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Market Structure, Regulatory Externalities and the Overloading of Trucks: An Industry Perspective.[1]

[1] Introduction to the Problem.

The overweighting of trucks can do considerable damage to the man-made environment. By causing degradation to the pavement surface, overladen trucks impose costs on other road-users in terms of increased travel times, and decreased comfort and road-safety. By increasing the amount of money which must be spent on road repairs the behaviour also imposes a burden on the public purse and thence upon society in general.

The economic incentive for an operator to overload his truck is clear - his revenue will (in general) be linearly increasing in the weight of produce which he hauls, whilst his operating costs increase only nominally. Much of the extra cost of excessive loading is, then, external to the operator, taking the form of increased infrastructural damage. Because of the externality imposed by trucks which are overloaded weight limits are set. The enforcement component of regulation is of unusual importance, in this context, because of the potential for 'outliers' to do disproportionate amounts damage. A 'rule of thumb' commonly used by civil engineers is that the severity of the pavement damage caused by the transit of a truck increases with the fourth power of gross axle weight (Stiglitz and Arnott (1988: 33)) - one severely overweighted truck can do the damage of hundreds of compliant ones.

One study estimates that overloaded trucks in Saskatchewan (which constitute 13% of loaded trucks and, therefore, significantly less than 13% of total truck movements in that province) are responsible for 98% of all damage to highways (Wyatt and Hassan (1984: 70)). Thus, according to Saskatchewan Highways and Transportation, the practice of overweighting accounted for some \$1.8 m of pavement damage in that province in 1984. Barron (1985) calculates that pavement damage attributable to overweight trucks in New Jersey could exceed US\$ 20 m per annum. Similar conclusions regarding the disproportionate impacts of violators of weight regulators have been reached for other jurisdictions. It should be noted that these estimates often understate the true damage done to infrastructure because studies (including that by Wyatt and Hussan (1984)) ignore damage done to bridges and other roadside structures. More general estimates of the potential effects of heavy trucks have been provided by the U.S. General Accounting Office (1979) and the Organisation for Economic Cooperation and Development, Environment and Transport Divisions (OECD, 1983). What is clear is that the damage associated with the antisocial activity of overloading lorries is considerable.

In this paper we assess the regulatory problem surrounding the enforcement of weight limits. In particular, the scope for industry self-regulation is considered. Regulation is assumed to comprise a weight limit and a level of enforcement effort which depends upon the compliance performance of the industry. In Canada, weight regulations vary between provinces, and between States in the US. Maximum loads are defined for each axle and for gross

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combination weight (GCW) by class of truck. Setting standards is not enough, in itself, however, to protect the road system from excessively heavy lorries. It cannot be assumed that operators will be uniformly scrupulous in complying with the regulatory requirements unless an adequate enforcement régime is installed. In this paper we concentrate on the problem of enforcing existing regulations, rather than that of at what stringency regulations should be set in the first place. In the context of a 'responsive' regulatory agency, we demonstrate that there are potential gains to be reaped by the industry from establishing a self-regulatory system to ensure a higher rate of compliance than would be the case if each firm acted independently.

The story which our model tells is, essentially, a simple one. Consider a trucking duopoly. On a particular route Firm A overloads some fraction of it's trucks, inducing an increase in the regulatory effort of the government on that route. This reduces the expected profits of Firm B, the other duopolist. Firm A can be said to inflict a 'regulatory externality' on Firm B. At the same time, however, Firm B is inflicting an analogous regulatory externality on Firm A. We demonstrate that, in general, there will be benefit to both firms from agreeing to some kind of mutual restraint on their respective violation rates. Such cooperative action on the part of the members of the industry is what we will call 'self-regulation'. The new (cooperative) equilibrium will not be characterised by full compliance, but will involve less frequent violation than in the non-cooperative equilibrium. For this reason the government regulatory agency should encourage this class of cartelisation by the industry.

The focus of this study is the problem faced by firms in the industry, and regulatory framework is to some extent 'black boxed', though we will motivate the external characteristics of that black box in several ways. In Section 2 we develop and solve a simple model of the loading problem faced by the individual truck operator. In Section 3 we consider the role of market structure on the compliance behaviour of the industry. It is shown that a less concentrated industry will, in aggregate, violate the weight standards more often than a more concentrated one. In Section 4 the scope for, and practicability of, self-regulation is examined. It is argued that the gains from industry self-regulation may be considerable, though empirical determination of those gains is likely to be hampered by the problem of adequately defining the boundaries of the market (how far is the industry segmented - both geographically and by the characteristics of the vehicle population). Suggestive examples taken from the North American industry are used throughout.

[2] A Stylised Model of the Truck-Loading Decision.

Weight regulation in a particular jurisdiction is based upon a weight limit, denoted W, which must not be exceeded. Loading a truck is a discrete choice problem: comply or overweight. The revenues and costs associated with complying or overweighting are, respectively, R_C, C_C, R_O, C_O. It is assumed that $R_C<R_O$ and $C_C<C_O$, but $(R_C-C_C)<(R_O-C_O)$. This last condition ensures that, in the absence of any regulatory enforcement, the operator faces an incentive to overweight - in not satisfied the problem is trivial.

An increase in cargo weight from 10 to 20 tons can cause the total cost of haulage to increase by only a few percent. The incremental incentive to overweight (net of penalties incurred), then, depends upon the going rate per pound on the route being travelled (see Tables 1 and 2 for some typical figures). Data on these rates is easily available and varies according to origin-destination combinations and the nature of the cargo. The incentive to overweight depends, then, upon what is being hauled and on which route.

The regulatory agency conducts random inspection of trucks in transit, in which permenant weigh-stations or patrol cars equipped with mobile scales are used to verify the truck's compliance status. The probability that a given truck on a given journey will be inspected in this manner will be denoted μ, and if the truck is found to be in violation of the weight limit its owner faces a fine of monetary value f. The proportion of the ith firm's trucks which are overweighted is denoted $ß_i$. The enforcement effort of the regulator, on any particular route or in any particular jurisdiction, is assumed to be an decreasing function of the propensity of the truck population to comply. If the industry in that segment is comprised of n firms indexed by lower case subscripts, with respective market shares denoted s_i, then $\mu=\mu(\Sigma ß_i.s_i)$ where it is supposed that $\mu'>0$, $\mu''<0$. Increased disobeyance of the regulations on any particular routeway (or in any particular market segment) induces, ceteris paribus, increases in the intensity with which that routeway is policed. Such a relationship can be generated by variations on a variety of 'familiar' models of enforcement strategy from the literatures on environmental protection, income tax collection and others. These will be outlined more fully in Section 3. For now we wish to focus on the problem from the point of view of the industry and treat the function $\mu=\mu(\Sigma ß_i.s_i)$ descriptively.

The trucking firm chooses a mixed strategy, described by the parameter ß which dictates the probability that the operator will dispatch an overweighted truck. Through time ß will come to be the proportion of truck-journeys which involve excessive loads. The term Ω will be used to denote the average rate of violation in the truck population as a whole. The problem faced by the ith firm, then, is to specify a mixed strategy (ie a ß such that $0\leq ß_i \leq 1$) to maximise expected profit P_i.

$$\text{(1)}\quad \underset{0\leq ß_i\leq 1}{\text{Maximise}}\; P_i=\{[1-ß_i].[R_c-C_c] + ß_i.[R_o-C_o] - ß_i.\mu(\Sigma s_i.ß_i).f\}$$

The first and second terms represent expected net operating surplus from compliant and overweighted trucks respectively, whilst the third term is the expected penalties to be paid. In the case of an interior solution and assuming Nash conjectures (ie that $(\partial ß_j/\partial ß_i)=0$ for all $i\neq j$, the firm takes the actions of it's competitors as given), the first-order and second-order conditions (where the latter is assumed to be satisfied) associated with the ith firms problem are

$$\text{(2)}\quad (\partial P_i(ß_i^*)/\partial ß_i) = G - \mu(\Sigma s_i.ß_i^*).f - ß_i^*.\mu'(\Sigma s_i.ß_i^*).f.s_i = 0,$$

and

Cargo Weight (tons)	Line-Haul Cost Per Mile	Line-Haul Cost Per Ton-Mile
10	0.891	0.089
15	0.895	0.060
20	0.903	0.045
25	0.905	0.036

Table 1: US Estimates of line-haul costs as function of cargo weight (in 1982 dollars). Notice how slowly per-mile costs rise and, thence, how rapidly costs per ton-mile decline as cargo weight is increased. (Source: Paxson and Glickert (1982: 34))

Vehicle Weight (lbs)	Cargo Weight (lbs)	Rate Per Pound (1982 US $)	Total Rate (1982 US $)
73 000	45 000	0.056	2520
75 000	47 000	0.054	2540
80 000	52 000	0.052	2700
90 000	62 000	0.050	3100

Table 2: Impact of cargo weight on operator revenue, US Estimates. Notice that revenue rises rapidly with cargo weight. Recalling from Table 1 that total operating costs rise only nominally as truck rate increases, this implies that there are significant incentives for operators to overload their trucks (a typical GCW weight limit would be 60 000 lbs). (Source: Paxson and Glickert (1982: 34).

$$(3)\quad \partial P_i^2(\beta_i^*)/\partial \beta_i^2 = -f.s_i.\{2.\mu'(\Sigma s_i.\beta_i^*) + \beta_i^*.s_i.\mu''(\Sigma s_i.\beta_i^*)\}<0$$

respectively, where the asterisk denotes the solution value and

$$G = [R_o\text{-}C_o] - [R_c\text{-}C_c] > 0,$$

is the increase in gross operating profit (ie abstracting from regulatory penalty considerations) generated by overweighting a truck which would otherwise be in compliance.

The first-order condition dictates that the firm will go on increasing the proportion of its trucks that it overweights upto the point at which the expected increase in gross profit from so doing equals the increase in expected penalties. The increase in penalties has a direct and an indirect component. There is an increased likelihood that if one of that firms trucks is inspected (which will be the case with probability μ) it will turn out to be overweight and thus draw a fine (of size f). In addition, the simultaneous increase in the proportion of non-compliant trucks on the road will lead to an increase in the enforcement effort of the regulator and thus increase the risk of detection of all of that firms (and, incidentally, every other firm's) overweight trucks. There is evidence that truck-operaters do trade-off the costs and benefits from breaching weight requirements in this way when travelling on any particular routeway. One study records that ".....truckers often have substantial experience to aid them in calculating the probability of being apprehended. Based on this probability they can calculate the expected costs (in fines) of overweighting", (Paxson and Glickert (1982: 34)).

Assuming that the optimal mixed strategy for firm i is described by an interior solution for ß (that is, the firm dispatches some, but not all, of it's trucks overweight) application of the implicit function to the first-order condition (equation 2) yields several comparative static results: $(\partial\beta_i^*/\partial R_c)<0$, $(\partial\beta_i^*/\partial R_o)>0$, $(\partial\beta_i^*/\partial C_c)>0$, $(\partial\beta_i^*/\partial C_o)<0$, $(\partial\beta_i^*/\partial f)<0$, $(\partial\beta_i^*/\partial\mu)<0$ and $(\partial\beta_i^*/\partial\beta_j)<0$, all of which have straight-forward interpretation and are strongly intuitive. A particular firm is more likely to violate when G (the gross gain associated with violation) is large, fines are small, inspection frequencies are low and/or it's competitors are violating relatively infrequently.

[3] Market Share and Overweighting.

The vector of n first-order conditions (or, where appropriate, corner solutions), one for each firm in the market segment which we are examining, implicitly serve to define the compliance behaviour of each individual firm, and thence the environmental performance of the industry as a whole. It is of some interest to consider both the impact of a particular firm's market share upon that firm's respect for the weight regulations and, more generally, the impact of market structure upon the compliance of the industry in aggregate. This is of particular interest in considering the possible impact of industry deregulation upon the integrity of the road network.

The inter-city road-haulage industry in Canada (as in most other developed economies) contains firms of many different sizes - from corporations with over a thousand trailers to independent operators with a small handful. Transport Canada data can be used to estimate four-firm concentration ratios for road-haulage services in the Canadian provinces (see Hirshorn (1981: 51)). The total figures range from 15% (for Quebec and Ontario) to as high as 46 and 52% for Manitoba and Saskatchewan respectively. The licences granted to firms are, in most cases, highly specific with regards to the types of vehicles and the precise routes which the operator can utilise.[2] The market structure for freight-haulage on any given routeway can, therefore, be significantly more concentrated than this.[3] The hypothesis of this paper is that operators in a particular market segment (ie on a given routeway) are engaged in a non-cooperative game. Larger firms will take account of the effect which their compliance decisions will have upon the regulatory enforcement effort and thus upon the profitability of their whole fleet of trucks. The operator of a single truck has no incentive to do this and will be more prone, according to our analysis, to overload.

[3.1] Market Share and Overweighting.

Consider the case of a symmetric, n-firm Nash equilibrium. In this case the market share of the representative ith firm is (1/n). Defining Ω to be the industry non-compliance rate (that is, $\Omega = \sum s_i.\beta_i$) the first-order condition associated with an interior solution to the ith firm's truck-loading problem is

$$(4)\quad \partial P_i(\beta_i^*)/\partial \beta_i = G - \mu([\beta_i^* + \sum \beta_h]/n).f - \beta_i^*.\mu'([\beta_i^* + \sum \beta_h]/n).f/n = 0.$$

The assumption that the ith firm has Nash conjectures regarding the reactions of rival firms to changes in his actions means that $(\partial \beta_h/\partial \beta_i)=0$, such that $(\partial \Omega/\partial \beta_i)=s_i=(1/n)$. It will be assumed, again, that the requisite sufficiency condition is satisfied. In equilibrium, symmetry requires that $\beta_i=\beta_h$, such that the subscripts which distinguish between firms can be dropped and the representative first-order condition becomes:

$$(5)\quad G - \mu(\beta^*).f - \beta^*.\mu'(\beta^*).f/n = 0.$$

To examine the impact of market structure upon the propensity of the industry to overload it's trucks, the implicit function theorem can be applied to this equation to show that,

$$(6)\quad \partial \beta^*/\partial n = -(1/J).\{\beta^*.f.\mu'(\beta^*)/n^2\}$$

where J represents the second-order condition associated with the representative firms problem and, as such, is assumed to be negative in the vicinity of $ß^*$. The term in braces is unambiguously positive, thus $(\partial ß^*/\partial n)>0$ - an increase in the number of constituent firms in a symmetric, n-firm Nash equilibrium industry will be associated with an increase in the proportion of trucks which each firm (and, thence, the industry as a whole) dispatch in violation of the weight regulations.

Subject to certain constraints upon the form of the regulatory reaction function, $\mu(\Omega)$, there will exist some N_{min} and N_{max} such that $ß^*=0$ when $n<N_{min}$ and $ß^*=1$ when $n>N_{max}$. That is, when the number of firms in the industry is sufficiently small there will be no overweighting in equilibrium (unless N_{min} turns out to be less than one, in which case this possibility is eliminated). When the number of firms in the industry is sufficiently large all trucks will be overweighted. Notice that N_{max} will be finite only if $G>\mu(1).f$, (ie if $\mu(1)$ is sufficiently small).

The most 'general' case, with both N_{max} and N_{min} being finite and greater than unity, is illustrated in Figure 1.

When one firm overweights one of it's trucks it induces, by increasing the fraction the industry population which is overweighted, an increase in the intensity of regulation. By so doing it inflicts a 'regulatory externality' on it's rivals. Increasing the number of firms in the industry increases the portion of costs due to the regulatory tightening which constitute external costs. As it's share of the industry-wide regulatory costs of overweighting decreases (ie as the industry becomes less concentrated) the firm disregards an increasing portion of those costs and thence overweights more frequently.

In the symmetric case the market share of each firm equals (1/n). Thus more overweighting is associated with firms with smaller market share. This result can be generalised to an asymetric case, in which the industry is populated by firms of different sizes. The analytic result that propensity to overweight is a decreasing function of the size (market share) of the carrier conforms to the evidence that it is the small, independent operator who is prone to frequent violations. Walton and Yu (1983) provide empirical and anecdotal evidence of this in a study of road-haulage in Texas: "Common carriers.......have low rates of violation. These data correspond well to comments rendered by DPS personnel with respect to their observation that independent (small) truck operaters are the significant challenge to License and Weight officers", (Walton and Yu (1983: 28)).

[3.2] Compliance Performance and Enforcement Effort.

Crucial to our model is the supposition that the enforcement efforts of the regulatory agency are 'reactive' in the sense that a change in the proportion of trucks not obeying the weight regulations will induce a change in the inspection rate. We have made the supplementary asssumption that the relationship is positive and concave, such that the 'reaction function' of the regulatory agency is as assumed in the last section.

It is not the aim of this paper to build-in any kind of model of optimal

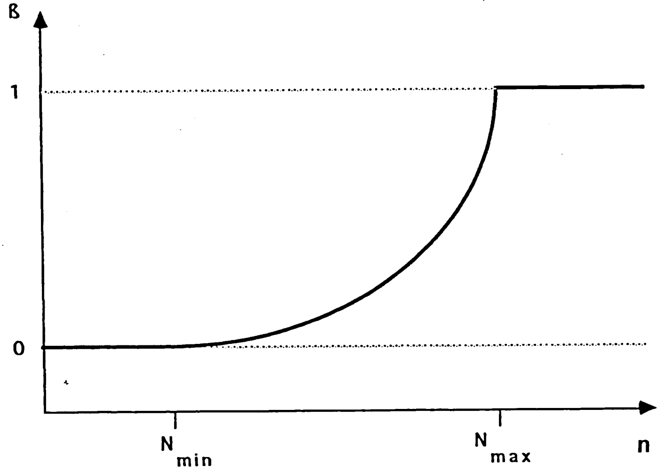

Figure 1: Derived relationship between number of symetric Nash competitors in the industry (n) and the equilibrium propensity of the representative firm to violate weight regulations (ß).

regulatory behaviour (ie to derive the reaction function). Though the regulatory problem has not, to our knowledge, been treated to rigorous economic examination a variety of familiar models could, we assert, be used to derive a reaction function with the requisite characteristics. These include; (i) simple 'crime and punishment' models in which the increased presence of non-compliers in the regulated population increases the productivity of the marginal dollar spent on inspection, thus causing more to be spent upon it, (ii) 'segmented market' models in which a national or provincial agency allocates some fixed budget across a set of market segments (ie different routeways) to maximise number of violators caught or some other objective function, (iii) models of a budget-constrained agency in which penalty income is 'recycled' (either directly or indirectly) into the agency's operating budget, (iv) 'transport planning' models, in which a central planning department (such as a Provincial Highway Commission) with overall control of maintaining the integrity of the road network finds it cost-effecive to respond to increased non-compliance rates by redirecting funds from its maintenance budget (ie damage repair) to its enforcement budget (ie damage prevention), (v) 'behavioural models' in which for (often ill-defined) bureaucratic reasons some desired compliance rate has been targetted by administrative or legislative mandate, and (vi) various 'political economy' models in which increased 'crime' rates and diminishing road quality standards increase public and political awareness of the problem, and thus the efficacity of the various automobile, environmental and other interested pressure groups.

This list of 'stories' which could be told to generate a functional form for $\mu(.)$ of the type assumed in our analysis is suggestive rather than exhaustive. Furthermore, they are not mutually exclusive - two or more effects could work at the same time. It should be straightforward, conceptually at least, to use time-series methods to estimate the relationship between non-compliance and enforcement effort.

[4] On the Benefits From Industry Self-Regulation.

There exist, in general, gains to the industry from self-regulation. Recall that P_i is the expected profit of the representative firm. Consider a small chage in Ω, generated by each firm's simultaneously changing its choice of ß by the same arbitrarily small amount. In the vicinity of the (non-cooperative) Nash equilibrium,

$$(7)\quad dP_i(\Omega^*)/d\Omega = \underset{(+)}{(\partial P_i(\Omega^*)/\partial\Omega)} + \underset{(-)}{(\partial P_i(\Omega^*)/\partial\mu)}.\underset{(+)}{\mu_\Omega(\Omega^*)}$$

The full impact of the change upon the expected profits of the ith firm is the sum of two components. The first is the 'direct effect', holding the level of regulatory enforcement constant. It is obvious that this term is negative, except in the case of n=1 (a monopolised industry) in which case the envelope theorem dictates that it should equal zero. The second term is the effect on expected profitability of the change in regulatory stringency induced by the change in the proportion of violators on the road. This effect will be unambiguously negative, as marked. It can be shown that the indirect effect always outweighs the direct effect by re-expressing Equation 7 (the substitution for the 'direct effect' can be made from the firm's first-order condition, Equation 2) as

$$(8)\quad dP_i(\Omega^*)/d\Omega = (1-s_i).\Omega.f.\mu_\Omega(\Omega^*) - \Omega.f.\mu_\Omega(\Omega^*)$$

$$= - s_i.\Omega.f.\mu_\Omega(\Omega^*) < 0$$

or, in the n-firm symmetric Nash case considered throughout this paper,

$$(9)\quad dP_i(\Omega^*)/d\Omega = -(1/n).\beta^*.f.\mu'(\beta^*) < 0$$

The implication is that an agreement by all firm's in the industry to reduce (each by an equal amount) the frequency with which they overweight their trucks would increase the expected profit of all firms. The result is a variation on the well known Pareto inferiority of Nash equilibria. In the non-cooperative context examined, no firm has an incentive to take account of the 'regulatory externality' which it imposes upon the other firm's in the industry. Thus, every firm overweights more frequently than it would if it were to take account of (or be liable for) the external costs it generates. The result is that the industry ends up in a 'frequent violation/high enforcement' equilibrium.

[4.1] Diagrammatic Exposition: The Duopoly Case.

It is easiest to illustrate the potential gains from self-regulation for the case of an industry comprised of two (symmetric) Nash competitors. In $\{\beta_1,\beta_2\}$-space it is possible to characterise a reaction function for each firm, of the form $\beta^*_1=f(\beta^*_2)$ and $\beta^*_2=f(\beta^*_1)$. It is straightforward to demonstrate that each of these will be downward sloping, as is the case in Figure 2, and truncated at $\beta=1$. There is, of course, no reason to suppose that the reaction functions will be linear - further characteristaion requires that functional forms be imposed.

An iso-expected profit contour for each firm is also sketched in in Figure 2. In each case the expected profit at each point on the contour is the level associated with the Nash equilibrium. The shaded area constitutes a core of $\{\beta_1,\beta_2\}$ pairs which ensure greater expected profits to both of the firms than the Nash equilibrium. Within the constraints of our analysis (ie that we only consider the welfare of the members of the industry) such a solution Pareto dominates the Nash equilibrium. There is, however, a third group whose interests have been suppressed in our analysis, namely the general public - in whose interest regulations are supposedly framed in the first place. It is reasonable to suppose, however, that this third group also prefer the new solution over the Nash equilibrium, since it is associated with a lower rate of violation (and thus road damage) and/or a lower rate of enforcement expenditure. The points in the 'core' can, then, be said to Pareto-dominate the Nash

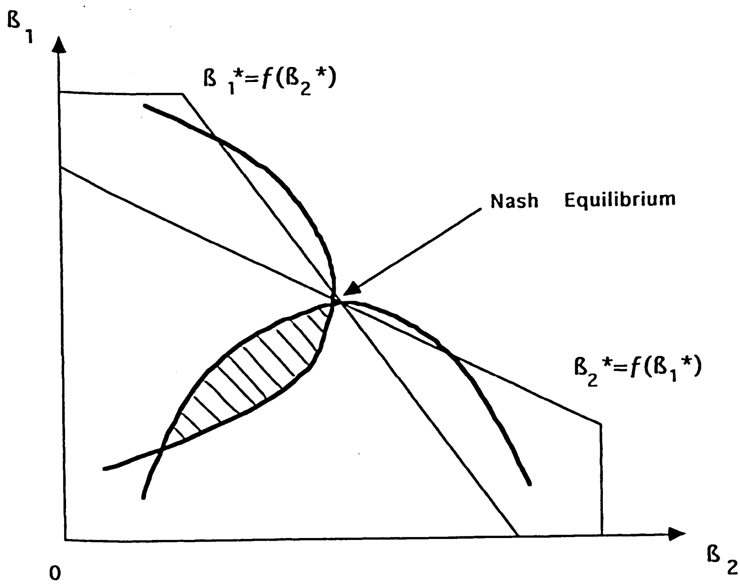

Figure 2: Simplified diagram illustrating the industry gains to self-regulation in the duopoly case. Areas in the core of points Pareto dominate the non-cooperative Nash solution. Representative iso-profit contours are marked (the inverted U-shaped one belonging to Firm 2).

equilibrium.

[4.2] Implementation and Sustainability of a Self-Regulatory Accord.

It is not enough to identify potential gains from cooperative action, in any given context. It is also necessary to examine the extent to which those gains can be reaped. The practical problems associated with implementation of the requisite cooperation may turn out to be formidable.

The procedure whereby the firms in the industry attempt to implement a point in the 'core' (rather than reverting to the non-cooperative Nash solution) is what we will term 'self regulation'. Some convention must be arrived at whereby all operators in the particular geographic market segment agree to comply with the weight regulations more frequently than would be the case in the absence of self-regulation. By how much each firm would be required to raise its own, particular compliance rate cannot be determined uniquely. This reflects the fact that there are a multiplicity of possible solutions involving self-regulation - each associated with a single point in the core marked (for the duopoly case) in Figure 2. Which of the possible points in the core will be 'chosen' by the industry to constitute the solution will depend on, amongst other things, the institutional structure of the industry and the internal framework set-up to facilitate inter-firm bargaining over the terms of self-regulation.

The self-regulated outcome will be associated with less frequent violation and lower enforcement intensity than the non-cooperative Nash solution. In effect, the self regulatory programme has displaced some part of the external regulatory programme and, in this sense, self regulation by the industry can be considered a legitimate (partial) substitute for administrative regulation. The potential Paretian improvements generated by replacing some part of the latter with the former have rested, so far, on the implicit asssumption that enforcement within in the industry would be costless, whereas enforcement from outside is costly. The case can clearly be made, however, whenever internal enforcement is less costly than external enforcement (though not necessarily costless).

The central problem associated with implementing an industry equilibrium with self-regulation is the familiar issue of sustainability (see Shubik (1975) for a classic textbook treatment). It is straightforward to see, from Figure 2 for instance, that from any point in the core every firm stands to increase it's expected profits by unilaterally defecting from that point. More generally, this is true for any point within the area bounded by the reaction functions and the axes. in $\{\beta_1,\beta_2\}$-space with the exception of that associated with the Nash equilibrium. Unless a more cogent story is told as to why the representative firm would not 'cheat' on any industry agreement it is unclear why any solution point other than the Nash equilibrium should be seriously considered. Even if the firms in the industry did agree to some mutual reduction in violation rates it would not be sustainable - we would soon expect to find operaters breaking the terms of the agreement and the self-regulatory system breaking down.

It is, then, necessary that we 'tack on' some additional tool whereby the firms in the industry will be able to sustain mutually beneficial cooperation. Our recommendation is the establishment of 'cartel fines'. Whenever the truck of a particular operator is fined for overweighting (news of such prosecutions are in the public domain) that operator would, as well as the f dollars paid to the formal regulatory agency, pay an additional 'cartel fine' equal to f_c dollars to the internal regulator. The funds thus generated would be paid to the the local truckers association or other nominated self-regulatory body.

The cartel fine which would implement the optimal (ie joint profit maximising) solution would be equal to

$$(10)\quad f_c = [(1-s_i)/s_i].f.\mu'(\Omega^*).\Sigma_{-i}\beta_i ,$$

Where the summation in the expression is done across all of the firms in the industry except for the ith. In the symmetric case this becomes

$$(11)\quad f_c = (n-1).f.\mu'(\beta^*).\beta^*$$

The cartel fine, f_c, constitutes a standard Pigovian corrective penalty and serves to internalise the regulatory externality which each firm would otherwise be visiting upon it's competitors. Notice, from equation 11, that the appropriate f_c is everywhere positive and increasing in n. As a particular firm's market share increases the magnitude of f_c diminishes - capturing the notion that a large firm generates a smaller externality. The biggest cartel fine would, for this reason, be payable by the small operator with a single trailer. It is questionable that a 'regressive' system would sit well with advocates of deregulation - seeming, as it does, to penalise the small firm disproportionately. The best we might hope for would be flat-rate cartel fines, though the distinction is, of sourse, trivial in the symmetric market structure case which was the focus of the earlier analysis. When n=1 (ie s_i=1) the industry is monopolised and the appropriate cartel fine would be zero - the monopolist generates no 'regulatory externality' because there is no other firm in the industry upon which such an externality could be incident.

Whether this type of self-regulation proved workable would depend, to a large extent, on institutional considerations. Implementability would vary among jurisdictions. There is an implicit assumption that some channel exists whereby each firm can be coerced into paying the requisite cartel fine - that by failing to do so it would be expelled from the Association and that expulsion losing the other benefits from membership. These other benefits may, in some cases, be too small to permit expulsion to constitute a serious enough sanction to, and this could hinder workability. One way around this might be to require each operator to deposit some fee with it's association, which would be forfeited if the operator failed to honour the terms of the self-regulatory agreement.

Economic theory predicts that implementation of 'cooperative' equilibria in a non-cooperative setting is likely to be particularly difficult when there are many players involved. It is also likely to be difficult to sustain cooperative action when the jurisdiction is host to a large number of 'transient' trucks which may use the routeways but are not party to the local self-regulatory accord. In examining the feasibility of a self-regulatory régime, then, it is important that the market be adequately delineated.

At a provincial or regional level the appropriate institutions for administering a self-regulatory framework (based on cartel fines or some other mechanism) would be the relevant trucking Associations.[4] One province in which cooperative action be the trucking industry could be expected to be practicable is Newfoundland. This is particularly true following the recent evolution of the market's structure there. Previously, the industry was highly fragmented with many small firms providing service which was not always efficient. With the emergence of of larger firms and a considerable reduction in the number of one-man carriers, a group of twelve carriers has now captured almost all of the trucking market in Newfoundland (the Sullivan Commission noted the rapid rate of small firm consolidations and the subsequent rise to predominance of "10 to 12 large carriers"). This relatively small 'club' of operators, along with the lack of any 'through' traffic (for obvious geographical reasons) of trucks belonging to operators outside of the jurisdiction of the local industry federation makes it particularly likely that a mutually advantageous self-regulatory accord (based, perhaps, on 'cartel fines') could be implemented in that province.

It may be, however, that the natural level of aggregation for such self-regulatory agreements is not at the provincial or regional level. The detailed restrictions on routes to be travelled on a given operators licence means that the industry can be treated as a highly segmented one, and it may be that agreements could be drawn-up at the segmental level. Thus, it is conceivable that the six competing firms on the Sault St. Marie to Sudbury route, mentioned earlier, could arrive at some agreement regarding overweighting on that route (ie in that market segment). In response to these cuts in violation frequency the government regulator would (rationally) cut the enforcement effort which he exerts on that routeway and, as our analysis has demonstrated, all of the six firms could expect to gain.

Cooperative action in any given market segment is also likely to be easier to sustain when the gains to the various parties from cooperation are well-defined. It would, we contend, be in the interests of the government agency to facilitate self-regulatory agreement by making the linkage between observed violation rates, on any given routeway, and future rates of inspection on that routeway more explicit. This would involve commitment to an announced enforcement policy which would serve, analytically, to render the μ-function common knowledge and, in so doing, make the gains to the industry from self-regulation more transparent.

[5] Conclusions.

In this paper we have shown that, in general, there are gains to be had by the trucking industry to (atleast partial) self-regulation of truck weight. As such, our results back-up those of Hildebrand, Prentice and Lipnowski (1990). In our model, however, these arise because of the existence of regulatory externalities.

Local feasibility of a self-regulatory programme is likely to depend upon local institutional factors. Case-study analysis of implementability by region (or even by well defined routeway) is an important next step, and one which we intend to pursue in future research. The main contribution of this paper has been to use economic theory to demonstrate that there are, in all but the most trivial cases, gains to be reaped by the industry from self-imposed regulatory programmes. These can be expected, in general, to take the form of 'codes of practice' and should be backed-up by credible monetary sanctions. We have also argued that such programmes will be socially beneficial and, as such, should be encouraged by government regulatory bureaux.

Endnotes:

(1) I would like to thank Robert Cairns, Christopher Green and Catherine Liston for comments on an earlier version of this paper. This paper was written whilst I was a graduate student in the Department of Economics at McGill University.

(2) See, for instance, Boucher (1981) for details of the limitations on the permits issued to hauliers on the principal Montreal to Quebec City route.

(3) Hirschorn (1981: 53) records the number of competitors on various different routeways in Canada. For one example amongst many, from Sault St. Marie to Sudbury there were six competing firms: four were large (with more than 600 trailers), one medium (300 to 600) and one small (less than 300) firm. On the primary Toronto to Ottawa route there were nine: two large, four medium and three small.

(4) In Canada there are seven of these (the Manitoba, Atlantic Provinces, Ontario and Saskatchewan Trucking Associations, the British Columbia and Alberta Motor Transport Associations and L' Association du Cammionage du Quebec), each affiliated to the Canadian Trucking Association. The position of smaller National organisations which represent smaller sections of the truck population (eg the Canadian Association of Movers or the Private Motor Truck Council of Canada) in a self-regulatory agreement is less clear - comprehensivity, or near comprehensivity, would be vital to the success of such a scheme.

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