OPERATING LEGALLY FATIGUED: A TYPOLOGY APPROACH TO UNDERSTANDING HOURS OF SERVICE

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ABSTRACT

This research uses a rational approach to understand why, despite continuous regulation changes, HOS regulations have yet to solve the problem of fatigued truck driving incidents. Research suggests that classification is a prerequisite for effective policy. Therefore, this research analyzes the differences in safety regulations through a typology classification process in order to explain why HOS is unable to effectively reduce fatigued truck driving. This approach offers explanative insights into preferred types of regulations, as well as predictive insights into how regulations might change over time.

INTRODUCTION

HOS has changed much more frequently over the last 15 years and has had more proposed changes than other safety regulations (FMSCA 2015; Anderson et al. 2017). Although there have been many changes, fatigue-related accidents caused by truck drivers are still a common occurrence (NTSB 1990; Jovanis et al. 2011; Williamson et al. 2011). Abrams et al. (1997) found that 28 percent of drivers fell asleep at the wheel in the prior month, and a third of those drivers fell asleep three to six times in that month. Their research also found that nearly 47 percent of truck drivers are aware they are tired but continue to operate. Paradoxically, truck drivers continue to operate legally within the limits of HOS, but break the intent of the regulation by being fatigued. Legislators, researchers, and the trucking industry cannot seem to come to a consensus regarding what HOS regulations are needed to prevent fatigue-related accidents. Much emphasis has been placed upon reducing driving hours (Hanowski et al. 2007; Soccolich et al. 2013) and restart provisions to ward off the effects of cumulative fatigue (Dongen et al. 2011; Van Dongen & Mollicone 2014; Brewster & Short 2014).

The purpose of this research is to examine safety policies within the commercial motor vehicle industry, and investigate through a classification approach why HOS may be a different, less effective policy than other safety policies. This paper contributes many findings for academics, policy-makers, and managers. First, this paper provides a unique typology approach to solving a thus far obscure HOS problem. Second, this research classifies and analyzes content from 1,058 changes within 14 different regulations from 1938 to 2016. The *types* of regulations created from this typology provide a qualitatively descriptive difference in regulation *types*, an explanative benefit from different regulation *types*, and a predictive capability of when and how a regulation *type* will evolve. The 1,058 changes are also analyzed based on the policymaker's rationale for changes, assuming that motivations or discussions were annotated in the Federal Register. Third, each classification *type* has associated characteristics that can be empirically differentiated. The characteristics of the regulation *type* are: 1) character count, 2) section count, and 3) time between changes. The regulation *types* can, therefore, be validated empirically by utilizing parametric and non-parametric testing techniques; thus, providing a quantitatively descriptive, explanative, and predictive capability for differentiating regulation *types*. Fourth, the theory of disjointed incrementalism was shown to be useful in understanding CMV safety policy. Additionally, this research extended the theory by specifying which *types* of policy lend itself more to disjointed and incremental policy creation. Fifth, this research provides a clear future direction

for policy creation within the truck industry that attempts to measure fatigue indirectly through hour restrictions. This research should help managers understand that following HOS may not guarantee safe fatigue-free driving and that they may need to implement new methods to ensure safe driving.

LITERATURE REVIEW

Policy Design and HOS Regulation Research

To date, no research has created a typology and subsequently classified *types* of safety policies within the CMV field. However, there is a plethora of research within social sciences that can be drawn from to bridge this research gap in the CMV policy field.

Direct or Indirect Policy

In policy design, Schneider and Sidney (2009) suggest the first step is to define the problem and goals pursued. The goal of the regulation may be straightforward, but the implementation of the policy may not be because of the inability to measure this goal—leading to an *indirect* policy. For example, the intent of the HOS regulation was to eliminate driving while fatigued (Federal Motor Carrier Safety Administration 2016); however, the regulation only restricts the duty and driving time, which have been shown to be factors in fatigued driving (Brown 1986; Torregroza-Vargas et al. 2014; Williamson et al. 1992; Williamson et al. 2011; Soccolich et al. 2013). However, there are many other factors that also contribute to truck driver fatigue. Fatigue factors not regulated by HOS include: multi-day driving patterns (Kaneko & Jovanis 1992); starting fatigue level (Crum & Morrow 2002); driving time of day (Blower & Campbell 1998); miles driven (Lyman & Braver 2003; Joshua & Garber 1990; Jovanis & Chang 1986); truck driver health (Anderson et al. 2012; Stoohs et al. 1994), traffic congestion (Taylor & Dorn 2006); truck driver obesity (Anderson et al. 2012; Stoohs et al. 1994); distracted driving (Olson et al. 2009; Hanowski et al. 2005); stress, health, and narcotics (Taylor & Dorn 2006; Hartley & Hassani 1994; Crouch et al. 1993); scheduling (Crum & Morrow 2002; Min 2009b); and attitudes toward safety regulations (Douglas & Swartz 2009). Thus, HOS may have different results than other safety regulations because it is not directly regulating fatigue.

Since many factors contribute to fatigue, restricting driving and duty hours may have unintended consequences. There have been conflicting claims about the effectiveness of these recent HOS regulation changes. Some trucking unions and some members of Congress have claimed negative safety implications due to prolonged traffic congestion during daytime hours and increased fatigue (Ferro 2014; Short 2013; Anderson et al. 2017). Although it is clear that driver fatigue is dangerous and has been linked to higher accident rates (Dinges 1995; Mackie & Miller 1978; Williamson & Friswell 2013; Summala & Mikkola 1994; Zhu & Srinivasan 2011), the effectiveness of HOS regulatory policy on reducing fatigue and making roads safer is still unclear (Arnold et al. 1997; Min 2009b). Research has found that 38 percent of drivers begin their driving periods fatigued by being awake for 6 to 12 hours before the trip, indicating that HOS may restrict the number of operating hours, but does not directly reduce fatigue or ensure that truck drivers are alert (Abrams et al. 1997).

Objective or Subjective Policy

Schane (2002) examines how laws are written and commonly found ambiguity in the law's wording. Ambiguity creates legal problems due to the multiple interpretations that arise, which are challenging to enforce. However, ambiguity is not always negative for policy. Veenhoven (2002) discussed how ambiguous, vague, or *subjective* words enable intent or direction of the goal, while clear or *objective* measures focus on the restrictions or limits of the policy. He states that a purely *subjective* policy may require change for clarity, while *objective* measures tend to be more myopic by looking at sum-scores. The combination of both *subjective* and *objective* regulations may lead to a more comprehensive regulation that can be objectively enforced by numbers and clear guidelines while also providing the goal or intent of the regulation.

Disjointed Incrementalism

The theory of disjointed incrementalism gives emphasis to the capacity of legislatures, their method, and the eventual acceptance of policy (Lindblom 1959). When there are agreed upon values, the ends justify the means. When there are conflicting values (which often occurs due to special interests groups, concerned citizens, and/or legislatures) the means and ends are simultaneously chosen for expediency and compromise. This method may lead to *disjointed* policy through exemptions and other aspects of the regulation and *incremental* changes in policy, which meet the aspirations of society and legislators constituents while minimizing political risk. This problem is further compounded by the policy maker's limited time and expertise on the particular subject. Disjointed incrementalism illuminates the process of policy creation and change. Since this research evaluates 78 years of policy, the changes in policy and positions of legislatures become difficult to appreciate and process without this theoretical approach. Incremental change minimizes political risk, while disjointed changes satisfy certain powerful special interests.

MATERIALS AND METHODS

Two monothetic dimensions were used to create a fourfold typology. Subjective and objective were chosen due to the prevalence of ambiguity and misunderstandings that occur in laws and regulations (Schane 2002). The dimension of direct and indirect were used due to the varying level of agreement that sometimes exists between the means (regulation) and ends (goals) of the regulation (Montgomery 1990; Nicoletti & Scarpetta 2003; Lindblom 1959). The four *types* are subjective-direct, subjective-indirect, objective-direct, and objective-indirect.

Bailey (1994) stated that the secret to classification is the ability to ascertain and differentiate the fundamental characteristics of the phenomenon studied. In our research, the clear and comprehensive definitions were critical to the success of this research and were developed after consulting with a lawyer, a compliance manager, and other researchers.

An analysis was performed on 1,058 CFR parts for 14 different CMV safety regulations under Title 49 that existed from 1938 to 2016. The 14 regulations were chosen because they were the major regulations of 1938 and they still exist in 2016 (Interstate Commerce Commission 1938). The 14 regulations were: 1) Brake Performance, 2) Sleeper Berth, 3) Inspection, Repair, and Maintenance, 4) Tires, 5) Hazardous Conditions, 6) Alcohol Prohibition, 7) Ill or Fatigued Drivers, 8) Necessary Driving Knowledge and Compliance of the Regulations, 9) Needed Skill and Experience, 10) Drugs and Other Substances, 11) Hearing Requirements, 12) Eyesight Requirements, 13) HOS, and 14) Safe Loading Procedures.

Data documentation enabled a qualitative and quantitative typology approach similar to Billot-Grasset et al. (2016). Instructions and 1,058 CFR parts were provided to direct the classification team (a full professor in policy, an associate professor in logistics, an associate professor in math, and an assistant professor in logistics) to classify each regulation into a *type* based on the instructions provided (see Appendix A). This process is useful in cases when a priori typology exists and multiple classifiers are used (Shenhar & Dvir 1996). Following the classification, a quantitative *types* analysis occurred on similar work from Peterman et al. (2014).

The quantitative analysis focused on the characteristics of each regulation within the various typologies; these characteristics were the character count, the growth in both characters and sections over time, the number of substantial changes, and the probability of change to a different *type*. To examine differences between *types*, averages, standard errors, and Analysis of Variance (ANOVA) testing was conducted followed by the posthoc Fisher's Least Significant Difference (LSD) pairwise comparison. ANOVA parametric assumptions were met for character and section count, which assessed normality using the Shapiro-Wilks test (Razali & Wah 2011); constant variance was assessed using Bartlett's test (Levene 1960), and independence was assessed via the Durbin-Watson test (Kanlayasiri & Boonmung 2007).

However, for the number of substantial changes parametric assumptions were not met. Consequently, non-parametric tests were conducted using the Wilcoxon Signed Rank test (Hollander et al. 2013).

ANALYSIS

The Cohen's Kappa value regarding the inter-rater reliability of the classification of regulation into specific *types* was 0.8 with an average pairwise agreement of 86.5 percent. This kappa value falls at the top of the substantial agreement range and just shy of almost perfect agreement (Landis & Koch 1977). Of the regulations that existed in 1938, 11 were classified initially as subjective-direct, two as objective-direct, and one as objective-indirect (see Figure 1). The objective percent and direct percent are shown for the average of every regulation in the research. A general trend was that each regulation became more objective over time. The general trend with regulation size was an increase in character count and sections, which was correlated with the shift to more objective regulation *types* (see Figure 2). Of the 11 regulations that began as subjective-direct, 8 became objective-direct, and 3 ended as subjective-direct. The 2 regulations that began as objective-direct remained that *type*. Hours of service regulation was the only regulation classified as objective-indirect, and it has remained this *type*.
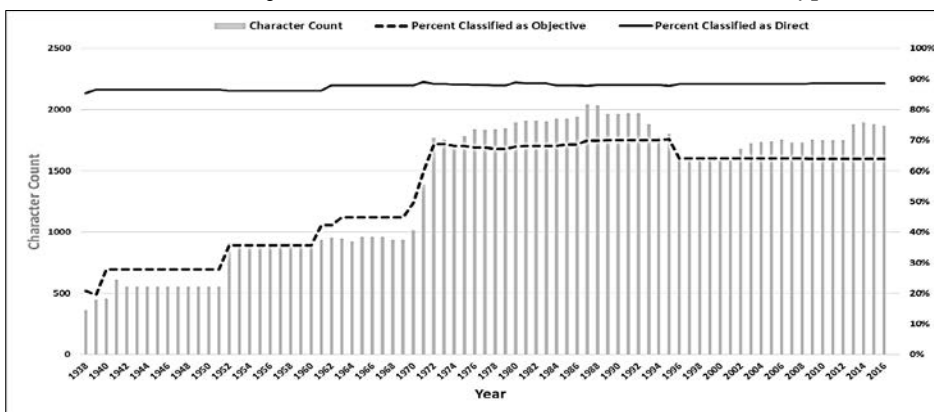

Figure 1 Character Count, Percent Objective and Direct Change in Regulations by Year
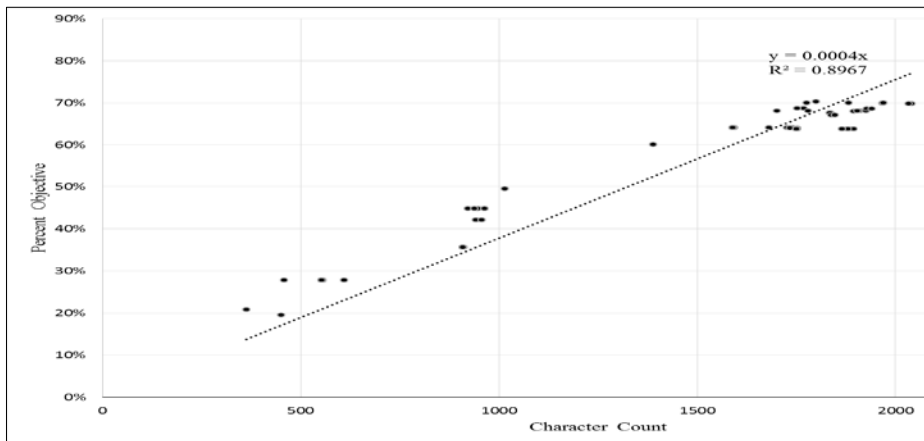

Figure 2 Correlation between Character Count and Objective Percent

Although the majority of regulations moved to the objective-direct *type,* there were many changes to subjective-direct regulations that remained that *type*. Subjective-direct regulations had a 71.5 percent chance of staying subjective-direct upon a substantial change to the regulation and a 28.5 percent chance of changing *type* to objective-direct. Subjective-direct regulatory *types had* substantial changes every 23.5 years with a standard deviation of 13.8 years. The objective-direct regulation *types* did not change *type* classification but did change at a faster rate within its *type*. Objective-direct *types* changed every 19.5 years with a standard deviation of 12.2 years. Indirect-objective regulation *types* never changed

type classification, but changed the most frequently within its *type*. Indirect-objective regulation *type* changed at a rate of 7.09 years with standard deviation of 7 years.

Although entire regulations did not change from *type* indirect to direct, there were sections of the regulation that did change due to legal clarity and technology. For example, in 1988 a bill was passed to stipulate that blood alcohol content of drivers not exceed .04, which moved aspects of the overall regulation from indirect to a direct measurement due to the ability to utilize a new technology (FHWA Docket No. MC-128 1988). Legal clarity and technology have been shown to be catalysts for change in policy (Rogge & Reichardt 2016). Our research more specifically investigates if legal clarity and technology are catalysts for change from an indirect to a direct *type*.

The *types* (objective-direct OD, subjective-direct SD, and objective-indirect OI) were significantly different from one another (see Table 1) for characters and sections (p-value < .0001). Subjective-direct regulations were statistically different from both the objective-direct (*p*-value = .017) and objective-indirect (*p*-value = .003) regulation *types*.

Table 1 Typology Characteristic Comparison (Character Count, Section Counts, Years until Substantial Change

	Character Count	Years Until Substantial Change
Objective Indirect (OI)	**2432.0** (± 826.0, n = 79)	**7.8** (± 7.0, n = 11)
Objective Direct (OD)	**1866.7** (± 1235.6, n = 553)	**14.4** (± 15.3, n = 43)
Subjective Direct (SD)	**637.5** (± 623.7, n = 439)	**23.5** (± 13.7, n = 25)
(P-Value)	OI>OD>SD (<.0001)	SD>OD (.017), SD>OI (.003)

DISCUSSION AND CONCLUSION

The conceptual typology model provided the ability to differentiate safety regulations based on different characteristics. Although this study does not discuss the efficacy of these different *types* of regulations, it can be assumed that based on the changes in regulation *type* there are more preferred or effective *types* of regulation. If a change occurred, subjective-direct regulation *types* moved to objective-direct 28.5 percent of the time, and only moved back 3 percent of the time (due to a unique situation); leading to 7 of the 11 initially subjective-direct *type* ending as an objective-direct *type*. This implies that objective regulations seem to be preferred to subjective regulations.

One main finding of this research is that HOS is the only regulation from the sample that began and ended as an indirect *type*. No regulations moved from direct to indirect or indirect to direct, but since the majority of regulations are classified as direct, it would seem that this *type* of regulations is preferred. Since HOS is regulating a factor related to fatigue but not fatigue itself, it is understandable why this regulation continually changes. This regulation substantially changed every 7.09 years on average, which was statistically more frequent than the subjective-direct *type* (*p*-value .003). If a technology came out that could measure driver-fatigue (such as a fatigue-alyzer), the HOS regulation may become direct. Until that time, it is very likely that more HOS regulatory reform will continue in an attempt to regulate fatigue indirectly.

Another discussion point that this research finds is the duration a *type* of regulation remains the same. Subjective-direct regulations *types* (19.67 years) changed significantly less frequently than objective-direct *types* (13.67 years) and objective-indirect *types* (7.09 years) (see Table 2). This research found that for most regulations, an objective approach appears to be preferred over time. However, some subjective regulations did not change *types*. A possible explanation for this is a lack of availability of new technology. For example, the hazardous conditions regulation (392.14) remained completely subjective-direct from 1938 to 2016. This regulation did not change much from its original form in 1938: "Extreme caution in the operation of motor vehicles shall be exercised under hazardous

conditions, such as snow, ice, sleet, fog, mist, rain, dust, smoke, or any other condition, which adversely affects visibility or traction, and speed shall be reduced accordingly." It is possible to make this regulation objective, but it is cost-prohibitive. For instance, airports use technology to provide very objective and detailed reports regarding the airport environment such as the runway surface condition (RSC) and the runway visual range (RVR). Attempting to do this on all roads would be prohibitively expensive; therefore, this regulation remains subjective. However, aspects of this regulation may begin to become more objective, in the near future, due to technologies like Light Detection and Ranging (LIDR), which may provide objective information about current visibility restrictions due to smoke, fog, rain or other particulates.

Another finding of this research is the statistical difference among the size (characters, and sections) of the different *types* of regulation. Of the three *types* classified in this research, all were significantly different (p-value $< .0001$). Subjective regulations were the smallest, which could be explained by the lack of regulation needed to describe intent rather than enforceable procedures. The objective-indirect *type* was substantially larger than either objective-direct or subjective-direct *type*. Since there are many indirect factors that contribute to the problem, indirect regulations may naturally grow in character count to control these many factors.

The theory of disjointed incrementalism has been used to further explore the policy governing the trucking industry. This research analyzed regulations from the past 80 years to understand how and why regulations move or change. From this retrospective, longitudinal research it was evident that regulations change incrementally and disjointedly within a specific *type*. For example, exemptions, especially when studied longitudinally, provide evidence to the disjointed nature of lawmaking. To illustrate this point, some of the HOS regulation exemptions occurred for agriculture drivers (1940), oilfield drivers (1963), or drivers in Alaska (1964). These changes occurred only while the regulation was an objective-indirect *type*. However, when regulations changed from subjective-direct to objective direct, there were sharp or major changes. This change in regulation and associated *type* change did not fit within the theory of disjointed incrementalism as it was far from a small change in regulation. For example, truck driver knowledge was classified as subjective-direct and had 1 section and 187 characters up until the year of 1971. The regulation changed to objective-direct and had 12 sections (1200 percent increase) and 3,429 characters (1,833 percent increase). Based on this research, disjointed incrementalism specifically applies to regulations that do not change types.

Given the new regulation typology proposed by this research, there is a plethora of future research needed to either further substantiate it or find its weaknesses in different fields. For example, research on policy regarding age and if it is a direct measurement of maturity. Additional research can be conducted on different characteristics of the *types* discussed in this research. Some of these include the efficacy of the regulation or rule to see which regulations tend to provide better results regarding their intended objective. Other characteristics such as cost could be explored to provide a better cost-benefit of different regulation *types*.

The implications of this research are far-reaching due to the practical typology created. Managers, legislators, and government agencies can benefit from understanding the different classifications while creating or modifying rules and regulations. Creating only subjective rules may most likely lead to less control and ambiguous policies, while creating objective regulations may lead to greater control and clearer policies. Indirect policies may result in more changes over time and more complex regulations. In creating rules and regulation, it would appear that some initial subjectivity is needed to provide the intent and goal, while the majority of the regulation should seek to be objective to provide more legal clarity and to utilize emerging technologies.

REFERENCES

References available upon request from Jason Anderson at Jason.anderson@afit.edu