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Deterrence and Compliance in a Demerit Point System

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Abstract - This paper attempts to outline the virtues and the perverse effects of a Demerit Point System (DPS). Under a DPS, once overcome a given threshold of demerit points, infringers are punished by severe non-monetary sanctions (such as the temporarily suspension of driving license in traffic enforcement). Surprisingly, no comprehensive economic theory has been provided to support the widespread implementation of DPS. This paper tries to fill this gap. We show that the impact of a DPS depends on the distribution of preferences of the population of potential infringers. For some agents a DPS far from increasing deterrence may actually reinforce deviant behavior. Only for some group of agents, once a given threshold of accumulated penalties has been reached compliance may occur. Thus compliance is obtained only after some level of under-deterrence is tolerated. We then provide some policy suggestions in order to improve general deterrence under a DPS for any given level of detection policy. Our results seem to be consistent with available evidence.

JEL Classification: K42

Keywords: Demerit Point System, Deterrence, Compliance, Recidivism, Public Law Enforcement, Traffic Law Enforcement

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1. Introduction

In most developed countries (Australia, Belgium, Canada, France, Germany, Italy, Japan, New Zealand, Norway, the United Kingdom and the USA) traffic law rules are backed by a system of deterrence and sanctions based on a Demerit Point System (DPS). This system explicitly aims at "identifying persistent traffic offenders who have a high accident risk by their accumulation of demerit points" and at "discouraging unsafe and irresponsible driving behavior by persistent offenders, as the accumulation of demerit points becomes a constant reminder that the drivers' license could be suspended" (NRMA 2002, pg 3).

A DPS is a penalty system that involves the allocation of some penalty points (demerits) to infringers for a range of harmful acts[1]. The more serious are the offences, the greater is the number of points that are allocated against infringers (in some cases, as in traffic law enforcement in UK, infringers accumulate points up to a given threshold -*totting-up system*-, while in some other, as in Italy, drivers have an initial endowment of points which they loose after violation occurs). DPSs are not substitute of monetary penalties but are generally coupled with them to support deterrence of violations and enforcement of traffic rules for road safety. Such schemes assign a certain amount of points to some of the traffic offences according to their gravity. When a driver accumulates[2] offences so as to trespass the maximum endowment of points available to him and within a specified time span, then automatic license suspension results (that is the non monetary sanction takes the form of 'incapacitation'). DPSs allow thus road users to make a certain number of errors before more serious penalties are incurred and the non monetary sanction is applied. Generally, drivers can restore their original endowment of points by attending a driving course. Recently DPS rules have been applied also to support environmental protection policies (Scheule M., Hughes P., Weier A. 2004). Likely, the main reason underlying the widespread adoption of DPS relies on the idea that there exists a significant correlation between the inclination to

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1 The first version of a Demerit Points Scheme was introduced in Connecticut in 1957 (Fondazione Filippo Caracciolo, 2003).

2 In the case in which drivers have an initial endowment of points, automatic license suspension results accordingly when the original endowment of points is lost. This is the case we are analyzing in our model.

accumulate demerit points and accident likelihood. By focusing especially on certain violations and by tracking recidivist violators, a DPS is generally intended as an effective way to cast out those drivers whose behavior is likely to be more socially harmful and that can be then properly deterred and punished.

The expected impact of a DPS on driving behavior has received attention in the literature (Dingle, 1985; Williams et al., 1992), but none has focused on the reason why economic agent should comply to a higher degree under a DPS, which is the focus of our paper. A first motivation provided in the literature (SWOV, 2005) explains DPS as a mean of differentiating between different types of road users (*signaling/selection effect*) thus providing information on the group of systematic infringers; a second motivation looks at DPS as a way of providing a regulated deterrent threat to those road users who consistently violate traffic laws (*frightening effect* or *deterrence effect against recidivism or multiple offenders*); a third motivation relies upon the discrimination operated by DPS in favor of those road users who usually follow the traffic rules and only exceptionally break those rules (*leniency effect*); and finally a fourth motivation for DPS has been found in the role of education for serious infringers (*correction effect*) which is generally activated after the critical threshold of demerit points has been reached and severe non-monetary sanctions have been enforced (such as educational courses for drivers who have lost their driving license)[3].

Despite the widespread adoption of DPS in all western world, the economic rationale surrounding its design, implementation and effectiveness remains largely unexplored. There is little mention of DPSs even in the law and economics literature on public law enforcement[4]. That the law and economic literature have overlooked at DPS should not come as a surprise. DPSs have been developed in the specific context of traffic law, generally considered as a field of research on its own[5]. However, we believe that some

3 As we can see all the above arguments refer to the effectiveness of DPS in reducing infringements rather than to the efficient design of sanctions aimed at equalizing private benefits with social harm. In this paper, we do not contend the efficiency reasons underlying the design of a DPS, for which we refer to some other explanations (Basili, Nicita and Rizzolli, 2005).

4 For comprehensive surveys of the literature and the main topics of law and economics, see Garoupa, (1997), Polinsky and Shavell (2000) and Shavell, (2003)

5 Some of this detachment may be due to the different meaning of deterrence adopted in traffic law enforcement literature and in the law and economics literature. While in law and economics literature deterrence is generally referred to as efficient deterrence (i.e. as the design of a sanction that equalizes private benefits and/or social harm) in traffic law enforcement literature deterrence is manly referred as effectiveness concerning individual or specific deterrence (see Zaal, 1994).

features of DPS are extremely interesting also to pursue general deterrence in the context of public law enforcement design, and that the widespread use of DPS deserves an attempt to provide an economic explanation of the incentives to comply under this regime, both from a positive and from a normative side.

From a *positive* side, it is relevant to understand how a DPS affects the incentives to adhere to traffic rules and the reason why agents should be induced to change their behavior after a DPS has been introduced. From a *normative* side, it might be interesting to outline how the mechanism design of a DPS may address some of long-debated issues of recidivism and marginal deterrence in public law enforcement[6].

In the present work we do not investigate the normative side of a DPS, rather we focus on the positive side, taking the existence of DPS as given and outlining the conditions under which agents might be induced to comply.

In order to understand how a DPS works it is important to have a look at available data. For any given level of detection policy, several empirical investigations (Zaal, 1994) show that, on average, within the time horizon of validity of a DPS (from two to three years) less than 25% of drivers incur in sanctions under a DPS[7]; less than 40% of infringers, result having cumulated about half of their demerits points, whereas about less then 1% of infringers incurred in the non monetary sanction (driving license suspension) after having lost all their demerit points. Another important result that has been observed is that, when demerit points are accumulated up to a certain threshold, the number of subsequent violations tends to decrease dramatically (Zaal, 1994; Vaa, 2000; Vaa and Glad, 1995). In an empirical investigation concerning the Australian city of Victoria, Haque (1987) showed that the time span interval between a second and third offence is longer than that between the first and second offence[8], thus outlining

6 In a related paper, Basili, Nicita and Rizzolli (2005) show the trade-off between marginal deterrence and recidivism. Increased sanctions for repeated offenders might decrease marginal deterrence at any time. In this respect, they outline how besides monetary sanctions, the introduction of a new instrument, based on virtual budget of penalty points and on non-monetary sanctions (temporarily 'incapacitation' ad driving license suspension) for repeated offences, may solve the above trade-offs.

7 This effect has been observed also in Germany where about 13% of drivers have been caught infringing traffic rules, but only 0.3% of infringers resulted having further accumulates demerit points up to the maximum amount permitted (Fondazione Filippo Caracciolo, 2003). The same result has been observed in Italy in 2002-2004, where only 0.4% of infringers consumed all their initial amount of points (Ministero per le Infrastrutture e i Trasporti, Italia)

8 In particular he assessed that the time interval between the second and the third violation is increased by 50% with respect to the time interval occurring between the first and the second violation. The increase is also statistically significant.

some compliance effect. An empirical investigation on the relationship between demerit points accrual and accidents has shown that the correlation between accumulation of demerit points during 1991-1992 and the probability of being involved in crashes during 1993-1994 is positive but decreasing in the number of points accumulated, thus suggesting a tendency for infringers to moderate deviant behavior as demerit points grow (Diamantopoulou, Cameron, Dyte and Harrison, 1997).

The available data outline that, for any given level of detection, a deterrence effect is observed. However this effect is neither homogenous nor complete. In particular it is remarkable that a portion of infringers seem to change their behavior after a given threshold of demerit points has been reached. At the same time, some drivers systematically infringe traffic law rules even under a DPS.

In our work we try to explain that outcome on the basis of the assumption that the population of drivers is made by several types of agents having different preferences on the number of demerit points and/or on incurring in non monetary sanctions (Dingle, 1985; Ehlrich, 1996)[9]. The design and the impact of a DPS should thus be analyzed considering how different type of agents are affected by DPS.

According to available data we assume that the population of drivers could be grouped in stylized 'types' according to their evaluation of the costs of losing demerit points and/or driving license. For the sake of simplicity, we assume three stylized types of agents: (i) *completely deterred agents*, those who generally obey to traffic rules, attributing infinite value to the preservation the original amount of points (*type 1*); (ii) *partially deterred agents*, those who occasionally break the traffic rules, valuing demerit points as a sort of input to deploy in order to obtain new consumption opportunities; however since they attribute infinite value to the preservation of driving license their opportunity cost of consuming points increases with consumption (*type 2*); (iii) *no deterred agents*, those who systematically break the rules, attributing zero value to preserving demerit points and the driving license (*type 3*). Given that the degree of deterrence is a continuum, the above partition is certainly simplistic but it is useful to

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[9] We are aware that the analysis should take into account agents- preferences towards monetary sanctions. However, since we are here interested in evaluating the impact of the introduction of demerit points in a system previously characterized by monetary sanctions, we can neglect income effects.

illustrate the different impact that DPS may generate according to agents' characteristics.

While a DPS is generally intended as increasing deterrence for the third type of agents (Dingle, 1985), we show that those agents might be unaffected by a DPS. On the other side, we outline some deterrence impact for the second type of agents, even if deterrence is obtained only once a critical threshold of accumulated demerit points has been reached. Only at that point agents will comply and moderate their deviant behavior. Thus, for type 2 agents, in order to obtain compliance under a DPS, society has to allow some infringements by individuals.

In the second part of the paper we will show the conditions under which a DPS may improve general deterrence for type 2 and for type 3 agents…

The paper proceeds as follows. In section 2 we outline the main assumptions of our model. In section 3 we analyze the choices of *partially deterred agents* in an inter-temporal setting. In section 4 we investigate the case of *non deterred agents*. In section 5 we derive some policy options for improving the effectiveness of a DPS, while in section 6 we draw the main conclusions.

2. Assumptions

Let us assume that a totting-down[10] DPS is introduced in a given country, such that a given amount of demerit points is assigned to drivers coupled with traditional pre-existing monetary sanctions. The exhaustion of points leads to the infliction of a non-monetary sanction (driving license suspension or alike). Any violation is thus rewarded with a monetary sanction increasing in the gravity of the violation along with a certain amount of demerit points

Let us assume that drivers have an initial endowment of income Y and points P (where the initial endowment of points P is the same for all the drivers and is equal to 20). We assume also that, according to their preferences and to their income, agents maximize their utility $U(M,C)$ which depends on the level consumption C and on the access to economic opportunities $M(Y, P)$ *granted* by consuming income and points.

10 It is worth to note that our conclusion could be easily referred also to totting-up systems.

Put it differently, we assume that M is a good produced by employing as inputs income Y and demerit points P (C is consumption composite good that the rational agent buys at a price 1). Each agent has thus initial endowment of points and income:

$$\begin{cases} \bar{P} = 20 \\ Y = \bar{C} \end{cases}$$

During his life the rational agent j can consume M also by using points at a given rate $\gamma>0$, paying a monetary fee or monetary sanction $\alpha_j(P,D)>0$, where D is a parameter associated with the detection policy implemented by the public enforcer. We assume that the larger the number of points lost the higher is the monetary punishment. Thus monetary sanction ($\alpha_j(P)>0$) is positively related to the points lost (P). For the sake of simplicity it is assumed that $M=(20-P)$ and $\gamma=1$, while D is assumed as exogenously determined. When points are totally consumed, a non-monetary sanction is inflicted and implies the incapacitation (as the driving license suspension) of the infringer to repeat the offence within a given time horizon. This means that the choice of consuming all the points to obtain M corresponds to the case of using the non monetary sanction as an input (such as 'loosing the driving license') for the same purpose.

Let us see what is the impact of this DPS on the typologies of agents previously illustrated, assuming that all three types of agents maintain distinct preferences about the desired amount M^* and, consequently, about the amount of points P (and about the consumption of when P=0). We distinguish these three types of agents according to: (*i*) their preferences towards respecting the rules independently of any economic opportunity raising by infringing the law; (*ii*) the value they attribute to the expected economic sanction both in terms of monetary and non-monetary opportunity costs.

(a) Type I Agents (*deterred*)

Deterred drivers are those who never intend to break the rule and thus never consume consciously their points. They attribute an infinite value to each preserved point and any eventual consumption of points is attributable to casual unconscious violation and it is not aimed at obtaining M;

(b) Type II Agent (*partially deterred*)

Partially deterred drivers are those who break rules from time to time and thus are willing to consume their points up to a certain amount in order to obtain a desired amount of *M.* Demerit points are perceived as an input to obtain economic opportunities M, but the cost incurring in the non-monetary sanction (or the value of saving the driving license from suspension) is always higher than any opportunity M gained by consuming points; the rate at which points are transformed in economic opportunities is not exogenous, but is dependent on the budget of points available in any single period. Thus the rate of substitution between *M* and *C* varies depending on the amount of *P* available to the agent at every period.

(c) Type III Agent (*non deterred*)

Non deterred drivers are those who never obey to traffic rules and consume all the budget of demerit points in order to obtain M. For them, the value of any amount of M is always higher than the cost of losing their driving license.

The problem of a *generic agent* can be represented as follows:

$$MaxU(M,C)$$
$$s.to$$
$$\alpha_j[(20-P),\overline{D}](20-P)+C=\bar{C}$$

Since $M=(20-P)$ and $\gamma=1$ the problem can be written as:

$$MaxU(M,C)$$
$$s.to$$
$$\alpha_j(P,\overline{D})M+C=\bar{C}$$

Let us assume that *M* and *C* are perfect substitute, but at a rate of substitution $\beta_i \geq 0$ that decreases at jumps according to the amount of points available, such that:

$$\beta_i(P)=\begin{cases}\beta_\delta & if \quad P\in\left[\bar{P},P_\delta\right]\\ \beta_\phi & if \quad P\in\left[P_\delta,P_\phi\right]\\ \beta_\varepsilon & if \quad P\in\left[P_\phi,P_\varepsilon\right]\\ \beta_m & if \quad P\in\left[P_\varepsilon,0\right]\end{cases} \text{ where } \beta_\delta\geq\beta_\phi\geq\beta_\varepsilon\geq\beta_m\geq 0.$$

The budget set is convex and describes the existence of a trade-off between consumption *C* and good *M*. The price of the consumption of good *C* is given and equal to 1, while the price of *M* increases using *P*, in a discrete way since penalty points are defined as natural numbers. It is worth to note here the analogy between good *M* and leisure of the agent's optimal choice in a labor market. The agent's preferences represent piece-wise perfect substitution among *C* and *M*. Because of convexity of the budget constrain function and convexity of preferences, the agent's optimal choice is a corner solution, such that the agent's *j* equilibrium is in the corner in which $MRS^j{}_{M,C}\in(\alpha_{ji},\alpha_{ji+1})$.

It is worth to note that $\beta_i\geq 0$ depends on agents' structure of preferences. On the other side $\alpha_j((20-P),D)>0$ depends on the structure of points and on the probability *D* of detecting a fraudulent behavior. If the loss of points does not induce an increase in welfare, then the agent will not use her endowment of points (which is the default behaviour of our conformist drivers). As a result, the equilibrium point, that is the optimal combination of *M*, *C* and the residual amount of license driving points maintained, depends on the agent's preferences and the cost of transforming *P* into *M*.

The following figure shows some possible equilibria according to the preferences of each group of agents reflected in different indifference curves. 'Deterred' agents will virtually preserve all their points (the minimum amount of demerit points preserved is $Pmin=P-\varepsilon$ with $\varepsilon\geq 0$). 'Partially deterred agents' will consume their points up to the threshold $Pmin=P-\eta$ with $\eta\geq\varepsilon$. 'Non deterred agents' will consume all their points ($Pmin=0$), which means that they will sustain the cost of the non-monetary sanction in order to obtain the maximum available amount of M.

Under the above assumptions the following behaviors could be traced:

- If the agent is rich or considers points only as a constraint on her utility function (as in the case of *partially deterred*), her marginal rate of substitution is low; the equilibrium s reached where P reaches the minimum amount P_{min}. Given the detection policy D, the choice of the amount of points to be preserved simply implies in that drivers will select an amount of infractions compatible with the threshold P_{min}. Once in P_{min}, they will change their behavior, thus acting like deterred agents;

- If the agent is rich or considers points only as inputs to obtain M without any constraint (as in the case of *non deterred drivers*), her marginal rate of substitution is zero and the equilibrium is reached at the level at which P=0;
- If the agent is poor or her marginal rate of substitution is very high, the equilibrium is in $\beta_i \geq \beta_m$ and the residual amount of demerit points is very large

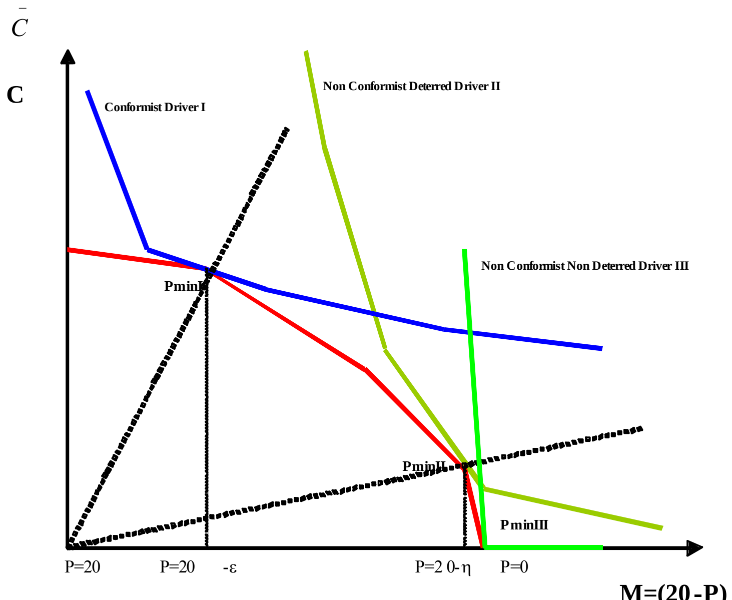


Figure 1
Indifference curves and optimal choices according to agents Õtype

(as in the case of *deterred drivers*).

Contrary to standard literature on traffic law enforcement, even in this simple heuristic it is possible to outline how the introduction of a DPS might induce *some level of under-deterrence* for type II agents and *total under-deterrence* for type III agents. The paradox here is that in order to obtain compliance by type II agents, it is necessary for them to consume some amount of demerit points: compliance implies under-deterrence at least for some period.

Given this heuristic, we outline in the next section an inter-temporal model of consumption of points for partially deterred drivers.

3. Inter-temporal Decisions by Partially Deterred Agents

In this section we set the more general problem of optimal inter-temporal use of demerit points in order to obtain *M*. In particular we focus here on the case of *partially deterred agents*.

Let *U(M,C*) be the utility function of the agent, where *M* is the economic opportunity obtained by consuming a given stock of points (20 in our case) of her driving license, *C* is a composite good, the price of which is 1, and *P* are demerit points.

We assume that during her life the agent can employ driving license points to produce the good *M* at a given rate γ, assumed constant for simplicity. Her endowment of driving license points at the beginning is given and equal to 20. We assume further that, during her life, she can restore her endowment of points, up to the maximum amount of 20, by attending a driving retraining course (which we represent by the restoration function *R*). Only if she consumes all the 20 demerit points it will be necessary to pass another driving examination. As a result driving license points can be considered as a renewable resource.

The inter-temporal optimal choice of the agent can be summarized as follow:

$$
\begin{cases}
\max \int_0^T U(M,C)dt \\
s.to \\
\frac{dC}{dt} = C^* - \alpha(P,\overline{D}) \\
\frac{dP}{dt} = R(P,\overline{D}) - \gamma M \\
C(0) = C^* \\
C(T) \geq 0 \\
P(0) = 20 \\
P(T) \geq 0 \\
\lambda(t) \geq 0 \\
\mu(t) \geq 0 \\
\lambda(T)C(T) = 0 \\
\mu(T)P(T) = 0
\end{cases}
$$

We further assume that:

$U_C > 0, U_{CC} < 0; U_M > 0, U_{MM} < 0$, that is to say that the marginal utility from C and M increases at a decreasing rate;

$\alpha_P > 0, \alpha_{PP} > 0$, which means that the cost of transforming points into M increases at an increasing rate;

$\gamma > 0$ where γ is the rate of technical transformation of points P into M;

$R_P > 0 \quad or \quad R_P < 0$, where the points re-production process is like a logistic function.

Thus we have the following results

:

Proposition 1

The agent consumes an amount of demerit points *P* such as to equalize the ratio between R_P, the rate of reproduction of points and α_P, the increasing marginal cost of transformation of *P* in *M,* with the ratio between the shadow prices of *C* and *M*.

Proof

The agent solves the following optimal control problem and obtains that:

$$H = U(M,C) + \lambda(C^* - \alpha(P,\overline{D})) + \mu(R(P) - \gamma M)$$

Then:

$$\frac{dH}{dP} = -\lambda\alpha_P + \mu R_P = 0 \quad \text{or} \quad \lambda\alpha_P = \mu R_P \qquad [1]$$

$$\frac{d\lambda}{dt} = -\frac{dH}{dC} = -U_C - \lambda \qquad [2]$$

$$\frac{d\mu}{dt} = -\frac{dH}{dM} = -U_M + \gamma\mu \qquad [3]$$

Equation [1] can be rearranged so as to provide the optimal solution:

$$R_P = \frac{\lambda}{\mu}\alpha_P \quad \text{or} \quad \frac{R_P}{\alpha_P} = \frac{\lambda}{\mu} \qquad [4]$$

QED.

Proposition 2

In equilibrium, the marginal rate of substitution between *M* and *C* is equal to the ratio between the technical rate of transformation of points in *M,* times the marginal cost of this transformation and the rate of reproduction of points.

Proof

Assuming that preferences are linear and additive, at least piece-wise, then $-\frac{dH}{dC} = \frac{d\lambda}{dt} = 0$ and $-\frac{dH}{dM} = \frac{d\mu}{dt} = 0$

Equations [2] and [3] can be written as:

$$\frac{d\lambda}{dt} = -\frac{dH}{dC} = -U_C - \lambda = 0 \quad \text{or} \quad -U_C = \lambda \qquad [5]$$

$$\frac{d\mu}{dt} = -\frac{dH}{dM} = -U_M + \gamma\mu = 0 \quad \text{or} \quad U_M = \gamma\mu \qquad [6]$$

Substituting the equations [5] and [6] in the equation [4] for the optimal solution, we obtain that:

$$\frac{\alpha_P}{R_P} = \frac{\frac{U_M}{\gamma}}{-U_C} = -\frac{U_M}{\gamma U_C} \text{ or } \left|\frac{U_M}{U_C}\right| = \frac{\gamma \alpha_P}{R_P} \qquad [7]$$

QED.

Proposition 2 shows the conditions under which a DPS induces compliance for this type of agents. When $\left|\frac{U_M}{U_C}\right| < \frac{\gamma \alpha_P}{R_P}$ agents are induced to increase their rate of violations. That is, as long as $\left|\frac{U_M}{U_C}\right| < \frac{\gamma \alpha_P}{R_P}$ agents are under-deterred even after the introduction of a DPS. The paradox here is thus that in order to obtain compliance some level of under-deterrence should be allowed. Other things being equal, an increase in α_P may indeed compensate the above inequality. The extent of under-deterrence will thus depend on the value of marginal cost of transformation of points in M, which in turn depends on the way in which points and monetary sanctions are designed and on the level of detection. That means that the introduction of a DPS might be accompanied by a short term increase of the rate of violations before observing compliance. That is consistent with some data outlining higher rates of violations after the introduction of a DPS and a decreasing consumption of points over time (Zaal, 2004). Moreover, for any given value of α_P, the extent of under-deterrence depends on the rate of restoration of points as stated in the following proposition.

Proposition 3

The smaller is the reintegration rate R_P the higher is the compliance effect, other things being equal. A reintegration rate R_P smaller than 1 reduces the under-deterrence effect and increases compliance.

Proposition 3 shows that decreasing the rate of restoration of points would increase the opportunity costs of using demerit points in order to obtain *M*. Thus, allowing for the renewal of points (as it is the case of driving retraining courses introduced by many DPSs) has always a countervailing effect on compliance. Both the provision of assigning 'merit' points to agents who have not been caught to be violating in a given period and the one that allows to regain lost points by attending a course in the same period, will only have the effect of increasing under-deterrence.

4. Inter-temporal decisions by Non Deterred Agents

Let us now focus on the behaviour of *non deterred* agents. We argue that these agents will not behave differently after the introduction of a DPS. The reason is rooted in the fact that we have assumed that they always value any amount of *M* higher than the cost of paying the non-monetary sanction associated. This result is independent of the amount of points allocated and of the rate of restoration. At any time, type III agents are not concerned with the choice of how many points are ought to be consumed but whether or not it is worth to incur in the non monetary sanction. Thus agents face a discrete choice between consuming or not consuming the total amount of points.

Let us assume, for the sake of simplicity that $R_P = 0$. If the agent considers the consumption of her driving point endowment as a discrete choice, she will solve the following problem:

$$\begin{cases} \max \int_0^T U(M,C)dt \\ s.to \\ \dfrac{dC}{dt} = C^* - \alpha(P) \\ 0 \le P \le 20 \\ C(0) = C^* \\ C(T) \ge 0 \\ P(0) = 20 \\ P(T) \ge 0 \\ \lambda(t) \ge 0 \\ \lambda(T)C(T) = 0 \end{cases}$$

Then we have that

$$L = U(M, C) + \lambda(C^* - \alpha(P)) + \mu_1(20 - P) + \mu_2 P$$

The optimal solution thus satisfies:

$$\frac{dL}{dP} = -\lambda\alpha_P - \mu_1 + \mu_2 = 0 \qquad [8]$$

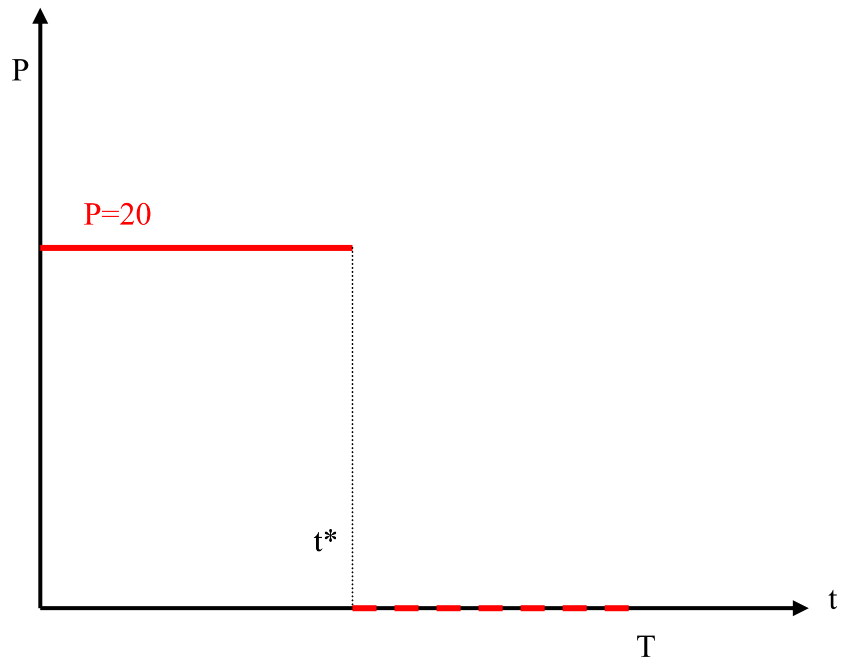
$$\frac{d\lambda}{dt} = -\frac{dL}{dC} = -U_C - \lambda \qquad [9]$$

$$\begin{aligned} &\mu_1 \geq 0; \mu_1(20 - P) = 0 \\ &\mu_2 \geq 0; \mu_2 P = 0 \end{aligned} \qquad [10]$$

From [8] it will be:

$$\begin{cases} P = 20 \quad \text{if} \quad \lambda < 0 \\ P = 0 \quad \text{if} \quad \lambda > 0 \end{cases}$$

As a result, in each period, the agent will consume all points in *t**, that is before the terminal point *T* (*Figure 2*).



Proposition 4

Non deterred agents will consume at any period *t**, the entire amount of points independently of the amount of points assigned.

Proposition 4 implies that for non deterred agents the introduction of DPS will not affect in any respect their behavior as along as there is the possibility of obtaining new driving licenses after suspension. The consumption of the entire amount of driving license points is thus transformed in a *bang-bang control variable problem* so that agents will consume all the amount of points at any period.

With respect to this type of agents, an optimal deterrence policy would not insist on demerit points but rather on increasing the cost of 'reloading the gun', that is to say the cost of renewing the driving license.

5. Some policy options to improve the effectiveness of a DPS

In the previous sections we have outlined how a DPS may induce some level of under-deterrence for non conformist deterred agents. We have also pointed out how the way in which the points scheme and the rate of points renewal are designed affect the dimension of the under-deterrence effect. Thus in order to increase the level of compliance it would be necessary to eliminate or minimize the rate of points restoration and to design a system of points which rapidly leads to the critical threshold of compliance. On the other side, for non conformist non deterred agents, we should never expect compliance since we have assumed that their evaluation of the economic opportunity gained by losing all the points is always higher than the cost inflicted by non monetary sanction. In order to induce this type of agents to comply, it might be necessary to increase exponentially over time the magnitude of the non monetary sanction, for instance by increasing the time interval of driving license suspension for recidivists. Since we do not know the distribution and the composition of deterred and non deterred drivers in a society, when designing a DPS system the public enforcer should try to achieve the maximum level of general deterrence, for any given amount of public expenditure in detection. In order to obtain the maximum level of general deterrence, a DPS should transform both demerit points and driving licenses in "exhaustible resources". In order to illustrate this case, let us assume the strongest DPS we could imagine: one which denies both the possibility of restoring the stock of points, *S*, after suspension and also the chance to regain the license once it has been lost, that is to say that 'incapacitation' is applied indefinitely.

In this case the agent problem is:

$$\max \int_0^T U(M,C)dt$$

$$s.to$$

$$\frac{dC}{dt} = C^* - \alpha(P, \overline{D})$$

$$\frac{dS}{dt} = -P$$

$$C(0) = C^*$$

$$C(T) \geq 0$$

$$P(0) = 20$$

$$P(T) \geq 0$$

$$\lambda(t) \geq 0$$

$$\mu(t) \geq 0$$

$$\lambda(T)C(T) = 0$$

$$\mu(T)P(T) = 0$$

The solution to this problem is given by:

$$H = U(C;M) + \lambda(C^* - \alpha(P, \overline{D})) - \mu P$$

Then:

$$\frac{dH}{dP} = -\lambda\alpha_P - \mu = 0 \qquad [11]$$

$$\frac{d\lambda}{dt} = -\frac{dH}{dC} = -U_C - \lambda \qquad [12]$$

$$\frac{d\mu}{dt} = -\frac{dH}{dM} = -U_M \qquad [13]$$

Equation [11] gives us the solution:

$$\alpha_P = \frac{\mu}{\lambda} = \left|\frac{U_M}{U_C}\right| \qquad [14]$$

Thus we obtain the following propositions:

Proposition 5

The deterrence effect induced by a DPS is maximal when the opportunity cost of reintegration is so high (maybe infinite) to induce economic agents to perceive the initial endowment of points as an exhaustible resource in the period *T*.

Proposition 6

Under the above assumption the initial endowment of demerit points *P* will be used to obtain growing amounts of *M* at a rate such that at *t*=*T* will be equal to 0.

Figure 3 illustrates the meaning of *Proposition 6*. The heavy line represents a constant rate of consumption of demerit points to obtain *M,* under the time horizon *T*. If agents consume very rapidly demerit points to obtain *M*, then their rate of points sacrifice will decline approaching *T*.

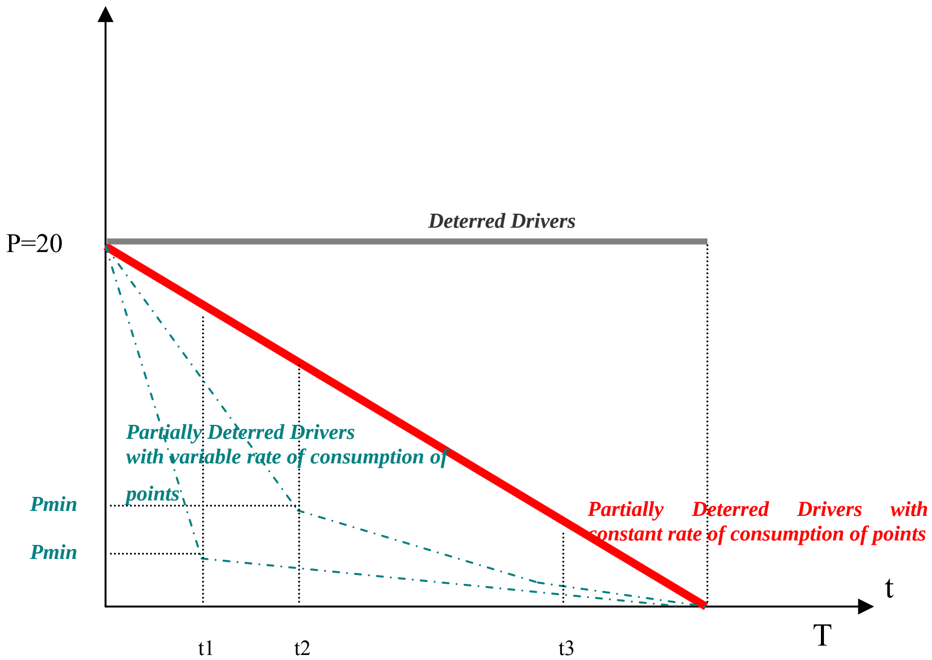


Figure 3

Comparing *Figure 1* and *Figure 3* we can thus conclude that, under a tough DPS (little or no chance of restoring points and regaining the license after suspension) agents will tend to consume very rapidly their points up to a maximum amount compatible with their highest indifference curve.

The rate of consumption of points will depend on the opportunity cost of reintegrating the endowment of points once exhausted. When this cost is high enough to induce agents to perceive points and the driving license as an exhaustible resource, than the rapid consumption of points will be followed by a decreasing rate of consumption in the period *T*.

A different policy based on a fixed stock of driving license points without the possibility of restoring when it is close to exhaustion but considering the possibility of new driving examination without limits could assure some compliance by *non conformist deterred agents* but will imply under-deterrence for *non conformist non deterred agents*.

For the same reasons, a policy which introduces merit points for non-infringers will induce a higher level of under-deterrence. Since reintegration is a common feature of most DPSs, we should ask whether it is convenient to induce reintegration of points within a short timespan. In countries such as US, France and Germany, the rate of reintegration is very slow and thus costly for infringers (from 3 to 6 months) (Makinen, Zaidel et al., 2003). Quite the contrary in Italy, where it is sufficient to attend 12 (18) hours of a course of training in driving and to spend an amount of 190 (210) euros in order to having reintegrated 6 (9) points (on a total budget of 20). The Italian system also assigns 2 merit points every two years up to a total maximum of 30 if the driver is not caught violating. A system like the one adopted in Italy is doomed to increase under-deterrence.

According to our model, some other systems, as the one adopted in Australia (New South Wales), seem being more effective in inducing general deterrence, by increasing the opportunity costs of consuming points for partially deterred agents and by raising the opportunity costs of losing driving license for non deterred agents. In NSW, unrestricted licence holders may accumulate up to 12 demerit points in a three years period. The amount of points is restricted to 7 points or to 4 points for provisional license. The NSW scheme also makes the period of suspension for an unrestricted license to be dependent on the number of demerit points a driver accumulates within a 3-year period. The suspension periods last 3 months (12 to 15 points), 4 months (16 to 19 points), 5 months (more than 20 points)[11]. If a driver is on a provisional licence and reaches the demerit point limit, the licence is suspended for 3 months. Moreover, if the driver does not want to have her licence suspended, She can submit herself to a 'good behaviour period' which allows her to continue to drive for 12 months subject to the condition of not violating traffic rules any longer. If the driver gets 2 or more points during the period, the licence will be suspended for twice as long as it was supposed to be previously suspended. Another interesting innovation of the NSW scheme regards the introduction of *double demerit points* for speeding, seatbelt and motorcycle helmet offences made during all holiday periods such as long weekends, Christmas, New Year and Easter. A recent investigation made by the Road Traffic Authority of NSW has shown how the introduction of this DPS has dramatically increased compliance (NRMA, 2002).

In NSW the final decision (without right of appeal) on driving license suspension is subject to a discretional decision made by the relevant authority, usually a judge who will selectively punish recidivists.

6. Conclusions

The widespread adoption of DPSs in traffic regulation in developed countries strikingly contrasts with the lack of economic analysis of the assumed causation between the introduction of a DPS and an increase in deterrence and compliance o traffic rules[12]. We the present work we intended to model and explain deterrence and compliance under a DPS.

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[11] It is possible to "gain" more than the suspension threshold points (12 in this case) in two cases: i) when several infractions are associated with a single event such as a car accident and ii) when an agent has previously accumulated several points before committing a severe violation

12 While some authors (Haque, 1987; Zaal, 1994) claim a positive effect in terms of the decline of the average annual number of casualties, some other reports (SWOV, 2005) question even the existence of a positive effect, rather stressing the risk of an increase of violations by those who are not deterred by monetary sanctions, after a DPS is introduced. On the other side, some authors have concluded that demerit points represented the only variable of importance in predicting future accident involvement. In particular, since it is the only one of these variables which can be altered by driver behaviour it

As Dingle (1985) has hypothesized, the introduction of a DPS should thus increase general deterrence by increasing compliance by non deterred agents. However in this paper we have pointed out two perverse effects of a DPS: (i) for partially deterred drivers the introduction of a budget of points may actually increase in the short-run rather than decrease their attitude to infringe traffic law up to the amount of points which makes the points' threshold binding; (ii) for non deterred drivers the mere introduction of demerit points might not affect in any respect their decisions to infringe traffic laws, as long as their expected utility derived from infringement is not affected by a rise in non monetary sanctions. That is non deterred drivers will continue to jump directly to the most beneficial action, independently of the introduction of a DPS.

In the above cases a DPS should be designed accordingly to the type of drivers to be deterred. In the case of *partially deterred drivers* it seems that some under-deterrence effect is unavoidable at least in the short term in order to obtain compliance. The available data confirm that the sooner the driver will consume some of her points the sooner higher level of compliance will occur (as in the case outlined in figure 3 for non conformist drivers with variable rate of consumption of points). Thus for this type of agents, it might be convenient to tolerate some degree of non-compliance at the beginning, just after the introduction of a DPS, in order to induce future compliance. This compliance effect will be obtained regardless of any increase in the probability of detection (thus without increasing social costs in monitoring and detection)[13]. However, as we have shown in a previous section, this outcome strictly depends on the way in which the rate of points' restoration is designed. An increase in the probability of restoration and/or the assignment of merit points after a 'good behavior period' will rapidly decrease compliance.

With reference to *non deterred* drivers, the only policy available is that of increasing exponentially the impact of non monetary sanctions such as for instance increasing the time length of license suspension and/or inhibiting license renewal).

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offers an opportunity to prevent accidents. Chipman and Morgan (1975) have investigated the relationship between demerit points, other driver characteristics, and the frequency or risk of future collisions and traffic convictions for licensed drivers in Ontario. A stratified sample of 500-600 drivers from each of five levels of demerit points was selected. According to their results, of the traits considered (demerit points, age, sex, class of licence, history of previous accidents), demerit points represented the only variable of importance in predicting future collision involvement.

13 A similar argument, in a different context, has been raised by Heyes and Rickman (1999).

The simple model outlined above shows some intrinsic features of a demerit point system, which could be summarized as follows:

i. a DPS presents the distinguishing feature of *warning by sanctioning* (the amount of penalties received acts as a warning on the behavior followed by drivers) and of *sanctioning by warning* (the consumption of points is coupled also with monetary sanctions)[14];

ii. a DPS implies that, at least for a group of agents (*partially deterred*), the opportunity cost of transforming demerit points into economic opportunities *M* increase as the initial endowment of points is dissipated; a DPS induces agents to jump to the maximum level of points dissipation which maximizes utility, keeping the minimum amount of points *Pmin* which allows them not to incur in non monetary sanctions such as 'incapacitation' to have future access to economic opportunities (such as losing the driving license);

iii. for those agents whose elasticity of economic opportunities *M* to the consumption of points is very high, a DPS induces a rapid consumption of points at the very beginning and then decreasing rates of points dissipation;

iv. a DPS is effective when the rate of reintegration is zero or delayed over time. In this respect it is more effective to increase the original amount of points endowment rather than allowing renewal of points or new license after suspension;

v. with respect to traditional monetary sanctions, a DPS is a more efficient sanction system since it induces a given level of (endogenous) compliance without requiring any increase in the probability of detection which is assumed to be socially costly;

vi. the higher is the scope of violations to which demerit points are applied the sooner the agents will reach the minimum amount of points lost after which agents start complying .

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14 That is a distinguishing feature of DPS both with respect to monetary and non monetary sanctions and to warnings. Here the effects of warnings induced by a DPS are different with respect to those outlined in the literature. Nyborg and Telle (2004) emphasized the role of warnings in inducing compliance in context characterized by asymmetric information between the infringer and the regulatory authority. Thus warnings act as a signal, revealing appropriate information to infringer so as to induce them to comply in order to avoid further sanctions. In our context, there is no asymmetric information on the nature of infringing actions. However the consumption of points exerts somehow the role of a warning for infringers.

A DPS also allows for self-selection of agents according to their preferences about the transformation of P in M, so as to expose to the harder non-monetary sanction only those agents who have a clear attitude towards systematically infringing traffic rules (thus giving further chances to those who simply make mistakes). Given the compliance effect observed under a DPS, it seems appropriate to test its effectiveness also in some other contexts, such as environmental protection, in which detection is costly and policy makers are interested in reducing the total amount of infringement by inducing economic agents to endogenously moderate their deviant behavior.

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