Economics Bulletin

Volume 32, Issue 4

Assessing the Role of Context in Traffic Light Violations

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Abstract

In France the struggle against red light running behaviour is a government priority for reducing road accidents and fatalities. The objective of this study is to measure the frequency of red light runnings and assess the factors impacting these behaviours. Pneumatic counters were used to measure running behaviours during several weeks in 2009 on 26 traffic lights in Nantes. A hierarchical Poisson model was run on the collected data to estimate the "individual demands for red light running" before the deployment of automated enforcement devices. Red light runnings are more numerous during rush hours, but the propensity to violate red lights is most marked at night. In addition to time periods and traffic conditions, traffic light violations vary significantly from one site to another, suggesting that environment influences the propensity to abide by traffic lights. These empirical results are discussed from a public policy perspective.

This research has been funded by the Delegation for Safety and Circulation on Roads, through the 2008-2010 research program of ERA AAPSER. The authors would like to thank Radoine Dik, Daniel Grégoire and Michel L'Houtelier from CETE de l'Ouest for their valuable research assistance. A previous version of the paper was presented at the 39th European Transport Conference, Glasgow, 2011. The authors are grateful for the informative comments they received after the presentation.
Citation: Laurent Carnis and Emmanuel Kemel, (2012) "Assessing the Role of Context in Traffic Light Violations", *Economics Bulletin*, Vol. 32 No. 4 pp. 3386-3393.
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Submitted: November 04, 2012.   **Published:** December 17, 2012.

1. Introduction

Red light running is a clear violation of the Highway Code. As the rules call for a definite stop, non-observation means not only the committing of an offence, but also the creation of a possible danger for the offender and for other users entering the intersection on a green light. In this respect, and above and beyond its impact on the accident rate, red light running (RLR) breaches "the social contract on the roads" and involves a social cost from the economic point of view. RLR can be interpreted as a third part effect.

In 2002 the French authorities decided to install an automated enforcement system of the Highway Code. These safety cameras enforce speed limit and signalized intersection regulation (Carnis 2009). Intersection surveillance devices went into operation in 2009 on the roads of major cities. To achieve efficient regulation, public authorities need information relating to this specific market (Ehrlich 1996). In the case of traffic light violations, there is little information concerning the prevalence of such behaviours. The objective of this paper is to highlight the importance of these phenomena and the factors influencing these behaviours through a field study in the city of Nantes. In other words, this study aims at assessing individual demands for red light running from field data, before the installation of automated enforcement devices.

The next section highlights the approach we used in regard to the existing literature. Section 3 presents the data and the model, while section 4 is concerned with the results. The findings are discussed in section 5.

2. Background

Red light running (RLR) is not only a violation of the Highway Code; it also constitutes a violation of a common rule and a deviation from expectations among the road user population. It is a source of "discoordination" among individual plans (Walliser 2000, p. 165). Such behaviour is also a dangerous driving practice and a source of accidents and fatalities. Red light running also implies a social cost that society and victims have to bear. From a micro-perspective, several studies suggest that RLR can be conceived as a typical example of risk-taking behaviour (Ellison-Potter *et al.* 2006; Horvath and Zuckerman 1993). Most of the literature dealing with traffic light violations focuses on driver characteristics (Chin 1989, p. 177; Johnson *et al.* 2011) and the deterrent impact of red light cameras (RLC) (Fitzsimmons *et al.* 2009; Lum and Halim 2006; Retting *et al.* 2003; Retting *et al.* 1999), However the impact of environmental factors (hour and day, urban and traffic context) on the red light running decision is rarely investigated. Regarding the impact of RLC, several studies have found that they provide a significant reduction of violations but with different impacts for road fatalities and injuries (Tay 2010; Wahl *et al.* 2010; Erke 2009; Shin and Washington 2007; Persaud *et al.* 2005; Retting *et al.* 2003; Retting and Kyrychenko 2002; Andreassen 1995; South *et al.* 1988). All in all, intervening with RLC remains a costly decision and implies economic tradeoffs for the public decision maker. It is thus important to assess the circumstances of traffic light violations for determining whether or not the deployment of automated devices represents an appropriate and effective countermeasure. When the decision to use automated devices has been made by authorities, such information is still helpful, for defining the best strategy for deployment (Tay and De Barros 2009).

3. Methodology

We propose a quantitative analysis of large red light running data sets. This original study aims at providing new information concerning red light running frequencies as well as a model of the factors predicting red light violations for a French case: the city of Nantes.

3.1. The field of investigation

The City of Nantes was considered for this study. It is the sixth largest city in France, with more than $300,000$ inhabitants. 230 signalized intersection accidents occurred over the 2007-2009 period, representing 21% of all accidents for the city of Nantes. Road accidents associated with RLR are a main concern.

26 traffic lights, located at 20 intersections were considered for recording red light runnings. The chosen sites were representative of the overall urban configuration of the city of Nantes (more or less dense central area, residential), of pedestrian traffic, and of local activities (extent of retail facilities, presence or absence of a school nearby). Traffic density (structural road network, urban thoroughfare, feeder road, transit or local traffic) was also taken into account.

3.2. The data

RLR observations were collected by installing a pneumatic counting device on each site for one week every three months. These counters recorded for each measurement hour the total traffic and the number of red light runners.

When counting anomalies were detected (missing or inconsistent data), the entire relevant week was removed from the list of data to be analysed. The most frequent problems were related to road works, detachment of the air hoses, or electricity supply failure for the counter. Finally, the average observation period was 2.8 weeks per intersection for the year under study.

Some periods presented particularly high rates of RLR (number of violations per total traffic). Hourly measurements in excess of 20% were considered aberrant[1] and removed from the dataset (2.5% of all observations). Finally, $56,020$ infringements were counted for a total of $3,799,700$ vehicle passages.

3.3. The model

In order to weight the relative impact of each environment factor on running behavior, an ANOVA was run on observed runnings. More precisely, the dataset consists of counted data and violation numbers, which are assumed to follow a Poisson distribution of parameter λ. Since the values of λ are positive, a log-linear model is considered.

$$log(\lambda) = m + \epsilon_{hour} + \epsilon_{day} + \epsilon_{month} + \epsilon_{site} \quad (1)$$

[1]This value corresponds to a deviation from the mean rate that is three times larger than the standard deviation.

In (1), each *factor* is considered as random effect $\epsilon_{factor} \equiv N(0, \sigma_{factor})$ and σ_{factor} has to be estimated. m is the grand mean. Equation 1 represents the baseline model, assessing the variance related to each factor. This model is then further developed insofar as other explanatory variables (fixed effects) are added in an explanatory perspective. Estimations are made using the lme4 package, developed for the R software.

4. Results

The results of the ANOVA (model 1) are presented in the first column of table 1. We observe that the factor showing the largest impact on the number of violations is the site under consideration. The impact of the variable "hour" presents a similar range. The role of month is less explicative, and the violations variable is also found to vary slightly with the day.

Table 1: Estimations of models models 1 and 2

	Factor	Estimate (Std Errors)			
Random effects	*Site*	0.70		0.73	
	Hour	0.68		0.08	
	Day	0.15		0.05	
	Month	0.28		0.31	
Fixed effects	*Intercept*	1.10	(0.22)	−2.73	(0.18)
	$log(Traffic)$			0.77	(0.01)
Goodness of fit	*Log Likelihood*	−19498		−17147	

Intuitively, violations may also depend on traffic conditions, and this factor may be correlated with the other environment factors. Traffic is thus considered in the model 2. Accounting for traffic conditions in the model significantly improves the likelihood (χ^2 test, $p < 0.001$). The elasticity of red light running to traffic is estimated at 0.77. The impact of other factors drops drastically, when the traffic variable is considered by the model. In particular, the standard deviation related to the hour is divided by a factor of almost ten. The standard deviation of the day effect is also divided by three. This suggests that hour and day effects were in fact due to traffic condition. Nevertheless, the site and month effects remain unchanged when traffic is included.

Table 2: Estimation of model 3

	Factor	Estimates (Std Errors)	
Random effects	*Site*	0.73	
	Hour	0.06	
	Day	0.04	
	Month	0.18	
Fixed effects	*Intercept*	−2.755	(0.257)
	log(Traffic)	0.788	(0.011)
	Monthtrend	−0.048	(0.023)
	Spring	0.073	(0.191)
	Summer	−0.100	(0.181)
	Fall	0.616	(0.011)
	Night	0.136	(0.031)
	Week end	−0.062	(0.037)
Goodness of fit	*Log Likelihood*	−17133	

Model 3 aims at explaining the variance measured in model 2 by adding the following explanatory variables: time period (day or night), day type (business day or weekend) and season (Table 2). A monthly trend is also included. These new variables significantly improve the likelihood of the model (χ^2 test, $p < 0.001$).

All things being equal, RLR are more numerous during night hours (+13%) and less numerous during weekends (−5%). The greater propensity to run red lights during night may be due to a specificity of night road users or to driving conditions (e.g. driving while intoxicated) that may induce higher risk-taking or driving errors. From a deterrence theory perspective, this reduced propensity to abide by traffic rules may derive from a lower risk of being caught by the police. The difference that is observed between business days and weekends is also consistent with the theory of rational criminals, since the profitability of red light running increases during business days when time value is higher.

Regarding seasonality, the most characteristic season is fall, with the number of violations higher by 60%. This season is also generally marked by the highest number of road fatalities (ONISR 2009). Over time a significant trend is observed, with a decrease of 5% per month. This may be due to the context of increased traffic rule enforcement and communication about the deployment of automated traffic cameras taking place elsewhere in the country during the studied period.

5. Discussion

This study proposed an empirical estimated analysis of RLR, which depend on individual demands[2] before the deployment of traffic light cameras. Regarding the impact of time context on such behaviours, the results are consistent with the prediction of rational crime theory. Beating road traffic constraints by forcing your way through and so reducing waiting time during a congestion period; avoiding stopping at an intersection at night, when there is little or no traffic, and consequently a low risk of being involved in a road accident; these things can incentivise deliberate breaking of the rules. This kind of violation definitely remains a matter of individual decision (Becker 1968), but a decision whose parameters are markedly influenced by the context in which they are taken. Indeed, the most original finding is that the main factor in red light running is the signalized intersection under study. This result suggests that in addition to individual rationality, the environmental context plays a crucial part in this type of illegal behaviour. Understanding why people run red lights, though, is not simply a matter of identifying personal characteristics (Porter and England 2000; Retting and Williams 1996). From a policy perspective, this pronounced variance between the sites suggests that besides deterrence, modifying intersection design may be a way to induce greater abidance by traffic lights. Regarding the overall occurrence for this type of illegal behaviour, red light violations are not an uncommon phenomenon. However, they do not always lead to consequences in terms of accidents. In this respect RLR do not take place regardless of the risk involved, and complementary studies are called for in determining the mechanism at work. From a public policy perspective, this also suggests that a cost-benefit analysis has to be considered before a general implementation of RLC.

This study offered a picture of illegal crossings at signalized intersections before the deployment of traffic light cameras. A straightforward development would consist in proceeding to a follow-up study after such devices are installed in Nantes. Regarding the impact of signalized intersection location on illegal behaviours, a sample of 26 sites offers only limited possibilities to further explore the variance between sites. A follow-up study could consider a broader sample of sites and attempt to capture their characteristics (geometry, urban environment, number of lanes) and their impact upon violations. Another direction for future research would consist in using more sophisticated counters to record individual data, identify the type of users committing the violation, and offering precise time-stamping to better characterize the red light running.

[2]These individual demands depend on gains associated with the RLR (such as time savings) and costs (risk of being involved in a road accident, of having a fine).

References

Andreassen, D. (1995) "A long term study of red light cameras and accidents" Australian Road Research Board Victoria, Australia.

Becker, G. (1968) "Crime and punishment: an economic approach" *The Journal of Political Economy* **76**, 169–217.

Carnis, L. (2009) "L'automatisation des contrôles de vitesse. Les nouvelles technologies et le gendarme" *Futuribles* 25–38.

Chin, H. (1989) "Effect of automatic red-light cameras on red-running" *Traffic engineering & control* **30**, 175–179.

Ehrlich, I. (1996) "Crime, punishment, and the market for offenses" *Journal of Economic Perspectives* **10**, 43–67.

Ellison-Potter, P., P. Bell and J. Deffenbacher (2006) "The effects of trait driving anger, anonymity, and aggressive stimuli on aggressive driving behavior" *Journal of Applied Social Psychology* **31**, 431–443.

Erke, A. (2009) "Red light for red-light cameras?: A meta-analysis of the effects of red-light cameras on crashes" *Accident Analysis & Prevention* **41**, 897–905.

Fitzsimmons, E., S. Hallmark, M. Orellana, T. McDonald and D. Matulac (2009) "Investigation of violation reduction at intersection approaches with automated red light running enforcement cameras in Clive, Iowa, using a cross-sectional analysis" *Journal of Transportation Engineering* **135**, 984–989.

Horvath, P. and M. Zuckerman (1993) "Sensation seeking, risk appraisal, and risky behavior" *Personality and individual differences* **14**, 41–52.

Johnson, M., S. Newstead, J. Charlton and J. Oxley (2011) "Riding through red lights: The rate, characteristics and risk factors of non-compliant urban commuter cyclists" *Accident Analysis & Prevention* **43**, 323–328.

Lum, K. and H. Halim (2006) "A before-and-after study on green signal countdown device installation" *Transportation Research Part F: Traffic Psychology and Behaviour* **9**, 29–41.

ONISR (2009) "La securite routiere en France, Bilan de l'annee 2009" .

Persaud, B., F. Council, C. Lyon, K. Eccles and M. Griffith (2005) "Multijurisdictional safety evaluation of red light cameras" *Transportation Research Record: Journal of the Transportation Research Board* **1922**, 29–37.

Porter, B. and K. England (2000) "Predicting red-light running behavior: a traffic safety study in three urban settings" *Journal of Safety Research* **31**, 1–8.

Retting, R., S. Ferguson and A. Hakkert (2003) "Effects of red light cameras on violations and crashes: a review of the international literature" *Traffic Injury Prevention* **4**, 17–23.

Retting, R. and S. Kyrychenko (2002) “Reductions in injury crashes associated with red light camera enforcement in Oxnard, California” *American Journal of Public Health* **92**, 1822.

Retting, R. and A. Williams (1996) “Characteristics of red light violators: results of a field investigation” *Journal of Safety Research* **27**, 9–15.

Retting, R., A. Williams, C. Farmer and A. Feldman (1999) “Evaluation of red light camera enforcement in Fairfax, Va., USA” *ITE journal* **69**, 30–35.

Shin, K. and S. Washington (2007) “The impact of red light cameras on safety in Arizona” *Accident Analysis & Prevention* **39**, 1212–1221.

South, D., W. Harrison, I. Portans and M. King (1988) *Evaluation of the red light camera program and the owner onus legislation* SR/88/1.

Tay, R. (2010) “Speed cameras improving safety or raising revenue?” *Journal of Transport Economics and Policy (JTEP)* **44**, 247–257.

Tay, R. and A. De Barros (2009) “Minimizing red light violations: how many cameras do we need for a given number of locations?” *Journal of Transportation Safety & Security* **1**, 18–31.

Wahl, G., T. Islam, B. Gardner, A. Marr, J. Hunt, N. McSwain, C. Baker and J. Duchesne (2010) “Red light cameras: do they change driver behavior and reduce accidents?” *The Journal of Trauma and Acute Care Surgery* **68**, 515.

Walliser, B. (2000) *L’économie cognitive* Odile Jacob.