The Principal-Agent Problem and Employee Monitoring

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ABSTRACT

This paper examines whether increased employee monitoring can create organizational value by reducing the principal-agent problem. Using a state-run vehicle monitoring program as a natural laboratory, I find that increased monitoring leads to significant decreases in fuel, maintenance, and accident costs. These cost savings appear to be driven by reductions in moral hazard issues and subsequent improvements in employee behavior.

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Classical theories of the firm maintain that firms set their boundaries to optimize the make-or-buy decision.[1] The primary tension of this decision revolves around solving the principal-agent problem, and as such, an extensive literature investigates this issue (see, e.g., Holmstrom and Milgrom, 1991; Lazear, 1995; Gibbons and Waldman, 1999; Prendergast, 1999). Firms address this problem in two ways: incentive contracts (Hart, 2009) and monitoring (Burkart, Gromb, and Panunzi, 1997).[2] Despite the significant role both of these methods play in practice, the academic literature has overwhelmingly focused on incentive contracts (Murphy, 1999). This paper complements this literature by providing evidence on employee monitoring and its effectiveness in reducing the principal-agent problem.

Organizations are increasingly monitoring employees because 1) technological innovations have made monitoring easy and cost effective, 2) monitoring can complement incentive contracts leading to more efficient outcomes than in the absence of any monitoring, and 3) there are types of organizations where incentive contracts are ineffective and monitoring may act as a substitute. For example, Kellough and Lu (1993) and Perry, Mesch, and Paarlberg (2006) find that performance-based incentives are largely ineffective in the public sector, which accounts for roughly 16% of wages in the United States.[3] Monitoring, therefore, has the potential to increase efficiency in a large portion of the economy, but much of the potential advantages and disadvantages remain understudied.

I use administrative data on a state-run vehicle monitoring program to examine the value creation associated with increased employee monitoring. The data is sufficiently rich to allow me to investigate the cost savings due to decreases in fuel, maintenance, and accidents, and the mechanisms producing these cost savings, such as slower driving and personal use of company vehicles. I also have data on annual performance reviews that allows me to investigate potentially negative spillovers due to decreased engagement within the organization. To identify these cost savings, I rely on several features of the implementation of the monitoring program. First, I have data on all state divisions and only some of them implemented the monitoring program. Second, the divisions that implemented the monitoring program did so in a staggered way. Finally, as

[1] A few seminal works relating to the theory of the firm are Coase (1937); Williamson (1989); Klein, Crawford, and Alchian (1978); Hart (1988); Hart and Moore (1990); Holmstrom and Milgrom (1994).

[2] My focus is on employee monitoring, which is complementary to most of the existing literature that focuses on large shareholders monitoring a CEO.

[3] This estimate is based on Organization for Economic Cooperation and Development data located at https://stats.oecd.org/Index.aspx?QueryId=78408

a robustness check, I implement an entropy weighting design to check the efficacy of my control groups.

I find that employee monitoring effectively reduced the principal-agent problem. Specifically, I find that divisions that implemented the monitoring program experienced a 9.6% decrease in fuel costs, 14% decrease in maintenance costs, and 40% decrease in accident costs. Taken together, I estimate that the monitoring program had an overall cost savings of $100,000 during the first year. I show that employees respond to the increased monitoring by decreasing their average speed, wearing their seat belts more, and limiting idling time and after-hours vehicle use. I also examine whether these efficiency improvements are permanent, or are the result of an observer effect in which employees temporarily improve productivity because they know they are being watched (Parsons, 1974). I find that reductions in fuel and accident costs were persistent, while reductions in maintenance costs reverted to baseline levels within six months.

To account for the advantages and disadvantages of employee monitoring, I consider a holistic view of the value for the organization. Specifically, I consider the cost reductions and potential negative spillovers that would manifest themselves in annual performance reviews, increased sick leave, and vacation time used. For example, if employees feel that increased monitoring violates employer-employee trust, they may feel marginalized and become less productive (Westin, 1992). Alternatively, workers may simply find the new level of monitoring unacceptable and shirk through increased time away from work (Chalykoff and Kochan, 1989). I find no evidence that monitoring decreased employee engagement.

The setting of this paper is most similar to work of Levick and Swanson (2005) wherein monitoring devices were installed in 36 ambulances in Arkansas. While they also document that employees used their seat belts more frequently and maintenance costs lowered by about 20%, they do not quantify value creation or explore the possible negative externalities that resulted from increased monitoring. Finally, my study has several advantages in identification because the monitoring program in my study was not implemented in all divisions and was implemented in staggered way, which provides me with several control groups.

The consequences of increased employee surveillance have been considered since at least the 1980's, and a large volume of literature has developed which explores subsequent employee reactions, mostly through survey evidence.[4] In general, increased monitoring tends to attract both academic and public attention because the boundaries of acceptable monitoring have yet to be established. An extensive legal literature which explores the ethics and laws surrounding employee monitoring has done little to remedy these concerns.[5]

This paper differs from previous work and contributes to the literature in the following ways. First, I show that increased monitoring helps solve the principal-agent problem by reducing moral hazard issues and altering employee behavior. Second, I help to fill a gap in the literature by providing plausibly causal evidence on the effect of monitoring in public organizations which respond poorly to incentive pay. Finally, my quantitative analysis complements the majority of the current studies which are qualitative in nature.

The paper proceeds as follows. Section I describes the sample and methods. Section II presents results. Section III discusses the results, and Section IV concludes.

I. Sample and Methods

A. Sample

Data comes from 30 agencies within the state of Utah.[6] Access to this data came with the condition that the name of each agency be anonymized. Vehicle monitoring data are aggregated at a monthly frequency and are available since the program's inception in January 2017. Vehicle monitoring devices are from the Geotab company.[7] These devices integrate into each vehicle's computer system and can be used to record a variety of driving conditions within a vehicle, such as seat belt usage, idling time, speed limit violations, and after-hours vehicle use. Depending on the settings used in each agency, monitoring devices can emit either short or continuous beeping sounds when policy violations occur. For example, when driving without a seat belt, the agency can program the device to a) emit a short series of reminder beeps, or b) continuously beep until

[4] Some examples include Attewell (1987); Chalykoff and Kochan (1989); Larson and Callahan (1990); Aiello and Kolb (1995); Regan (1996); Ball and Wilson (2000); McGrath (2004). For a review of the literature see (Ball, 2010; Alge and Hansen, 2014).

[5] Some examples include Hash and Ibrahim (1996); Wilborn (1997); Lasprogata and King (2004); Cohen and Cohen (2007); Ciocchetti (2011).

[6] A few examples of state agencies within the state of Utah include Law Enforcement, Division of Natural Resources, Department of Corrections, Department of Health, etc.

[7] The Geotab company offers fleet management software that assists companies to better manage their automotive assets. See `https://www.geotab.com/` for more information.

the violation is corrected. Email notifications can also be sent to supervisors when the device is removed, the check engine light is on, the vehicle exceeds a specific speed, or a possible accident occurs, depending on agency settings.

The implementation of the monitoring program was staggered across several agencies, although the majority of the monitoring devices were installed by March 2017. Figure 1 provides a timeline of device installation and alarm setting changes. Table I details statistics on agency size, total number of vehicles in each agency, and the percentage of agency vehicles monitored as of June 2017.

To asses the effect of monitoring on fuel efficiency and maintenance costs, the complete fuel and maintenance records of each state-owned vehicle were provided at a monthly frequency from January 2016 to April 2018. These records include miles driven, gallons of fuel used, total fuel cost, and maintenance costs. Maintenance costs are separated into two categories: internal maintenance, which includes maintenance performed by the state, and commercial maintenance, which includes maintenance performed by third-party contractors.

Data was also provided for accidents that occurred from January 2016 to April 2018. The data includes the identification number of the vehicle involved in the accident, the cost of the accident, and a description of the accident cause. The State of Utah was willing to provide annual employee performance review data, as well as monthly vacation and sick leave data, aggregated at the agency level for a subset of agencies.

Summary statistics of fuel efficiency, maintenance costs, accident costs, average hours driving, performance rating changes, vacation hours, and sick leave are reported in Table II.

B. Selection Bias

The monitoring program was implemented by the Utah Division of Fleet Operations. This agency is responsible for sourcing, maintaining, and optimizing the State's fleet of vehicles. The program was put into effect to better determine and improve upon how automotive assets were utilized.

When the monitoring program was implemented, all State agencies were invited to participate. This means that the agencies which did participate self-selected into the program. Because monitoring was not randomly assigned, interpretation of my findings requires consideration of the selection bias inherent in the experimental design. Fleet Operations indicates that agencies that drove more or had more vehicles to monitor were more likely to select into the monitoring program.

According to Fleet Operations, the following agencies self-selected into the monitoring program for these reasons. Agency D participated in the monitoring program because the agency had received reports that employees were not completing the tasks they were assigned or were using state vehicles for personal use during work hours. Agency E participated in the program after an audit revealed that employees may have been utilizing vehicles after hours for personal use. Agency F participated in the program to lower costs and become more efficient because it is solely funded by the work it completes. If the services provided by the department become too expensive, the State outsources these services to external contractors.

One possible concern with my findings is that selection into the monitoring program could lead to a lack of external validity if only those departments which would have benefited from employee monitoring chose to participate. For example, if the non-monitored departments were already at maximum efficiency, or their employed workers were more compliant with seat belt regulations, speed limitations, and after-hours vehicle use, then monitoring employee driving habits in these departments would not have the same effect.

While this is certainly a possibility, the function of other agencies as controls in this experiment only requires that *changes* in outcome variables specific to control agencies do not coincide with vehicle monitoring in treated agencies. The *levels* of outcome variables in control agencies relative to treated agencies will not bias my estimates in the presence of agency fixed effects.

C. Methods

To estimate the effect of monitoring on fuel and maintenance costs, I use a staggered difference-in-differences approach:

$$Outcome_{ait} = Monitoring_{ait} + \delta_a + \gamma_t + \epsilon_{ait} \tag{1}$$

where $Outcome_{ait}$ is either *MPG* (Miles Per Gallon), *Miles Driven*, *Gallons Fuel*, *Fuel Cost*, *Commercial Maintenance*, or *Internal Maintenance* for vehicle i in agency a during month t. $Monitoring_{ait}$ is an indicator variable set to one when vehicle i in agency a is being monitored during month t, and is zero otherwise. δ_a is an agency fixed effect which controls for time-invariant agency characteristics that affect the outcome variable but are not affected by monitoring. γ_t is a monthly time fixed effect that controls for time varying conditions (such as air conditioning use in the summer) that affect the outcome variables but are not affected by monitoring. In unreported results, I have replaced agency fixed effects with vehicle fixed effects and get similar results of lower magnitude for most specifications. Because Fleet Operations indicated that agencies began reassigning less efficient vehicles to areas of lower use once the monitoring data become available, vehicle fixed effects likely eliminate these within-agency efficiency improvements. As such, I have chosen not to utilize vehicle fixed effects in my main specifications.

To estimate the effect of monitoring on accident probability, the following logit model is used:

$$Accident_{ait} = Monitoring_{ait} + \delta_a + \gamma_t + \epsilon_{ait} \tag{2}$$

where $Accident_{ait}$ is an indicator variable set to one when an accident occurs involving vehicle i in agency a during month t, and is zero otherwise. $Monitoring_{ait}$ is an indicator variable set to one when vehicle i in agency a is being monitored during month t, and is zero otherwise.

To estimate the effect of monitoring on employee performance, sick leave, and vacation use, the following specification is used:

$$Outcome_{at} = PctMonitored_{at} + \delta_a + \gamma_t + \epsilon_{at} \tag{3}$$

Where $Outcome_{at}$ is either *HR Rating Change* or *Self Rating Change* for agency a during year t for employee performance outcomes, or *Vacation Hours* or *Sick Hours* for agency a during month t for vacation and sick leave outcomes. $PctMonitored_{at}$ is either *Percent Vehicles Monitored* or *Percent Employees Monitored*, and represents the fraction of the agency a's vehicles which have monitoring devices, or the number of monitored vehicles per employee in agency a, respectively. δ_a is an agency fixed effect which control for time-invariant agency characteristics. γ_t is either a year or month fixed effect which controls for time varying conditions, such as holidays or economic conditions, which might impact the outcome variable.

II. Results

A. Reductions in Maintenance Costs

Table III examines the effect of vehicle monitoring on fuel efficiency and maintenance costs. Panel A presents unweighted regressions, and Panel B presents regressions that are entropy weighted by miles driven per vehicle and number of vehicles per agency. Weighted regressions assure that covariates between treatment and control groups are balanced. Panel A Column 1 shows that fuel efficiency of monitored vehicles increased by 0.67 mpg. Columns 2 and 3 show that gallons of fuel used and total fuel costs decreased by 2.81 gallons and $14.8, respectively.

Columns 4 and 5 examine the effect of vehicle monitoring on commercial and internal maintenance costs. Internal maintenance costs include maintenance performed by the state of Utah, and commercial maintenance costs include maintenance performed by third-party contractors. Some agencies rely more heavily on one maintenance source than the other. Column 4 shows that monitoring decreased commercial maintenance costs by approximately $11.7 per month per vehicle, which represents a 15% reduction in costs from the pre-treatment average. Column 5 shows that internal maintenance costs decreased by $2.22 per month per vehicle, which represents an 11% reduction from the pre-treatment average.

Fleet Operations reports that replacing brake pads and tires represents the bulk of maintenance costs. If employees began driving more slowly because of monitoring, this would lead to less stress and friction on brakes and tires, which is consistent with maintenance costs decreasing. The vehicle monitoring program also notifies supervisors of check engine and other maintenance lights signaled by the vehicle, which prevents vehicle neglect from resulting in more expensive repairs in the future. For example, monitoring devices discovered that one employee was driving with a damaged transmission that was near complete failure. Early detection of this problem allowed the state to repair the transmission rather than replace it.

Table III Panel B provides similar estimates to Panel A, although they are of lower magnitude. Because the agencies that self-selected into the monitoring program were likely to drive more or have more vehicles to monitor, re-weighting the sample by miles driven and vehicles per agency helps to account for this bias.

Another study which examined the effect of vehicle monitoring on ambulances also found that maintenance costs decreased by 20% upon vehicle monitoring (Levick and Swanson, 2005). Because I find similar results, this adds confidence to my findings and suggests that vehicle monitoring has the potential to generate significant firm value.

B. Reductions in Accident Costs

Table IV examines the effect of monitoring on accident probability and cost. Panel A presents unweighted regressions, and Panel B presents regressions that are entropy weighted by miles driven per vehicle in order to account for probability of an accident increasing with miles driven. Panel A Columns 1-3 use logit models to examine the effect of monitoring on probability of having an accident, with and without agency and month fixed effects. Agency fixed effects control for the conditions specific to each agency's vehicle use that would alter the probability of an accident. For example, vehicles used in law enforcement or construction may have a higher probability of being involved in an accident. Month fixed effects control for seasonal effects that affect the probability of an accident, such as snow or rain.

Panel A Column 1 shows that without any fixed effects, the probability of an accident increases by 28% when vehicles are monitored. Columns 2 and 3 show that the probability of being involved in an accident is statistically indistinguishable from zero once vehicle or year fixed effects are included. Columns 4-6 examine the effect of monitoring on accident costs. With or without agency or month fixed effects, all three regressions indicate that the average accident costs about \$2000, and vehicle monitoring reduces the cost of the average accident by approximately 40% or \$800. Panel B ensures that miles driven per vehicle are consistent across treatment and control groups. The estimates are nearly identical to those reported in Panel A.

C. Duration of the Monitoring Effect

I also consider the duration of the monitoring effect. On one hand, changes in asset utilization and learned behavioral changes may have long-lived effects. Alternatively, employee monitoring may simply induce an observer effect, in which employees temporarily change their behavior because they know they are being monitored.[8]

[8] The observer effect, also known as the Hawthorne effect, stems from the studies done at the Western Electric Hawthorne Works factory between 1924 and 1932. Researchers observed that both positive and negative changes to employee work environments led to productivity improvements, presumably because workers knew they were being

Thus far, my evidence on the duration of monitoring outcomes is mixed. Seat belt and speeding results in Figures 2 and 3 indicate that continued use of the the alarms maintains monitoring-induced changes in employee behavior. However, idling results in Figure 5 show that when these alarms are removed, idling returns to baseline levels. Because much of the cost savings resulting from the monitoring program are due to reduced fuel, maintenance, and accident expenses, the persistence of these changes determines the long-term value the program creates.

Figure 6 plots the average monthly residual of regressing *Fuel Cost*, *Commercial Maintenance* cost, *Internal Maintenance* cost, and *Accident Cost* on agency and month fixed effects. Panel A shows that fuel savings persist, while Panels B and C indicate that maintenance costs revert to pre-monitoring levels after approximately 6 months. Panel D, which shows changes in accident costs, is more noisy and difficult to visually interpret.

Table V also investigates the duration of the monitoring effect by removing the first six months of data from monitored vehicles. Columns 1 and 4 show that fuel and accident savings persisted for the entirety of the sample. Columns 2 and 3 show that changes in maintenance costs became insignificant, indicating that maintenance costs reverted to pre-treatment levels after six months. I discuss these results further in Section III.B.

D. Quantifying Value Created By Vehicle Monitoring

Table VI quantifies costs and savings which resulted from the vehicle monitoring program. The cost of vehicle monitoring devices is broken down into device cost, monthly device service cost, device administration cost to initiate and maintain the device monitoring program, and device installation costs. Fleet Operations was able to negotiate a complete waiver of device costs, and a reduction of service costs per device to $19.75 per month. Administration and implementation of the monitoring program is estimated to have taken the resources of one full-time administrative employee per year at a cost of $62,850. With 1012 monitoring devices, this equates to a cost of approximately $5.50 per vehicle per month. Fleet Operations estimates that it takes approximately 15 minutes to install the device, and one hour total to install the device once travel time is included.

studied. Although the study has been heavily contested, the idea that humans act differently when they know they are being watched remains salient and continues to draw academic attention. See Parsons (1974); Monahan and Fisher (2010); Crofoot, Lambert, Kays, and Wikelski (2010); McCambridge, Witton, and Elbourne (2014) for a few examples in the literature.

At \$30/hour and a lifespan of 60 months, this equates to a installation cost of \$0.50 per vehicle per month.

Table III estimates the commercial maintenance cost savings per vehicle per month to be \$11.70, internal maintenance savings to be \$2.22, and fuel cost savings to be \$14.8. To estimate the monitoring effect on accident costs, I multiply the probability of an accident per vehicle per month (0.7%) by the costs savings per accident calculated in Table IV. The 95% confidence intervals of these estimates reported in Table VI indicate a Return on Investment (ROI) of 43%. These estimates suggest that fleet monitoring saved the State of Utah over \$100,000 during the first year of the program.

Because reductions in maintenance costs appear to be temporary (see Section II.C), the savings calculated above may be exaggerated. When reduced maintenance expenses are not included in the value analysis, the program costs about \$9 per vehicle per month. However, because the program improved asset monitoring, increased employee safety, and reduced accident lawsuit liability, these positive externalities may still lead to a net value creation. The continued operation of the Geotab company, the provider of the vehicle monitoring service, is consistent with this possibility.

E. Changes In Employee Behavior

In order to better understand the mechanism that led to fuel, maintenance, and accident cost savings, I utilize data from Geotab devices to analyze whether these changes were driven by employee behavior. If increased monitoring does reduce the principal-agent problem by reducing moral hazard issues, this predicts that employee behavior should improve.

E.1. Seat Belts

I first examine the changes in employee behavior that resulted from the seat belt alarms. The majority of monitoring devices for agencies D, E, and F were installed as of March 2017. Upon device installation, agencies D and F instituted a continuous beeping alarm when drivers were not wearing their seat belts and vehicles were traveling more than 6 mph. Agency E initially instituted a different seat belt violation system in which seat belt alarms only lasted for a few seconds.

In September 2017, agency E switched to the same continuous beeping warning used in agencies D and F. Figure 2 shows that when the continuous seat belt beeping alert was instituted, the number of seat belt warning incidents decreased to levels similar to agencies D and F. Discussions with Fleet Operations suggest that seat belt violations continued to occur in these agencies at a low level due to the idiosyncratic nature of the agencies involved.

The increase in value that can be attributed to increased seat belt use is difficult to quantify due to the inability of observing the counterfactual scenario of not having worn seat belts. Aggregated data from the United States Department of Transportation reports that in 2016 the lack of seat belts resulted in 10,428 fatalities in the US, accounting for 28% of all auto fatalities.[9] To put this figure in perspective, fatalities due to drunk driving also accounted for 28% of all auto accident deaths.

E.2. Speeding

Figure 3 examines the effect of monitoring on speeding. Because it was not possible to monitor vehicle speed prior to installation of the monitoring devices, we can only examine changes in behavior that occurred during the treatment period.

Upon implementation of the monitoring program, agencies D, E, and F began tracking instances in which a vehicle traveled over 75 mph (*Speed 75*), 85 mph (*Speed 85*), or 95 mph (*Speed 95*). This monitoring, combined with several speeding tickets given to employees traveling more than 95 mph, led to a large reduction in the average number of *Speed 75* incidents per vehicle, and a near elimination of *Speed 85* and *Speed 95* incidents per vehicle. In September 2017, agencies D, E, and F instituted beeping indicators for speeding 10-15 mph over posted speed limits. This resulted in a near elimination of all speeding incidents.

The data shows that when employees are reminded that they are speeding, the tendency to break posted speed limits significantly decreases. By reducing speeding incidents, employees significantly reduce the probability of personal injury and property damage, although, like seat belt usage, the cost savings of this change in behavior is difficult to quantify. Other studies which investigate the effects of speeding indicate that in 2016, speeding resulted 10,111 fatalities in the US, accounting for 27% all auto fatalities.[10] A study by the National Council on Compensation Insurance found

[9] USDOT Releases 2016 Fatal Traffic Crash Data. NHTSA, NHTSA, 23 Apr. 2018, www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data.

[10] USDOT Releases 2016 Fatal Traffic Crash Data. NHTSA, NHTSA, 23 Apr. 2018, www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data.

that traffic accidents are the leading cause of high-severity worker compensation injuries (Restrepo and Shuford, 2012), and a study by the World Health Organization indicates that an increase in average speed of 1 km/h typically results in a 3% higher risk of a crash involving injury, with a 4 to 5% increase in the probability that a crash will result in fatalities.[11]

E.3. After-hours Vehicle Use

Figure 4 examines the effect of monitoring on after-hours vehicle use. After vehicle monitoring was implemented, the number of times employees in agencies D, E, and F used state vehicles for personal use declined. This decrease in after-hours vehicle use occurred without any auditory alarms indicating that after-hours driving was being monitored. This change in behavior resulted in lower accident liability for the state and reduced fuel expenses.

E.4. Time Spent Idling

Agency F was the sole agency to implement alarms in an attempt to reduce idling. Figure 5 shows that after monitoring devices were installed, the average idling time of agency F vehicles decreased from approximately 400 minutes per month to approximately 50 minutes per month. In September 2017, agency F reported that some of its vehicles needed to idle to operate specific vehicle equipment (e.g. boom lift or fuel truck), and the idling alarms were removed from these vehicles. In the months that followed, idling increased to approximately 100 minutes per month.

Because the removal of idling alarms resulted in employee behavior returning to pre-alarm levels, Figure 5 suggests that alarm-initiated changes in employee behavior revert once the alarms are removed.

F. Consideration of Externalities

Results thus far show that vehicle monitoring increased employee safety by encouraging employees to use seat belts more frequently, speed less often, and decrease after-hours vehicle use. At the same time, these changes in behavior also increased public safety and reduced lawsuit liability exposure. Because personal injury lawsuits from automotive accidents can cost millions of dollars,[12]

[11] World Report on Road Traffic Injury Prevention. World Health Organization, World Health Organization, 5 Sept. 2014, www.who.int/violence_injury_prevention/publications/road_traffic/world_report/en/.

[12] See Estate of Patrick G. Nunez v. Utica Transit Mix and Supply, Co. Inc. and Charles L. Dreyer

reducing these rare-disaster risks could be substantial enough to recapture the entire cost of the monitoring program.

It is also possible that monitoring employees comes with negative externalities that are difficult or impossible to measure. For example, if employees feel that increased monitoring violates employer-employee trust, they may feel marginalized or become less productive (Westin, 1992). Alternatively, high quality workers may choose to work for employers that provide greater privacy (Chalykoff and Kochan, 1989).

To examine these possibilities, Table VII investigates the effect of monitoring on employee performance as proxied by annual employee reviews. I define monitoring at the agency level in two different ways. *Percent Vehicles Monitored* measures the fraction of agency vehicles that have monitoring devices, and *Percent Employees Monitored* measures the number of monitored vehicles per employee. If the ratio of employees to vehicles is high, *Percent Employees Monitored* may more accurately measure monitoring effects.

Columns 1 and 2 show that the monitoring did not alter employee performance as measured by the human resources department. Both monitoring measures suggest that the performance ratings improved by approximately 1% upon monitoring, although neither point estimate is statistically significant.

Columns 3 and 4 estimate the effect of monitoring on internal reviews submitted by each agency. If increased monitoring has an effect on performance not visible to the human resources department, such as a negative effect on agency culture, the agency self assessment may provide a better estimate of any resulting performance change. Point estimates indicate that the percentage change in performance was between -5 to 1% depending on the specification, but again, neither estimate is statistically significant.

Columns 5-8 estimate the effect of monitoring on the use of vacation and sick leave. If monitoring has negative externalities that impact firm culture or encourages employees to seek new employment, this effect may be apparent by employees using more vacation days to interview at other jobs or using more sick days due to monitoring-induced dissatisfaction or stress.

Columns 5 and 6 indicate that employees used approximately 0.29-0.48 more vacation hours per month depending on the monitoring specification. Economically, these estimates represent an average increase in vacation use of approximately 3-6 hours per year. Columns 7 and 8 show that monitored employees increased sick leave use by 0.14-0.74 hours per month depending on the specification. Economically, these estimates represent an average increase in vacation use of approximately 2-9 hours per year, although 3 of the 4 estimates are statistically insignificant.

III. Discussion

A. The Unquantified Effects of Monitoring

Performance review, vacation, and sick leave results indicate that vehicle monitoring did not generate observable externalities that would negatively impact firm value. While Fleet Operations reports that some employees initially expressed dissatisfaction at the idea of having "big brother" watching them, this resistance reportedly dissipated as employees realized that vehicle monitoring was not as intrusive as they expected or realized other benefits of monitoring.

For example, employees who drove vehicles in rural areas without cell phone coverage had historically experienced difficulty being located when breakdowns occurred. Several anecdotal incidents of people walking long distances for help had been documented. When the monitoring program was implemented, employees were able to signal help to their exact location with a push of a button. This improvement in safety may have been seen as a benefit of monitoring, which may have made monitoring more tolerable.

Because the fleet monitoring program had such obvious implications for employee safety, there may have been fewer negative externalities than with other more intrusive or less relevant forms of monitoring. For example, it may be harder for employees to rationalize audio or video surveillance as a necessary intrusion, and therefore such programs may be met with greater resistance.

B. A Temporary Effect?

Table V shows that the effect of monitoring on fuel and accident costs was persistent, while the effect of monitoring on maintenance costs lasted less than six months. One possible explanation for this difference could be managerial follow-through.

Fleet Operations indicated that when the monitoring program was initially implemented, employees were unclear about what parts of their driving were being monitored. Because of this, it could be that employees improved all aspects of their driving behavior initially, and then allowed behaviors which did not trigger alarms to return to baseline levels.

Speeding results in Figure 3 show that the reduction of speeding violations persisted more than six months– which is consistent with long-term reductions in fuel and accident costs. Asset re-deployment is also likely to be a permanent change that contributes to the persistence of fuel savings.

The monitoring program, however, did not monitor changes in aggressive driving (e.g. hard braking and cornering). Because aggressive driving increases tire and brake pad wear, and brakes and tires represent the bulk of maintenance costs, failure of managers to monitor aggressive driving may explain the temporary effect of these savings. For example, it could be that drivers drove less aggressively when the program was implemented and then reverted to their original behavior when they realized such behavior was not being monitored.

IV. Conclusion

This paper examines whether increased employee monitoring can create value by reducing the principal-agent problem. On one hand, increased monitoring may improve organizational value by reducing moral hazard issues and increasing productivity. Alternatively, increased monitoring may sufficiently harm organizational culture such that employee engagement decreases and value suffers. Because the effect of increased monitoring on firm value is ambiguous, this paper helps to fill this gap in the literature.

I find that employee monitoring effectively reduced the principal-agent problem. Specifically, I find that divisions that implemented the monitoring program experienced a 9.6% decrease in fuel costs, 14% decrease in maintenance costs, and 40% decrease in accident costs. Taken together, I estimate that the monitoring program had a return on investment of 40% during the first year. I find that employees respond to the increased monitoring by decreasing their average speed, wearing their seat belts more, and limiting idling time and after-hours vehicle use.

Finally, I also provide evidence that monitoring can increase employee productivity in public organizations, which have historically responded poorly to incentive pay. As public organizations account for roughly 16% of wages in the United States, monitoring has the potential to increase efficiency in a large portion of the economy.

Appendix A.

Table I

Variable	**Variable Definition**
Miles Driven	Number of miles a vehicle traveled over a one-month period
Gallons Fuel	Number of gallons a vehicle used over a one-month period
Fuel Cost	Total cost of fuel per vehicle over a one-month period
MPG	Miles Driven over the Gallons Fuel
Commercial Maintenance	Maintenance costs from work provided by a third-party contractor over a one-month period
Internal Maintenance	Maintenance costs from work performed by the State of Utah over a one-month period
Accident Cost	Total cost of an accident payed out by insurance (workers compensation costs not included)
Average Speed	Average speed which a monitored vehicle traveled over a one-month period
Hours Driving	Miles Driven over Average Speed
Seat Belt Incident	Number of incidents logged by the vehicle monitoring system for unbuckled seat belt when vehicle is traveling more than 6 mph
Speed 75	Number of incidents logged by the vehicle monitoring system for driving more than 75 mph
Speed 85	Number of incidents logged by the vehicle monitoring system for driving more than 85 mph
Speed 95	Number of incidents logged by the vehicle monitoring system for driving more than 95 mph
Idling Incident	Number of incidents logged by the vehicle monitoring system for idling more than 3 minutes
HR Rating Change	Percent change in employee performance rating reported by the human resources department
Self Rating Change	Percent change in employee performance rating self reported by the agency
Vacation Hours	Average number of vacation hours used per employee per month
Sick Hours	Average number of sick hours used per employee per month

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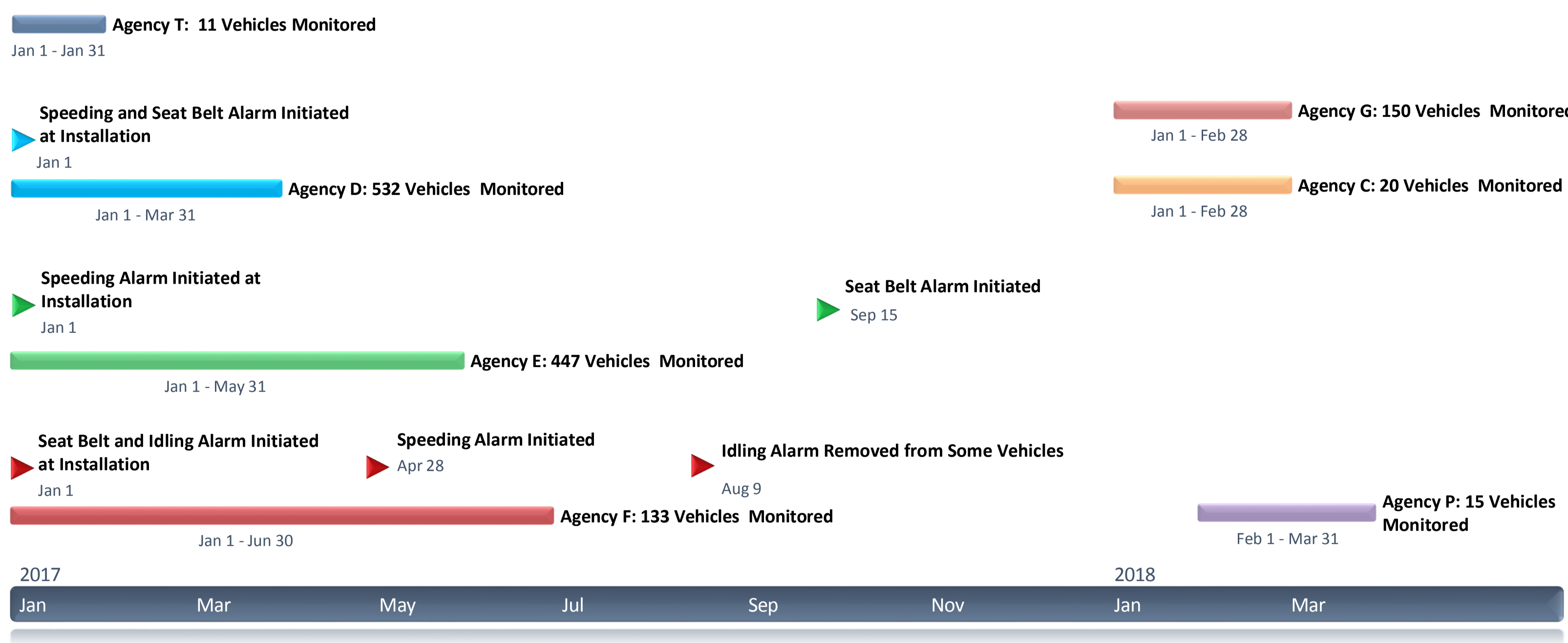

Figure 1.

Vehicle Monitoring Timeline

This figure shows the timeline of vehicle monitoring device installation and changes to alarm settings. Each agency is color coded. Bars represent the interval of monitoring device installation. Triangles describe monitoring alarm initiation and changes.

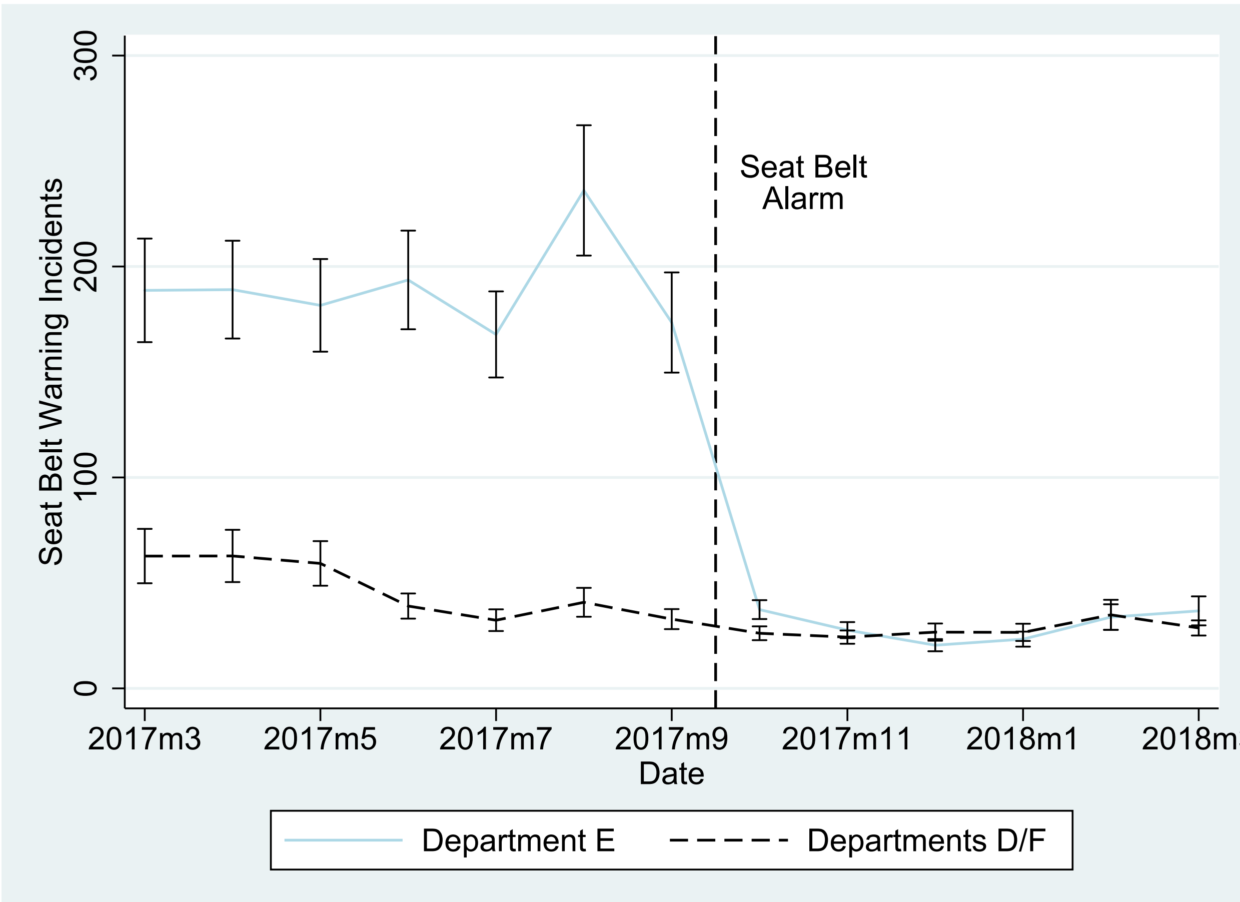

Figure 2.
Effect of Monitoring on Seat Belt Usage
This graph shows the average number of seat belt incidents per month by agency. On September 25, 2017, agency E initiated a continuous seat belt alarm when the vehicle was traveling more than 6 mph and seat belt(s) were not fastened. Agencies D and F utilized a similar continuous seat belt alarm upon installation. Error bars present 95% confidence intervals.

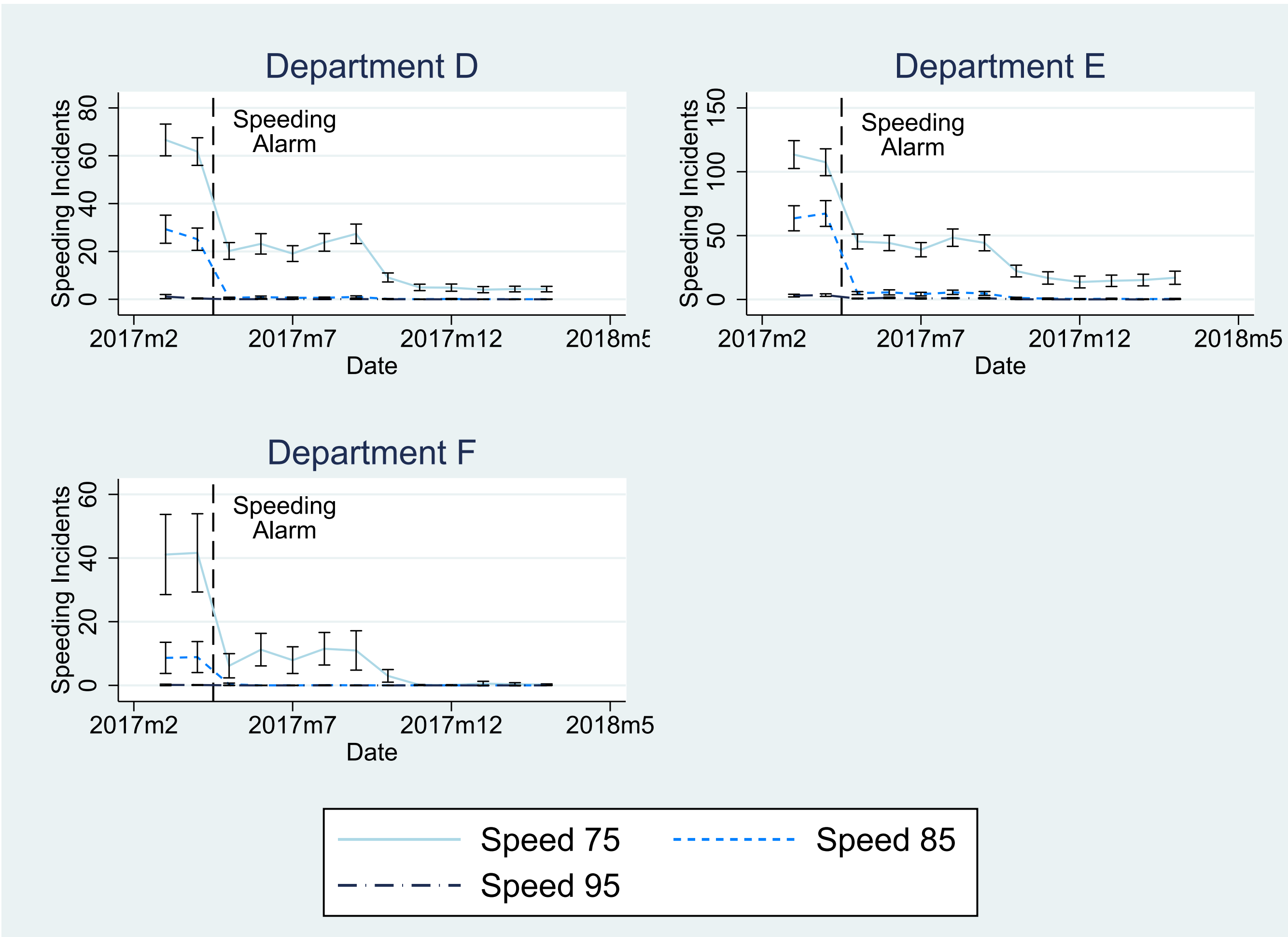

Figure 3.
Effect of Monitoring on Speeding
These graphs show the average number of speeding incidents per month per vehicle by agency. *Speed 75* indicates that the vehicle was traveling over 75 mph. *Speed 85* indicates that the vehicle was traveling over 85 mph, and *Speed 95* indicates that the vehicle was traveling more than 95 mph. The vertical line labeled *Speeding Alarm* indicates that these departments initiated a short alarm when the vehicle was traveling more than 75 mph, 85 mph, or 95 mph. Near September 2017, alarms for traveling more than 10-15 mph over the posted speed limit were initiated, although the exact timing and rules differed across agencies.

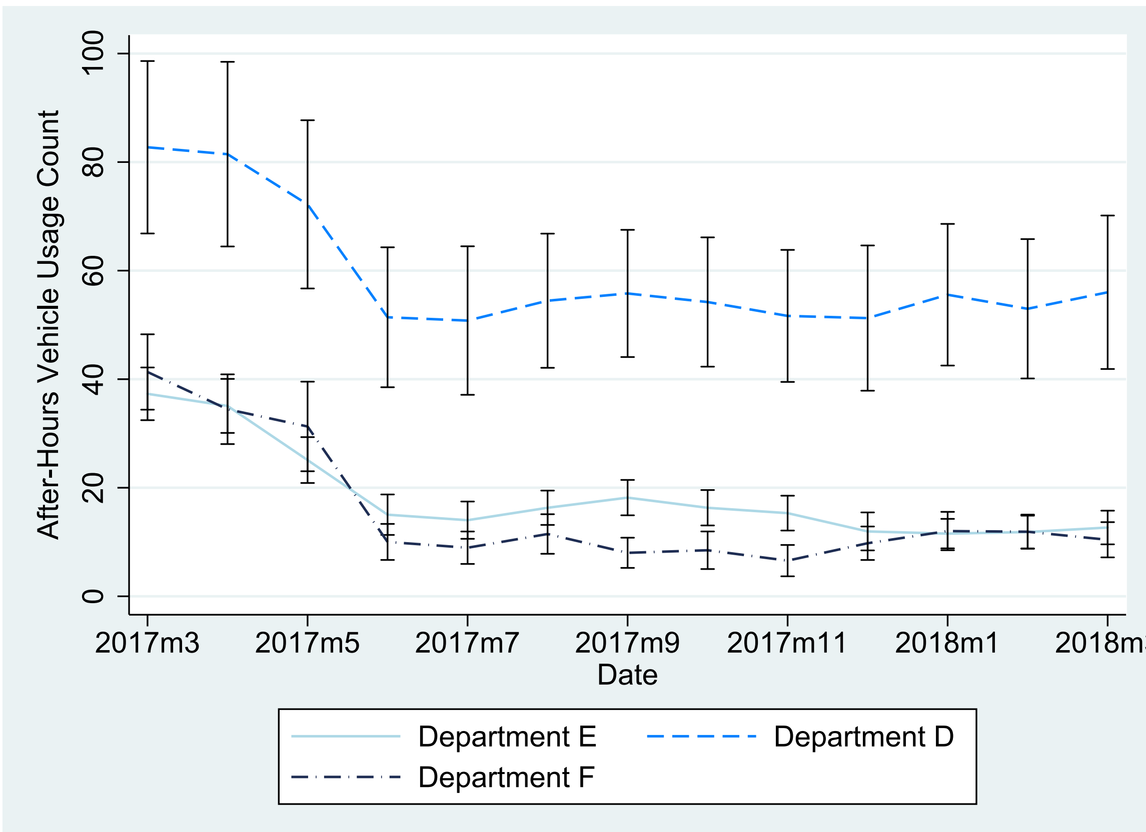

Figure 4.
Effect of Monitoring on After-Hours Vehicle Use
This graph shows the average after-hours vehicle use in agencies D, E, and F.

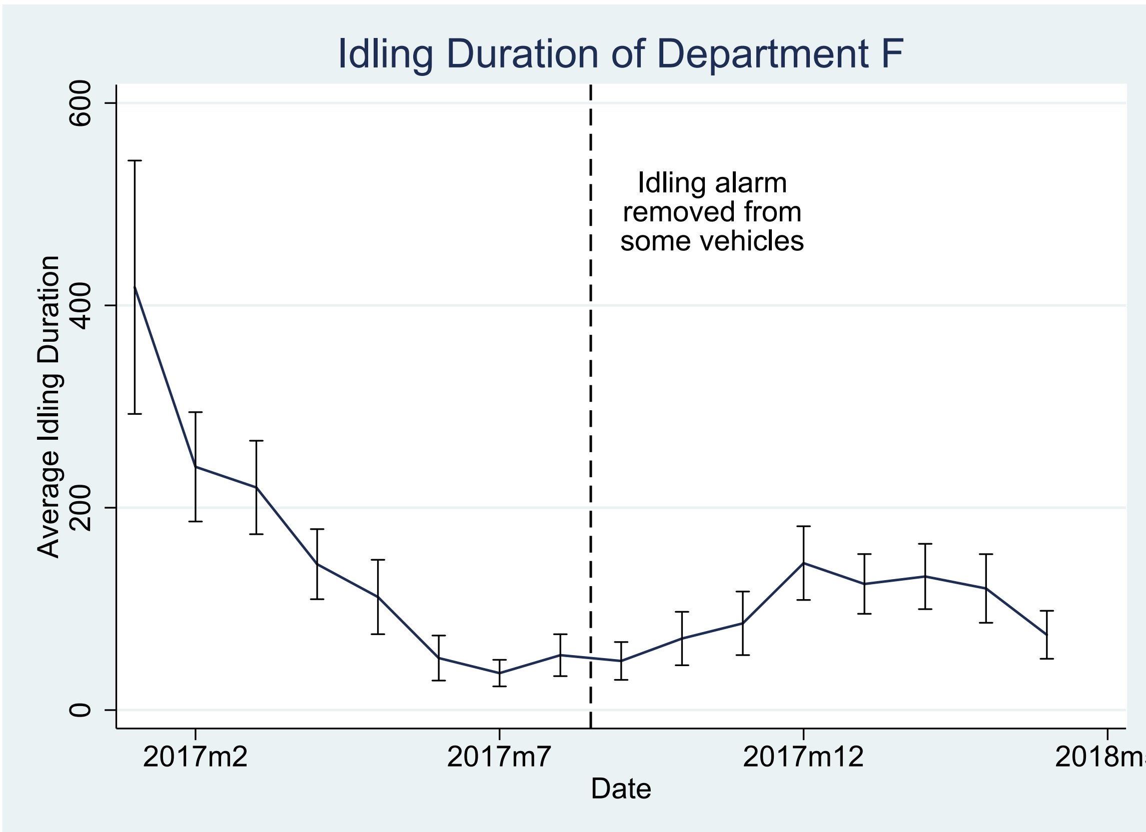

Figure 5.
Effect of Monitoring on Idling
This graph shows the average minutes spent idling per vehicle per month in Agency $F-$ the only department to utilize idling alarms. Upon installation, the monitoring devices were programmed to emit a continuous alarm when the vehicle idled more than 3 minutes. On August 9, 2017, the idling alarm was removed some agency vehicles that required idling to optimally function (e.g. boom lifts or fueling trucks).

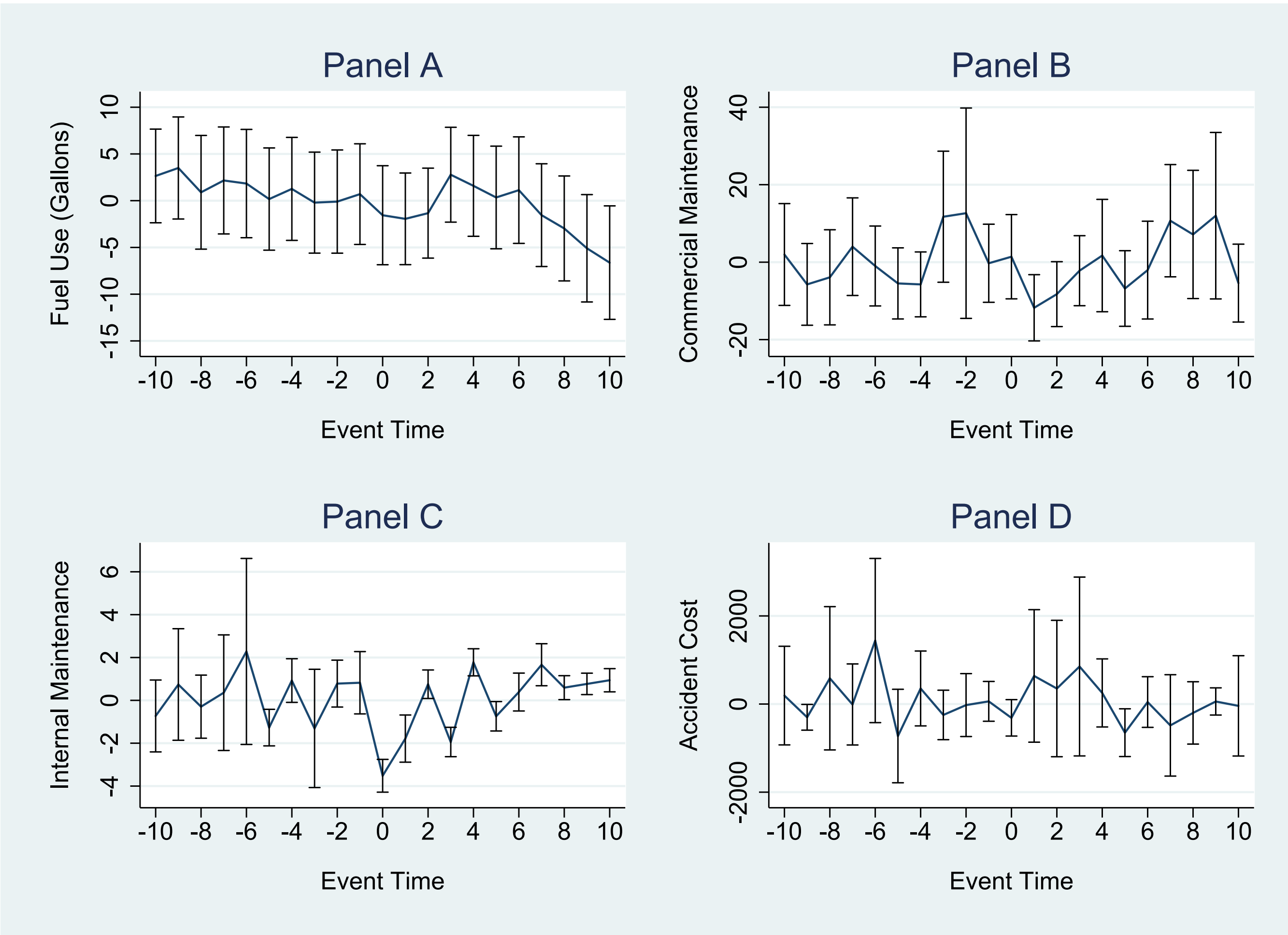

Figure 6.
Duration of Monitoring Effect
This figure displays the average monthly residuals of regressing the dependent variable on agency and month fixed effects. Event time is in months relative to when the monitoring device was first installed.

Table I
Data Summary
This table describes the data used in the paper. *Total Vehicles* represents the average number of vehicles in an agency over the sample period. *Percent Vehicles Monitored* is the percentage of the agency vehicles monitored as of June 2017. *Maintenance & Mileage Observations* reports the monthly observations available with maintenance, mileage, and fuel data. *Observations With Accidents* reports the number of observations with maintenance, mileage, fuel, and accident data. *Performance Review Data* indicates whether performance review data is available for a particular agency. *Vacation and Sick Leave Data* reports whether performance vacation and sick leave data are available for a particular agency. *Employees* is the average number of employees in an agency over the sample period.

Agency	(1) Total Vehicles	(2) Percent Vehicles Monitored	(3) Maintenance & Mileage Observations	(4) Observations With Accidents	(5) Performance Review Data	(6) Vacation and Sick Leave Data	(7) Employees
A	729	0	21,163	81			
B	751	0	21,836	112			
C	926	0	27,122	46			
D	**501**	**93**	**14,275**	**42**			
E	**435**	**97**	**12,576**	**35**			
F	**126**	**92**	**3,654**	**12**	**Yes**	**Yes**	**434**
G	138	0	3,997	11	Yes	Yes	238
H	78	0	2,311	6	Yes	Yes	554
I	148	0	4,292	5			
J	52	0	1,501	3			
K	140	0	4,025	10			
L	39	0	1,115	1			
M	51	0	1,484	3			
N	23	0	666	2			
O	38	0	1,100	2			
P	16	0	453	4	Yes	Yes	114
Q	57	0	1,646	4			
R	12	0	348	0			
S	26	0	770	1	Yes	Yes	2231
T	**10**	**78**	**291**	**2**	**Yes**	**Yes**	**276**
U	18	0	537	4			
V	21	0	607	0	Yes	Yes	702
X	6	0	174	0			
Y	8	0	232	0			
Z	9	0	253	0			
ZB	2	0	58	0			
ZC	15	0	399	0			
ZD	**3**	**33**	**87**	**0**			
ZE	1	0	22	0			
ZG	1	0	29	0			
Time Period		01/2016-05/2018	01/2016-05/2018	01/2016-05/2018	2016-2018	01/2016-05/2018	01/2016-05/2018
Data Frequency		Monthly	Monthly	Monthly	Yearly	Monthly	Monthly

Table II
Summary Statistics
This table reports summary statistics. *Miles Driven* is the number of miles a vehicle traveled over a one-month period. *Gallons Fuel* is the number of gallons a vehicle used over a one-month period. *Fuel Cost* is the total cost of fuel a vehicle used over a one-month period. *MPG* is the miles driven over the gallons fuel. *Commercial Maintenance* is the maintenance costs performed by a third party over a one-month period. *Internal Maintenance* is the maintenance costs performed by the State of Utah over a one-month period. *Accident Cost* is the total cost of an accident payed out by insurance (workers compensation costs not included). *Average Speed* is the average speed which a monitored vehicle traveled over a one-month period. *Hours Driving* is the average number of hours driven per vehicle per month. *HR Rating Change* is the percent change in employee performance rating reported by human resources department. *Self Rating Change* is the percent change in employee performance rating self-reported by agency. *Vacation Hours* is the average number of vacation hours used per employee per month per agency. *Sick Hours* is the average number of sick hours used per employee per month per agency.

	(1)	(2)	(3)	(4)	(5)
Variable	Mean	Stdev	p10	p90	N
MPG	20.4	11.1	9.51	39.1	113431
Miles Driven	1140	907	37	2430	127023
Fuel Cost	154	131	31.8	340	114355
Gallons Fuel	76.6	62.9	16.6	168	114355
Commercial Maintenance	83.9	573	0	178	122590
Internal Maintenance	22	385	0	29.3	122590
Accident Cost	32.4	424	0	0	60820
Average Speed	35.7	13.2	17	52.9	15164
Hours Driving	28.2	18.1	7.17	51.1	15164
HR Rating Change	-0.00199	0.145	-0.01	0.00806	18
Self Rating Change	-0.00667	0.0529	-0.0284	0.0310	18
Vacation Hours	8.77	4.33	4.52	15.0	168
Sick Hours	4.87	1.03	3.60	6.40	168

Table III
Effect of Monitoring on Fuel Efficiency and Maintenance Costs
This table reports the effect of vehicle monitoring fuel efficiency and maintenance. Panel A presents unweighted regressions, and Panel B presents regressions that are entropy weighted by miles driven per vehicle and the number of vehicles per agency. *MPG* is the number of miles per gallon a vehicle utilized. *Commercial Maintenance* includes maintenance costs performed by third-party contractors. *Internal Maintenance* includes maintenance costs performed by the state internally. *Monitoring* is an indicator variable set to one when a vehicle has a monitoring device installed. Costs are reported in January 2016 Consumer Price Index (CPI) adjusted dollars (https://fred.stlouisfed.org/series/CUSR0000SETD). Variable definitions can be found in Appendix A. The characters *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Standard errors are clustered at the vehicle level.

Panel A: Unweighted

	(1)	(2)	(3)	(4)	(5)
		Gallons	*Fuel*	*Commercial*	*Internal*
	MPG	*Fuel*	*Cost*	*Maintenance*	*Maintenance*
Monitoring	0.67***	-2.81***	-14.8***	-11.7***	-2.22*
	(3.0)	(-2.8)	(-7.2)	(-3.9)	(-1.9)
Observations	113,499	114,433	114,574	123,977	123,977
R-squared	0.306	0.214	0.224	0.022	0.045
Agency FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes

Panel B: Entropy Weighted

	(1)	(2)	(3)	(4)	(5)
		Gallons	*Fuel*	*Commercial*	*Internal*
	MPG	*Fuel*	*Cost*	*Maintenance*	*Maintenance*
Monitoring	0.53**	-1.42	-6.05***	-8.08**	-2.64***
	(2.0)	(-1.5)	(-3.0)	(-2.3)	(-2.7)
Observations	113,640	114,574	114,574	123,977	123,977
R-squared	0.306	0.214	0.224	0.022	0.045
Agency FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes

Table IV

Effect of Monitoring on Accident Probability and Accident Cost

This table reports the effects of vehicle monitoring on accident probability and accident cost. Panel A presents unweighted regressions, and Panel B presents regressions that are entropy weighted by miles driven per vehicle. *Accident Dummy* is an indicator set to one if a vehicle has one or more accidents during the month. *Accident Cost* reports the dollar cost of the accident reported on insurance records. *Monitoring* is an indicator variable set to one when a vehicle has a monitoring device installed. Costs are reported in January 2016 CPI adjusted dollars (`https://fred.stlouisfed.org/series/CUSR0000SETD`). Variable definitions can be found in Appendix A. The characters *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Standard errors are clustered at the vehicle level.

Panel A: Unweighted

	(1) *Accident Dummy*	(2) *Accident Dummy*	(3) *Accident Dummy*	(4) *Accident Cost*	(5) *Accident Cost*	(6) *Accident Cost*
Monitoring	0.28**	0.070	-0.075	0.00	6.83***	1.41
	(2.6)	(0.5)	(-0.5)	(0.0)	(3.8)	(0.8)
Accident Dummy				2,020***	2,020***	2,019***
				(10.0)	(10.0)	(10.0)
Accident Dummy × *Monitoring*				-797***	-796***	-798***
				(-2.8)	(-2.8)	(-2.8)
Observations	119,584	118,456	118,456	119,584	119,584	119,584
R-squared				0.136	0.136	0.136
Model	Logit	Logit	Logit	OLS	OLS	OLS
Agency FE	No	Yes	Yes	No	Yes	Yes
Month FE	No	No	Yes	No	No	Yes

Panel B: Entropy Weighted

	(1) *Accident Dummy*	(2) *Accident Dummy*	(3) *Accident Dummy*	(4) *Accident Cost*	(5) *Accident Cost*	(6) *Accident Cost*
Monitoring	0.31***	0.015	-0.17	0.00	6.33***	1.65
	(2.8)	(0.1)	(-1.2)	(9.4)	(9.4)	(9.4)
Accident Dummy				2,051***	2,051***	2,051***
				(9.4)	(9.4)	(9.4)
Accident Dummy × *Monitoring*				-828***	-828***	-828***
				(-2.8)	(-2.8)	(-2.8)
Observations	119,584	118,456	118,456	119,584	119,584	119,584
R-squared				0.153	0.154	0.154
Model	Logit	Logit	Logit	OLS	OLS	OLS
Agency FE	No	Yes	Yes	No	Yes	Yes
Month FE	No	No	Yes	No	No	Yes

Table V
Duration of Monitoring Effect
This table examines whether the effect of monitoring was temporary by removing the first six months of data from monitored vehicles. *MPG* is the number of miles per gallon a vehicle utilized. *Commercial Maintenance* includes maintenance costs performed by third-party contractors. *Internal Maintenance* includes maintenance costs performed by the state internally. *Accident Dummy* is an indicator set to one if a vehicle has one or more accidents during the month. *Accident Cost* reports the dollar cost of the accident reported on insurance records. *Monitoring* is an indicator variable set to one when a vehicle has a monitoring device installed. Costs are reported in January 2016 CPI adjusted dollars (https://fred.stlouisfed.org/series/CUSR0000SETD). Variable definitions can be found in Appendix A. The characters *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Standard errors are clustered at the vehicle level.

	(1) *Fuel Cost*	(2) *Commercial Maintenance*	(3) *Internal Maintenance*	(4) *Accident Cost*
Monitoring	-9.35***	2.55	-1.84	1.76
	(-3.5)	(0.6)	(-1.6)	(0.6)
Accident Dummy				2,083***
				(9.4)
Monitoring ×				-991***
Accident Dummy				(-2.6)
Observations	98,541	111,168	111,168	111,168
R-squared	0.235	0.024	0.043	0.138
Agency FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes

Table VI
Quantifying the Measurable Costs of Monitoring
This table reports the estimated costs and savings that resulted from the vehicle monitoring program. Fleet Operations negotiated the Geotab devices at no charge, with a monthly service fee of $19.75 per device per month. Installation of the device takes approximately 15 minutes, which I round up to 1 hour for vehicle traveling time, at $30 per hour and assuming a device life of 60 months. Fleet Operations estimates that setting up and maintaining the monitoring program to have utilized 1 full-time employee per year at an estimated cost of $66,850 for the 1012 vehicles monitored as of June 2017. *Commercial Maintenance*, *Internal Maintenance*, and *Fuel Cost* savings are estimated from the 95% confidence intervals reported in Panel A Table III. Accident cost savings are estimated by calculating the probability of an accident per vehicle per month for vehicles that were eventually monitored in the pre-treatment period (0.7%), and multiplying that the 95% confidence interval of costs savings per accident calculated in Panel A Table IV. Costs are reported in January 2016 CPI adjusted dollars (`https://fred.stlouisfed.org/series/CUSR0000SETD`).

	$ Cost Per Vehicle per Month
Device Cost	0.00
Device Service Cost	19.75
Device Administration Cost	5.50
Device Installation Cost	0.50

	$ Savings Per Vehicle per Month (95% Confidence Interval)
Commercial Maintenance Savings	10.8 to 18.9
Internal Maintenance Savings	0.1 to 4.5
Fuel Cost Savings	5.9 to 17.6
Accident Savings	1.6 to 9.61

ROI	43%
(95% Confidence Interval)	-28% to 96%

Table VII
Effect of Monitoring on Employee Reviews and Sick Leave
This table reports the effects of vehicle monitoring on employee ratings, and job attendance. Employee reviews are by agency year, and are either performed by the human resources department or the reporting agency. Reviews are in percentage change of agency review score. Vacation and sick leave are reported as average hours per agency per month. *Percent Vehicles Monitored* is the fraction of agency vehicles that have a monitoring device. *Percent Employees Monitored* is the number of vehicles with a monitoring device divided by the number of employees in an agency. Variable definitions can be found in Appendix A. The characters *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively. Standard errors are clustered at the agency level.

	(1) *HR Rating*	(2) *HR Rating*	(3) *Self Rating*	(4) *Self Rating*	(5) *Vacation Hours*	(6) *Vacation Hours*	(7) *Sick Hours*	(8) *Sick Hours*
Percent Vehicles	0.011		-0.049		0.29*		0.14	
Monitored	(0.6)		(-0.7)		(2.3)		(1.0)	
Percent Employees		0.015		0.015		0.48		0.74
Monitored		(0.5)		(0.1)		(0.8)		(1.8)
Observations	21	21	21	21	196	196	196	196
R-squared	0.408	0.391	0.280	0.262	0.819	0.819	0.730	0.731
Agency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	No	No	No	No
Month FE	No	No	No	No	Yes	Yes	Yes	Yes