TRANSPORT LAW ENFORCEMENT: A FRAMEWORK FOR THE
OPTIMISATION OF ECONOMIC BENEFITS

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1 Introduction

A growing number of opportunities exist for using enforcement as a means of managing and enhancing the performance of operations, infrastructure and traffic management proposals within the transport sector. Schemes which may benefit include congestion charging, parking, speed management and goods vehicle restrictions.

Economic principles, which underpin most appraisal methods, are widely accepted to lead to a more efficient and effective allocation of both public and private sector resources. The methods used in modelling transport movement and the framework used in evaluation is clearly (if not perhaps fully) defined. Economic principles have had an important influence in both model development and the derivation of parameters used in evaluation. By implication the effort put into this activity is assumed to lead to a more efficient and effective allocation of resources - to such an extent that it justifies the expenditure. It follows that economics may present a means of optimising investment in enforcement resources and maximising scheme outputs.

This paper tracks an area of research that has been followed and developed by the author over the past 20 years. The essential argument is that a feasible economic framework for resource allocation decisions does indeed exist. The theoretical basis is relatively well developed, having been first put forward by the Chicago School economist Gary Becker in 1968. Based on the economist's concepts of social cost and utility, it sets as its target the minimisation of the social cost of offences. This category includes all the costs of offences including the sum of enforcement and social damage costs. Minimisation is achieved by manipulation of two deterrence variables, the certainty and severity of sanctions which are both under the control of a (usually) public authority.

Subsequent research has indicated some theoretical and practical issues which need to be resolved in advance of widespread application, including the treatment of equity and the accommodation of the framework within the existing decision-making procedures of enforcement institutions (Pyle, 1983, Ehrlich, 1996). A number of enhancements to the basic framework have been identified. Previous transportation research had tested the applicability of the framework in the field of parking regulation enforcement (Calthorp, 2001) and traffic management (Black et al, 1991) and found it capable of producing useful directions to enforcement policy. Further, desk based, case studies suggest it is
also applicable to a number of other transport related offence types (Brown et al, 1998). The growth of new traffic measures such as congestion charging offer further opportunities for the application of an economic approach to enforcement.

The following sections suggest applications of this enforcement framework at both strategic and micro levels to improve the quality of decision making within the transport law sector, and make recommendations for further research into the detailed applicability of the enhanced framework. Conclusions are drawn with applications to all developed cities and transport networks.

2 An Economic Framework for Enforcement

Gary Becker's work in the late 1960s provides the conceptual framework to address the issue of how to allocate resources in the enforcement system so as to minimise the total social cost of offending and enforcement.

His framework consists of six key elements, comprising four costs and two behavioural functions:

- the social cost of enforcement;
- the cost of prosecution and punishment;
- the social cost of the harm caused to society by the offences;
- the gain to offenders from illegal behaviour;
- the effect of different levels of enforcement on the certainty of punishment; and
- a "demand for offences" function defining a relationship between the level of sanctions (certainty and severity of punishment) and the rate of offending.

Enforcement Cost, E

This cost (abbreviated to E) is usually incurred by enforcement agencies, e.g. police or other enforcement officers. The key relationship is between E and the probability of detecting offences (defined as p) i.e. $p = r(E)$ - with p assumed to rise with increasing E.

Prosecution and Punishment, P

A decision to prosecute also has implications for social cost, usually involving further expenditure by enforcement agencies as well as the courts. Punishment (f) can be by fine, custodial sentence, or other sanction, such as a driving ban. The economic approach distinguishes between a fine (a zero-sum transfer between economic entities) and imprisonment or community service (which consumes resources, including those of the offender).
The total cost of \( P \) depends on the number of convictions, which in turn depends on the certainty of conviction \( (p) \) and the number of offences \( (O) \) committed, i.e. \( P = p(O) \), \( P \) increasing with rising \( O \). There are a series of probabilities in the prosecution and conviction process, the probabilities of: detecting an offence; a decision to prosecute; conviction; and the penalty being paid. Full analysis of the process must consider the interrelationship between these declining probabilities.

**Harm to Society, \( H \)**

Offences harm other members of society. In the context of transport, offences can increase:

- cost to other road users (increased congestion within a road pricing zone);
- cost to public authorities (road damage through overloaded lorries);
- risk of accidents (speed limit violations);
- environmental damage (due to vehicle condition or pollution from non permitted journeys);
- loss of revenue (fare/congestion charge evasion).

Again a distinction is drawn between resource costs and transfer payments where loss is balanced by gain to the offender (e.g. fare evasion). \( H = h(O) \) and is an increasing function of the number of offences.

**Gain to Offenders, \( G \)**

For completeness, gains to offenders from their offending (lower journey times, shorter walks from illegal parking locations) also need to be included. The net gain is the consumers’ surplus from their illegal activities, and is closely related to the demand curve for offences. This net gain, \( G_n \), increases as the number of offences rises, and is the difference between the gross gain \( (G_g) \) of the offence and the expected punishment cost \( p(f) \). As noted, \( f \) is partly a transfer \( (f_1) \) and partly resource cost \( (f_2) \). Thus \( G_n = G_g(O) - p(f_1 + f_2) \).

**Total Social Cost, \( S \)**

The sum of these four elements gives \( S \),

\[
S = E + P(O) + H(O) + pf - \{G_g(O) - p(f_1 + f_2)\},
\]

Transfer payments \( f_1 \) (e.g. fines) cancel out, and if the resource cost suffered by offenders is included in the social cost of prosecution and punishment, the calculation simplifies to:

\[
S = E + P(O) + H(O) - G_g(O)
\]
Becker's approach suggests that society should aim to minimise $S$ by selecting an appropriate combination of the policy weapons, severity of punishment ($f$) and certainty of conviction ($p$). To resolve this problem a relationship that explains the level of offending, a "demand curve" for offences, is necessary.

Becker argued that criminals behave basically like all other individuals in that they attempt to maximise utility subject to a budget constraint. An individual therefore commits a crime if the expected utility (gain), $EU$, from doing so exceeds that of alternative legitimate activities, where:

$$EU = pU(Y-f) + (1-p)U(Y)$$

where: $p = \text{subjective probability of conviction};$
$U = \text{the individual's utility index};$
$Y = \text{the gain from committing the offence};$ and
$f = \text{monetary equivalent of punishment if convicted}.$

Non-monetary costs and benefits of criminal activity (e.g. moral repulsion, machismo pleasure) are included by attempting to convert such psychological factors into a wealth equivalent attached to the offender's gain ($Y$). The psychological and inconvenience costs of imprisonment are included in the punishment term ($f$). If $EU(\text{crime})$ is greater than $EU(\text{alternative})$, a rational individual will commit the offence, if it is less, they will not.

Given a set of individuals with different assessments of the costs and benefits of offending, a demand curve, $O = O(p,f)$, can be hypothesised in which the number of offences committed ($O$) relates to the probability of conviction ($p$) and punishment if convicted ($f$). The logic of utility calculations leads to the conclusion that any increase in either $p$ or $f$ will lead to a decrease in the number of offences committed. An issue that is particularly critical in the context of law enforcement compared to other uses of a demand curve is that of perception. If perceptions of the probability of conviction $p$ and/or the severity of punishment $f$ are biased then the framework needs to be adapted. A similar issue occurs in transport policy appraisal, where individuals do not correctly perceive the full (social) cost of car use.

The law enforcement model thus has five basic, or structural, relationships:

- social cost $S = E + P(pO) + H(O) - G(O)$;
- the demand for offences function $0 = O(p,f)$;
- the effectiveness of enforcement function $P = f(E)$;
- the prosecution & punishment function $P(pO)$; and
- the harm function $H(O)$.

The objective is to minimise $S$ using the two instruments of: 

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enforcement resources (E) - which affects the certainty of conviction (p); and
- the severity of punishment (f).

Marginal analysis suggests that the optimal number of offences occurs when marginal gain $G^\prime$ equals marginal social cost ($S^\prime$). Mathematically when:

$$G^\prime(O) = E^\prime,O + P^\prime (0) + H^\prime(O)$$

At this optimum, the expected punishment from an offence ($pf$) is equal to the marginal gain, and most importantly, to the sum of marginal social cost $S$. Thus the economists' principle of 'price equal to marginal social cost' guides the choice of expected punishment. Just as in the setting of environmental or congestion taxes the aim is to make the user aware of the full costs of his/her potential action - i.e. offending. If his/her gain does not exceed the social costs then no offence occurs, but if, for some reason, the gains are in excess of the social costs of offending then the offence takes place. Strictly, from a behavioural point of view, the last sentence should refer to perceived gains and perceived cost. In the economic approach, therefore, the perspective is switched to understanding the social costs of certain behaviours and, if a social cost minimum is to be pursued, to ensuring the combination of probability and severity of punishment reflect the social costs of offending to potential offenders.

Even having identified the optimal (perceived) level of expected punishment ($Pf$), the enforcement authority must still decide the split between the punishment ($f$) and probability of punishment ($p$). (The required resources (E) are derived from $p$.) However, the logic of a resource cost approach (i.e. netting out fines as merely a transfer payment with no resource implications) tends to drive the solution to an excessive use of fines, rather than custodial sentences ($f_2$) or greater $p$ (which both consume real resources). An 'optimal' solution of a £1,000,000 fine with a very low probability of conviction for illegal parking is quite possible. This pursuit of minimum social cost is solely concerned with efficiency rather than equity. Yet who gains or loses, and how much, is of concern as expressed eloquently in the phrase - 'the punishment should fit the crime'. A £1million fine for parking offends this notion of fairness. In practice, therefore, the calculus of social cost minimisation is constrained by notions of fairness on the level of punishment.

Thus whilst Becker’s economic framework provides a coherent basis for decision making, its implementation requires the identification of a number of empirical functions and the resolution of a number of conceptual issues.
3 Case Studies

Becker’s work stimulated a large amount of subsequent research in the fields of enforcement economics and deterrence modelling, virtually all of which has supported and reinforced his framework. Deterrence models in particular have been developed and tested for a wide range of offence types, including a number of transport offences.

Case studies suggest that the model has the potential to provide practical and informed support to resource allocation decisions in the area of transport enforcement. Five case studies are presented, examining the practicality of operationalising the framework in the area of transport-related offences:

• speeding;
• drink-driving;
• congestion charging;
• parking; and
• fare evasion,

The acceptability of an economic type framework depends on four issues:

• the comprehensibility of, and respect by the public for a Cost-Benefit approach;
• the availability of robust data and relationships;
• how it fits into the existing decision making institutions concerned with
  • enforcement; and
• the cost of use.

It should be emphasised that currently some sort of framework already exists for taking decisions on the level of resources to devote to enforcement, how that budget should be allocated (influencing the probability of punishment) and punishment levels. The logic behind this decision making is rarely transparent. The case studies are therefore concerned with how a more transparent and economic approach could provide an improvement over the existing procedures.

Speeding

To a certain extent the existing framework takes into account certain resource or social costs but not as wide a range of these (or benefits) as is either possible or desirable. The relationship between speed and the number and severity of accidents is now fairly well documented and understood by the public and a great volume of data already exists. There is also a growing public awareness of the damaging environmental impact of speeding road vehicles (noise, higher fuel consumption and lower fuel-burn efficiency).

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Further work may be needed on public perception of probability of prosecution in relation to the use of speed cameras for instance, and on the development of speed:accident rate relationships for a wide variety of road types and traffic mixes.

The framework is applicable at a number of points in the existing decision making hierarchy, from the setting of national targets and guidelines to the determination of the optimal allocation of a local police force's enforcement budget. A debate currently exists in the UK Press over the hypothecation of revenues from motorists detected by speed cameras and the insinuated revenue raising goals of some Police forces. The economic framework provides a rational basis for optimising the distribution of speed cameras, the setting of fines and the hypothecation of speed offence related fines to fund increased enforcement.

While the full economic approach will certainly require extra data collection and analysis, this closely parallels work already being undertaken for accident analysis which already involves some of the evaluation criteria. Full implementation should not be unduly expensive in its consumption of resources.

One interesting by-product of a full social cost-benefit approach would be an estimate of the financial benefit to railway companies of a more rigorous enforcement of the speed limit on major highways. This is of particular relevance in view of the relatively high proportion of motorway drivers who regularly exceed the speed limit (estimated variously at between 15-30%). At the margin, this increases the (time) cost to the user of longer trips by car and makes rail a more attractive alternative.

**Drink-driving**

As with speeding, there is wide public awareness of the social harm associated with the offence. Education and publicity have an important role to play, both increasing public enthusiasm for a cost-effective approach and influencing perceptions of p and f (and thus forming part of the enforcement effort). The costs of the offence are well established, thus defining an appropriate level for expected punishment. In this context as in others there is no need for authorities to estimate gains to offenders or demand curves; the focus of the approach is to make the potential offender aware of the social costs of his/her actions.

Copious data exists on the relationships between blood-alcohol content and the rate and severity of accidents, and on the costs of prosecution and punishment. More work is, however, needed on the effectiveness of various enforcement initiatives. No clear relationship emerges from studies which attempt to explain regional differences in drink-driving behaviour by reference to different perceptions of p and f, but these highlight the distinction between actual and perceived probabilities of being apprehended (Maycock, 1997).
Considerable variation exists between authorities in the enforcement effort applied which suggests that the prime initial use of the framework should be at a national level, setting targets and guidelines. There is also a local application in prioritising effort by time of day or year, and between localities at the micro level using local knowledge of social and drinking behaviour.

A cost of use will be the establishment of empirical relationships between enforcement effort and the rate (and severity) of offending. At the decentralised level costs should not be large. Decisions about resource use are currently being made using coherent targeting criteria, the economic framework merely emphasises this approach.

**Congestion Charging**

Congestion charging, the pricing of highway use within defined (normally urban) areas is an emerging field within transport planning that would appear to lend itself well to this economic framework. The objectives of congestion charging often correspond with the optimisation of economic efficiency, whilst the impacts lend themselves to modelling and measurement (eg: traffic speed).

Public support for enforcement should be high, be it from public transport users or (legitimate) motorists (Dft, 2004). Significantly, the Gain to Offenders issue should not be relevant as, unlike illegal parking or speeding, the only gain is the avoidance of payment (the supply of charged road space is not rationed). Thus a relatively straightforward economic analysis can be undertaken in which the cost of enforcement is traded-off with the damage cost arising from illegal behaviour.

The availability of data should be less of a challenge than for most other offence types. Many cities have existing traffic models and data on traffic speed and congestion levels is regularly collected. As congestion charging schemes are generally being implemented for the first time, enforcement costs will tend to be well researched and understood. The principal challenge will be in establishing the ‘supply of offences’ function through constructing a relationship between enforcement effort (p and f) and the level of offending (O). This will require research into both perceptions of the level of deterrence associate with variations in the certainty and severity of sanctions and observations of actual variations in the level of offending for difference deterrence levels. The results of observations should be used to calibrate the perceptions research.

The application of an economic framework to the enforcement of congestion charging will have both strategic and local value. Enforcement costs can be considerable and tend to rise disproportionately with the size of the area concerned. They can determine the overall viability of a congestion charging scheme, hence optimisation of enforcement should be a critical part of scheme design. At a local level, considerable seasonal and diurnal variations often exist.
in traffic conditions which result in a widely differing optimal level of enforcement. Major policing and social damage cost savings could be achieved by optimising the level of enforcement to reflect such seasonal and diurnal variations. An economic framework would be instrumental here.

**Parking**

Application of the framework in this area is already well researched (Brown 1991). Established methods exist for the measurement and valuation of the social costs of illegal parking (congestion, accidents, enforcement, etc.), but gain to offenders is more controversial. Public support for enforcement is lower than for other transport related offences - all trips *have to have* a parking element, whereas speeding or drinking are optional elements. The level of support could be increased by the use of a clear and explicit cost-benefit approach to enforcement, but there are complex equity issues surrounding the levels of \( p \) and \( f \) which may prove less comprehensible to the public than other issues related to the economic framework.

As noted, data and robust relationships are available on most social costs, but the relationship between enforcement effort (\( pf \)) and level of offending is less clear. There may also be data problems at the micro level with a complex relationship involving cost of an offence, propensity to offend, land use, traffic flow, other traffic management measures-etc.

Again, the framework can play a role at two levels of the decision making hierarchy: strategic, in the setting of regional or metropolitan targets and budgets; and micro, involving the optimisation of the enforcement effort in particular areas or at particular times.

Strategic costs of use could be quite high, as it may require development of separate deterrence models for each city. Likewise, local costs of implementation would be high, at least initially when data are being collected for the establishment of social cost relationships. Once these relationships are established, however, use of the framework would be almost costless, merely making better use of resources that would have been deployed anyway.

**Fare evasion**

Public support is high, the costs of enforcement are easily calculated, and gains to the offender simple to calculate. Care is needed, however, in selecting the level of detail at which the framework is applied. Viewed at a simple level, the offence involves a transfer payment, i.e. there is no net harm to society. The objective of minimising social cost therefore needs some adjustment, with due recognition of the problem of equity.
The demand curve for offences has been well researched by a number of large public transport organisations, enabling estimates of the transferability of results to be made, and the effectiveness of various enforcement tactics to be compared. Existing data suggests that, within Train Operating Companies operating within South-East England, expenditure constraints have resulted in a sub-optimal level of ticket-checking, i.e. the railway operator would experience a net revenue benefit from the increased expenditure on enforcement that would result if the economic framework was operationalised.

Strategic decisions involve the level of offending to be tolerated and the enforcement technology to be used, while the framework would also have local applications in allocating resources over time and space (the propensity to evade being known to vary between routes as well as cities).

Within any transport organisation data will already be available to complete a cost benefit analysis of enforcement policy. Costs of operationalisation would thus be low.

4 Issues Emerging from the Proposed Framework

While the results of the case studies are encouraging, further development work, mainly of an empirical nature, is required in order to prepare the framework for application within the specific fields of transport considered here. The original framework requires certain refinements, most notably in its ability to optimise the trade-offs between the various social cost functions and, as noted, its treatment of equity.

Assessment of the case for an economic framework for the allocation of enforcement resources has raised a number of issues. The case studies helped to clarify and illustrate a number of issues, which fall into a three distinct categories:

- deterrence issues - concerned with the offences-sanctions relationship;
- enforcement issues - concerned with the issue of resource allocation; and
- implementation issues - related to the point in the planning process at which the framework is used.

The principal deterrence issues identified by the research are:

- Rationality of Offending Behaviour and Perceptions - two people can respond in a markedly different manner to the same level of deterrence, yet still display rational behaviour. The framework can capture this, via the use of disaggregate behavioural modelling in developing deterrence
models. Perceptions are a major issue in this area revolving around people's gathering and interpretation of small sample sizes - is there a difference from objective measures, and how does it affect the optimal levels of p and f?

- Basic Causes of Deterrence - research demonstrates that certainty (P) and severity (t) of punishment may be contingent on each other, in any of several permutations. Other factors also have an influence, including enforcement technology, perceived p, and the probability of a conviction resulting in f. Nevertheless, p and f remain core concepts in deterrence theory. Moreover, it has been demonstrated that both are amenable to measurement and prediction within the proposed enforcement framework.

- Normative Influences on Behaviour - variables other than p and f influence individuals in decisions to offend or comply. Again, the methods used to operationalise the framework are capable of taking account of such normative factors.

- Transferability - a major challenge is to construct a robust set of deterrence functions, even for one offence type, that recognise the variety of circumstances found in time and space in which offences can take place.

The principal enforcement issues are:

- Underlying Rationale for Enforcement - minimising the social cost of offences provides an explicit objective to justify the rationale for enforcement. As with other areas of applied economics, an objective provides a clear framework in which to optimise investment of scarce resources. The inclusion of G and the recognition of f. as transfer payments are elements of this.

- Targeting of Enforcement - the framework enables enforcement planners to target enforcement resources, both spatially and temporally, so as to minimise social costs.

- Potential for De-criminalisation - by incorporating G, the framework allows an explicit trade-off between marginal social cost and marginal private benefit. Where social damage cost is low or even zero, the framework can provide an argument for de-criminalisation, with regulation replacing a criminal justice regime (Pistor and Xu, 2002)

- Value of the Framework beyond the Economic Paradigm - where an alternative value system dominates (eg: income maximisation), cases can

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be envisaged in which a preferred course of action does not coincide with the aim of minimising social costs. An economic framework is of value to provide planners with useful information to assist their decision-making in two respects here:

1) by applying weights to values within the framework to reflect the alternative preferences (e.g. value of time or accidents; opportunity costs of enforcement resources; etc.); this may be applicable in the case of motorway speed enforcement, where a key variable may be the size of the opportunity cost of traffic enforcement resources and the approach to the valuation of these;

2) a traditional application of the framework will make explicit the costs or benefits foregone of an alternative (non-economically optimal) course of action. EG: a town’s parking system may be designed to maximise income to the Borough rather than minimise social costs. Applying this economic framework would make transparent the economic benefits lost as a result of pursuing a purely financial goal.

• Public Acceptability - case studies suggest that most of the analytical techniques needed to operationalise the framework are already widely applied in the economic appraisal of transport projects, suggesting that the framework would receive public support.

• Data Availability - it should be possible to apply the model for a large number of transport offence categories. The greatest challenge is to recognise the great variety of circumstances.

Issues concerning the application of the framework within the decision-making hierarchy concern its two particular applications:

1) as a means of assisting decisions at a strategic level, within an annual budget planning process; and

2) at a micro level, to assist in prioritising and allocating resources between geographical areas, types of technology, and offence categories.

An enforcement agency's budget planning process could involve the framework to assist officials in their analysis of the costs and benefits of different levels of resource investment in different areas of enforcement. Potential issues that could be addressed here include:

• the optimal number of parking wardens to employ within a city or force;
• the optimal investment in revenue protection staff by a Train Operating
Company;
• Optimising the number of fixed and mobile enforcement cameras in a congestion charging zone;
• the trade-off of investment in speed cameras against patrol vehicles to police speed limits on major highways across a region;

The compatibility between the framework and the institutional environment surrounding the budget-setting process remains to be determined and represents an important area of further work.

Application of the framework at a strategic level would require an appreciation of how social costs vary across cities, regions or forces. This would reflect the unique relationships between offences and social damage costs; enforcement effort and enforcement cost; and deterrence variables and rate of offending. Ideally, the framework applied in each instance would follow a set of guidelines prescribed according to national procedures (cost-benefit analysis manuals provide a broad analogy).

The application of the framework at a micro level, whilst involving the same theoretical basis, requires a somewhat different approach to the strategic application. The output would be a handbook containing standard relationships which define broad relationships between enforcement inputs and social cost. This would assist practitioners to allocate enforcement resources in an optimal fashion.

Different relationships would need to be researched and established for different environments and resources would be needed to establish the handbook initially.

5 Recommendations

There is no doubt that the economic approach as described above has the potential to develop a set of rules for resource allocation that are explicit, based on an acceptable rationale and practical in their application. Its development into a tool for use by enforcement authorities requires research resources and its use also requires resources (though these need not be dramatically larger than those devoted to current decision making).

Whether this extra effort is worthwhile depends on firstly accepting the philosophy of a social cost minimisation approach. Cohen (2000) encapsulates this argument with the assertion that too much deterrence can have negative consequences. A further argument is that in the sphere of transport offences decriminalisation may be appropriate and does not raise any moral objections. Assuming this is accepted then the second requirement is that the framework leads to better decision making, or in economists' terms, a lower total social cost.
(of offences and enforcement activity).

It would seem that one way to measure any possible improvement is to use social cost analysis in order to compare the impact of the current, not very transparent, decision making framework with the economists' framework. Such an approach would effectively provide the basis for an economic approach; and by definition prove its superiority! Rather less scientific is to ask the question whether motorists and other transport users recognise the true social costs of their actions - if they do not then the guiding hand of an economist steeped in social cost analysis should lead to an improvement of some magnitude. Alternatively one can ask the question whether offences in certain areas appear too high or too low, without too careful analysis of why this perception is held. If this is the perception then an economic approach can help to expose the appropriate level of offending.

This argument, based admittedly on tentative evidence, is not only that the economic approach offers an acceptable way forward but that benefits are to be found at a modest cost in resources. The recommendation therefore is that further research and development be pursued in both the strategic applications of the approach, and the development of guidelines for applying the approach at the local level.

The potential widespread introduction of highway tolling, congestion charging, parking controls, information systems and other demand management schemes increases further the importance of enforcement in the management of the transport system. The economic framework, proposed here, provides a means of optimising the social benefits of such schemes.
Bibliography


