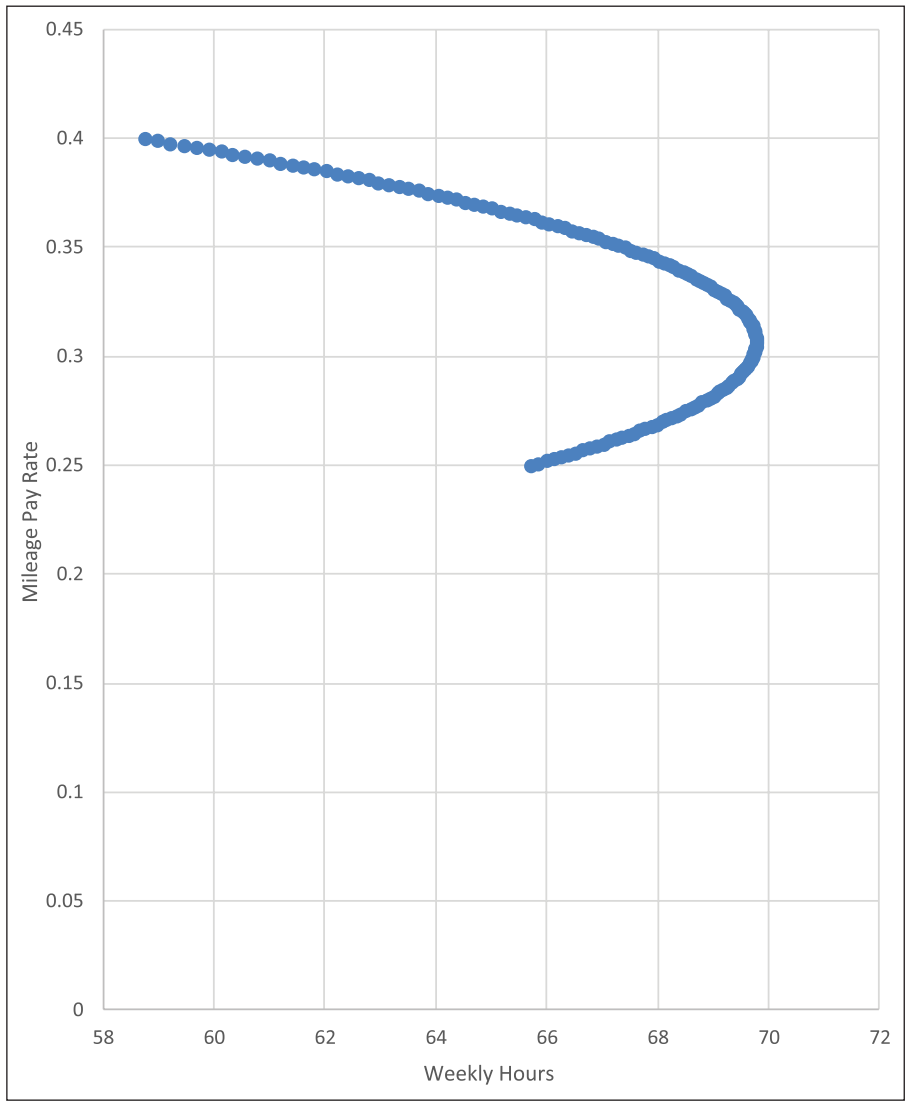

Figure 4. Labour supply curve for long-distance truck drivers.

weekly hours from 69.2 (at the average mileage rate of USD0.286 per hour) to 64.7 hours per week and further reduce hours to 60 at the USD0.395 per mile rate – very close to the top rate set by Hunt at that time.

Joint decisions of drivers and firms at higher or lower rates of pay may also explain the shape of the labour supply curve. Firms paying a high rate may have a systematic preference that their drivers obey the HOS regulations, while firms that pay a low rate of pay may recognise that their drivers cannot make a living without working more

hours than the regulations allow and may allow (look the other way), encourage or coerce them to work more hours and drive more miles; this understanding may be consistent with low-rate firms' need to extract additional productivity from each truck and driver to support their businesses. The point estimates suggest that if the mileage rate were to increase to USD0.395 per mile, drivers would reduce their weekly hours to the 60-hour legal limit. At this rate, drivers' compensation is sufficient for them to satisfy their income requirements without having an incentive to work more than mandated by law.

Discussion and policy implications

This study's findings suggest that truck drivers work long hours because they have target earnings; that is, they need to earn a certain amount of money each week to pay their bills. For the growing number of lease-purchase drivers, who lease their trucks from motor carriers from which they obtain their freight, this pressure is especially intense (Viscelli, 2016). While truck drivers made a substantial living during the era of economic regulation and strong union bargaining power, the liberalisation of trucking economic regulation and resultant de-unionisation have reduced compensation by more than half; union density has declined from about 60% in 1977 to below 10% in 2017 (Hirsch and Macpherson, 2017).

This low union density, along with changing industry structure since 1980 that intensified competition, has substantial implications for supply chains and their governance. Replacement of institutional with market regulation in the US, starting in 1977 administratively and institutionalised by the Motor Carrier Act of 1980 and the subsequent dissolution of the Interstate Commerce Commission and Congressional mandate of intrastate deregulation, prompted intense competition (Belzer, 2000). Neoliberalism allowed cargo owners to gain substantial economic power, creating economic welfare, the economic rents from which they have captured, bringing customers lower prices while creating sweatshop conditions for commercial motor vehicle drivers (for a global analysis of unequal distribution of rents, see Milanovic, 2016). Global supply chains, driven by the power of the customer, left the transportation providers to compete with few limitations.

Various institutional actors have tried to regulate this competition. In Australia, the Transport Workers Union (TWU) has conducted a decades-long 'comprehensive campaign' for 'safe rates' and the extension of employment regulation to cover unioniseable owner drivers at the state and national level, dovetailing with the unique Australian industrial relations system featuring expert industrial tribunals mandating minimum industrial practices. The TWU also incorporated a 'chain of responsibility' strategy to try to match legal responsibility with the sophisticated supply chains that developed after deregulation (Kaine and Rawling, 2010). This strategy included a mechanism with which to incorporate the interests of subcontractors and precarious workers (Rawling and Kaine, 2012), whose numbers have increased with deregulation.

In response to an interest expressed by the International Trade Union Confederation, the International TWU, the International Organisation of Employers and the International

Road Transport Union, the International Labour Organisation (ILO) hosted a tripartite sectoral council meeting on road transport safety and health, producing a report (ILO et al., 2015), and the negotiations produced a resolution implying the need for safe rates to level the playing field for motor carriers and drivers (ILO, 2015a, 2015b, 2016). The ILO continues to grapple with these supply chain workplace regulations questions, and consensus on a policy response remains in development.

Perhaps, the most important policy implication resulting from this research is that long-haul drivers will not have an economic incentive to reduce their working hours unless they are paid for all their work time. Truck drivers paid on a piecework basis (by the mile, by the load or a percentage of revenue) will continue to have an incentive to record non-driving labour as off duty, which pushes them to work up to 100 or more hours per week, depending on the number of unpaid non-driving hours embedded in their work. Although a hard cutoff is arbitrary, because evidence suggests that working more than approximately 60 hours per week substantially increases negative consequences for truck driver and public highway safety, as well as truck driver health, this research supports the safe-rates public policy advocated by employers, worker representatives and governments as negotiated within the ILO framework.

Conclusion

We derived a labour supply curve from the UMTIP Driver Survey Data. While this study is limited by the cross-sectional nature of the data, it uses the most precise sample of drivers known to exist. This curve represents a joint employer−employee decision to trade pay rates against the number of hours worked. We estimated the bundle of attributes associated with the job − the combination of pay rate and working time − and the tradeoff that truck drivers make between compensation and job attributes.

Our estimates supported the hypothesis that drivers have target earnings. Drivers first choose between local jobs, which are likely to provide more regular daily schedules and fewer work hours, as well as lower total weekly earnings, and long-distance jobs that require drivers to be away from home for extended periods and work much longer hours. Once drivers are away from home for extended periods, they more likely prefer to keep working and earning as much as they can because almost all of their pay is determined by mileage (Viscelli, 2016); see the extension of the standard model in Figure 2.

Long-distance drivers paid lower than average earnings sought to earn about USD750 per week (USD1138 per week in 2017 dollars) by increasing their hours, accepting more trips and more miles, confirming the ‘target earnings’ hypothesis. Figure 4 depicts the labour supply curve for long-distance employee truck drivers paid by the mile. Long-haul drivers preferred jobs that made more work hours available as pay increased, up to an average of 30.75 cents per mile (46 cents per mile in 2017 dollars) and 69.767 hours per week (well beyond the legal limit). As pay rates increased above this level, drivers worked fewer hours and, at the margin, traded labour for leisure. That is, at higher pay rates drivers will ‘pay’ for more non-work time, which they would prefer to take at home, or at least resting. At approximately 39.5 cents per mile (60 cents per mile in 2017

dollars), drivers preferred to work 60 hours (approximately the legal limit before the FMCSA effectively increased hours in 2004), and a higher pay rate was associated with the preference for fewer hours; this may be a 'safety pay rate', associated with the choice to limit hours to 60 per week, on average. Notably, in this survey, on average, truck drivers at the lowest mileage pay rate already worked for more than 60 hours per week. As their rate increased, they worked even more hours before topping out at almost 70 hours per week before beginning to limit their hours.

While previous research has shown the relationship between compensation and safety, it has not explained why higher pay leads to greater safety. This research, supporting the target earnings hypothesis, has shown that as pay increases above target earnings, drivers prefer a job package associated with fewer work hours. As driver hours decrease, at the margin, trucking becomes safer. Truckers drive fewer miles and work fewer hours, are less likely to change jobs and are less likely to have a crash. As turnover declines and firms attract and retain more experienced truck drivers, trucking operations become safer and the occupation regains the attractiveness it needs for workforce stability and skill development.

How do truck drivers actually work this many hours, on average, when regulations limit them to 60 hours in a 7-day week? Viscelli claims during his recent time as a truck driver, he worked between 90 and 100 hours per week by logging his non-driving work time off duty, and that most other long-haul truckers did the same. Ouellet (1994) reported similar experiences in the non-union sector dating back some 35 years, suggesting that nothing has really changed. Regulations are hard to enforce and include a maze of loopholes. Truck drivers can take a 34-hour 'restart' after they reach their 70-hour limit for an 8-day week, which they can easily reach in five busy days, and with a 'restart' can continue to work as many as 84 hours during a 7-day week. In addition, regulations formerly allowed drivers to log off duty whenever they were not 'responsible' for the truck or the freight. The rule required the carrier to specify the off-duty period in advance, with a beginning and end. However, FMCSA loosened the rule in 2013, removing most constraints on this off-duty provision (Ferro, 2013).

This research shows the underlying economic force inducing long-haul commercial motor vehicle drivers to work extremely long hours, compared with similarly situated workers, and how their choice to become long-distance drivers leads directly to a choice to work exceedingly long hours within the existing regulatory regime, with deleterious safety and health consequences. Cargo owners remain the underlying force driving the market, as they compete for the customer dollar.

Funding

Although no funding has been received since 2002 for the ongoing research on which this article is based, initial support came from the Sloan Foundation for a driver survey and from the FMCSA for a broad study of the relationship between compensation and safety.

References

Bayard K and Troske KR (1999) Examining the employer-size wage premium in the manufacturing, retail trade, and service industries using employer-employee matched data. *American Economic Review* 89(20): 99–103.

Beilock R (1994) Schedule tightness and work hours of long-distance tractor trailer drivers in the United States. In: *Canadian Transportation Research Forum*. Victoria, BC, Canada: Canadian Transportation Research Forum, pp. 519–531.

Belman DL, Monaco KA and Brooks TJ (2004) *Sailors of the Concrete Sea: A Portrait of Truck Drivers' Work and Lives*. East Lansing: Michigan State University Press.

Belzer MH (2000) *Sweatshops on Wheels: Winners and Losers in Trucking Deregulation*. Oxford: Oxford University Press.

Brown C and Medoff JL (1989) The employer size-wage effect. *Journal of Political Economy* 97(50): 1027–1059.

Burks SV, Belzer MH, Kwan Q, et al. (2010) *Trucking 101: An Industry Primer*. Washington, DC: Transportation Research Board.

Cadotte ER, Sink HL and Chatterjee A (1997) Human factors and their influence on accidents involving long-haul, tractor trailers in the United States. *In: Proceedings of International Large Truck Safety Symposium*, Knoxville, TN, 27–29 October, pp. 225–231.

Camerer CF, Babcock L, Loewenstein G, et al. (1997) Labor supply of New York City cabdrivers: one day at a time. *Quarterly Journal of Economics* 112(2): 407–441.

Chatterjee A, Cadotte E, Sink H, et al. (1994) *Driver-Related Factors Involved with Truck Accidents*. Raleigh: Institute for Transportation Research and Education, North Carolina State University.

Chen GX, Sieber WK, Lincoln JE, et al. (2015) NIOSH national survey of long-haul truck drivers: injury and safety. *Accident Analysis and Prevention* 85: 66–72.

Dembe AE, Delbos R, Erickson JB, et al. (2005) The impact of overtime and long work hours on occupational injuries and illnesses: new evidence from the United States. *Occupational and Environmental Medicine* 62(9): 588–597.

Dembe AE, Delbos R, Erickson JB, et al. (2006) Nonstandard shift schedules and the risk of job-related injuries. *Scandinavian Journal of Work, Environment & Health* 32(3): 232–240.

Dembe AE, Delbos R, Erickson JB, et al. (2007) Associations between employees' work schedules and the vocational consequences of workplace injuries. *Journal of Occupational Rehabilitation* 17(4): 641–651.

Federal Motor Carrier Safety Administration (FMCSA) (2014) Large truck and bus crash facts 2014. Available at: https://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2014#A3 (accessed 17 July 2017).

Federal Motor Carrier Safety Administration (FMCSA), US Department of Transportation (2005) *FMCSA Field HOS Survey: Motor Carrier Industry Implementation and Use of the April 2003 Hours of Service Regulations*. Washington, DC: FMCSA, US Department of Transportation.

Ferro AS (2013) 49 CFR part 395: hours of service for commercial motor vehicle drivers. regulatory guidance concerning off-duty time; regulatory guidance. *Federal Register* 78: 41852–41853.

General Accounting Office, US Congress (1991) *Freight Trucking: Promising Approach for Predicting Carriers' Safety Risks*. Washington, DC: General Accounting Office, US Congress.

Gerhold D (1993) *Road Transport before the Railways: Russell's London Flying Waggons*. Cambridge: Cambridge University Press.

Hensher DA, Batellino HC, Gee JL, et al. (1991) *Long Distance Truck Drivers': On-Road Performance and Economic Reward*. Sydney, NSW, Australia: Institute of Transport Studies, Graduate School of Management and Public Policy, University of Sydney.

Hertz RP (1991) Hours of service violations among tractor-trailer drivers. *Accident Analysis and Prevention* 23(1): 29–36.

Hirsch BT and Macpherson DA (2017) Union membership and coverage database. *Current Population Survey*, 31 January. Available at: Unionstats.com (accessed 16 July 2017).

International Labour Organisation (ILO) (2015a) Conclusions on safety and health in the road transport sector. In: *Tripartite sectoral meeting on safety and health in the road transport sector* (ed A Cruz-Ross), Geneva, 12–16 October. Geneva: ILO. Available at: http://www.ilo.org/wcmsp5/groups/public/—ed_dialogue/—sector/documents/meetingdocument/wcms_422440.pdf (accessed 18 July 2017).

International Labour Organisation (ILO) (2015b) Resolution concerning best practices in road transport safety. Available at: http://www.ilo.org/sector/Resources/recommendations-conclusions-of-sectoral-meetings/WCMS_422448/lang–en/index.htm (accessed 18 July 2017).

International Labour Organisation (ILO) (2016) *Note on the Proceedings: Tripartite Sectoral Meeting on Safety and Health in the Road Transport Sector* (ed Sectoral Policies Department). Geneva: ILO. Available at: http://www.ilo.org/wcmsp5/groups/public/—ed_dialogue/—sector/documents/meetingdocument/wcms_458146.pdf (accessed 18 July 2017)

International Labour Organisation (ILO), Sectoral Policies Department and Cruz-Ross A (2015) *Priority Safety and Health Issues in the Road Transport Sector: Report for Discussion at the Tripartite Sectoral Meeting on Safety and Health in the Road Transport Sector, Geneva, 12–16 October*. Geneva: ILO. Available at: http://www.ilo.org/wcmsp5/groups/public/—ed_dialogue/—sector/documents/publication/wcms_400598.pdf (accessed 16 July 2017)

Kaine S and Rawling M (2010) 'Comprehensive campaigning' in the NSW transport industry: bridging the divide between regulation and union organizing. *Journal of Industrial Relations* 52(2): 183–200.

Levinson HM (1980) Trucking. In: Somers GG (ed.) *Collective Bargaining: Contemporary American Experience*. Bloomington, IL: Industrial Relations Research Association, pp. 99–150.

Lin T-D, Jovanis PP and Yand C-Z (1993) Modeling the safety of truck driver service hours using time-dependent logistic regression. *Transportation Research Record* 1407: 1–10. Available at: http://onlinepubs.trb.org/Onlinepubs/trr/1993/1407/1407-001.pdf (accessed 16 July 2017).

Lockley SW, Cronin JW, Evans EE, et al. (2004) Effect of reducing interns' weekly work hours on sleep and attentional failures. *New England Journal of Medicine* 351(18): 1829–1837.

McCartt A, Hammer MC and Fuller SF (1997) Understanding and managing fatigued driving: study of long-distance truck drivers in New York State. Paper presented at *International Large Truck Safety Symposium*, Knoxville, TN, pp. 199-213.

Mason JM Jr, Patten ML, Plummer CM Jr, et al. (1991) *Safer Truck Travel*. University Park: Pennsylvania Transportation Institute, Pennsylvania State University (Lancaster: Kelly Michener Incorporated; Pennsylvania Department of Transportation).

Mayhew C and Quinlan M (2006) Economic pressure, multi-tiered subcontracting and occupational health and safety in Australian long-haul trucking. *Employee Relations* 28(3): 212–229.

Milanovic B (2016) *Global Inequality: A New Approach for the Age of Globalization*. Cambridge, MA: Belknap Press.

Monaco K and Williams E (2000) Assessing the determinants of safety in the trucking industry. *Journal of Transportation and Statistics* 3: 69–81.

National Academies of Sciences, Engineering, and Medicine (2016) *Commercial Motor Vehicle Driver Fatigue, Long-Term Health, and Highway Safety: Research Needs*. Washington, DC: The National Academies Press. Available at: https://doi.org/10.17226/21921 (accessed 17 July 2017).

National Transportation Safety Board, U.S. Department of Transportation (1990) *Safety Study: Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes*. Washington, DC: National Transportation Safety Board.

National Transportation Safety Board, U.S. Department of Transportation (1995) *Factors That Affect Fatigue in Heavy Truck Accidents* (2 volumes). Washington, DC: National Transportation Safety Board, U.S. Department of Transportation.

Ouellet LJ (1994) *Pedal to the Metal: The Work Lives of Truckers*. Philadelphia, PA: Temple University Press.

Prendergast C (1999) The provision of incentives in firms. *Journal of Economic Literature* 37(1): 7–63.

Rawling M and Kaine S (2012) Regulating supply chains to provide a safe rate for road transport workers. *Australian Journal of Labour Law* 25(3): 237–257.

Rodriguez DA, Targa F and Belzer MH (2006) Pay incentives and truck driver safety: a case study. *Industrial & Labor Relations Review* 59(20): 205–225.

Saltzman GM and Belzer MH (2007) *Truck Driver Occupational Safety and Health: 2003 Conference Report and Selective Literature Review* (CD with supporting documents). Washington, DC: The National Institute for Occupational Safety and Health (NIOSH), Public Health Service, Centers for Disease Control and Prevention, U.S. Department of Health & Human Services.

Viscelli S (2016) *The Big Rig: Trucking and the Decline of the American Dream*. Oakland: University of California Press.

Williamson A, Bohle P, Quinlan M, et al. (2009) Short trips and long days: safety and health in short-haul trucking. *Industrial & Labor Relations Review* 62(3): 415–429.

Yellen JL (1984) Efficiency wage models of unemployment. *American Economic Review* 74: 2200–2205.

Author biographies

Michael H Belzer teaches economics at Wayne State University. He has spent decades studying the relationship between truck driver compensation and safety. He has also served on two US National Academies Panels, providing oversight for the Large Truck Crash Causation Study and most recently on the Panel on the Review of the Compliance, Safety and Accountability (CSA) Programme of the Federal Motor Carrier Safety Administration.

Stanley A Sedo has taught economics at the University of Michigan for 20 years. His research focus has been on trucking compensation and safety, discrimination, economic history and economic forecasing.